NVO-273

NVO--273

DE84 008210

LONG-TERM HYDROLOGIC MONITORING PROGRAM

RULISON EVENT SITE

GRAND VALLEY, COLORADO

Prepared By:

Environmental Branch
Health Physics Division
Nevada Operations Office
U.S. Department of Energy

January 1984

DISCLAIMER

TABLE OF CONTENTS

Section		Page
I.	INTRODUCTION	1
II.	SITE DESCRIPTION	2
	A. Geographic and Topographic Setting	2
	B. Climate and Meteorology	3
	C. Geology	6
	D. Hydrology	9
III.	SITE HISTORY	11
	A. Event Information	11
	B. Contamination at the Site	11
	C. Site Cleanup	12
	D. Groundwater Contamination Prediction	14
	E. Hydrologic Monitoring	15
	1. Preevent Hydrologic Monitoring	15
	2. Postevent Hydrologic Monitoring	15
IV.	LONG-TERM HYDROLOGIC MONITORING PROGRAM	16
	A. Introduction	16
	B. Sampling Points	17
	C. Frequency of Sampling	20
	D. Analyses	20
	E. Sample Retention	21
	F. Flagging System	21
	G. Reports	21

TABLE OF CONTENTS

(Continued)

REFERENCES		23
APPENDIX	EPA Sample Results for Tritium, 1972-1982	24
DISTRIBUTION		25

Illustrations

		Page
Figure 1.	Index Map of Project Rulison Site	4
Figure 2.	Rulison Area Wind Regimes	5
Figure 3.	Geologic Cross Section of Rulison Site Along Trend of Battlement Creek	7
Figure 4.	Project Rulison--Generalized Geologic Cross Section	8
Figure 5.	Hydrologic Sampling Network	18
Figure 6.	Rulison Area Stratigraphy	19

LONG-TERM HYDROLOGIC MONITORING PROGRAM

RULISON SITE

GRAND VALLEY, COLORADO

I. INTRODUCTION

The Nevada Operations Office (NV), U.S. Department of Energy (DOE)*, acknowledges the responsibility of obtaining and having available for dissemination data for all locations where nuclear devices have been tested appropriate and adequate to:

1. Assure the public safety.

2. Inform the public, the news media, and the scientific community relative to radiological contamination.

3. Document compliance with existing federal, state, and local antipollution requirements.

---

*Under the provisions of the Energy Reorganization Act of 1974, the U.S. Atomic Energy Commission (AEC) was abolished on January 19, 1975, and the U.S. Energy Research and Development Administration (ERDA) established in its place. By executive order, ERDA was abolished on September 30, 1977, and the U.S. Department of Energy (DOE) was created to perform essentially all of the programs carried out by the AEC/ERDA. Most of the activities described herein occurred prior to the establishment of ERDA/DOE; therefore, for the purposes of this report, AEC will be used for activities prior to January 19, 1975; ERDA for activities from January 20, 1975 to September 30, 1977; and DOE for activities after that date. Any and all commitments made by the AEC and ERDA will be honored by DOE.

This responsibility can best be fulfilled by execution of a long-term hydrologic monitoring program. This program is carried out by the Monitoring Operations Division, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, Nevada (EPA/EMSL-LV), under the cognizance of the Environmental Branch, Health Physics Division, DOE/NV.

It is contemplated that the long-term monitoring program will remain in effect until, based on program results, action is taken to modify or terminate it.

II. SITE DESCRIPTION

A. Geologic and Topographic Setting

The Project Rulison site is located in Section 25, Township 7 south, Range 95 west, Garfield County, Colorado. It is situated on the north slope of Battlement Mesa on the upper reaches of Battlement Creek. The site elevation is approximately 8,200 feet (2,500 meters). The valley is open to the north-northwest and is bound on the other three sides by steep mountain slopes rising above 9,600 feet (2,927 meters) (Reference 1).

The site is accessible by a graveled road which connects with the county road system. The nearest city with commercial airline service is Grand Junction, population about 28,500*, approximately 40 miles

*Based on the 1980 Population Census.

(64.5 kilometers) to the southwest. The nearest city with substantial industry is Rifle, which has a population in excess of 3,250*, and is located about 12 miles (19.3 kilometers) to the northeast. The closest town is Grand Valley, population of around 340*, which lies approximately 6 miles (9.7 kilometers) northwest of surface ground zero.

In all, about 60 people live within 5 miles (8.1 kilometers) of surface ground zero and 300 people live from 5 to 10 miles (8.1 to 16.1 kilometers) of SGZ. Approximately four permanent habitations are located closer than 3.5 miles (5.6 kilometers) (Figure 1) (Reference 2).

B. Climate and Meteorology

The average annual precipitation at the Rulison site is 20 inches (50 cm). The temperature range is from -10°F to +98°F (-23°C to +37°C (Reference 3). The Rulison site lies in a mountain valley which extends in a NNW-SSE direction resulting in a pronounced diurnal wind regime. Movement of air away from the Rulison SGZ is primarily controlled by three wind regimes. Valley drainage winds and daily upslope winds in both the Battlement Creek Valley and the Colorado River Valley comprise two separate wind regimes. Regional gradient winds, the third regime, blow generally to the east-northeast above the topographical features throughout the year (Figure 2) (Reference 4).

---

*Based on the 1980 Population Census.

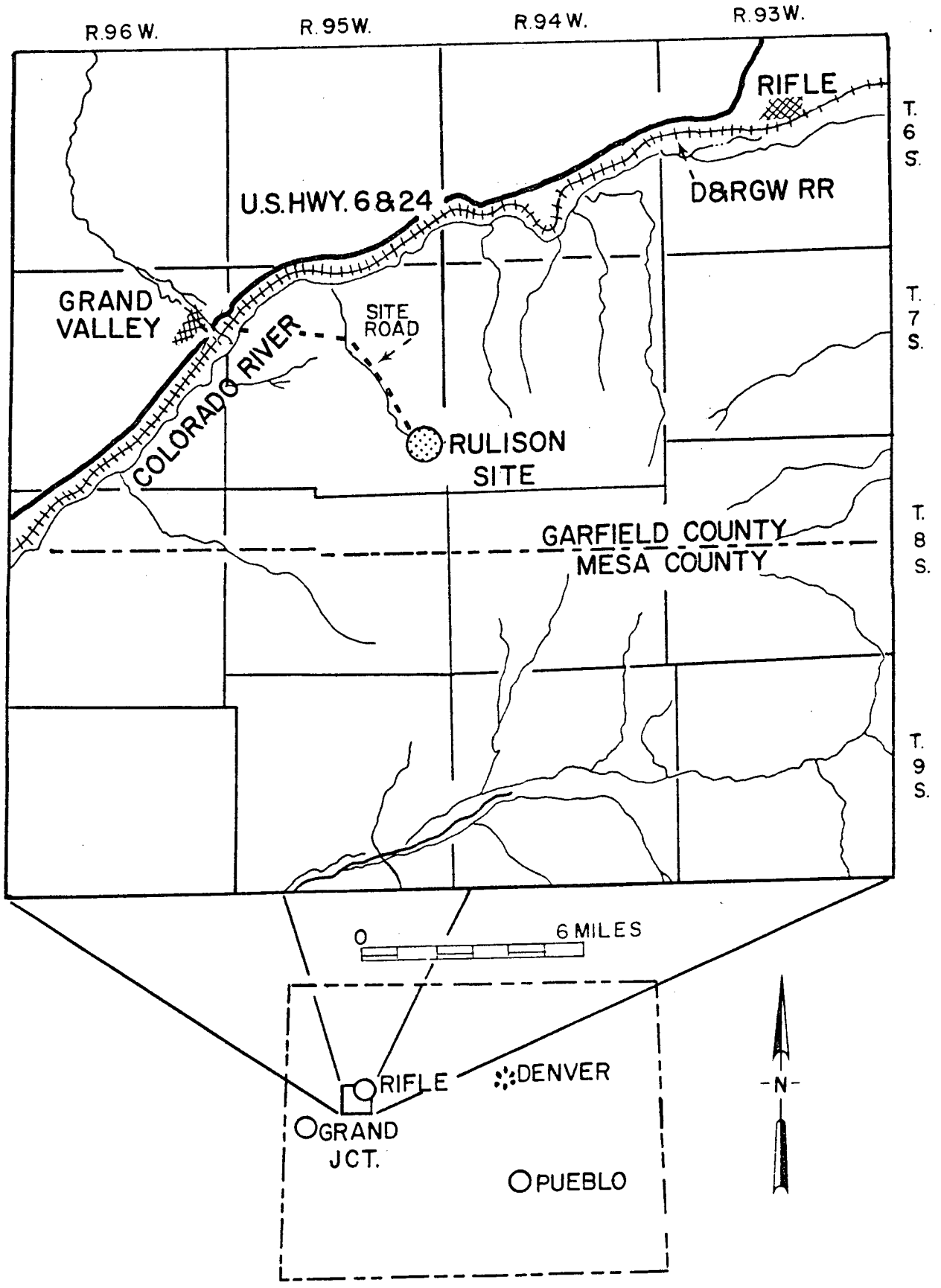

Figure 1: Index Map of Project Rulison Site

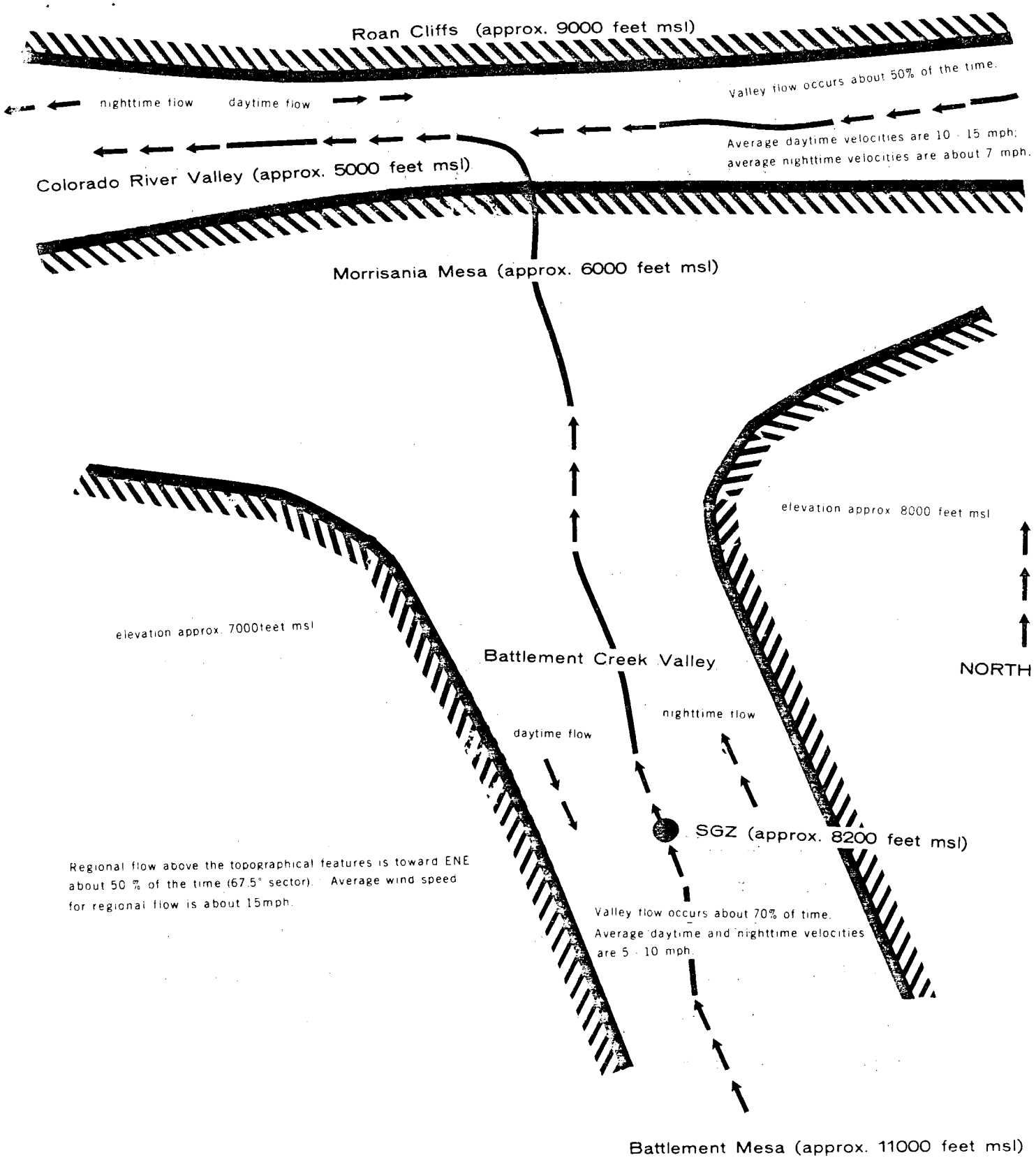

Figure 2: Rulison Area Wind Regimes

C. Geology

The project Rulison site is on the southwest limb of the Piceance Creek basin, a large northwest-trending structural downwarp in northwestern Colorado. Beds penetrated by the exploratory and emplacement holes dip northeastward at 2° or less. The rocks underlying the Rulison site range in age from Quaternary to Precambrian. However, the stratigraphic section of interest extends only through the Mesa Verde Group (Figures 3 and 4) (Reference 5).

Formations penetrated by the exploratory and emplacement drill holes are in descending order:

Quaternary deposits average in thickness from 20 to 40 feet (6.1 to 12.2 meters), but locally may be over 100 feet thick (30.1 meters). Deposits include mud flows, talus accumulations, fan and pediment gravel, slump blocks, and alluvium at Battlement Creek and the Colorado River.

The Green River Formation, of Tertiary age, has four submembers. In descending order they are the Evacuation Creek, the Parachute Creek, the Garden Gulch, and the Douglas Creek members. This formation is about 1,700 feet (518.3 meters) thick at the Rulison site and is composed chiefly of shale and marlstone, with minor amounts of sandstone, siltstone, and limestone.

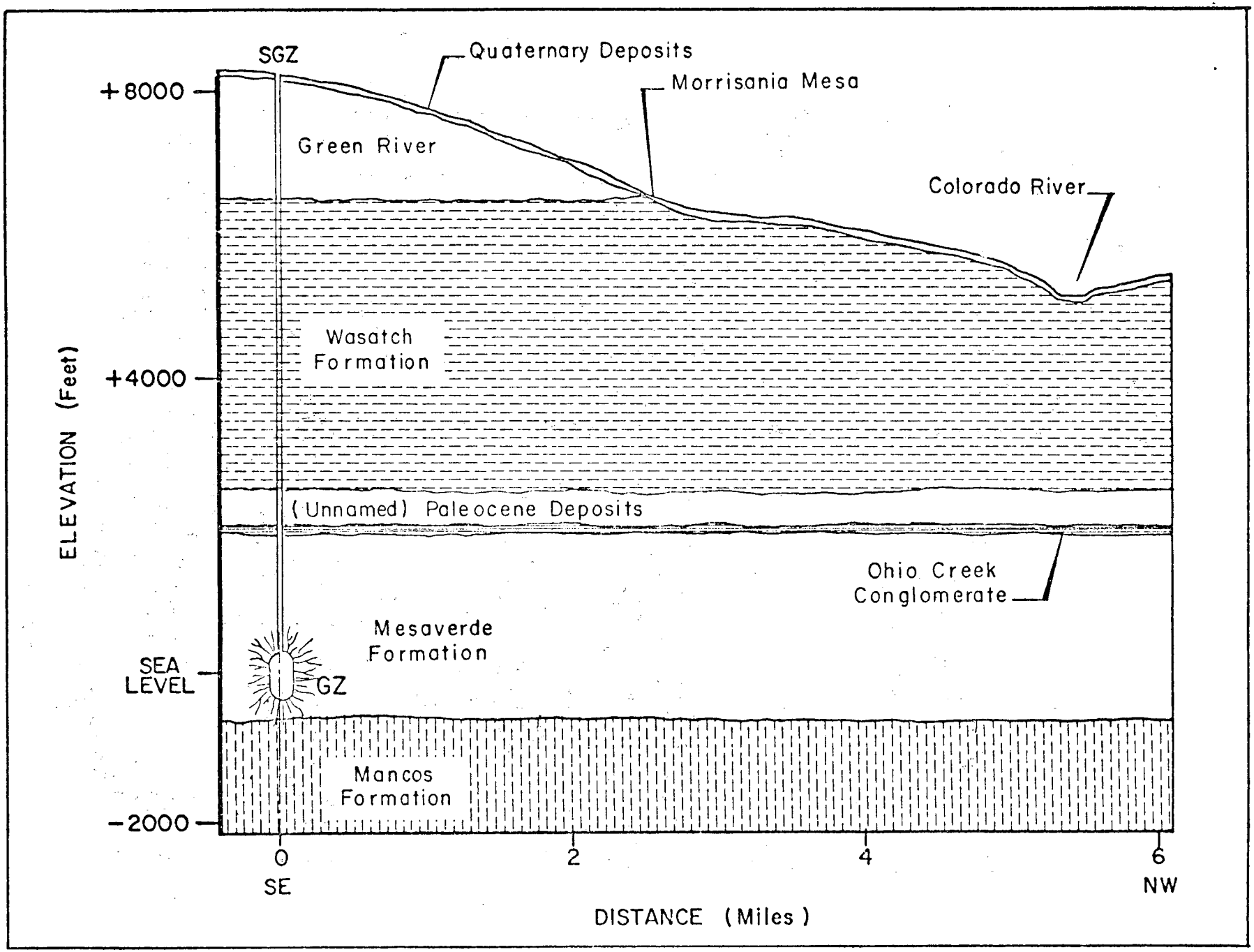

Figure 3: Geologic Cross Section of Rulison Site
Along Trend of Battlement Creek

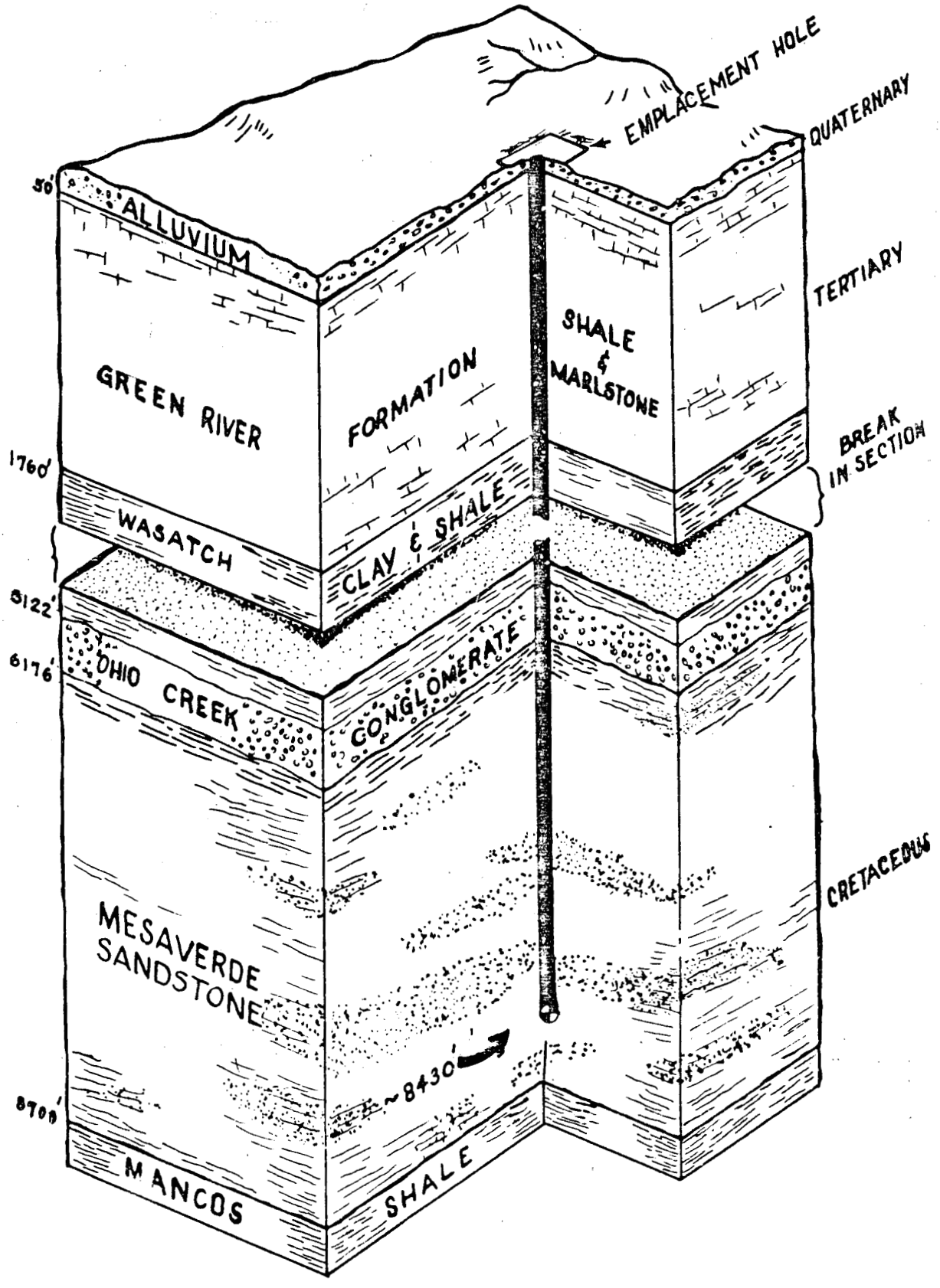

Figure 4: Project Rulison--Generalized Geologic Cross Section

The Wasatch Formation, of Tertiary age, is approximately 3,900 feet (1,189 meters) thick at the Rulison site. It is composed of brightly colored clay and shale with sporatic sandstone lenses.

The Fort Union Formation, of Tertiary age, is less than 500 feet (152.4 meters) thick in the Rulison area. It consists primarily of sandstone and shale, with a few thin beds of coal.

The Ohio Creek Formation, the lowermost Tertiary unit in the area varies in thickness from 37 to 76 feet (11.3 to 23.2 meters). It consists primarily of conglomerate, sandstone, and siltstone.

The Mesa Verde Group, which is upper Cretaceous in age, has three submembers. In descending order, they are the Lewis-Lance equivalent, the Williams Fork, and the Isle. Total thickness of the Mesa Verde Group is approximately 2,500 feet (762.2 meters) and consists chiefly of sandstone with interbedded shales.

D. Hydrology

The northern part of the Piceance Creek structural basin is drained by the White River. The southern part of the basin is drained by the Colorado River. Drainage in the vicinity of the Rulison site is northward to the Colorado River. The Colorado River and its larger tributaries in the area flow on alluvial deposits. Limited coring, conducted by the U.S. Geological Survey, shows that suballuvial floors

of the valley are approximately 80 to 100 feet (24.4 to 30.5 meters) below the flowing stream levels (Reference 6).

Most precipitation is carried into the Colorado River by small streams or underflow in alluvial fill or alluvial terraces. A few springs are present where the underflow in the alluvium is deflected to the surface by impermeable bedrock.

The Quaternary deposits produce a good supply of groundwater to shallow wells. The Green River Formation has only minor amounts of groundwater. The Wasatch Formation is not generally a source of water. The Fort Union Formation is not known to yield water in the Rulison area. The Ohio Creek Formation yields only minor amounts of water locally. The Mesa Verde Group yields no significant groundwater.

Hydrologic tests were conducted in the Rulison exploratory hole, thereby defining the hydrologic system overlying the detonation point. These tests were conducted by the U.S. Geological Survey. The USGS concluded that little or no mobile water exists in the Ohio Creek conglomerate or the Mesa Verde Group which are the stratigraphic units most likely to yield water to the zone of effects (Reference 6).

III. SITE HISTORY

A. Event Information

The Rulison program was divided into three phases. Phase I included drilling the preshot exploratory hole (R-EX) and the emplacement hole (R-E). Phase I also included preshot gas production tests and preshot geologic and hydrologic investigations.

Phase II included surface construction, emplacement, and detonation of the 43 $\pm$ 8 KT yield nuclear device on September 10, 1969, at a depth of 8,430 feet (2,570 meters) below the land surface.

Phase III of the experiment, initiated by April 1970, involved controlled drillback into the cavity followed by flow testing of the gas to determine the cavity size and the rate and volume at which the natural gas could be produced (Reference 7).

B. Contamination at the Site

Essentially all of the explosion-produced radionuclides in the Rulison event were contained within the Mesa Verde Formation (Reference 8). The only contaminants released at the Rulison site were in the form of gases during the gas production testing phase. All gas releases were carefully controlled. An extensive on-site and off-site radiation surveillance effort failed to detect any radioactivity other than ^{3}H

and ^{85}Kr in the environment. Typically, the concentrations of these isotopes in air ranged from about a 10-millionth to a 100-millionth of their concentration in the gas (Reference 9).

The highest air concentration seen was 10^5 times less than the level established by the AEC Manual 0524 for occupational workers. Analysis of on-site vegetation and samples showed only worldwide fallout and natural activity, except for areas with known spills and the close-in area contaminated with fallout or snowout from the flare stack (Reference 10).

C. Site Cleanup

Eberline Instrument Corporation (EIC) was assigned under contract to furnish radiological support for the cleanup of the Project Rulison site. Three EIC employees plus one man from the NV Radiological Operations Division participated. As the funding organization for the cleanup operations, the Austral Oil Company provided one supervisor plus a five-man labor crew.

There were three sampling programs conducted at the Rulison site. After completion of production testing in 1971, soil around the flare stack was sampled in a radial pattern. The second program was conducted in conjunction with the 1972 general cleanup. It included soil, vegetation, and water on and around the R-EX area, including more samples around the flare stack. The third program was part of

the final cleanup (1976) connected with well plugging and abandonment. It included extensive soil sampling in areas of known or potential contamination based on the results of prior sampling and operating experience. This program also included sampling the creek above and below the site as well as spring water at the site.

The three sampling programs adequately delineated the extent of soil and water contamination in the site area after completion of plugging procedures on the R-E and R-EX wells. The only radioactive nuclide in the environment of the site, other than those naturally occurring or resulting from worldwide fallout, was tritium. Final survey concentration did not exceed the guideline limit of 3×10^{-2}) μCi/ml (3×10^4 pCi/ml) of soil moisture as cited in NVO-174 (Rev. 1) (Reference 11).

After the final cleanup was completed, a survey of the site was made at 1 cm distance on a 50-foot grid (10-foot grid over areas of known spills) using a HP-210 beta-gamma probe having less than 7 mg/cm^2 absorber. No reading was obtained greater than the ambient background (0.02 mrad/hr) of the area (Reference 11).

No burial of radioactive solids was made on the Rulison site (Reference 12). All waste materials with contamination levels approaching the above discussed site disposal criteria were appropriately packaged and disposed of at the project's termination. It was concluded that no hazards due to radioactivity are currently

present at, or in proximity to, the land surface on the Rulison site (Reference 13).

D. Groundwater Contamination Prediction

Teledyne Isotopes (TI), Palo Alto Laboratory, made preshot investigations of the hydrologic environment at the Project Rulison site. TI, using field data accumulated by the U.S. Geological Survey, predicted the extent of groundwater contamination for the Rulison event. The Rulison device was emplaced near the base of the Mesa Verde Formation (see Figure 2) at a depth of 8,430 feet (2,570 meters). This depth of burial was considerably greater than that required for normal containment purposes. Essentially all of the explosion-produced radionuclides were contained within the Mesa Verde Formation. Groundwater movement in this formation is estimated to be a maximum of one foot (0.3 meters) per day. The most probable rate being closer to zero (Reference 8).

Assuming the one foot (0.3 meter) per day rate of flow, TI predicted that tritium, the radionuclide of concern, would move less than one mile (1.61 kilometers) before decaying to a concentration less than the established Radiation Concentration Guide (RCG) for drinking water, which at that time was 1×10^6 pci/L. After 1979, the RCG for drinking water was lowered to 2×10^4 pCi/L.

E. Hydrologic Monitoring

1. Preevent Hydrologic Monitoring

The U.S. Geological Survey conducted a preshot inventory of wells and springs in the Rulison area between March 20 and May 25, 1969. The purpose of the inventory was to document the condition of wells and springs and to collect water samples for chemical and radiochemical analysis. All known wells within a 6.2-mile (10-kilometer) radius of the Rulison emplacement hole were inventoried. Selected wells and springs were inventoried within a 10- to 20-mile (16.1- to 32.2-kilometer) radius. A total of 29 sample locations were selected for background radiochemical analyses. Subsequently, a sampling network of 21 stations was established to provide the basis of evaluating postshot changes in radionuclide concentrations (Reference 8).

2. Postevent Hydrologic Monitoring

The preestablished hydrologic network of 21 stations initiated for radiochemical analysis was sampled 10 days after the Rulison event. Analysis confirmed that the event had not caused any increase in radioactivity in surface or groundwater supplies (Reference 8).

The USGS sampled this network before and after detonation, before and after drillback, and following each of the three gas production tests with the same negative results.

IV. LONG-TERM HYDROLOGIC MONITORING PROGRAM

A. Introduction

The Hydrologic Program Advisory Group (HPAG) reviewed the Long-Term Hydrologic Monitoring Program proposed for the Rulison site at their December 12, 1971, meeting. They found the program adequate and recommended its immediate initiation.

B. Sampling Points Figures 5 and 6

DEPTH FEET	WELLS	LOCATION	PROBABLE FORMATION
150	Lee L. Hayward Ranch Well	T7S, R95W, Sec. 10, NE 1/4, SE 1/4, NW 1/4	Pleistocene
145	Robert Searcy Ranch Well (Schwab)	T7S, R95W, Sec. 10, NE 1/4, SE 1/4, SW 1/4	Pleistocene
130	Albert Gardner Ranch Well	T7S, R95W, Sec. 20, NE 1/4, NW 1/4, NW 1/4	Pleistocene
93	Felix Sefcovic Ranch Well	T7S, R94W, Sec. 6 SE 1/4, SE 1/4, SE 1/4	Recent
45	CER Test Well	T7S, R95W, Sec. 14, SW 1/4, SW 1/4	Recent
	SPRINGS		
N/A	Grand Valley City Supply	T7S, R95W, Sec. 5 SE 1/4, SW 1/4, SE 1/4	---
N/A	Potter Ranch Spring	T6S, R94W, Sec. 31 NW 1/4, NW 1/4, NW 1/4	---
N/A	Spring	T7S, R95W, Sec. 25 NW 1/4, NW 1/4, SW 1/4	---
	SURFACE WATER		
N/A	Battlement Creek at Nearest Down Gradient Accessible Location	T7S, R95W, Sec. 15, SE 1/4, NE 1/4	---

Analylical results are listed in the Appendix.

Flexibility remains in the monitoring program to the extent that monitors are directed to collect for analysis, water samples from any water system about which there is local public concern.

Appropriate wells will be added to the monitoring network as they become available. Some wells eventually will be lost to the program by destruction.

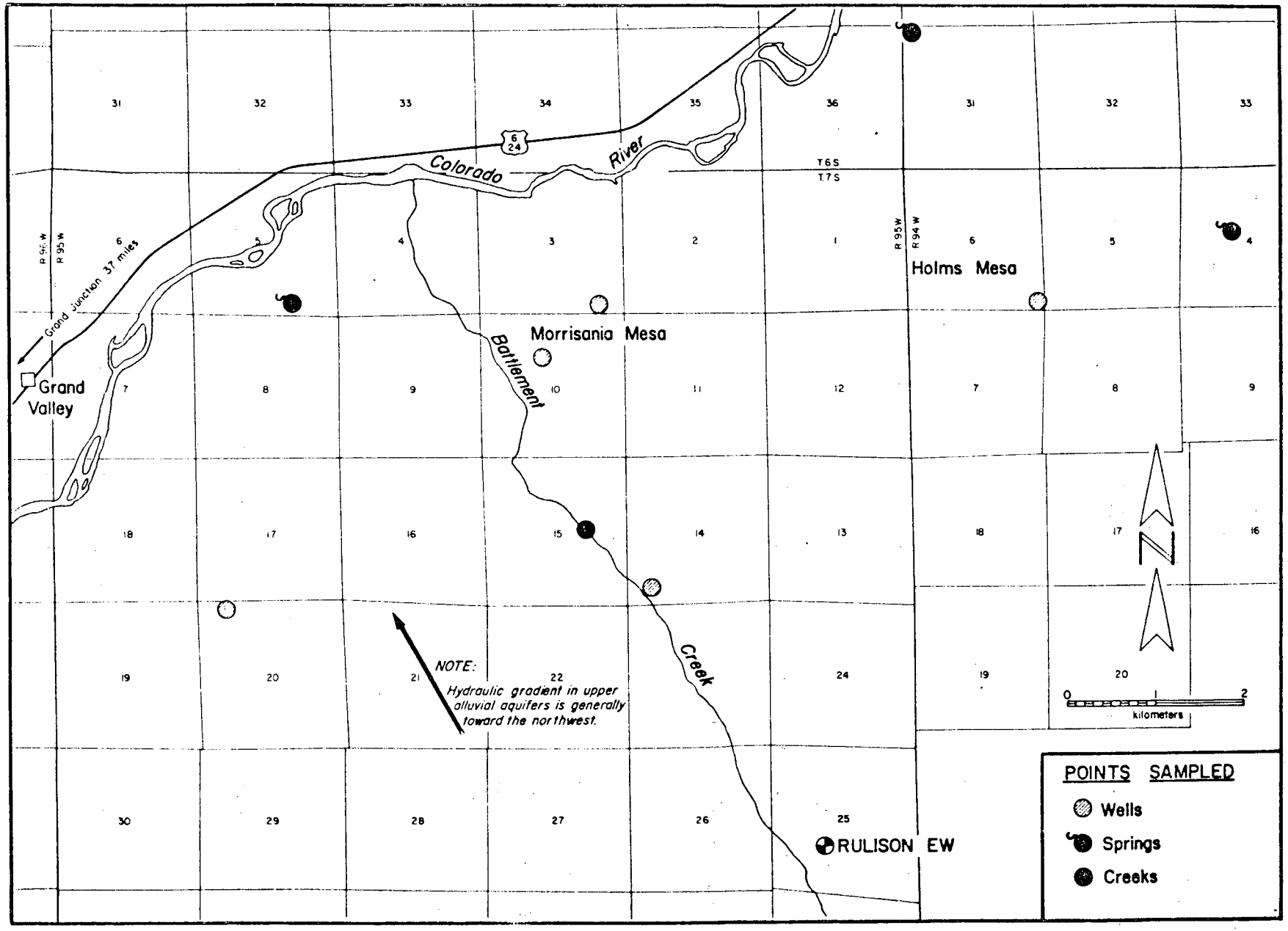

Figure 5: Hydrologic Sampling Network

SYSTEM AND PERIOD			FORMATIONS	GENERAL LITHOLOGY	APPROX. THICKNESS
QUATERNARY			"Recent"	Low terrace, floodplane, and alluvial deposits	100'
			"Pleistocene"	Terrace and fan sand and gravel, pediment gravel, colluvium, mudflow, and solifluction deposits	200'
TERTIARY			(?)	Basalt flows underlain by variegated claystones and gravel	1,000'
			Green River	Oil shales, marlstones, and sandstones (dark color)	2,100'
			Wasatch	Bright colored clays and shale with minor sandstone	5,000'
			Fort Union	Brown-gray shale and coal	1,000'
			Ohio Creek	Sandstone and conglomerate	50'
CRETACEOUS	UPPER	MESAVERDE	Lewis-Lance Equiv.	Shale ~ sandstone	2,500'
			Williams Fork	Shale	
			Isle	Shale ~ sandstone	
	LOWER		Mancos	Gray shale	1,700'
			Naturita	Shale ~ sandstone	600'
			Dakota Cedar Mt.	Sandstone	200'
JURASSIC			Morrison	Variegated shale and sandstone with interbedded tuff and ash	800'
TRIASSIC			State Bridge	Red arkosic sandstone	600'
			Schoolhouse	Sandstone	60'
PERMIAN			Minturn	Continental red beds interbedded with white Weber type sandstone	1,000'
			Maroon	Buff-red sandstone	
PENNSYLVANIA			Eagle Valley	Evaporites (chiefly anhydrite)	2,800'
			Belden	Gray to black shale with basal conglomerate	
CAMBRIAN THROUGH MISSISSIPPIAN			Madison, etc.	Limestone, dolomite and quartzite	~700'
PRE-CAMBRIAN				"Basement" metamorphics and plutonics	

Figure 6: Rulison Area Stratigraphy

C. Frequency of Sampling

Samples will be collected annually, at about the same dates each year. Sampling frequency will be increased appropriately if analytical results suggest this would be advantageous.

D. Analyses

The hydraulic head, temperature in ^{o}C, pH, and electrical conductance are recorded at the time of sample collection.

Prior to October 1, 1979, each sample was analyzed for gamma emitters and tritium. Gross alpha and beta radioactivity measurements were made on all samples collected. After October 1, 1979, these analyses were discontinued in favor of high-resolution gamma spectrometry using a GeLi detector. For each sample location, samples of raw water and filtered and acidified water are collected. The raw water samples are analyzed for tritium by the conventional method. Those samples with concentrations that are below the detection level for this method are then analyzed by the enrichment method. Portions of the filtered and acidified samples are analyzed for gamma emitters.

E. Sample Retention

A split of each sample collected is retained for specific nuclide determination until it is demonstrated that the need to retain them does not exist (normally one year from date of collection).

F. Flagging System

A computer flagging system to detect anomalous analytical results and make appropriate notification is operational on a routine basis.

Incoming analytical results are compared by computer with historical results. In the event that significant change is observed, appropriate DOE and EPA staff are notified. Steps are taken as necessary, including reanalysis of sample splits retained for this purpose and, in some cases, resampling to explain the cause for the anomalous analytical result.

G. Reports

In the event that a meaningful increase in radionuclide concentration is demonstrated, the Health Physics Division, NV, is to be notified immediately.

Annual reports are to be prepared by EPA/EMSL-LV, which contain the following:

1. Description of the sampling network.

2. Results, with comments on analytical techniques used and degree of accuracy achieved.

3. Interpretation of results.

4. Evaluation of the monitoring program with suggested modifications for its improvement.

REFERENCES

1. U.S. AEC. 1973. Project Rulison--Manager's Report. U.S. AEC Report, NVO-71. p. 7.

2. Personal Communication with Lee Hayward, Parachute, Colorado, October 19, 1983.

3. Personal Communication from USGS.

4. Evans, R. B., and D. E. Bernhardt. 1970. Public Health Testing, Project Rulison (Production Testing). U.S. Public Health Service, Southwestern Radiological Health Laboratory Report, SWRHL-96. p. 6.

5. USGS. 1970. Geohydrology-Project Rulison, Garfield County, Colorado. U.S. Geological Survey Report, USGS-474-68. pp. 4-5.

6. U.S. AEC. 1973. Project Rulison-Manager's Report. USAEC Report, NVO-71. p. 48.

7. U.S. AEC. 1973. Project Rulison-Manager's Report. USAEC Report, NVO-71. pp.1-3.

8. U.S. AEC. 1973. Rulison Site Cleanup Report. USAEC Report NV-136. p. 18; "Radioactivity in Water--Project Rulison" by William E. Nork and Paul R. Fenske. February 1970. NVO-1229-131; and "Radioactivity in the Hydrologic Environment--Project Rulison by William E. Nork. April 23, 1969. PALTR-1229-213.

9. U.S. AEC 1972. Project Rulison Final Operational Radioactivity Report. Product Tests. U.S. AEC Report, NVO-112. pp. 2-8. (Also Rulison Open File Report, PNE-R-57.)

10. U.S. AEC 1973. Project Rulison-Manager's Report, USAEC Report, NVO-71. pp. 75-76.

11. EIC. 1977. Rulison Radiation Contamination Clearance Report, Prepared by Eberline Instrument Corporation, Santa Fe, New Mexico, for U.S. ERDA. p. 2. (Also as Open File Report, PNE-R-68.)

12. U.S. ERDA. 1977. Project Rulison-Well Plugging and Site Abandonment, Final Report. U.S. ERDA Report, NVO-187. p 21.

13. U.S. AEC 1973. Rulison Site Cleanup Report Report, NVO-136, p. 5-9.

APPENDIX

Rulison Tritium Results in pCi/L for 1972-1982

	1972		1973		1974		1975		1976		1977		1978		1979		1980		1981		1982	
	3H	$3H^+$	3H	$3H^+$	3H	$3H^+$	3H	$3H^+$	3H	$3H^+$	3H	$3H^+$	3H	$3H^+$	3H	$3H^+$	3H	$3H^+$	3H	$3H^+$	3H	$3H^+$
HAYWARD RANCH WELL	380±230		<300		480±13		350±12		480±210		440±230		710±350		390±11		330±11		360±10		370±8.4	
SEARCY RANCH WELL (SCHWAB)	740±240		670±250		800±16		380±13		740±270			430±14	690±350		440±11		360±11		250±8.9		320±8.3	
GARDNER RANCH WELL	770±240		420±240		510±12		510±15		610±270	310±9.8	390±230		650±350		310±9.8		300±10		240±8.8		250±7.7	
SEFCOVIC RANCH WELL							580±15		420±11		520±240		880±350		300±10		310±11		290±9.5		320±8.4	
CER TEST WELL	770±240		800±250		610±15		540±16		350±11		560±240		580±350		230±8.9		240±9.6		190±7.7		280±8.0	
BERNKLAU RANCH WELL	250±230		320±240		350±13		510±19		350±9.6													
GRAND VALLEY CITY SUPPLY (SPRING)	270±230		<300		170±11		130±9.6		<6			56±8.3		<20	40±6.8		31±6.6		46±6.1		74±5.8	
POTTER RANCH SPRING											460±240		680±350		280±9.5		230±9.4		210±8.2		270±7.6	
SPRING (300 YDS. N.W. OF GZ)	510±230		740±250		450±13		480±16		270±9.3			170±11	730±350		180±8.5		210±9.2		130±7.7		190±7.1	
BATTLEMENT CREEK (SURFACE)	860±240		510±240		580±15		300±12		250±13			330±13	850±350		240±9.1		140±8.2		200±8.5		190±7.1	

3H = Tritium analysis by conventional method.
$3H^+$ = Tritium analysis by enrichment method.