

COAL-SPOIL AND GROUND-WATER CHEMICAL DATA FROM TWO COAL MINES;  
HANNA BASIN AND POWDER RIVER BASIN, WYOMING

By L. R. LARSON

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## CONVERSION FACTORS

For use of readers who prefer to use metric (International System) units, rather than the inch-pound units, the following conversion factors may be used:

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
foot (ft)	0.3048	meter
inch	25.40	millimeter
mile	1.609	kilometer
ton, short	0.9072	tonne

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C} = 5/9(^{\circ}\text{F} - 32^{\circ})$$

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NDVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly call "Mean Sea Level of 1929."

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ABSTRACT

*Coal-spoil data and water-quality data for samples collected from two Wyoming coal-mining areas are presented in six tables. The Medicine Bow and Seminoe Number 1 Mines in the Hanna basin comprise one site, and the Cordero Mine in the Powder River basin is the other site. The data consist of X-ray diffraction analysis of spoil samples, analysis of the saturated paste extract of spoil samples, sulfur-forms analysis of spoil samples, analysis of water samples obtained from batch-mixing experiments, and analysis of ground-water samples collected from wells in the spoil and coal aquifers. The data were collected as part of a regional study which will evaluate methods used to predict post-mining ground-water quality of aquifers affected by the strip mining of coal in the West.*

INTRODUCTION

Purpose and Scope

A considerable amount of data has been collected from mines in Wyoming, Montana, Colorado, Oklahoma, North Dakota, and Texas in order to evaluate methods used to predict post-mining ground-water quality of aquifers affected by the strip mining of coal in the West and to determine the geochemical processes involved. The purpose of this report is to document all data collected in Wyoming for this regional study. The data collected are as follows: 1. mineral composition of spoil samples, 2. saturated paste-extract analysis of spoil samples, 3. sulfur-forms analysis of spoil samples, 4. chemical analysis of water samples obtained from batch-mixing experiments, 5. common-constituent analysis of water samples from coal and spoil aquifers, and 6. trace-constituent analysis of water samples from coal and spoil aquifers. The two Wyoming mining locations selected for inclusion in the regional study are the Medicine Bow-Seminoe Number 1 Mines in the Hanna basin and the Cordero Mine in the Powder River basin. (The adjoining Medicine Bow and Seminoe Number 1 Mines are treated as a single site in this report.) Spoil samples and ground-water samples from the coal and the mine spoil were collected in 1984 and 1985.

Physical and Climatic Settings

The Medicine Bow-Seminoe Number 1 Mines are in Carbon County, northeast of Rawlins. The Medicine Bow Mine is located between the two arms of Seminoe Reservoir which are formed by the North Platte River and the Medicine Bow River (fig. 1). Seminoe Number 1 Mine is south of and contiguous to the Medicine Bow Mine. These two adjacent strip mines are on the western side of the Hanna structural basin. The Ferris Formation of Paleocene age, which outcrops here, has seven coal seams which have been or

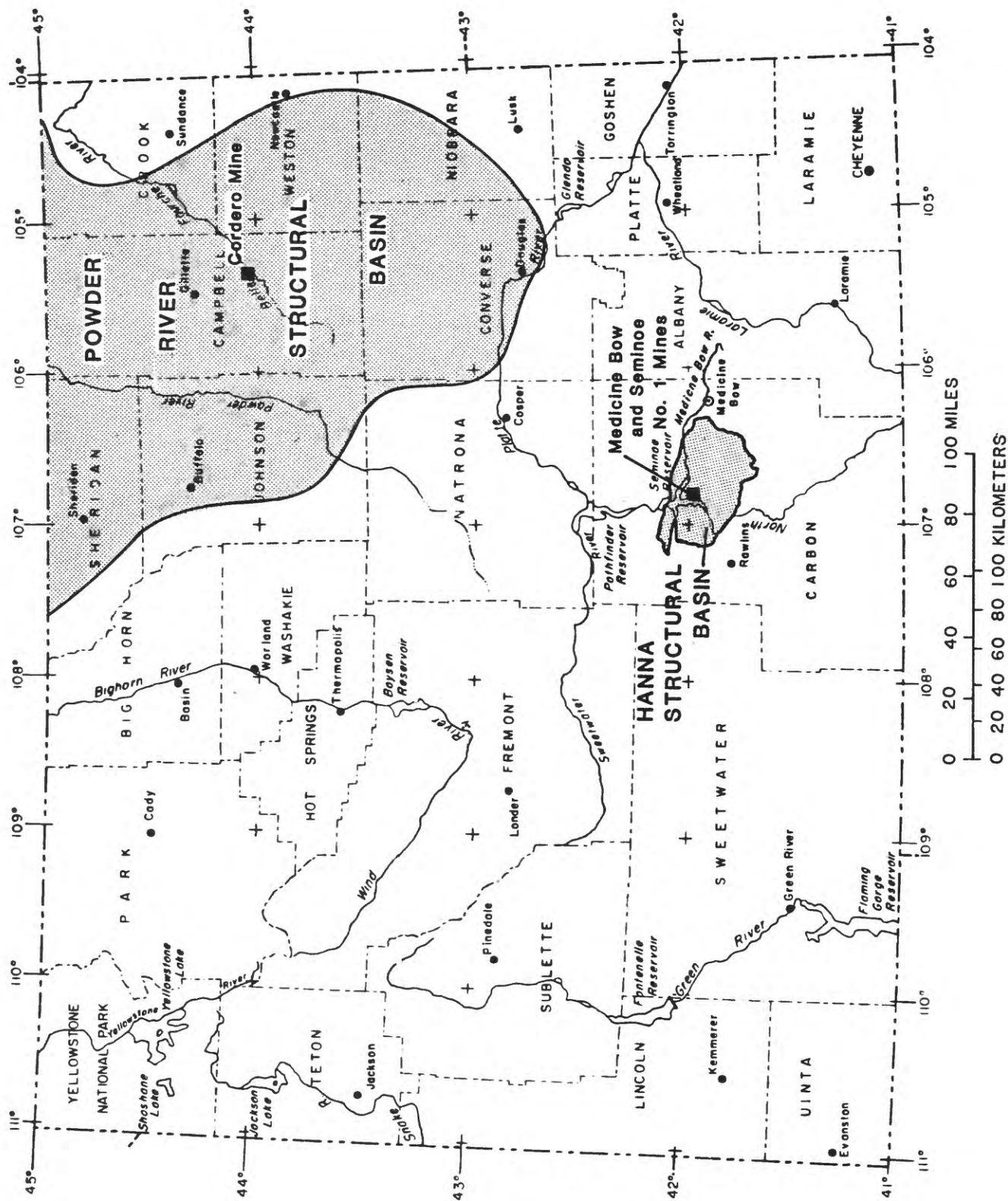


Figure 1.--Location of mine sites.

are being mined. Several other mines, both active and inactive, are located to the east of the Medicine Bow-Seminole Number 1 Mines. The coal seams in the Ferris Formation at Medicine Bow-Seminole Number 1 Mines dip about 6 degrees eastward--toward the center of the basin.

Precipitation at Medicine Bow-Seminole Number 1 Mines averages about 11 inches per year, although significant variations occur from year to year. Annual precipitation at Rawlins, about 20 miles to the southwest, ranged from about 6.5 inches to 11.3 inches during the 15 years from 1966 to 1980. Annual precipitation at the town of Medicine Bow, about 30 miles east of the mines, ranged from 7.4 inches to 19 inches for the same 15-year period (U.S. Department of Commerce, 1984).

The Cordero Mine, in the coal-rich Powder River structural basin, is located about 20 miles south of Gillette in Campbell County (fig. 1). More than 88 million tons of coal were mined in Campbell County during 1983 (Jones, 1984, p. 32). The Cordero Mine, which began operation in 1976, is one of about a dozen mines presently extracting a portion of the thick layer of strippable coal that extends diagonally from the northwest corner of Campbell County to the southeast corner of the county and beyond. The Wyodak-Anderson coal and stratigraphically equivalent beds in the Fort Union Formation of Paleocene age are the source of the coal being mined.

The overburden at the Cordero Mine consists of rock from the Fort Union Formation and the overlying Wasatch Formation of Eocene age. As mining progresses, the dip of the coal seam and the increase in the altitude of the land surface results in an increasing proportion of rock from the Wasatch. Connor and others (1976) have pointed out that the mineralogy of these formations differs one from another.

Precipitation at the Cordero Mine averages about 13 inches per year, based upon data collected at the mine. More than half of the annual precipitation usually falls during April, May, and June. Rainfall, however, is highly variable, as indicated by the range in values for precipitation at Gillette for the month of May. The lowest rainfall measurement on record for May is 0 inches--the highest is more than 11 inches. High summer evapotranspiration rates on the prairies, much in excess of normal summer rainfall, usually result in the drying of prairie grasses by early summer at both the Powder River and Hanna basin mine sites.

The ranges of average daily temperature at Rawlins and Gillette are indicated in the following table:

Average daily temperatures, in degrees Fahrenheit				
City	July		January	
	maximum	minimum	maximum	minimum
Rawlins	84	51	31	12
Gillette	88	56	33	11

The relatively high altitude of the mine areas moderates the summer temperatures. The altitude of Medicine Bow-Seminole Number 1 Mines is about 6,500 feet above sea level, and the altitude of Cordero Mine is about 4,500 feet. The normally clear skies and dry air permit rapid radiation of heat after sunset, which results in cool evenings, even during the summer months (Martner, 1981, p. 5-8).

### Acknowledgments

The cooperation and assistance of personnel from the Arch Minerals Corporation and the Sundeco Coal Company are greatly appreciated.

## METHODOLOGY

### Spoil Samples

Spoil samples were collected at three sites at each of the two mine sites. Three samples were collected at each site: one near the base of the spoil, one near the top of the spoil, and one midway between the base and the top. In addition, duplicate samples were collected at one of the three sites to provide a basis for determining repeatability of sampling technique and laboratory analyses. Thus, a total of 12 spoils samples were collected from each mine site.

The spoil-sample designation consists of four or five characters. The first character, a letter, designates the state (W = Wyoming); the second, a number, designates the mine site (1 = the Medicine Bow-Seminole Number 1 Mines, 2 = the Cordero Mine); the next character, a letter, designates the sampling site; and the fourth character, a number, designates the vertical location at a site (1 = base, 2 = midway, and 3 = top). When used, the fifth character, the letter D, designates a duplicate sample of spoil material was taken and analyzed. The letter S (used in the batch-mixing experiments analysis) indicates the water sample was split for analysis. (The split samples give an indication of laboratory precision.)

Each spoil sample was air dried, thoroughly mixed, and then divided. Part of each sample was sent to the U.S. Geological Survey (Geologic Division) Laboratory, Denver, Colorado for crushing and grinding. The mineral composition (table 1) was determined (Schultz, 1960; Jacobs, 1984) by the North Dakota Mining and Mineral Resources Research Institute, Grand Forks, North Dakota. Analysis (table 2) of the saturated paste-extract (Sandoval and Power, 1977) was by Minnesota Valley Testing Laboratories, Inc., Bismarck, North Dakota. The sulfur-forms analysis (table 3) was determined (Jackson and others, 1987) by the U.S. Geological Survey (Geologic Division) Laboratory, Denver, Colorado.

The spoil material that was not crushed and ground was used in batch-mixing experiments using a method as described by Davis (1984). In these experiments, water and spoil were combined in weight ratios of 2:1 and 5:1 (water:spoil). Sample designations (table 4) with ending numbers 21, have a 2:1 ratio; those with ending numbers 51, have a 5:1 ratio. The water used in the experiments was obtained from a well in the coal at each site in order to simulate the assumed major source of recharge to the spoil. Mixing



was accomplished by fastening the bottles (which were completely filled with the water and spoil mixture to exclude oxygen) to a vertical wheel 3 feet in diameter and then rotating them for 2 hours at 3 revolutions per minute. The spoil was then allowed to settle. After a total contact time of about 24 hours, the water was filtered first through a 0.45-micrometer filter and then through a 0.10-micrometer filter. The filtrate was analyzed (table 4) by the Geological Survey (Water Resources Division) Laboratory, Denver, Colorado.

### Water Samples

Water samples were collected from wells completed in the coal and wells completed in the spoil at each mine site. The samples were analyzed in the field for specific conductance, pH, temperature, and bicarbonate and carbonate concentrations. If the odor of hydrogen sulfide was detected, the samples were analyzed at the sampling site for sulfide. If the hydrogen sulfide odor was not detected, the samples were analyzed on site for dissolved oxygen. The samples also were analyzed (Skougstan and others, 1979) by the Geological Survey (Water Resources Division) Laboratory, Denver, Colorado for selected common and trace constituents. The water samples were filtered through a 0.45-micrometer filter. In addition to the 0.45-micrometer filtration, water analyzed for silica, aluminum, iron, and manganese was filtered through a 0.10-micrometer filter. Although filtration through a 0.45-micrometer filter generally is assumed to pass only dissolved constituents, a 0.1-micrometer filter was used to ensure that colloidal forms of silicon, aluminum, iron, and manganese did not pass through the filter. This step is critical in geochemical studies.

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DATA

Table 1.--Mineral composition of spoil samples determined by X-ray diffraction

[Analyses by the North Dakota Mining and Mineral Resources Research Institute. Concentrations in percent by weight. Abbreviation: <, less than. Sample numbers ending in the letter "D" designate a duplicate sample]

Sample	Mixed-layer clays	Smectite	Chlorite	Muscovite illite	Kaolinite	Gypsum	Quartz	Potassium feldspar			Plagioclase feldspar	Dolomite	Calcite	Total
								Number	1	Mines				
Medicine Bow-Seminoe														
W1A1	0	14	4	10	24	9	26	1		2		<1	2	93
W1A2	1	0	2	7	24	3	37	6		6		4	4	94
W1A3	2	4	6	8	28	4	35	3		5		2	2	99
W1B1	2	5	4	9	29	6	32	6		6		1	2	102
W1B1D	2	4	5	8	31	14	24	4		4		1	0	97
W1B2	3	4	3	8	29	3	33	4		6		2	3	98
W1B2D	2	2	6	8	35	3	28	8		3		2	2	99
W1B3	1	0	5	15	26	3	30	4		3		2	12	101
W1B3D	0	0	1	11	20	1	32	6		7		1	17	96
W1C1	2	3	3	4	30	16	26	3		3		3	2	95
W1C2	1	2	1	8	6	6	45	7		9		2	10	97
W1C3	0	0	4	11	33	0	36	4		10		1	2	101
Cordero Mine														
W2A1	6	8	0	3	37	13	31	4		<1		Trace	2	105
W2A2	9	10	1	4	18	9	33	8		2		2	2	98
W2A3	0	0	0	1	44	16	28	8		2		<1	0	100
W2B1	15	26	2	7	15	4	24	5		0		Trace	0	98
W2B1D	13	24	2	11	19	<1	28	2		0		0	0	100
W2B2	13	21	3	8	23	0	30	2		0		0	0	100
W2B2D	8	16	3	8	38	0	28	1		0		0	0	102
W2B3	10	13	0	4	8	3	45	19		0		1	2	105
W2B3D	9	14	0	3	4	4	51	14		0		2	2	103
W2C1	5	9	3	5	31	1	38	2		0		<1	0	95
W2C2	7	36	1	5	16	1	27	2		0		Trace	7	102
W2C3	6	18	5	6	32	0	31	2		0		0	0	100

Table 2.--Analysis of the saturated paste extract of spoil samples

[Analysis by Minnesota Valley Testing Laboratories, Inc. Concentrations in milligrams per liter (mg/L) or milliequivalent per 100 grams (meq/100 g); specific conductance in microsiemens per centimeter at 25 degrees Celsius ( $\mu\text{S}/\text{cm}$ ). Sample numbers ending in the letter "D" designate a duplicate sample]

Sample	Paste pH	Specific conduc- tance (μS/cm)	Ion concentration in saturation extract				Cation exchange capacity using ammonium acetate (meq/100 g)
			Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	
Medicine Bow-Seminole Number 1 Mines							
W1A1	5.30	6,653	92	51	17	73	5.65
W1A2	6.80	5,363	154	27	6.1	97	2.90
W1A3	6.60	6,007	123	44	6.9	165	3.10
W1B1	6.30	8,073	193	58	22	207	6.92
W1B1D	6.30	7,806	202	70	26	184	6.27
W1B2	7.20	6,471	111	51	13	86	4.64
W1B2D	6.90	6,245	124	54	16	104	4.97
W1B3	6.70	4,138	164	18	3.1	87	2.29
W1B3D	6.80	3,992	171	20	3.9	87	2.34
W1C1	6.50	6,586	223	70	20	197	6.41
W1C2	7.10	7,596	249	71	25	302	7.67
W1C3	6.60	5,589	262	62	17	157	5.62
Cordero Mine							
W2A1	6.01	6,256	62	24	51	340	73.0
W2A2	7.29	5,857	113	88	24	593	12.9
W2A3	4.23	7,477	14	89	8.8	216	8.6
W2B1	6.52	5,926	108	45	83	610	67.0
W2B1D	6.58	6,011	112	52	85	625	61.1
W2B2	7.28	3,401	38	13	57	253	140
W2B2D	7.40	3,511	44	15	61	264	132
W2B3	7.56	5,422	65	40	34	356	39.0
W2B3D	7.52	5,432	61	47	38	366	42.6
W2C1	7.06	6,274	97	51	63	509	52.1
W2C2	7.59	5,725	83	52	28	466	24.2
W2C2D	7.56	5,588	81	47	22	471	19.6
W2C3	7.65	3,087	15	6.4	36	129	212

Table 3.--Sulfur-forms analysis of spoil samples

[Concentrations are in percent by weight. Abbreviation: <, less than.  
Sample numbers ending in the letter "D" designate a duplicate sample]

Sample	Total sulfur	Sulfate sulfur	Sulfide	Organic sulfur
Medicine Bow-Seminole Number 1 Mines				
W1A1	0.22	0.23	<0.01	0.00
W1A2	.28	.09	.10	.09
W1A3	.27	.09	.11	.07
W1B1	.19	.15	<.01	.04
W1B1D	.16	.12	<.01	.04
W1B2	.31	.08	.19	.04
W1B2D	.41	.08	.23	.10
W1B3	.42	.03	.17	.22
W1B3D	.36	.03	.13	.20
W1C1	.34	.02	.02	.30
W1C2	.17	.17	<.01	.00
W1C3	.12	.06	<.01	.06
Cordero Mine				
W2A1	.24	.22	<.01	.02
W2A2	.18	.22	<.01	.00
W2A3	.80	.86	<.01	.00
W2B1	.30	.08	.16	.06
W2B1D	.30	.08	.14	.08
W2B2	.08	.01	.03	.04
W2B2D	.09	.02	.03	.04
W2B3	.09	.10	<.01	.00
W2C1	.06	.08	<.01	.00
W2C2	.28	.23	.01	.04
W2C2D	.13	.15	<.01	.00
W2C3	.04	.02	<.01	.02

Table 4.--Chemical analyses of

[Analyses by the U.S. Geological Survey. Concentrations in milligrams per liter (mg/L) 25 degrees Celsius; CaCO<sub>3</sub>, calcium carbonate; <, less than. Sample numbers ending in designate the sample was split for analysis. Spoil samples used in the experiment were 25 degrees Celsius]

Sample	Specific conduc- tance (μS/cm)	pH	Cal- cium (mg/L)	Mag- nesium (mg/L)	Sodium (mg/L)	Potas- sium (mg/L)	Bicar- bonate (mg/L)	Carbo- nate (mg/L)	Alka- linity as CaCO <sub>3</sub> (mg/L)
Medicine Bow-									
W1A121	3,980	6.31	260	170	510	11	460	0	370
W1A151	3,750	6.82	200	160	520	11	690	0	560
W1A221	4,700	7.12	400	230	520	18	800	0	650
W1A251	4,080	7.32	260	170	500	14	860	0	700
W1A321	4,800	6.71	370	270	490	17	720	0	590
W1A351	4,050	7.14	250	200	500	13	810	0	660
W1B121	5,000	6.74	370	260	640	14	820	0	670
W1B121D	5,140	6.66	390	280	630	16	790	0	650
W1B151	4,250	6.81	280	190	560	11	750	0	610
W1B151D	4,140	6.78	250	180	550	11	740	0	610
W1B221	4,580	6.88	280	250	540	22	680	0	560
W1B221D	4,660	6.88	310	260	570	21	680	0	560
W1B251	3,920	7.12	200	180	520	16	780	0	640
W1B251D	3,980	7.11	210	180	520	16	780	0	640
W1B321	4,100	7.10	310	180	510	17	780	0	640
W1B321D	4,130	7.06	310	190	500	18	750	0	610
W1B321S	4,100	7.11	310	190	500	17	770	0	630
W1B351	3,700	7.23	210	150	530	16	820	0	680
W1B351D	3,740	7.20	210	150	500	14	810	0	660
W1B351S	3,700	7.25	210	150	520	13	820	0	680
W1C121	5,320	6.85	410	330	610	24	730	0	600
W1C151	4,180	7.02	250	190	530	18	780	0	640
W1C221	5,330	7.30	390	300	630	16	840	0	690
W1C251	4,440	7.34	290	200	540	13	870	0	710
W1C321	4,520	6.87	380	200	530	11	670	0	550
W1C351	3,930	7.05	270	150	520	10	770	0	630
WWW11 <sup>1</sup>	3,410	7.44	130	140	530	10	910	0	740
WWW12 <sup>1</sup>	3,420	7.42	120	130	500	10	900	0	740
WWW13 <sup>1</sup>	3,450	7.47	130	130	530	9.0	880	0	720

water from batch-mixing experiments

or micrograms per liter ( $\mu\text{g/L}$ ). Abbreviations:  $\mu\text{S/cm}$ , microsiemens per centimeter at the letter "D" designate a duplicate sample; sample numbers ending in the letter "S" collected March 1984. Batch-mixing experiments performed at a room temperature of

Sul- fate (mg/L)	Chlo- ride (mg/L)	Fluo- ride (mg/L)	Silica (mg/L)	Dis- solved solids (mg/L)	Alumi- num ( $\mu\text{g/L}$ )	Boron ( $\mu\text{g/L}$ )	Iron ( $\mu\text{g/L}$ )	Man- ganese ( $\mu\text{g/L}$ )	Stron- tium ( $\mu\text{g/L}$ )
Seminole Number 1 Mines									
2,000	49	0.3	7.0	3,200	50	130	36	83	4,000
1,500	34	.3	7.0	2,800	30	130	23	48	4,700
2,500	32	.3	8.0	4,100	30	230	14	1,100	6,100
1,900	27	.3	9.0	3,300	20	190	14	660	6,100
2,500	30	.5	8.0	4,000	20	180	15	620	5,400
1,800	26	.5	9.0	3,200	20	190	5	360	5,600
2,400	80	.4	9.0	4,100	30	250	21	230	4,900
2,500	79	.4	9.1	4,300	30	240	26	220	4,200
1,900	45	.5	8.9	3,400	30	170	14	210	5,200
2,000	46	.3	8.6	3,400	30	170	14	91	4,800
2,400	40	.3	9.0	3,900	30	210	3	540	5,800
2,200	21	.5	8.9	3,700	20	200	8	570	6,100
1,700	31	.5	9.0	3,000	20	160	7	310	5,500
1,900	30	.5	9.0	3,200	20	160	7	340	5,600
2,000	27	.2	10	3,400	20	200	15	650	6,600
1,800	27	.3	9.9	3,200	20	210	13	690	6,600
1,900	27	.2	10	3,300	20	200	14	660	6,700
1,400	25	.3	10	2,700	20	180	5	40	7,100
1,600	26	.3	10	2,900	20	170	33	430	6,600
1,500	25	.3	10	2,800	20	160	16	420	7,000
2,700	52	.5	9.5	4,500	20	270	7	480	6,500
1,800	34	.4	9.0	3,200	20	150	6	230	5,500
2,600	67	.4	8.7	4,400	20	250	23	220	5,900
2,000	40	.4	9.0	3,500	20	190	16	160	6,000
2,400	73	.1	11	3,900	40	260	11	82	2,300
1,700	43	.3	10	3,100	20	160	77	59	2,700
1,200	22	.3	11	2,500	20	130	11	140	9,600
1,100	21	.3	11	2,300	20	160	10	120	9,000
1,200	24	.3	11	2,500	20	130	7	140	9,100



Table 4.--Chemical analyses of water

Sample	Specific conductance ( $\mu$ S/cm)	pH	Cal- cium (mg/L)	Mag- nesium (mg/L)	Sodium (mg/L)	Potas- sium (mg/L)	Bicar- bonate (mg/L)	Carbo- nate (mg/L)	Alka- linity as CaCO <sub>3</sub> (mg/L)
Cordero									
W2A121	3,730	6.62	440	120	310	30	610	0	500
W2A151	2,670	6.78	270	64	260	20	720	0	590
W2A221	3,880	7.22	500	220	230	9.9	910	0	740
W2A251	2,910	7.20	330	120	230	8.6	930	0	760
W2A321	4,040	5.64	490	270	220	8.9	160	0	130
W2A351	3,320	6.16	420	150	230	7.6	390	0	320
W2B121	2,740	6.87	220	80	310	25	710	0	580
W2B121D	2,670	6.87	210	78	310	26	720	0	590
W2B151	2,000	6.93	130	43	250	18	790	0	650
W2B151D	2,010	7.05	130	44	250	17	820	0	670
W2B221	1,980	7.34	100	33	270	21	890	0	730
W2B221D	1,930	7.35	100	34	280	21	910	0	740
W2B251	1,600	7.29	65	24	250	17	940	0	770
W2B251D	1,610	7.33	70	25	260	17	930	0	760
W2B321	2,480	7.24	190	98	280	15	910	0	750
W2B321D	2,440	7.26	180	93	270	14	910	0	750
W2B321S	2,480	7.30	190	97	280	14	910	0	750
W2B351	1,930	7.21	120	54	250	13	920	0	760
W2B351D	1,880	7.24	110	49	240	9.6	920	0	760
W2B351S	1,930	7.24	120	53	250	10	930	0	760
W2C121	3,410	7.25	370	150	290	17	880	0	720
W2C151	2,260	7.22	180	72	260	12	910	0	750
W2C221	3,720	6.43	440	190	230	30	470	0	380
W2C251	2,620	6.74	260	99	230	22	650	0	530
W2C321	1,810	7.55	71	27	300	22	940	0	770
W2C351	1,530	7.47	53	21	260	18	950	0	780
WWW21 <sup>1</sup>	1,320	7.20	44	16	230	7.3	910	0	750
WWW22 <sup>1</sup>	1,320	7.28	45	17	240	7.5	910	0	750
WWW23 <sup>1</sup>	1,330	7.19	45	17	240	7.7	920	0	760

<sup>1</sup>Replicate analysis of the well water (from coal aquifer) used in the batch-mixing

from batch-mixing experiments--Continued

Sul- fate (mg/L)	Chlo- ride (mg/L)	Fluo- ride (mg/L)	Silica (mg/L)	Dis- solved solids (mg/L)	Alumi- num (µg/L)	Boron (µg/L)	Iron (µg/L)	Man- ganese (µg/L)	Stron- tium (µg/L)
Mine									
1,700	14	0.1	11	2,900	20	560	10	240	4,400
950	13	.2	8.8	1,900	20	310	14	120	2,500
1,700	29	.6	11	3,100	20	180	11	<1	3,800
940	19	.6	10	2,100	20	130	8	<1	2,300
2,400	24	.4	14	3,500	400	380	37	1,800	2,300
1,800	17	.3	6.6	2,800	100	210	16	900	1,700
990	14	.2	8.0	2,000	20	270	12	570	3,800
940	14	.3	8.0	1,900	20	250	30	480	3,700
510	13	.4	7.6	1,400	20	160	5	290	2,100
500	13	.4	7.3	1,400	20	170	7	280	2,100
380	13	.6	6.6	1,300	10	100	4	57	1,900
350	13	.6	7.1	1,300	20	100	5	58	2,000
140	13	.7	7.5	980	20	100	4	43	1,400
150	13	.7	7.8	1,000	20	550	<3	42	1,600
690	13	.4	9.0	1,700	20	80	10	58	2,400
730	13	.4	9.0	1,800	20	80	14	49	2,300
930	14	.4	9.0	2,000	20	80	12	54	2,400
350	13	.6	8.8	1,300	20	90	4	35	1,500
300	13	.6	8.5	1,200	20	90	3	29	1,400
340	13	.6	8.7	1,300	20	80	5	35	1,500
1,200	18	.8	16	2,500	20	100	11	<1	5,100
630	15	.7	13	1,600	30	100	6	2	2,500
2,000	20	.2	6.9	3,100	30	140	19	190	5,100
1,000	15	.2	6.3	2,000	20	120	13	69	2,900
210	14	.7	8.9	1,000	10	70	<3	11	1,800
91	13	.7	9.2	930	30	70	4	11	1,800
2.2	12	.9	7.7	770	30	90	<3	11	860
1.6	12	.9	7.9	780	20	80	<3	11	890
2.3	13	.9	7.8	790	20	90	<3	15	890

experiment.

Table 5.--Common-constituent concentrations in

[Constituents are dissolved and concentrations are reported in milligrams per  
at 25 degrees Celsius; <, less than; ND, not

Well depth (feet)	Specific conduc- tance ( $\mu$ S/cm)	pH	Temper- ature (°C)	Oxygen	Sul- fide	Cal- cium	Mag- nesium	Sodium	Potas- sium	Bicar- bonate	Carbo- nate
41°54'42" 106°47'45" (Seminoe Number											
71	5,400	6.71	11.4	0.4	ND	480	260	170	25	900	0
41°55'36" 106°48'01" (Medicine											
140	3,780	7.30	9.1	.6	ND	150	150	540	9.8	950	0
44°01'36" 105°20'44" (Cordero Mine,											
110	6,000	6.78	8.9	.6	ND	580	310	680	33	600	0
44°01'33" 105°21'18" (Cordero Mine,											
188	1,478	7.22	12.5	.3	<1	48	18	250	18	940	0
44°01'13" 105°20'54" (Cordero Mine,											
307	2,580	7.48	8.0	5.2	ND	250	110	190	8.2	390	0

<sup>1</sup>Sample filtered through a 0.10-micrometer filter.

water from selected wells in the mine areas

liter. Abbreviations: °C, degrees Celsius; µS/cm microsiemens per centimeter detected. Samples were collected June 1984]

Sul- fate	Chlo- ride	Fluo- ride	Silica	Dis- solved solids	Ni- trite as ni- trogen	Nitrate plus nitrate as nitrogen	Ammonia as nitrogen	Ammonia plus organic nitrogen, as nitrogen	Phos- phorus	Ortho- phosphate as phos- phorus
1 Mine, spoil aquifer, well S1BW-2)										
1,700	66	0.2	8.1 19.7	3,160	<0.01	<0.10	5.0	6.0	0.05	0.01
Bow Mine, coal aquifer, well 8452)										
1,400	24	.4	11 113	2,750	<.01	<.10	4.1	5.5	.01	.01
spoil aquifer, well MB-26-1-P)										
3,300	130	.3	13 113	5,640	<.01	<.10	.97	1.4	.01	.01
coal aquifer, well MC-27-4-T)										
2.6	13	1.0	8.3 18.4	820	<.01	<.10	1.5	.01	.01	.01
coal aquifer, well MC-27-6-P)										
1,200	1.7	.3	10 112	1,960	<.01	.51	.01	.01	.01	.01

Table 6.--Trace-constituent concentrations in water from selected wells  
in the mine areas

[Constituents are dissolved, and concentrations are reported in micrograms per liter. Abbreviation: <, less than]

Date (month- day- year)	Well depth (feet)	Aluminum <sup>1</sup>	Boron <sup>2</sup>	Iron <sup>1</sup>	Man- ganese <sup>1</sup>	Molyb- denum <sup>2</sup>	Selen- ium <sup>2</sup>	Stron- tium <sup>2</sup>
41°54'42" 106°47'45" (Seminole Number 1 Mine, spoil aquifer, well S1BW-2)								
6-25-84	71	20	100	13,000	4,800	2	<1	6,500
41°55'36" 106°48'01" (Medicine Bow Mine, coal aquifer, well 8452)								
6-26-84	140	20	12	1,100	140	<1	<1	10,000
44°01'36" 105°20'44" (Cordero Mine, spoil aquifer, well MB-26-1-P)								
6-27-84	110	<10	150	220	200	4	<1	9,100
44°01'33" 105°21'18" (Cordero Mine, coal aquifer, well MC-27-4-T)								
6-28-84	188	20	90	430	17	<1	<1	900
44°01'13" 105°20'54" (Cordero Mine, coal aquifer, well MC-27-6-P)								
6-28-84	307	<10	100	33	18	1	7	2,800

<sup>1</sup>Sample filtered through a 0.10-micrometer filter.

<sup>2</sup>Sample filtered through a 0.45-micrometer filter.