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EPA

Annual Water Sampling and Analysis, Calendar Year 2000:

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

YN RUL 420.
CAI 410.06

Annual Water Sampling and Analysis, Calendar Year 2000

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

by

Max G. Davis

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ABSTRACT

The U. S. Environmental Protection Agency, Radiation and Indoor Environments National Laboratory in Las Vegas, Nevada (R&IE), operates the radiological surveillance program surrounding the Nevada Test Site (NTS) and, in addition, monitors former nuclear test areas in Alaska, Colorado, Mississippi, Nevada, and New Mexico, each year under the Long Term Hydrological Monitoring Program (LTHMP). The LTHMP is designed to detect residual man-made radionuclides in surface and ground water resulting from underground nuclear test activities. This report describes the sampling and analysis of water samples collected from six former nuclear test sites in three western states during 2000; Projects Rulison and Rio Blanco in Colorado; Projects Shoal and Faultless in Nevada; and Projects Gasbuggy and Gnome in New Mexico. Monitoring results for Alaska and Mississippi are reported separately.

Radiological results for 2000 are consistent with results from previous years and no increase was seen in either tritium concentrations or gamma-ray emitting radionuclides at any site. Tritium levels at the sites are generally decreasing or stable and are well below the National Primary Drinking Water Standard for tritium of 20,000 pCi/L, with the exception of samples from several deep wells adjacent to the nuclear cavity at the Gnome site. As in previous years, the highest tritium value recorded for any sample, 4.5×10^7 pCi/L, was from one of these wells, Well DD-1 (Project Gnome).

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ACRONYMS AND ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
DOE	U.S. Department of Energy
DRI	Desert Research Institute
RSL	Radiation Sciences Laboratory
EPA	U.S. Environmental Protection Agency
DCG	Derived Concentration Guide (20,000 pCi/L for Tritium in Drinking Water)
g	gram
$^{3}H+$	Enriched Tritium
^{3}H	Tritium
HpGe	high purity germanium gamma detector
IAG	Interagency Agreement
keV	kilo electron volts (one thousand electron volts)
kg	kilogram, 1000 grams
KT	kiloton (one thousand tons TNT equivalent)
LTHMP	Long-Term Hydrological Monitoring Program
L	liter
m	meter
min	minute
MDC	minimum detectable concentration
MeV	one million electron volts
mL	milliliter (one thousandth of a liter)
MT	megaton (one million tons TNT equivalent)
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, Las Vegas, NV
SGZ	surface ground zero
USGS	U.S. Geological Survey
IT	International Technology Corp.

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1.0 INTRODUCTION

Under an IAG with the DOE, the R&IE, formerly Radiation and Sciences Laboratory (RSL), Office of Radiation and Indoor Air (ORIA), 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 former 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 February, May, June, and July of 2000, 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

Radiochemical procedures used to analyze the samples collected for this report are described in Johns, et al. (1979) and are summarized below (see Appendix for typical minimum detectable concentration (MDC) values for gamma spectroscopy). These include standard methods to identify natural and man-made gamma-emitting radionuclides, tritium, plutonium, strontium, and uranium in water samples. Two types of tritium analyses were performed; conventional and electrolytic enrichment. The enrichment method lowers the MDC from approximately 300 pCi/L to 5 pCi/L. An activity limit of activity of 800 pCi/L has been established for the conventional method because sample cross contamination becomes a problem at higher levels.

In late 1995, it was decided that a maximum of 25 percent of all samples collected would be analyzed by the low-level enrichment method. This decision was based on the time required for analysis, budgetary constraints, and an assessment of past results. Under the current sampling and analysis protocol for the site, all samples are initially screened for tritium activity by the conventional method, and selected samples are enriched. At this time only sampling locations that are in a position to show migration are selected for enrichment.

Sufficient sample is collected from new sampling locations to perform all routine analyses, and a full-suite of other radiochemical determinations including assays for strontium, plutonium, and uranium.

Summary of Analytical Procedures

Type of Analysis	Analytical Equipment	Counting Period (Min)	Analytical Procedures	Size of Sample	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%.	~150	Radionuclide concentration quantified from gamma spectral data by online computer program.	3.5L	Varies with radionuclides and detector used, if counted to a MDC of approx. 5 pCi/L for ^{137}Cs.
^{3}H	Automatic liquid scintillation counter	300	Sample prepared by distillation.	30 - 40 mL	300 to 700 pCi/L
^{3}H+ Enrichment	Automatic liquid scintillation counter	300	Sample concentrated by electrolysis following distillation.	250 mL[c]	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.

[c] Sample distilled, then concentrated to ~5ml by electrolysis.

2.1 Sampling at Project RULISON, Colorado

History

Co-sponsored 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 on July 12, 2000, from all sampling locations at Grand Valley and Rulison, Colorado. 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 five sites in the vicinity of SGZ, including one test well, a surface-discharge spring and two wells (RU-1 and RU-2) located at SGZ.

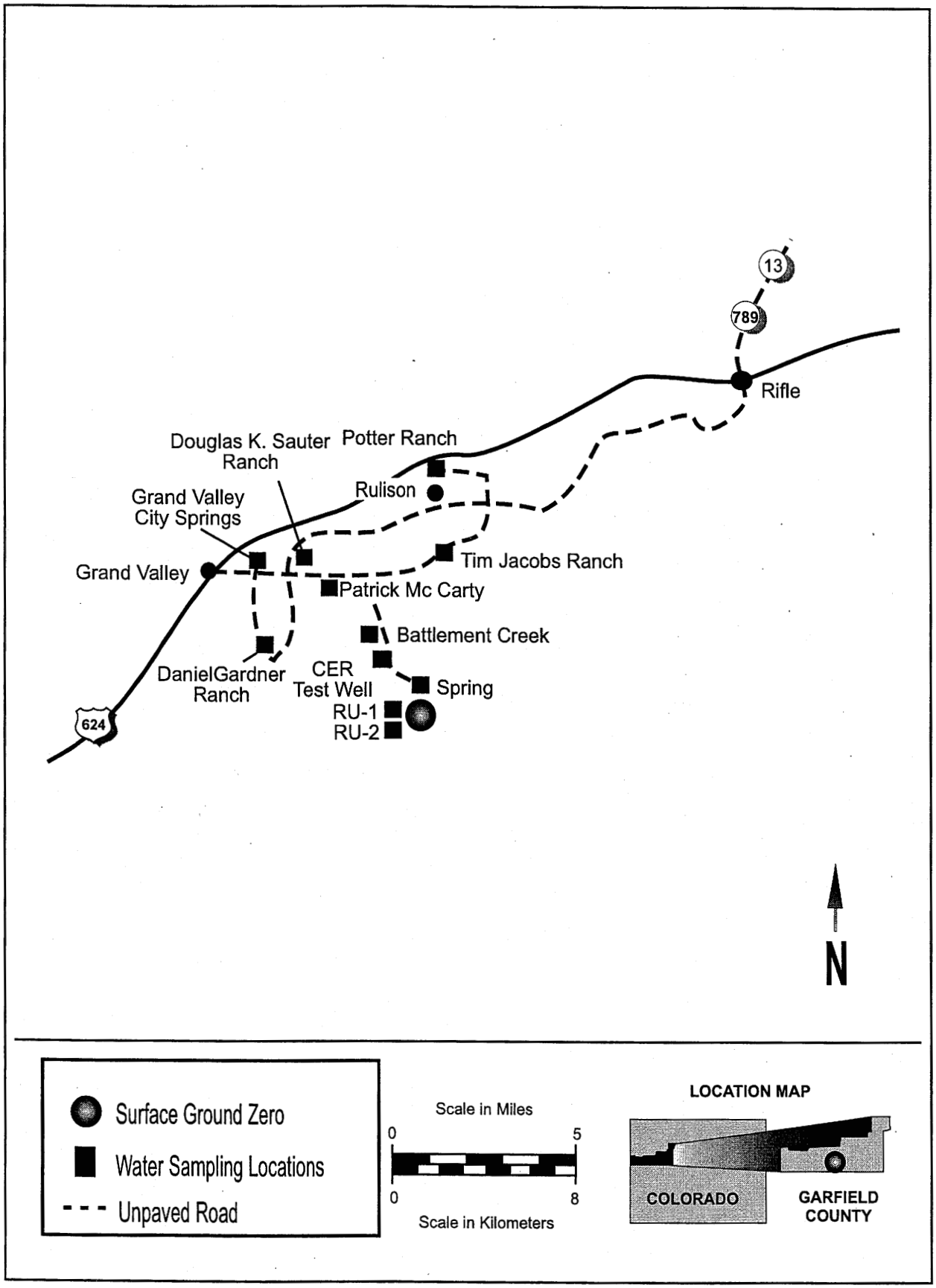

Figure 1. RULISON Site sampling locations for July 2000.

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 2000 was from 32 ± 4.3 pCi/L at RU-1 to 66 ± 4.3 pCi/L at Patrick McCarty Ranch (see Table 1). All enriched values were less than 0.5 percent of the DCG (20,000 pCi/L). The detectable tritium activities are consistent with values found in current precipitation and, perhaps, a small residual component remaining from clean-up activities at the site. This is supported by Desert Research Institute analysis, which indicates that most of the sampling locations at the RULISON site are shallow, drawing water from the surficial aquifer, and therefore, unlikely to become contaminated by radionuclide migration from the Project RULISON cavity (Chapman and Hokett, 1991).

Analysis Results for Water Samples Collected at RULISON Site - July 2000

TABLE 1

Sample Location	Collection Date 2000	Enriched Tritium pCi/L ± 2 SD	(MDC)	Tritium[a] pCi/L ± 2 SD	(MDC)	Gamma Spectrometry[b] pCi/L	(MDC)
Battlement Creek	7/12/00			12.5 ± 122	(201)	ND	(4.9)
City Springs	7/12/00			112 ± 124	(201)	ND	(4.4)
David Gardner	7/12/00			62 ± 123	(201)	ND	(4.8)
CER Test Well	7/12/00			112 ± 124	(201)	ND	(4.8)
Patrick McCarty	7/12/00	66.7 ± 4.3	(5.0)			ND	(5.0)
Potter Ranch	7/12/00			74.9 ± 123	(201)	ND	(4.7)
Douglas Sauter	7/12/00			104 ± 124	(201)	ND	(4.6)
Tim Jacobs	7/12/00			37.4 ± 123	(201)	ND	(5.0)
Spring 300 yds N. of GZ	7/12/00			99 ± 124	(201)	ND	(4.8)
Well RU-1	7/12/00	32 ± 4.1	(5.7)			ND	(4.6)
Well RU-2	7/12/00			74.9 ± 123	(201)	ND	(4.9)
Well RU-3	7/12/00	30.9 ± 3.8	(5.1)			ND	(4.9)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

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. In general, the current level of tritium in shallow wells at the RULISON site cannot be distinguished from the rain-out of naturally produced tritium augmented by, perhaps, a small amount of residual global "fallout tritium" remaining from nuclear testing in the 1950s and 1960s. All routine samples were analyzed for presence of gamma-ray emitting radionuclides. None were detected above the MDC (see Table 1, page 4).

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 on July 13-14, 2000, and locations are shown in Figure 2. The routine sampling locations included four springs, four surface, and five wells, three of which are located near the cavity. At least two of the wells (Wells RB-D-01 and RB-D-03) are 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. None of the 15 samples collected were above the MDC for enriched tritium. This year Well RB-W-01 was not sampled, as it was inaccessible (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 July 2000. All samples were analyzed for presence of gamma-ray emitting radionuclides. None were detected above the MDC.

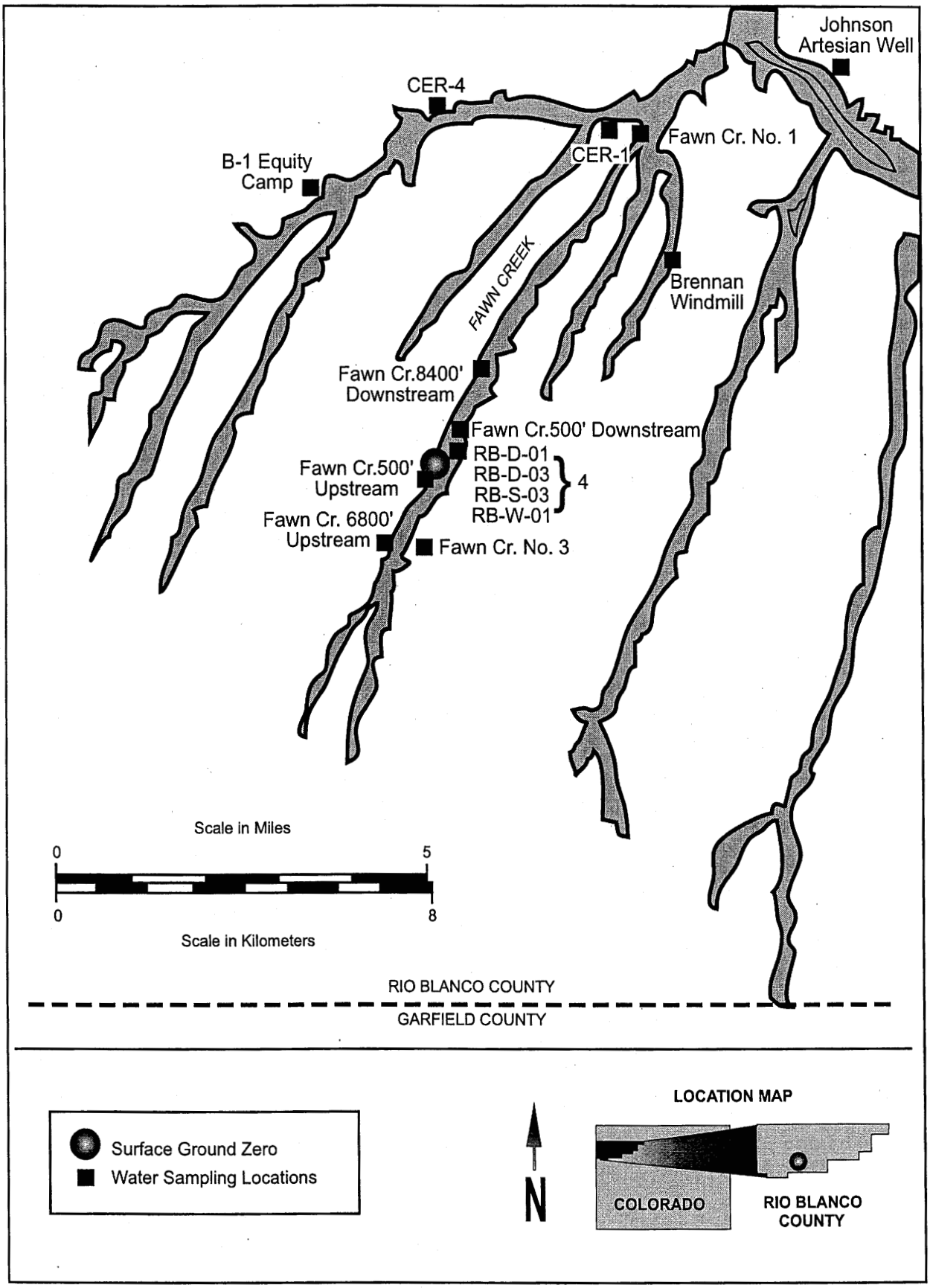

Figure 2. RIO BLANCO Site sampling locations for July 2000.

Analysis Results for Water Samples Collected at RIO BLANCO Site - July 2000

TABLE 2							
Sample Location	Collection Date	Enriched Tritium pCi/L ± 2 SD	(MDC)	Tritium[a] pCi/L ± 2 SD	(MDC)	Gamma Spectrometry[b] pCi/L	(MDC)
B-1 Equity Camp	7/14/00			117 ± 124	(201)	ND	(5.0)
Brennan Windmill	7/13/00			-66.6 ± 120	(201)	ND	(4.9)
CER #1 Black Sulphur	7/14/00			25 ± 122	(201)	ND	(4.6)
CER #4 Black Sulphur	7/14/00			-16.6 ± 121	(210)	ND	(4.9)
Fawn Creek #1	7/13/00			45.8 ± 123	(201)	ND	(4.7)
Fawn Creek #3	7/13/00			-29.1 ± 121	(201)	ND	(4.9)
Fawn Creek 500' Upstream	7/14/00			-66.6 ± 120	(201)	ND	(4.9)
Fawn Creek 6800' Upstream	7/13/00			-45.8 ± 121	(201)	ND	(4.6)
Fawn Creek 500' Downstream	7/14/00			20.8 ± 122	(201)	ND	(4.7)
Fawn Creek 8400' Downstream	7/14/00			8.3 ± 122	(201)	ND	(4.8)
Johnson Artesian Well	7/13/00			-95.7 ± 120	(201)	ND	(4.9)
Well RB-D-01	7/13/00	3.3 ± 3.0 (a)	(4.8)	-22 ± 127	(201)	ND	(4.6)
Well RB-D-03	7/13/00			18 ± 128	(201)	ND	(4.8)
Well RB-S-03	7/14/00	3.7 ± 3.1 (a)	(4.9)			ND	(4.7)
Well RB-W-01	7/14/00			Not Sampled			

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

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 in March and July 2000. Sampling locations are shown in Figure 3. They include one spring and six wells of varying depths. A new well was added in March 2000. This well is located at Twin Springs Ranch.

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. Enriched tritium concentrations were less than the MDC and less than 0.02 percent of the DCG. 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 above minimum detectable levels 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. No gamma-ray emitting radionuclides were detected above the MDC.

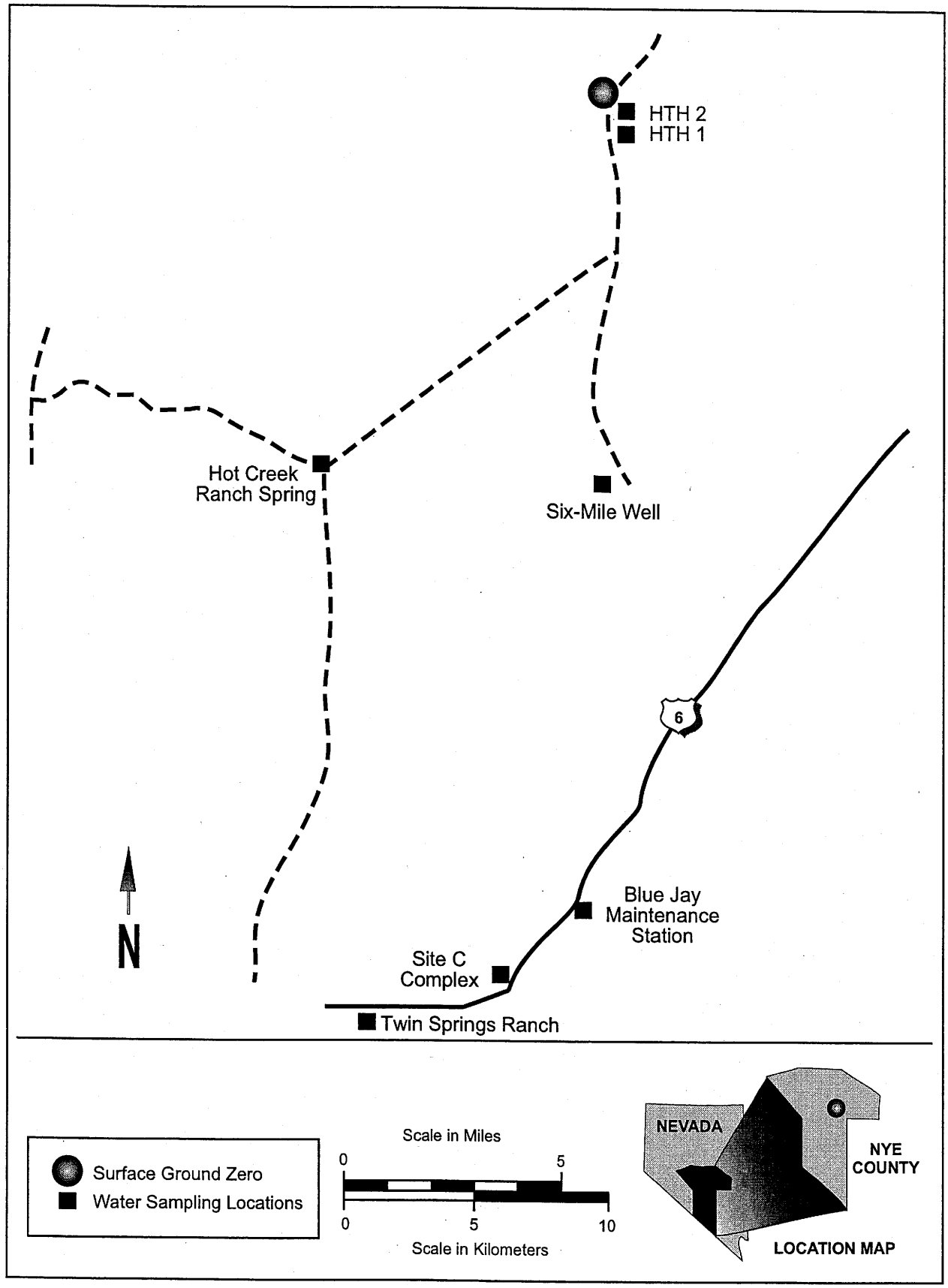

Figure 3. FAULTLESS Site sampling locations for March 2000.

Analysis Results for Water Samples Collected at FAULTLESS Site - March & July 2000.

TABLE 3							
Sample Location	Collection Date	Enriched Tritium[a] pCi/L ± 2 SD	(MDC)	Tritium[a] pCi/L ± 2 SD	(MDC)	Gamma Spectrometry[b] pCi/L	(MDC)
Hot Creek Ranch Spring	3/14/00			6.2 ± 127	(209)	ND	(4.9)
Blue Jay Maint Station	3/13/00			-44.8 ± 126	(209)	ND	(1.7)
Well HTH-1	3/14/00	-.75 ± 3.2	(5.2)			ND	(4.5)
Well HTH-2	7/26/00	-4.6 ± 3.3	(5.1)			ND	(4.8)
Site C Complex	3/13/00			-117 ± 124	(209)	ND	(4.6)
Six Mile	3/14/00	Not Sampled					
Twin Springs Ranch	3/14/00	-2.4 ± 3.5	(5.8)			ND	(1.6)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

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 on February 15 through 17, 2000. The sampling locations are shown in Figure 4. Only eight of the nine routine locations were sampled. Since 1997, eight new wells have been added to the LTHMP at this site which are positioned near GZ. Two of the eight new wells drilled at Shoal in 1999 were designed for conducting a tracer test. Previous modeling of the site found that the effective porosity of the aquifer was a very important, but highly uncertain, parameter. The purpose of the tracer test is to determine the effective porosity of the fractured granite aquifer. The test was conducted in two phases. The initial, smaller, injection consisted of iodide, carbon-13, and deuterium and occurred on November 3, 1999. Its primary purpose was to provide information for the major injection. The major injection occurred on November 10, 1999, and consisted of lithium, bromide, and poly-fluorinated benzoic acid. On November 28, 1999, cesium was injected, and in June 2000, polystyrene microspheres were injected. The breakthrough has been slow, leading to an extension of the test beyond its planned four-month time period to the end of the federal fiscal year (September 2000). Both the injection well, HC-6, and pumping well, HC-7, are likely to contain remnants from the tests for some time to come.

The routine sampling locations include one spring, one windmill, and seven wells of varying depths. At least one location, Well HS-1, should intercept radioactivity migrating from the test cavity, if it occurs (Chapman and Hokett 1991).

2.4.1 Water Analysis Results

Analysis of a well sample from the Shoal Site collected in February 2000, (Well HC-3, sample #72839) has brought to light a potential problem in this program. Apparently, because of fairly significant sediment loading, this sample, as received in the lab, assayed at about 19 pCi/L for natural uranium (U-234+U-235+U-238). It should also be noted that these fairly unusual results occurred even though the sample was filtered in the laboratory prior to analysis. Even more intriguing, an un-acidified sample collected from this well at the same time for tritium analysis showed only ~3 pCi/L of natural uranium.

The difference between the two results is probably due to differences in the collection processes. Specifically, the sample collected for radiochemistry was acidified with nitric acid; the second sample, collected as a spare for tritium analysis, was not. Apparently the acid added to the radiochemistry sample leached uranium from the sediments in the sample. Subsequent filtering in the laboratory removed the bulk of the uranium-containing sediment from the sample but would of course, not be effective in removing what is now dissolved uranium.

One could make the point that some radionuclides in the un-acidified sample might have plated out on the sides of the glass sample bottle - i.e, if the results for the field acidified sample are too high those for the un-acidified sample may be too low. This is not likely for uranium as long as dissolved oxygen and complexing anions, like carbonates, are present. Only re-sampling would sort out the true in-situ "dissolved" uranium content of the water in this well.

In 1987, it was decided that field filtering of water samples was unnecessary and the practice was discontinued. Prior to the annual water sampling in 2001, the issue of filtering water samples will be addressed by DOE and EPA. We recommend that any water sample that shows visible amounts of sediment should be filtered in the field before being acidified with nitric acid. This would also be prudent for any new sampling location and would prevent uncertainty of the type encountered in the analysis of this sample. Standard treatment for ground-water samples submitted for inorganic analysis is filtration through a 0.45 micron filter before acidification. For examples, Gelman Scientific makes a 0.45 micron filtration cartridge that is used by a lot of environmental/hydrology groups. A single filter cartridge used on a battery-operated peristaltic pump or pressurized tank system is sufficient to filter several gallons of water in the field and the used filters should probably be saved in case analysis of the water indicates something unexpected.

As a final note, the "as received" gross alpha result for this sample would probably exceed the Safe Drinking Water Standard of 15 pCi/L (alpha), which could trigger further, and probably un-necessary work, based on a sampling artifact. Because we initially analyzed this sample for uranium (one of the SDWA follow-up analyses for samples that exhibit high alpha activity), we are fairly confident the source of the elevated activity is largely due to the leaching of uranium-containing sediments in the sample by acid added at the time of collection.

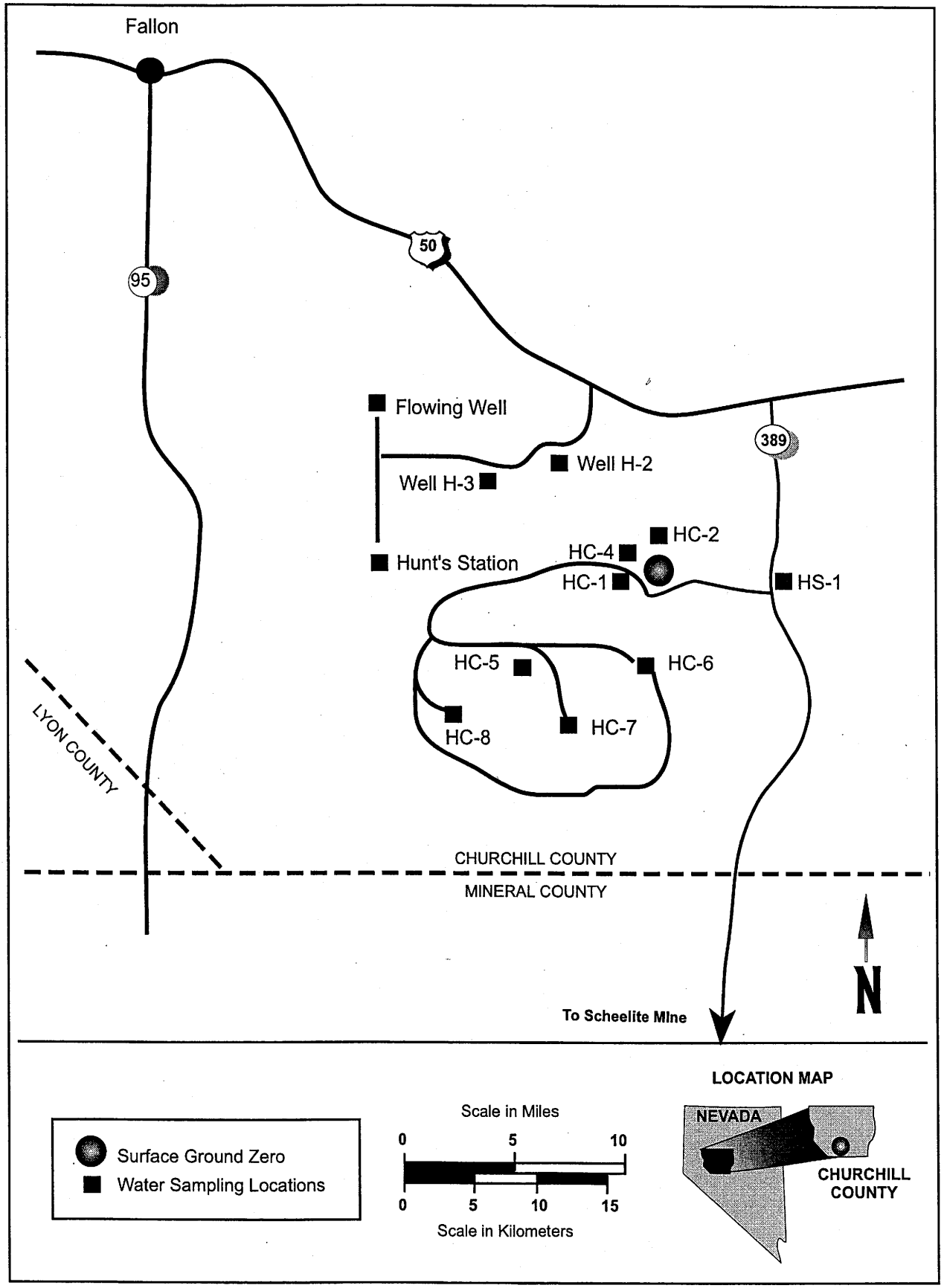

Figure 4. SHOAL Site sampling locations for February 2000.

Gamma-ray spectral analysis results indicated that no man-made gamma-ray emitting radionuclides were present in any samples above the MDC. Tritium concentration at all the locations were below the MDC (see Table 4, below).

2.4.2 Conclusions

No radioactive materials attributable to the SHOAL nuclear test were detected in samples collected in the offsite areas during 2000.

Analysis Results for Water Samples Collected at SHOAL Site - February 2000

TABLE 4

Sample Location	Collection Date	Enriched Tritium pCi/L ± 2 SD	(MDC)	Tritium[a] pCi/L ± 2 SD	(MDC)	Gamma Spectrometry[b] pCi/L	(MDC)
Hunts Station	2/15/00			79 ± 123	(200)	ND	(3.0)
Flowing Well	2/15/00			105 ± 124	(200)	ND	(3.2)
Well H-2	2/17/00			66.2 ± 123	(200)	ND	(3.1)
Well H-3	2/15/00			57.7 ± 123	(200)	ND	(3.8)
Well HS-1	2/17/00	.75 ± 2.9	(4.8)			ND	(3.3)
Well HC-1	2/17/00			147 ± 125	(200)	ND	(3.1)
Well HC-2	2/17/00			49 ± 878	(200)	ND	(3.3)
Well HC-3	2/16/00	1.8 ± 2.9	(4.8)			ND	(3.2)
Well HC-4	2/15/00			442 ± 708	(200)	ND	(3.1)
Well HC-5	2/15/00	0.2 ± 3.2	(5.2)			ND	(3.1)
Well HC -7	2/15/00	2.9 ± 3.3	(5.2)			ND	(3.8)
Well HC-8	2/17/00	-0.6 ± 3.3	(5.4)			ND	(3.7)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

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. A nuclear explosive with a 29-KT yield was detonated at a depth of 1,290 m (4,240 ft) to stimulate

a low productivity natural gas reservoir. 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, and the San Jose formation and Nacimiento formation.

Both surficial aquifers contain 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 8 -10, 2000. All of the routine sampling locations were collected (see Figure 5).

2.5.1 Water Analysis Results

The Cedar Springs sampling site yielded enriched tritium activities of 35 ± 3.8 pCi/L which is less than 0.5 percent of the DCG and similar to the range seen in previous years. Tritium samples from the other locations were all below the average MDC.

Well EPNG 10-36 has yielded tritium activities between 100 and 560 pCi/L in each year since 1984, except in 1987. The sample collected in June 2000, yielded a tritium activity of 88 ± 5.0 pCi/L. The migration mechanism and route are 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 principal aquifers in the region (Chapman 1991). In either case, fractures extending from the cavity may be the primary or a contributing mechanism. The proximity of the well to the test cavity suggests the possibility that the activity increases may indicate migration from the test cavity.

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

2.5.2 Conclusions

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

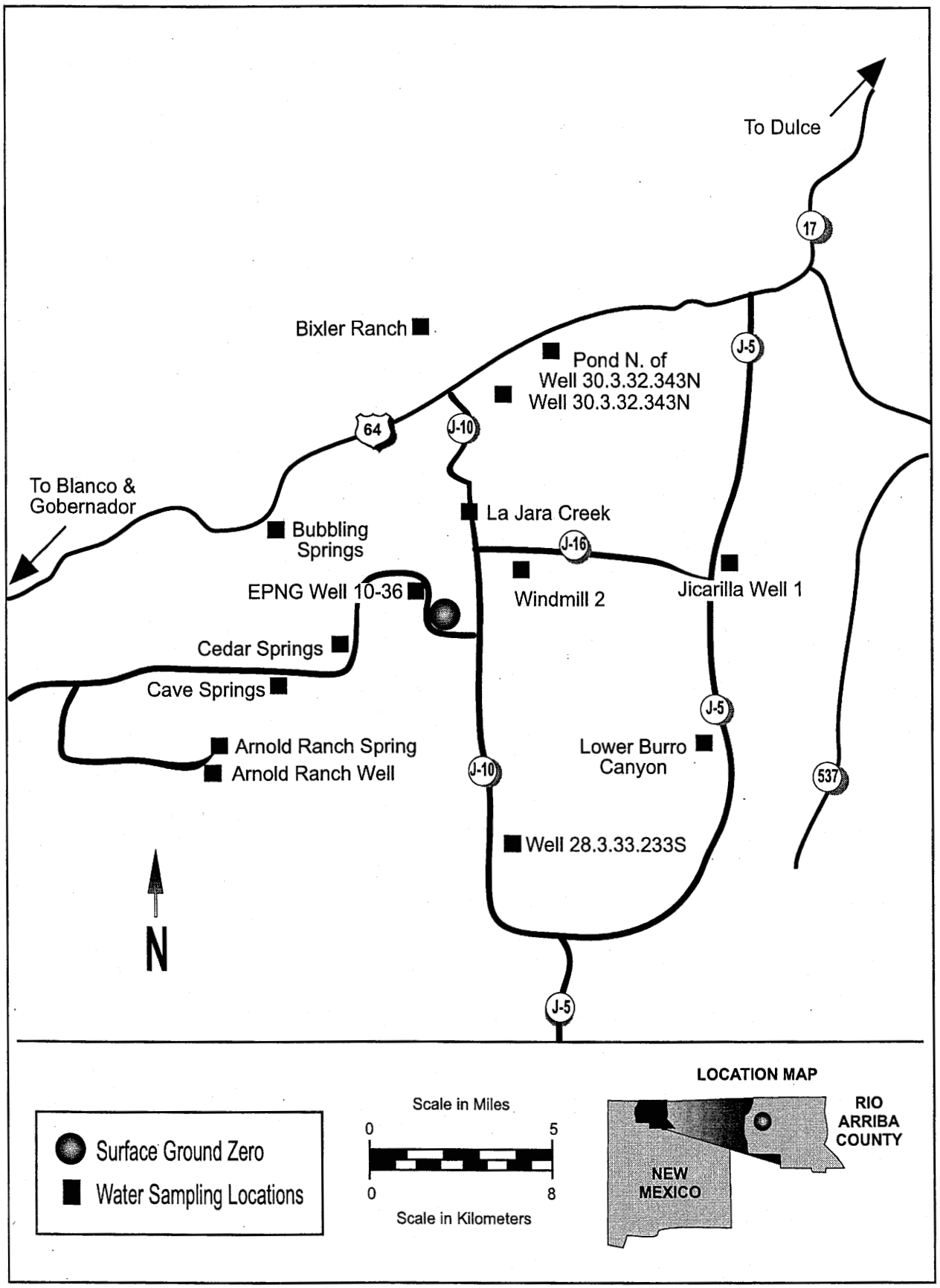

Figure 5. GASBUGGY Site sampling locations for June 2000.

Analysis Results for Water Samples Collected at GASBUGGY Site - June 2000

TABLE 5							
Sample Location	Collection Date	Enriched Tritium pCi/L ± 2 SD	(MDC)	Tritium[a] pCi/L ± 2 SD	(MDC)	Gamma Spectrometry[b] pCi/L	(MDC)
Arnold Ranch Spring	6/10/00			-7 ± 110	(181)	ND	(4.7)
Bubbling Springs	6/09/00			-62 ± 108	(181)	ND	(4.9)
Cave Springs	6/09/00			40 ± 109	(181)	ND	(4.6)
Cedar Springs	6/08/00	35.3 ± 8.8	(5.1)			ND	(4.8)
La Jara Creek	6/08/00			-69 ± 108	(181)	ND	(4.9)
Lower Burro Canyon	6/08/00			-73 ± 108	(181)	ND	(4.5)
Pond N. of Well 30.3.32.343	6/09/00			73 ± 111	(181)	ND	(4.5)
Well EPNG-10-36	6/08/00	88.3 ± 5.0	(5.6)			ND	(5.0)
Jicarilla Well 1	6/08/00			-66 ± 108	(181)	ND	(4.9)
Well 28.3.33.233 (South)	6/08/00			-77 ± 108	(181)	ND	(4.6)
Well 30.3.32.343 (North)	6/08/00			-44 ± 109	(181)	ND	(4.7)
Windmill #2	6/10/00			-4 ± 110	(181)	ND	(4.7)
Arnold Ranch Well	6/10/00			-55 ± 108	(181)	ND	(4.9)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

2.6 Sampling at Project GNOME, New Mexico

Project GNOME, conducted on December 10, 1961, near Carlsbad, New Mexico, was a multipurpose test emplaced at a depth of 1,216 ft in the Salado salt formation. The explosive yield was slightly-more-than 3-KT. 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; using Wells USGS 4 and 8. During remediation activities in 1968-69, contaminated material was placed in the test cavity and the 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. Potentially this may increase as the salt around the cavity compresses, forcing contamination upward and distorting and cracking the concrete stem and grout.

Annual sampling at Project GNOME was completed during June 2000. The routine sampling sites, depicted in Figure 6, include ten monitoring wells in the vicinity of surface GZ; the municipal supplies at Loving and Carlsbad, New Mexico.

2.6.1 Water Analysis Results

No tritium activity was detected in the Carlsbad municipal supply or the Loving Station well. An analysis by Desert Research Institute (Chapman and Hokett, 1991) indicates that these sampling locations, which are on the opposite side of the Pecos River from the Project GNOME site, are not connected hydrologically to the site and, therefore, cannot become contaminated by Project GNOME radionuclides.

Tritium results greater than the MDC were detected in water samples from four of the 12 sampling locations in the immediate vicinity of GZ. Tritium activities in wells DD-1, LRL-7, USGS-4, and USGS-8 ranged from 4.5×10^7 (DD-1) to 1.7×10^3 (LRL-7) pCi/L. Well DD-1 collects water from the test cavity; Well LRL-7 collects water from a sidedrift; and Wells USGS-4 and USGS-8 were used in the radionuclide tracer study conducted by the USGS. None of these wells are sources of potable water.

In addition to tritium, ^{137}Cs and ^{90}Sr concentrations were observed in samples from of Wells DD-1, LRL-7, and USGS-8, while ^{90}Sr activity was detected in Well USGS-4 as in previous years (see Table 7). No tritium was detected in the remaining sampling locations, including Well USGS-1, which the DRI analysis (Chapman and Hokett 1991) indicated is positioned to detect any migration of radioactivity from the cavity. All other tritium results were below the MDC.

2.6.2 Conclusion

No radioactive materials attributable to the GNOME Test were detected in samples collected in the offsite areas during June of 2000.

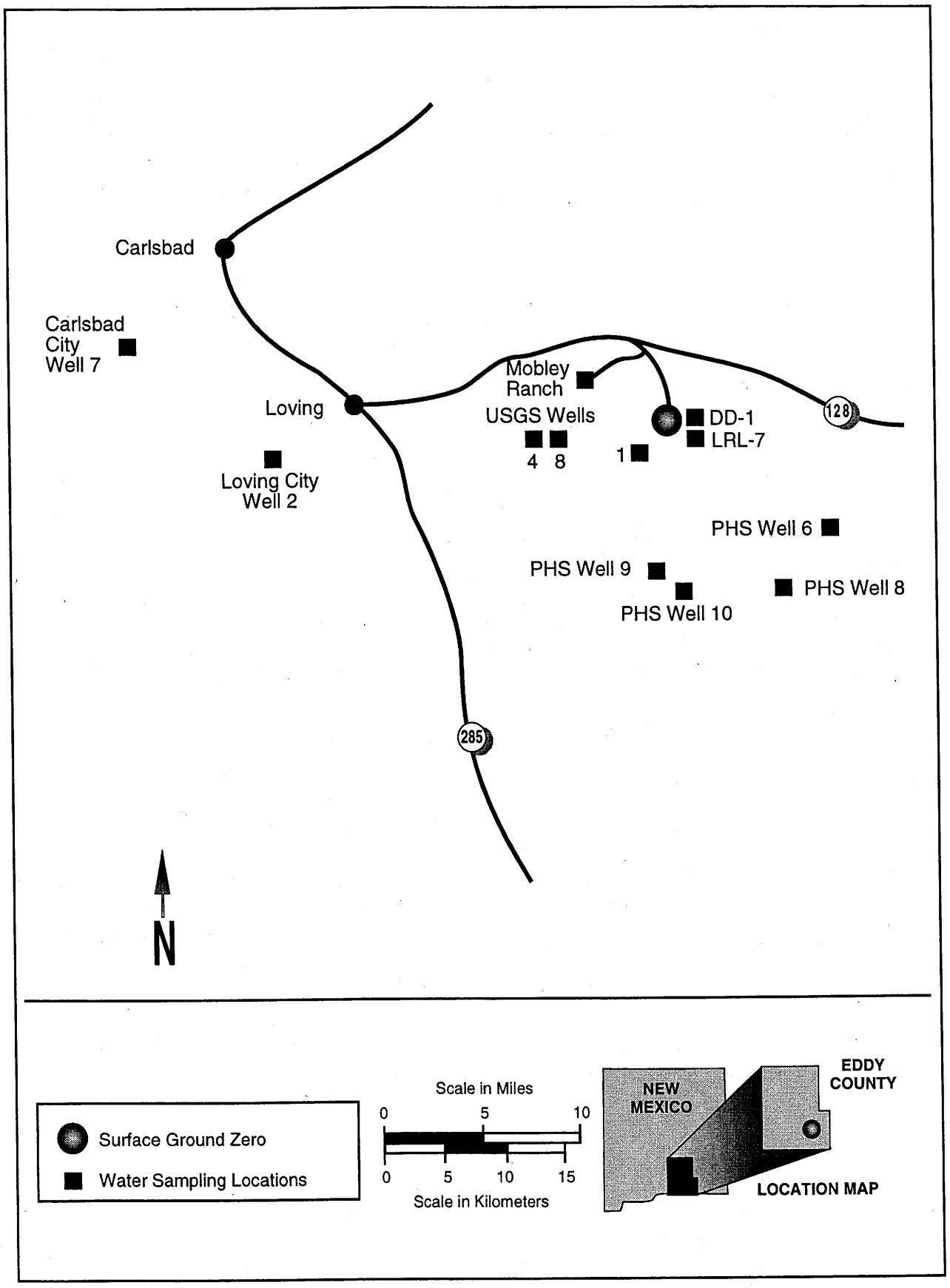

Figure 6. GNOME Site sampling locations for June 2000.

Tritium Results for Water Samples Collected at GNOME Site - June 2000

TABLE 6				
Sample Location	Collection Date	Enriched Tritium pCi/L ± 2 SD (MDC)	Tritium pCi/L ± 2 SD (MDC)	Gamma Spectrometry[b] pCi/L (MDC)
Well 7 City	6/13/00		-1.10 ± 107 (181)	ND (5.0)
Well 2 City	6/13/00	4.2 ± 3.5 (a) (5.6)		ND (5.0)
PHS 6	6/14/00		-18.3 ± 109(a) (181)	ND (4.6)
PHS 8	6/14/00		3.7 ± 110 (a) (181)	ND (4.9)
PHS 9	6/15/00		-54.9 ± 109(a) (181)	ND (4.1)
PHS 10	6/14/00		-14.6 ± 109(a) (181)	ND (4.9)
USGS Well 1	6/13/00	-1.7 ± 3.0 (a) (5.0)		ND (4.9)
USGS Well 4	6/14/00		$7.4 \times 10^4 \pm 748$ (181)	ND (1.5)
Well USGS 8	6/14/00		$5.7 \times 10^4 \pm 538$ (181)	Cs-137 73.4 ± 9.1 (1.54)
J. Mobley Ranch	6/13/00	3.7 ± 3.5 (a) (5.5)		ND (5.0)
Well DD-1	6/15/00		$4.5 \times 10^7 \pm 1.2 \times 10^5$	Cs-137 (4.2×10^3) $6.7 \times 10^5 \pm 1.2 \times 10^5$
LRL-7	6/15/00		$1.7 \times 10^3 \pm 142$ (181)	Cs-137 27.8 ± 4.8 (4.9)

(a) Indicate results are less than MDC (enriched or conventional method).
(b) Value in parenthesis represents ^{137}Cs MDC (pCi/L).
ND Non-detected.

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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 for selected samples 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 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.