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UNIVERSITY OF WYOMING
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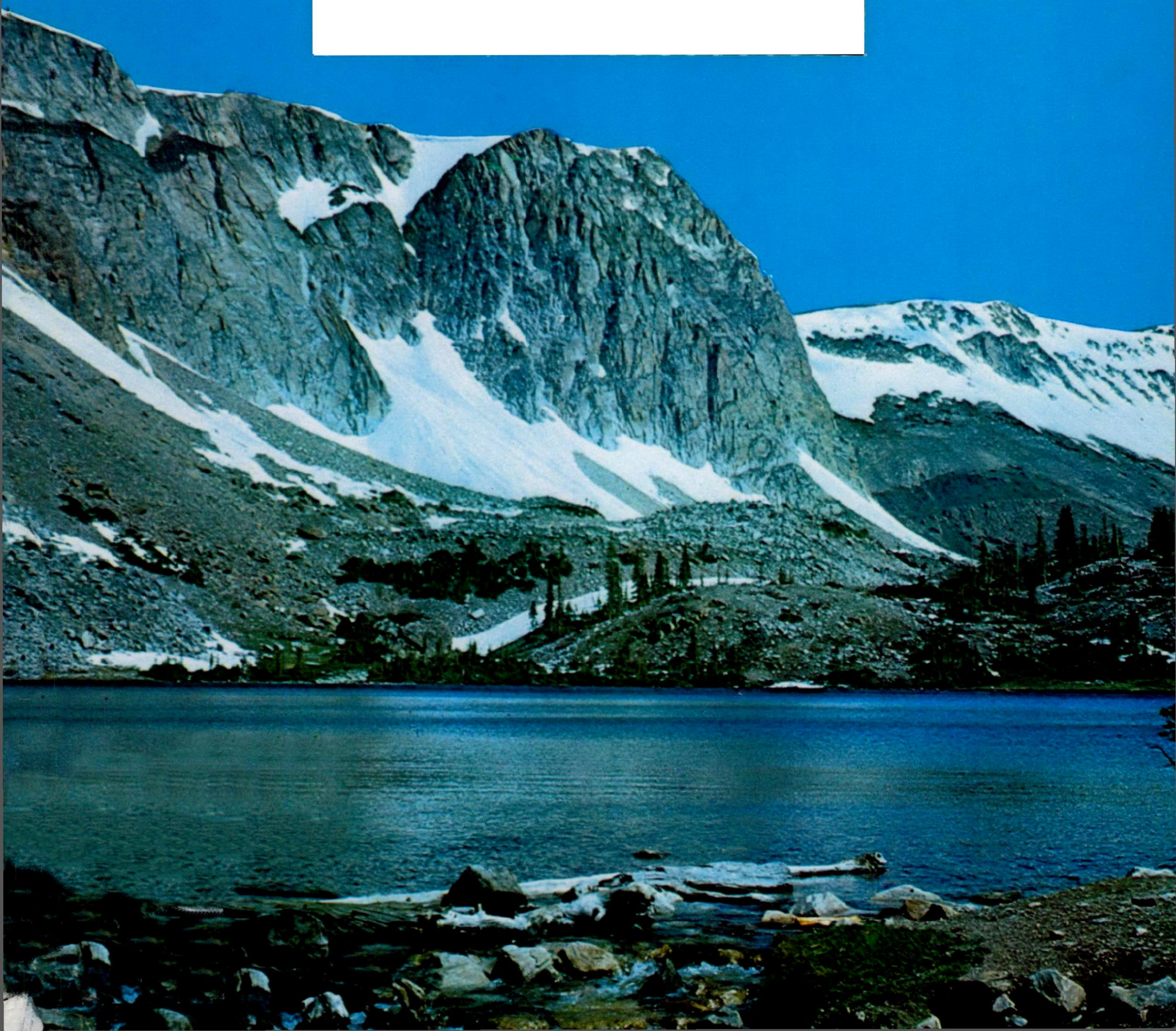
VOLUME IV-A

OCCURRENCE AND CHARACTERISTICS OF
GROUND WATER IN THE
WIND RIVER BASIN, WYOMING



VOLUME IV-A

OCCURRENCE AND CHARACTERISTICS OF GROUND WATER IN THE WIND RIVER BASIN, WYOMING

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I. SUMMARY OF FINDINGS

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1. Eleven aquifers and one aquifer system are identified by this report in the Wind River basin, Wyoming. The aquifers are the (1) Flathead, (2) Phosphoria, (3) Sundance-Nugget, (4) Cloverly, (5) Muddy, (6) Frontier, (7) Mesaverde, (8) Fort Union-Lance, (9) Wind River, (10) Arikaree, and (11) Quaternary deposits. The aquifer system is herein referred to as the Tensleep aquifer system and is comprised of the (a) Tensleep, (b) Amsden, (c) Madison, (d) Darby, and (e) Bighorn subaquifers.

Recharge to the various aquifers occurs by (1) infiltration of precipitation directly into outcrops of the units, (2) leakage of water from adjacent units, and (3) stream losses into permeable units.

With the exception of the Quaternary and Arikaree aquifers, the various saturated units underlie the entire basin and crop out along the flanks of the Wind River Mountains, Owl Creek Mountains, Gas Hills, and Casper Arch. The Quaternary deposits are geographically confined to major surface drainage areas, whereas the Arikaree aquifer is present only in the Granite Mountains area.

The various aquifers are stratigraphically separated from each other by regional leaky confining layers. The confining layers are generally characterized by massive sequences of relatively impermeable shale and siltstone. Major confining layers include the (1) Cody Shale, (2) Mowry Shale, (3) Thermopolis Shale, and (4) Chugwater Group.

Although this report is primarily concerned with the identification and characterization of regional aquifers, virtually all stratigraphic units in the basin are locally capable of yielding small quantities of water to wells and springs.

The most productive aquifers in the basin are the (1) Wind River, (2) members of the Tensleep aquifer system, (3) Arikaree, and (4) Quaternary aquifers. Reported production for selected wells completed in these aquifers range up to several thousand gallons/minute.

2. Permeabilities in the rocks in the basin are locally dominated by fractures associated with faults and folds. Fracture permeabilities are typically several orders of magnitude larger than adjacent unfractured rocks.

With the exception of the Quaternary and Arikaree aquifers, the rocks comprising the sedimentary section have small interstitial permeabilities. Sandstone units are generally tightly cemented by calcium-carbonate and silica cement. Permeabilities in well-cemented saturated sandstones are generally less than 10 gallons/day/foot^2. Interstitial permeabilities in the Quaternary and Arikaree aquifers are relatively large because the Quaternary deposits are unconsolidated, whereas the Arikaree aquifer is poorly consolidated. Permeabilities in the Quaternary and Arikaree aquifers range up to several hundred gallons/day/foot^2.

3. Estimated water use in the basin is about 1.7×10^5 acre-feet/year. This total is based on estimated domestic, industrial, and agricultural use. About 20 percent or 3.4×10^4 acre-feet/year of the total water demand is supplied by ground water.

The total water use estimate is at best conservative. This is because both ground- and surface-water rights within the Wind River Indian Reservation are currently being challenged in the Wind River

Adjudication suit. Because of this suit federal, state, and local authorities were unable to release current water use data for the reservation. As a result, much of the reported water use data for the reservation is incomplete and dated.

Estimated domestic water use is 7.6×10^3 acre-feet/year. About 72 percent or 5.5×10^3 acre-feet/year of the domestic water demand is supplied by ground water. The Wind River and Quaternary aquifers supply the largest quantity of ground water for domestic use.

Principal industries using ground and surface water are petroleum, uranium, and iron ore companies. Estimated water use for the various industries is 2.2×10^4 acre-feet/year. About 91 percent or 2×10^4 acre-feet/year of the industrial water demand is supplied by ground water. Petroleum companies are the principal industrial user of ground water in the basin. Major sources of ground water for industrial use include (1) Quaternary deposits and (2) the Wind River, Frontier, Cloverly, Phosphoria, Tensleep, and Madison aquifers.

Agricultural water use is about 1.4×10^5 acre-feet/year. Ground-water sources supply about 3 percent of the agricultural water demand. Principal sources of ground water developed by the agriculture industry are the Wind River, Arikaree, and Quaternary aquifers.

4. Water qualities vary widely within and between the various saturated units. In general, ground water with total dissolved solids less than 500 mg/l are encountered in outcrops of the Flathead, Tensleep, Frontier, Arikaree, and Quaternary aquifers along the flanks of the Wind River and Owl Creek mountains. This is because the flanks are major recharge areas where residence times are short and flow rates are great. Water qualities in the aquifers deteriorate

basinward as residence times increase and flow rates decrease. As the water flows basinward, soluble salts leach from the aquifer matrices and adjacent confining layers, and there is enrichment of poor quality waters leaking from adjacent units. In general, total dissolved solids increase as ground-water flow length increases.

Ground waters in the Flathead aquifer are calcium-bicarbonate and sodium-sulfate-bicarbonate rich. Water qualities are generally very good with total idssolved solids less than 500 mg/l.

Ground waters in the Tensleep aquifer system are of three predominant types: (1) calcium-magnesium-bicarbonate, (2) calcium-magnesium-sulfate, and (3) sodium-sulfate. Good quality water with dissolved solids less than 500 mg/l is generally encountered along the flanks of the Owl Creek and Wind River mountains. Water quality deteriorates basinward and with increased drilling depths. Tensleep waters are distinguishable from waters in the overlying Phosphoria aquifer on the basis of sodium and sulfate concentrations.

Ground waters in the Phosphoria aquifer are predominantly mixed cation-bicarbonate type. Water quality is generally poor with dissolved solids concentrations greater than 2,000 mg/l. Water quality improves (dissolved solids less than 1,500 mg/l) in densely fractured parts of the aquifer.

Ground waters in the Sundance-Nugget, Cloverly, Muddy, and Frontier aquifers are predominantly sodium-chloride, sodium-sulfate, sodium-bicarbonate, and sodium-sulfate-bicarbonate rich. Water quality is generally poor with dissolved solids concentrations greater than 2,000 mg/l. Major factors influencing water qualities are: (1) lithology,

(2) long residence times, and (3) leakage of poor quality waters from adjacent units.

Mesaverde aquifer waters are sodium-sulfate-bicarbonate rich. The gross chemical character of the water is controlled by dissolution of calcite, dolomite, and gypsum from the aquifer matrix with cation exchange of sodium for calcium and magnesium.

Water qualities in the Fort Union-Lance aquifer are highly variable, as evident by total dissolved solids concentrations ranging from 500 to 20,500 mg/l. Dissolved solids concentrations less than 1,000 mg/l are encountered in areas where the aquifer crops out. Dissolved solids increase basinward and with drilling depths to the aquifer. Fort Union-Lance aquifer waters are sodium-sulfate, sodium-chloride, and sodium-bicarbonate rich.

Water qualities in the Wind River aquifer are highly variable. Principal factors controlling water qualities are lithology and recharge mechanisms. Correlation exists between major anion water chemistries and total dissolved solids concentrations. For example, (1) the dominant anion in waters with dissolved solids less than 800 mg/l is bicarbonate, (2) the dominant anion in waters with dissolved solids greater than 2,000 mg/l is sulfate, and (3) anion composition is mixed in waters with dissolved solids ranging between 800 and 2,000 mg/l.

Arikaree aquifer waters are calcium-bicarbonate and sodium-sulfate rich. Water qualities are generally very good with dissolved solids concentrations less than 500 mg/l.

Water qualities in the Quaternary deposits are highly variable and dependent on (1) lithology, (2) geographic location, (3) depth to water, and (4) recharge mechanisms. Total dissolved solids concentrations range from about 200 to 3,300 mg/l.

II. INTRODUCTION

II. INTRODUCTION

The purpose of this report is to provide baseline information for the implementation of the U.S. Environmental Protection Agency Underground Injection Control program. Synthesized herein are the hydrogeologic properties of the sedimentary rocks, chemical qualities of ground waters, and quantification of ground-water use by source and economic sector. Interpretations and conclusions in this report are based mainly on the author's assessment of existing structural and hydrogeologic data. Field work undertaken during the course of this study was conducted during June 1 to June 15, 1981.

Funding for this report was provided by the U.S. Environmental Protection Agency through contract G-008269-79.

This report is the fourth in a series of seven ground-water investigations conducted by Wyoming Water Resources Research Institute, summarizing known hydrogeologic conditions within the ten structural basins of Wyoming.

GENERAL

Location

The location of the study area is shown on Figure II-1. The area is entirely contained within the region between latitudes 42°30' and 43°30' and longitudes 106°30' and 109°30'. The area encompasses approximately 7,900 square miles of state, federal, and privately owned lands situated in Fremont and the western part of Natrona counties, Wyoming. All discussions in this report refer to the area within these boundaries, herein referred to as the basin, unless otherwise stated.

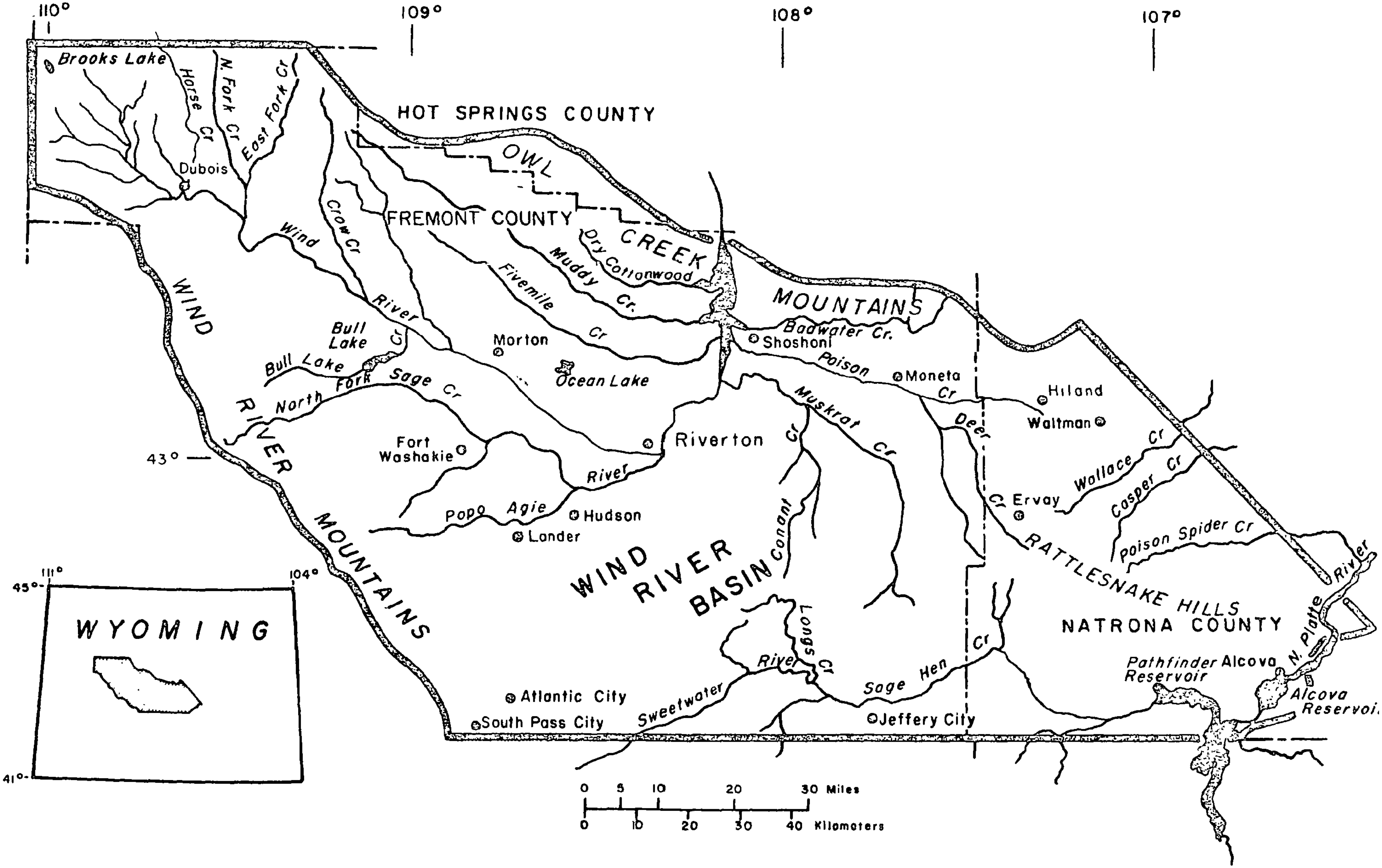


Figure II-1. Location of study area and principal surface drainages, Wind River basin, Wyoming.

Geographic Setting

The physiography of the basin is dominated by a relatively flat, rolling hills interior with less than several hundred feet of topographic relief, and rugged bounding mountain ranges with maximum topographic relief of about 6,000 feet. Elevations within the basin interior generally range between 5,400 and 6,000 feet, whereas elevations greater than 10,000 feet are common in the various bounding mountain ranges.

The basin is bounded to the east by the northwest-trending Casper Arch; to the west by the northwest-trending Wind River Mountains; to the south by the east-trending Granite Mountains; and to the north by the east-trending Owl Creek Mountains. The Casper Arch, and the Wind River, Granite, and Owl Creek mountains, respectively, separate the basin from the Powder River, Green River, Washakie-Red Desert, and Bighorn structural basins.

Surface Drainage

The basin is situated in the Missouri River drainage system, Bighorn River basin. Principal surface-water drainages within the basin are shown on Figure II-1.

The Bighorn River basin is informally divided into four drainage divisions (Wyoming State Engineer, 1972), one of which is included in the Wind River basin. Table II-1 summarizes the various divisions. The U.S. Department of Agriculture and others (1974), the Wyoming State Engineer (1972), and the Wyoming Department of Economic Planning and Development (1969) provide detailed descriptions of the surface-water drainage basins.

Table II-1. Bighorn River basin surface drainage divisions by tributary rank and downstream order, Wind River basin, Wyoming.

- Missouri River System
  - Bighorn River Basin
    - Wind River Division
      - Du Noir Creek
      - Horse Creek
      - Wiggins Fork
      - Dinwoody Creek
      - Crow Creek
      - Bull Lake Creek
      - Little Wind River
        - North Fork
        - South Fork
        - Popo Agie River
          - North Popo Agie River
          - Little Popo Agie River
        - Beaver Creek
      - Muskrat Creek
      - Fivemile Creek
      - Poison Creek
      - Badwater Creek
      - Muddy Creek
    - Bighorn River Division[a]
    - Little Bighorn River Division[a]
    - Clarks Fork River Division[a]

[a]Not included in study area.

Climate

The climate of the basin ranges from semi-arid continental in the basin interior to humid-alpine in the various bounding mountain ranges. Elevation is the principal control for local climatic conditions.

Annual precipitation in the basin interior is less than 8 inches; 10 to 15 inches is common along the elevated flanks of the basin; 60 inches is common along the high peaks of the bounding mountain ranges (U.S. Department of Agriculture and others, 1974).

The weighted annual temperature in the basin (Riverton, Wyoming, station) is 38.7°F for the period 1970 to 1979. Mean monthly temperatures range between 7°F in January and 71.4°F in July, although extreme temperatures for the same period are -31°F and 104°F.

Population and Employment

Much of the basin is sparsely populated. According to preliminary 1980 Census figures, about 39,000 people or approximately 5 persons per square mile reside in the basin. About 27,000 people, representing 70 percent of the basin population, reside in cities and unincorporated towns. Population distribution is summarized by town on Table II-2.

Major industries in the basin include agriculture, energy production, and retail trade. These industries employ about 70 percent of the employable population in the basin.

Land Use and Ownership

About 49 percent of the land in the basin is privately owned. Federally owned lands account for about 47 percent of the basin. Table II-3 summarizes land ownership by federal, state, and private sector.

Table II-2. Population by county and town, Wind River basin, Wyoming.[a]

County Town	1970	1980	1990
Fremont	28,352	39,074	52,350
Dubois	898	1,067	1,600
Ethete-Fort Washakie	-	2,439	3,700
Hudson	381	513	800
Lander	7,125	7,943	10,000
Pavillion	181	277	350
Riverton	7,995	9,569	13,200
Shoshoni	562	875	2,000
Jeffery City[b]	-	2,967	5,700
Natrona	51,264	71,589	90,400
Powder River[b]	-	50	

[a]Sources of data include U.S. Department of Commerce, Bureau of the Census, 1970 Census, Preliminary 1980 Census; Wyoming Department of Administration and Fiscal Control, Wyoming Population and Employment Forecast Report, June 1980; Institute of Policy Research, University of Wyoming; Fremont County Clerk.

[b]Unincorporated town.

Table II-3. Land ownership, Wind River basin, Wyoming.[a]

Land Owner	Square Miles	Percent[b] Basin
Federal		
Bureau of Land Management	2,300	29
National Forest Service	1,360	17
Other	16	*
State	315	4
Private		
Private	1,150	15
Indian Reservation	2,660	34

[a]Sources of data include Wyoming State Engineer (1972), U.S. Department of Agriculture and others (1974).

[b]* = less than 1 percent.

About 55 percent of the land within the basin is utilized for agricultural purposes. Although most of the agricultural land is unimproved, sagebrush-covered grazing land, about 6 percent of the basin is irrigated cropland. Eighty-five percent of the cropland is located within the boundaries of the Wind River Indian Reservation. Industrial, residential, and recreational areas occupy nearly all of the nonagricultural land.

GEOLOGY

This report is primarily concerned with the physical properties of the rocks within the basin as they relate to the occurrence of ground water and incidentally with the problems of stratigraphy and lithology. As a result the reader is referred to the following for detailed summaries of regional stratigraphic data: Paleozoic rocks, Keefer and Van Lieu (1966); Mesozoic rocks, Love and others (1945 a, b, c, 1947), Thompson and others (1949), Keefer and Rich (1957), Yenne and Pipiringos (1954), Keefer (1965); Cenozoic rocks, Van Houten (1964), Keefer (1957), Tourtelot (1957).

Stratigraphy

Sedimentary rocks within the basin range in age from Cambrian to Recent, and are summarized on Figure II-2. The sedimentary sequence is about 18,000 feet thick. Descriptions of the rocks appear in Chapter IV, Table IV-1. Stratigraphic nomenclature used here conforms to Love and others (1955), Keefer and Van Lieu (1966), and Denson (1965). See their works for citations of original sources.

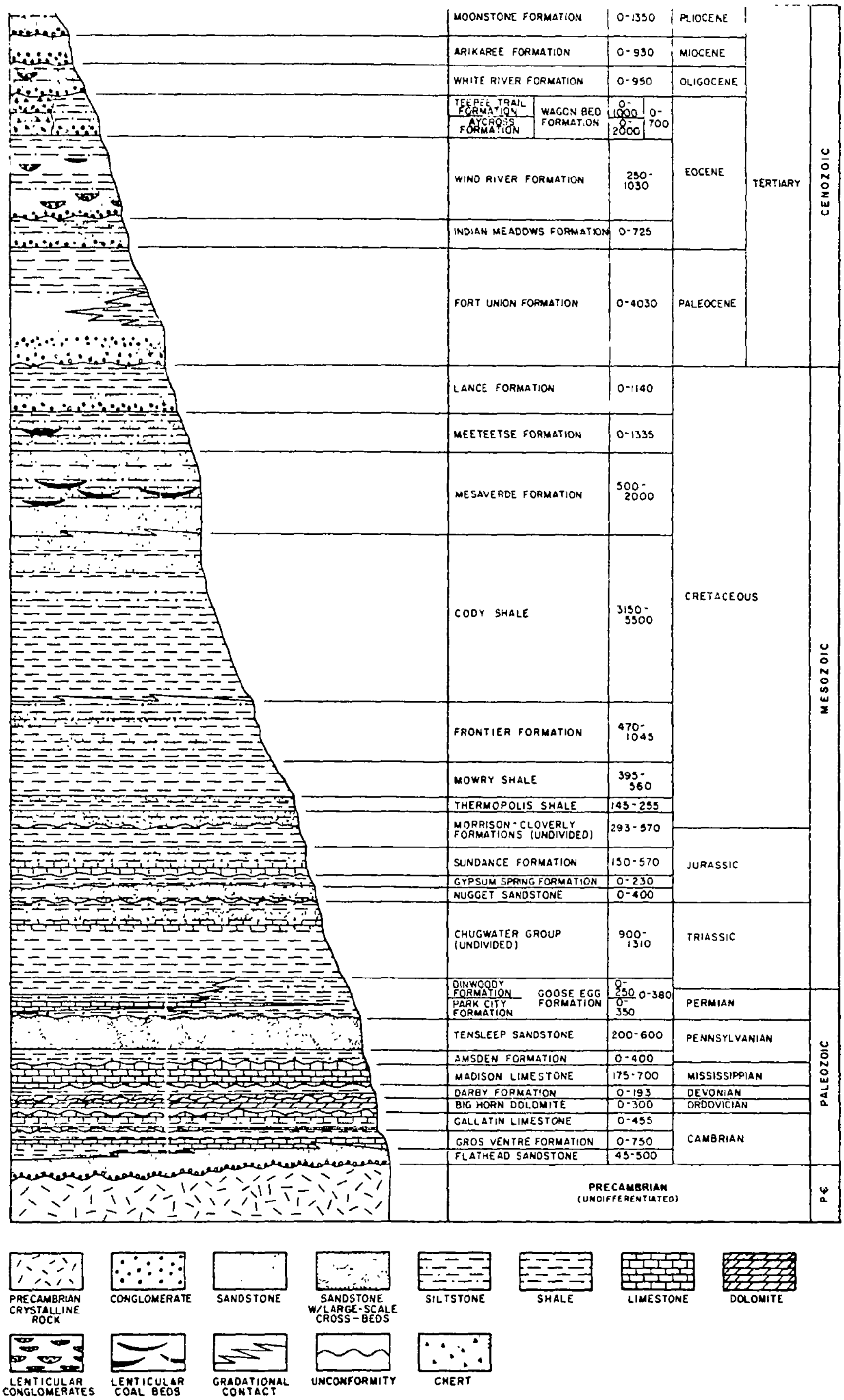


Figure II-2. Ages, lithologies, and thicknesses of the rocks exposed in the Wind River basin, Wyoming.

Structure

The Wind River basin is an intermontane structural basin. Its location relative to other intermontane structural basins in Wyoming is shown on Figure II-3.

The basin is a broad, asymmetric structural depression that contains about 18,000 feet of Cenozoic, Mesozoic, and Paleozoic sediments that rest unconformably on Precambrian crystalline basement rocks. Paleozoic and Mesozoic formations dip basinward at angles of about 10 to 20 degrees along the south and west margins of the basin; along the north and east margins the units are often vertical to overturned. According to Keefer (1970) the main trough of the basin lies 3 to 15 miles south of the Owl Creek Mountains and intersects the north end of the Casper Arch at a right angle. Along the main trough the elevation of the top of the Precambrian rocks is 24,000 feet below sea level. Maximum structural relief here is 30,000 to 35,000 feet.

Individual structural features within the basin are too numerous to be discussed here. The structural geology of the basin is summarized on Figure II-4 and Plate A-1, which respectively show geologic cross-sections and the structural elevation of the top of the Cretaceous Cloverly Formation.

Hydrostratigraphy

The sedimentary sequence within the basin is comprised of permeable saturated rocks herein referred to as aquifers, and relatively impermeable rocks herein referred to as leaky confining layers. The

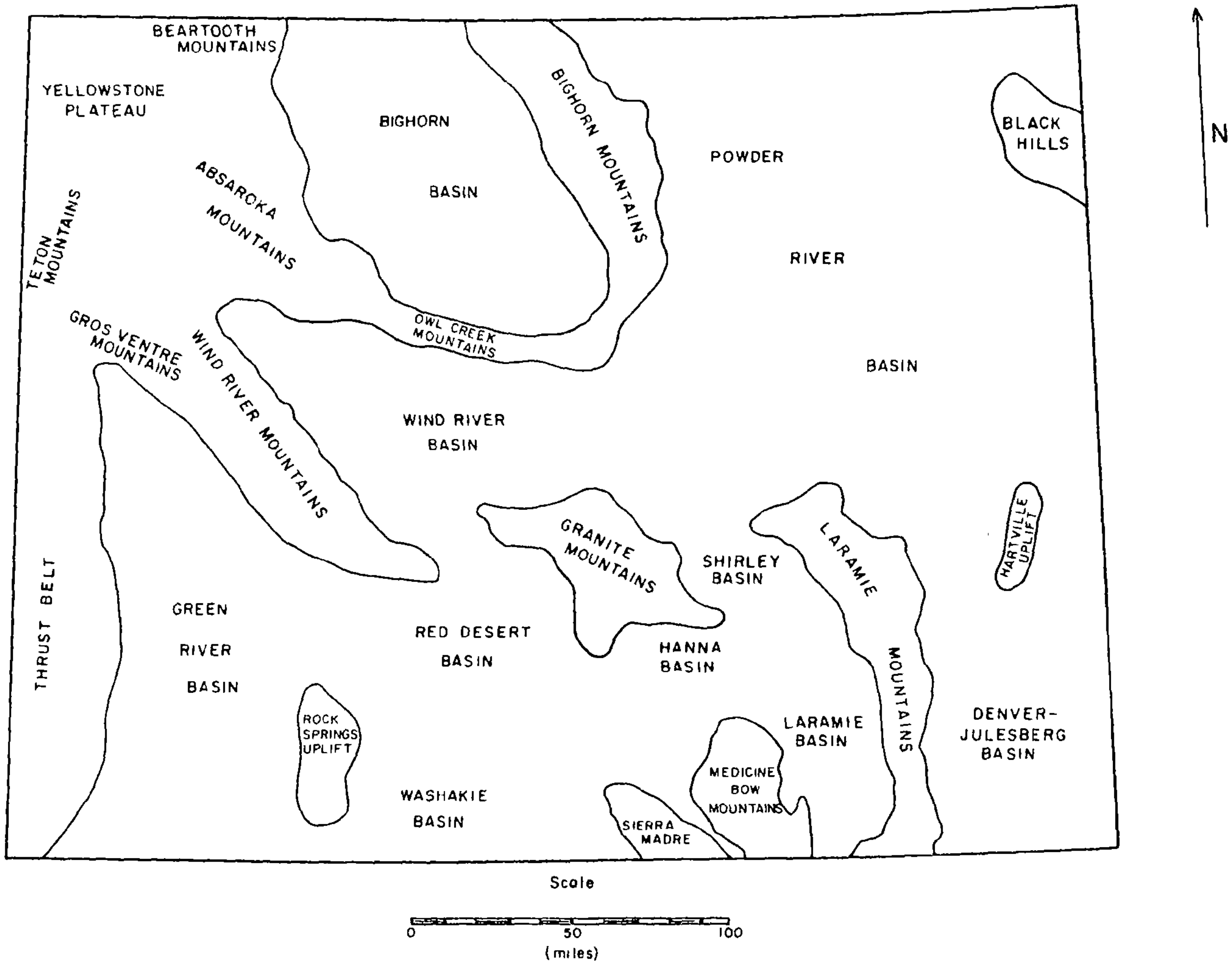


Figure II-3. Index map showing intermontane structural basins in Wyoming.

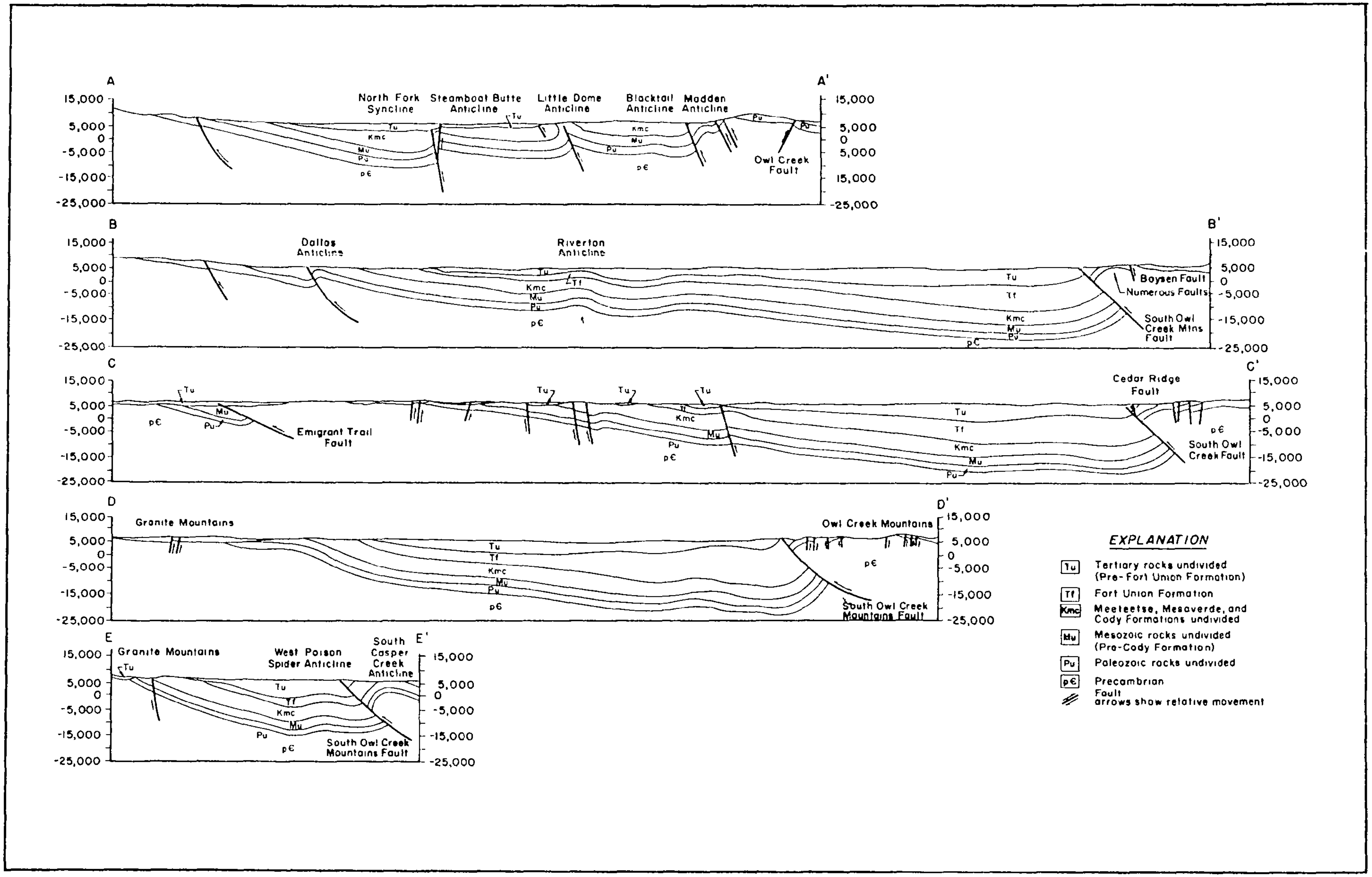


Figure II-4. Geologic cross sections, Wind River basin, Wyoming (adapted from Keefer, 1970). Locations of cross sections are shown in Figure II-5.

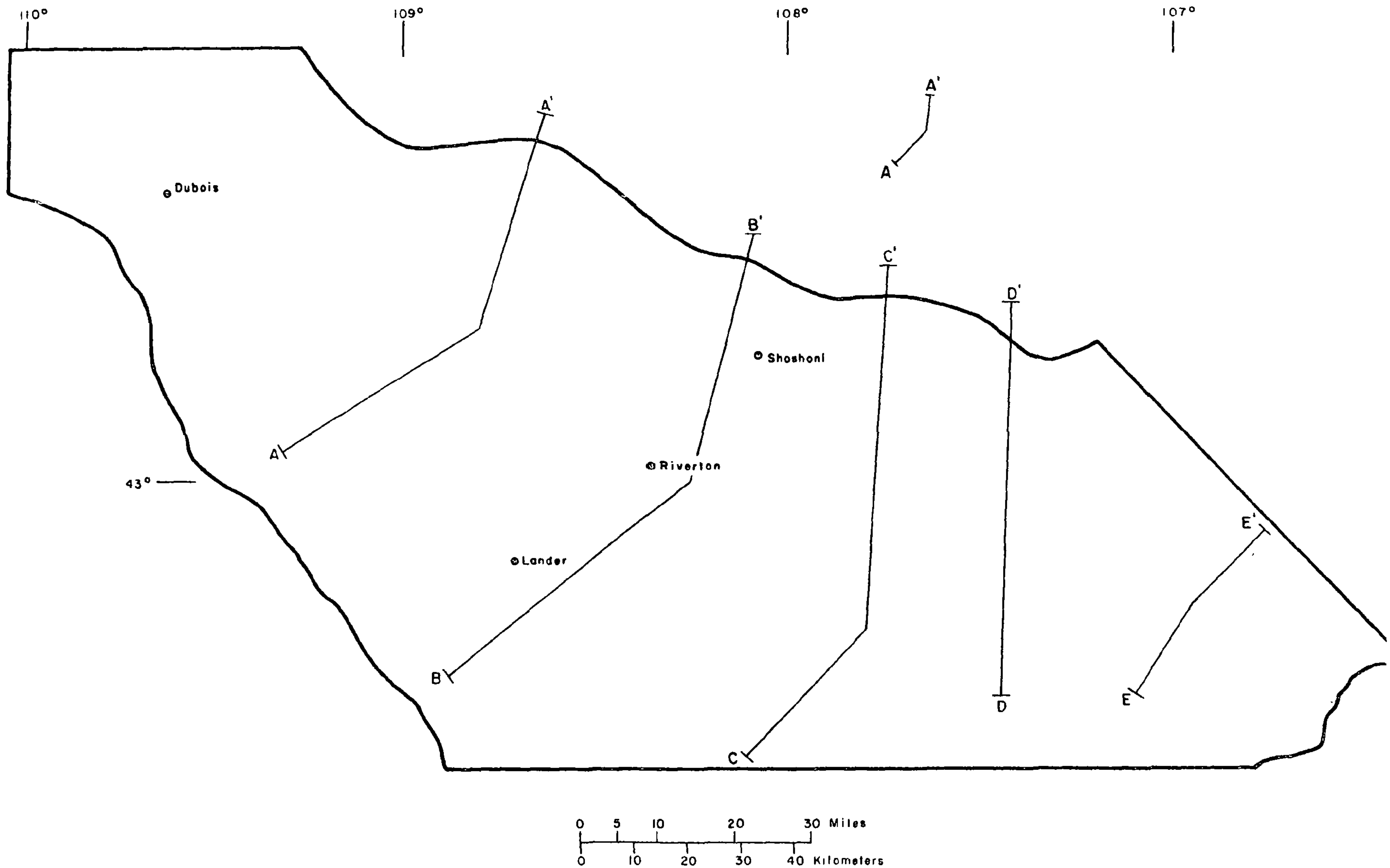


Figure II-5. Index map showing locations of geologic cross sections, Wind River basin, Wyoming.

stratigraphic position of the various aquifers and leaky confining layers are shown on Figure II-6.

By definition an aquifer is a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs (Lohman and others, 1972). This definition is, of course, vague because the word "sufficient" must be defined by the user. It is important to understand that aquifers are not dependent on formational boundaries, but rather they are dependent on permeability characteristics and recharge-discharge mechanisms.

An aquifer system as defined here is comprised of a series of aquifers that (1) are hydraulically connected, (2) have similar hydraulic properties, (3) are areally extensive, (4) have similar water quality characteristics, and (5) are sealed from younger and older water-bearing formations by confining layers.

A leaky confining layer as defined here is a formation, group of formations, or part of a formation that has a lower ability to transmit water than the aquifers that it separates. Although confining layers have small permeabilities they are not impermeable. Given sufficient area and time, a confining layer is usually capable of leaking large quantities of water to adjacent units.

Virtually all of the sedimentary rocks in the basin are capable of yielding at least small quantities of ground water to wells. Even wells completed in predominantly shale and siltstone units, given sufficient time, will produce water. For example, as shown on Figure II-6, the Cody Shale and Thermopolis Shale are leaky confining layers;

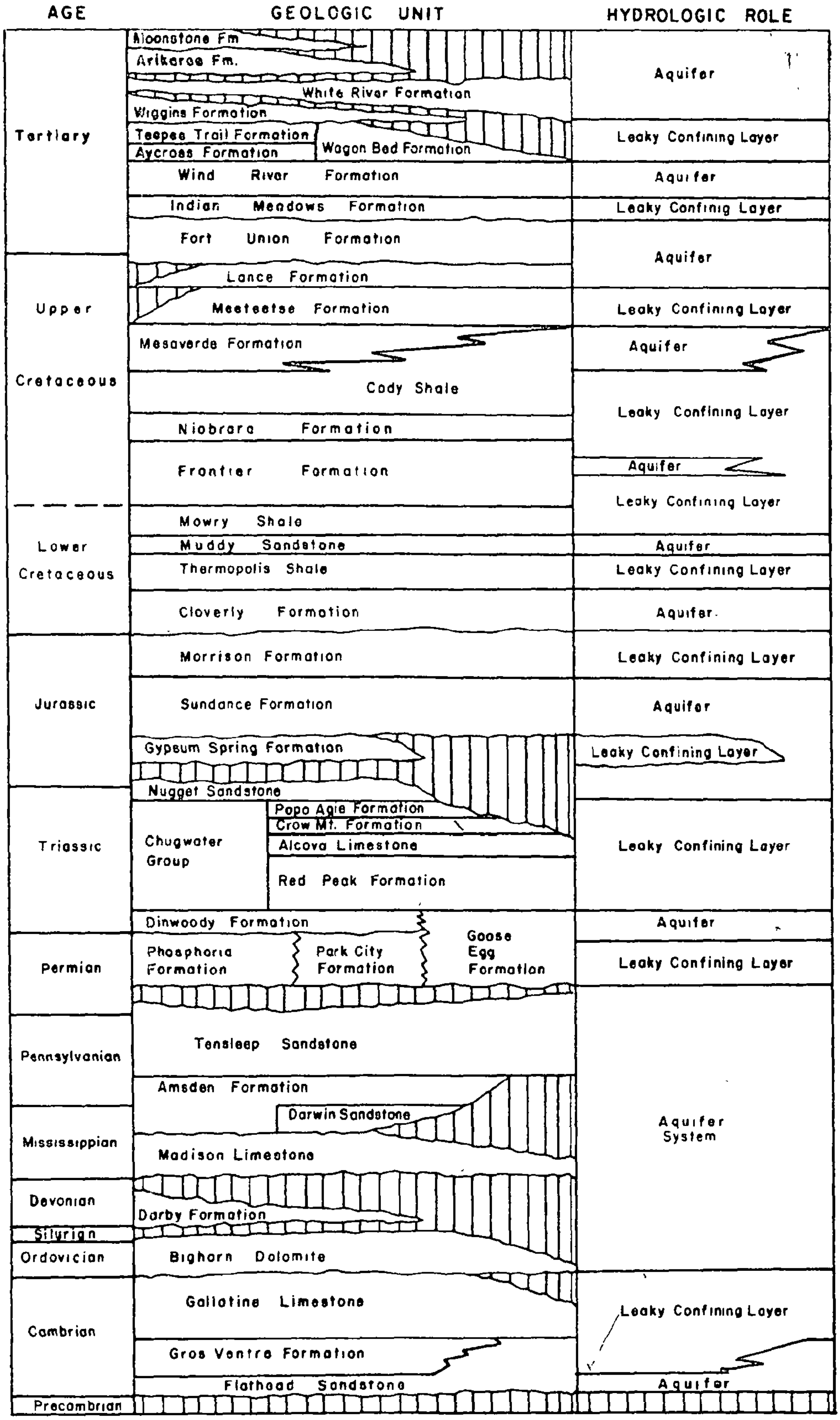


Figure II-6. Hydrologic roles and ages of the rocks in the Wind River basin, Wyoming.

however, according to the Wyoming State Engineer's Office (1981), there are about 100 stock and domestic wells completed in these units.

The principal distinction between aquifers and confining layers is permeability. The aquifers are, of course, saturated and permeable, whereas the confining layers are saturated but have negligible to small permeabilities. Obviously, the larger the permeability, the greater the potential for ground water to circulate through the rock unit when subjected to differences in hydraulic head.

III. WATER USE

III. WATER USE

A principal objective of this report was to quantify water use in the Wind River basin by economic sector and geologic source. The following methodology was used to accomplish this objective: (1) obtain available data for permitted water wells with domestic and stock use from the Wyoming State Engineer's Office; (2) obtain available public water supply data for community and non-community water systems from the U.S. Environmental Protection Agency, Region VIII, Water Supply Division; (3) obtain available industrial water use data by contacting various state agencies and all major industries within the basin; (4) obtain available agricultural water use data from the Wyoming State Engineer's Office, county irrigation district offices, and the Soil Conservation Service; (5) identify the ground-water sources developed by the previously mentioned domestic, industrial, and agricultural sectors based on (a) well location, (b) well depth, and (c) regional and site-specific geology; and (6) quantify water use based on reported and inferred well yields.

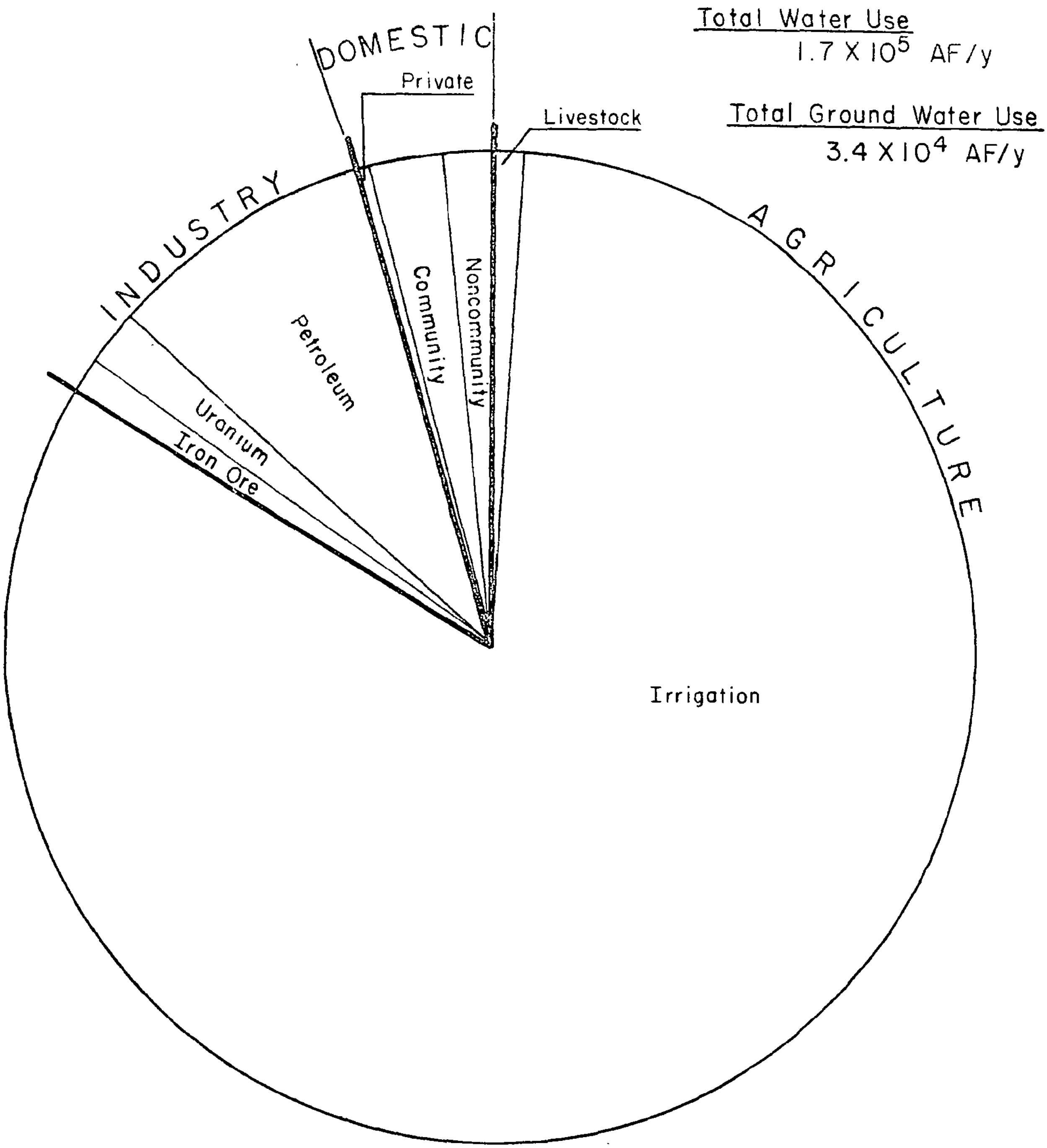
Because both ground- and surface-water rights within the Wind River Indian Reservation are currently being challenged in the Wind River Adjudication suit, federal, state, and local authorities were unable to release current water use data for the reservation. As a result, much of the reported water use data for the reservation is incomplete and dated; therefore, total basin water use estimates are, at best, conservative.

Both ground and surface water are used in the basin for domestic, industrial, and agricultural purposes. Surface water provides much of the water consumed; however, most surface water is geographically confined to major drainage areas, and withdrawals are restricted by interstate compacts. Conversely, ground water exists throughout the basin but extensive development is hindered by (1) inadequate delineation of developable aquifers, (2) drilling and development costs, (3) ground-water qualities, and (4) water development policies that emphasize utilization of surface water.

Estimated total water use in the basin is about 1.7×10^5 acre-feet/year. This total is based on estimated domestic, industrial, and agricultural use (Wyoming State Engineer's Office, 1981 and various; U.S. Environmental Protection Agency, 1980; U.S. Department of Agriculture and others, 1980; Wyoming Crop and Livestock Reporting Service, 1980; Wyoming Oil and Gas Conservation Commission, various; Soil Conservation Service, various; Fremont and Natrona County Officers, various). About 20 percent or 3.4×10^4 acre-feet/year of the total water demand in the basin is supplied by ground water. Total water use arranged by economic sector, percent ground-water use, and percent surface-water use is summarized on Figure III-1.

DOMESTIC WATER USE

Domestic water supplies are divided into public and private systems. Public systems are subdivided into community and noncommunity systems. A community system as used here serves 25 or more permanent residents, whereas a noncommunity system serves less than 25 permanent residents, but may serve a transient population of 25 or more.



Economic Sector	Percent total water use	Percent ground water use by respective sector	Percent surface water use by respective sector
DOMESTIC	4	72	18
INDUSTRY	12	90	10
AGRICULTURE	84	97	3

Figure III-1. Percent total water use arranged by economic sector. Shaded areas designate percent ground-water use; unshaded areas designate surface-water use. Agriculture water use is a consumptive estimate and does not include system losses and return flow.

Noncommunity systems include restaurants, hotels, bars, schools, and campgrounds.

There are a total of 30 community (Table III-1) and 50 noncommunity (Table III-2) water supply systems in the basin. Sources of water used by the various community and noncommunity systems, respectively, are compiled in Tables III-1 and III-2.

Based on data presented in Table III-1, total water use for community public water supply systems is about 4.1×10^3 acre-feet/year. Ground-water sources supply about 2.1×10^3 acre-feet/year, whereas surface-water sources supply about 2.0×10^3 acre-feet/year.

Total water use for noncommunity systems is about 1.7×10^2 acre-feet/year (Table III-2). About 52 percent (9.1×10^1 acre-feet/year) of the noncommunity water demand is supplied by ground water.

A summary of water use by domestic sector and source of water is compiled in Table III-3. Based on data presented in Tables III-3 and III-4, the Wind River Formation supplies the greatest quantity of ground water for domestic use, with Quaternary deposits the second greatest source.

The total number of permitted private domestic water wells in the basin is 3,500 (Wyoming State Engineer's Office, 1981). Permitted private domestic wells for which location and water source are known are shown on Plate B-1. A summary of the number of water wells according to formation is compiled in Table III-4. Insufficient data exist to allow accurate quantification of total water consumption for permitted private domestic use. However, based on the population estimate of about 16,400 rural residents and assuming that these residents are supplied by private domestic wells and have an average per capita

Table III-1. Permitted community public water supply systems in the Wind River basin, Wyoming.[a]

COUNTY Name of Facility	Location[b]	Source	Average Production gal/day	 ac-ft/yr	Population Served
FREMONT					
Village of Arapahoe	1S-4E-23	Little Wind River	142,020	159	789
Dubois	41-106-6	Quaternary deposits	67,000[c]	75[c]	1,200
	41-106-7	Quaternary deposits	--	--	--
	41-107-1	Wind River Formation	--	--	--
	41-107-2	Wind River Formation	--	--	--
Hudson	34-98-20	Quaternary deposits	75,000	84	500
Jeffery City	29-92-15	Arikaree Formation	90,000	101	300
Lander	32-100-3	Popo Agie River	150,000[c]	1,680[c]	8,000
	32-100-9	Popo Agie River	--	--	--
	33-100-25	Tensleep Sandstone	--	--	--
	33-100-25	Amsden Formation	--	--	--
Pavillion	3N-2E-7	Wind River Formation	20,000	22	320
Riverton	1N-4E-18	Wind River Formation	1,000,000	1,120	10,000
	1N-4E-27	Wind River Formation			
	1N-4E-29	Quaternary deposits			
	1N-4E-34	Quaternary deposits			
	1N-4E-35	Wind River Formation			
Shoshoni	38-94-29	Wind River Formation	240,000	269	1,100
	3N-6E-15	Wind River Formation			
Arapahoe Utility Organization	1S-4E-23	Little Wind River	147,600	165	820
Big Eagle Mine Camp	N.A.	N.A.	5,250	6	70
Brentwood Subdivision	1N-4E-28	Wind River Formation	4,500	5	90

Table III-1. (continued)

COUNTY Name of Facility	Location[b]	Source	Average Production gal/day	ac-ft/yr	Population Served
FREMONT (continued)					
Cottonwood Court	N.A.	Wind River Formation	5,000	6	120
Dickenson Trailer Court	1N-4E-23	Wind River Formation	15,000	17	225
Federal-American Partners	N.A.	Wind River Formation	16,000	18	350
1st Fike Subdivision	1N-4E-22	Wind River Formation	20,000	22	200
Kings Trailer Court	1N-4E-27	Wind River Formation	2,250	3	45
Lucky Mc Mine	N.A.	Wind River Formation	200,000	224	150
Midvale Irrigation District	3N-2E-7	Wind River Formation	2,100	2	28
Mountain View Acres	1N-4E-30	Wind River Formation	3,500	4	45
Nipper Mobile Homes	1N-4E-35	Wind River Formation	4,500	5	90
2nd Fike Subdivision	N.A.	Wind River Formation	4,800	5	60
Shoshone Tribe - Boulder Flats Utility Organization	N.A.	Wind River Formation	22,900	26	127
Spencer Homesites	1N-4E-23	Wind River Formation	4,500	5	60
Spencer Water Company	1N-4E-27	Wind River Formation	7,700	9	155
Weslee Mobile Home Village	1N-4E-35	Wind River Formation	10,000	11	72

Table III-1. (continued)

COUNTY Name of Facility	Location[b]	Source	Average Production gal/day	 ac-ft/yr	Population Served
FREMONT (continued)					
Western Mobile Home Court	1N-4E-2	Wind River Formation	6,300	7	125
Wyoming Correctional Institute	1N-4E-35	Wind River Formation	2,800	3	55
NATRONA					
Alcova Texaco	N.A.	N.A.	2,000	2	75
Natrona County Parks Comm.	30-83-33	Tensleep-Chugwater Formation	24,000	27	800
Sloane Company	30-83-24	Quaternary deposits	3,500	4	50

[a] Sources of data are U.S. Environmental Protection Agency (1980), Wyoming State Engineer's Office (1981).

[b] Township (north) - range (west) - section, unless otherwise specified; U.S. Geological Survey well numbering system shown in Appendix A.

[c] Reported production is cumulative average for all sources included in this facility.

Table III-2. Permitted noncommunity public water supply systems in the Wind River basin, Wyoming.[a]

COUNTY Name of Facility	Location[b]	Source	Average Production gal/day	 ac-ft/yr	Population Served
FREMONT					
Amirs Bar and Restaurant	29-92-14	Arikaree Formation	1,000	1.2	100
Atlantic City Mercantile Inc.	29-100-12	Precambrian	3,000	3.3	300
Bonneville Bar	N.A.	N.A.	500	.6	50
Boysen State Park - Cottonwood C.G.	4N-5E-4	Wind River Formation	25	.1	25
Boysen State Park - Fremont Bay C.G.	3N-6E-5	Wind River Formation	25	.1	25
Boysen State Park - Tuff Creek C.G.	39-94-20	Wind River Formation	25	.1	25
Boysen State Park - Lower Wind River	5N-6E-4	Flathead Formation	500	.6	50
Brooks Lake Lodge	N.A.	N.A.	2,500	2.8	50
CM Dude Ranch	N.A.	N.A.	1,900	2.1	25
Coffeetime	N.A.	N.A.	1,000	1.1	50
Cove Bar and Grocery	N.A.	N.A.	250	.3	25
Cross Mill Iron Ranch	N.A.	N.A.	2,000	2.2	40
Crowheart-Big Wind Hall	N.A.	N.A.	350	.4	35
Dog Patch Sandwiches	N.A.	N.A.	50	.1	50
Dubois KOA	N.A.	N.A.	1,750	2	50
Fremont Co. Youth Camp	N.A.	N.A.	625	.7	25

Table III-2. (continued)

COUNTY Name of Facility	Location[b]	Source	Average Production gal/day	 ac-ft/yr	Population Served
FREMONT (continued)					
Gardner's Market	N.A.	N.A.	1,000	1.2	50
K-Bar Ranch	N.A.	N.A.	5,250	5.8	150
Lakeside Resort	N.A.	N.A.	3,000	3.3	100
Lander KOA	N.A.	N.A.	2,625	2.9	75
Lava Creek Ranch	N.A.	N.A.	2,250	2.5	45
Lazy L and B Ranch	N.A.	N.A.	1,000	1.1	25
Louis Lake Lodge	N.A.	N.A.	1,250	1.4	25
Mill Creek School	N.A.	Big Wind River	10,750	12	430
Miners Delight Dining Room	29-100-12	Precambrian	500	.6	25
Ocean Lake Resort	2-2-11	Wind River Formation	7,000	7.8	75
Pilot Butte Inc.	2-1-28	Wind River Formation	500	.6	50
Pinnacle Motor Lodge	N.A.	N.A.	2,600	2.9	100
Red Barn Store	N.A.	N.A.	500	.6	50
Red Rock Lodge	5-6-13	Quaternary deposits	1,750	1.9	50
Red Rock Ranch	N.A.	Quaternary deposits	1,200	1.3	30
Ring Lake Ranch Inc.	N.A.	N.A.	1,650	1.8	35
River Campground	30-95-27	Quaternary deposits	1,250	1.4	25
Riverton KOA Campground	2N-4E-36	Wind River Formation	2,250	2.5	75
Rocky Acres Camping	2N-1E-17	N.A.	1,400	1.5	40

Table III-2. (continued)

COUNTY Name of Facility	Location[b]	Source	Average Production gal/day	 ac-ft/yr	Population Served
FREMONT (continued)					
Sawmill Lodge	N.A.	N.A.	1,050	1.1	30
Sinks Canyon State Park	32-100-17	Middle Popo Agie River	500	.6	100
South Pass Historic Site	29-100-20	Precambrian	2,000	2.2	100
Sweetwater Station	30-95-27	Arikaree Formation	1,000	1.1	150
Teepee Bar	N.A.	N.A.	50-	.6	50
Triangle C Ranch	N.A.	N.A.	3,000	3.3	60
U.S. Steel Corporation	29-100-14	Rock Creek	50,000	56	500
Wind River High School	2N-1E-2	N.A.	10,000	11.2	200
Wind River Ranch	N.A.	N.A.	3,500	3.9	250
NATRONA					
Bright Spot	36-88-2	Wind River Formation	1,500	1.6	150
Hells Half Acre	36-86-36	Hauls water from Casper, WY	4,200	4.7	100
Powder River School	35-85-1	Hauls water from Casper, WY	600	.7	30
Tumble Inn Bar	35-85-7	Hauls water from Casper, WY	500	.6	50
Union Carbide Corporation	N.A.	Wind River Formation	8,000	8.9	25
Waltman Store	36-86-19	Wind River Formation	50	.6	100

[a] Sources of data are U.S. Environmental Protection Agency (1980), Wyoming State Engineer's Office (1981).

[b] Township (north) - range (west) - section, unless otherwise specified; U.S. Geological Survey well numbering system shown in Appendix A.

Table III-3. Summary of water use arranged by domestic sector and source of water, Wind River basin, Wyoming.[a]

Domestic Sector	Water Source	Estimated Water Use (ac-ft/yr)
Community	Wind River Formation	1.8×10^3
	Surface water	2.0×10^3
	Quaternary deposits	1.6×10^2
	Arikaree Formation	1.0×10^2
	Tensleep Sandstone	2.7×10^1
	Unknown sources	$.8 \times 10^1$
	TOTAL	4.1×10^3
Noncommunity	Wind River Formation	2.9×10^1
	Surface water	8.5×10^1
	Unknown sources	4.8×10^1
	Precambrian rocks	$.67 \times 10^1$
	Quaternary deposits	$.46 \times 10^1$
	Arikaree Formation	$.23 \times 10^1$
	TOTAL	1.7×10^2
Private	Various sources[b]	3.3×10^3
	TOTAL	7.6×10^3

[a]Sources of data are Wyoming State Engineer's Office (1981); U.S. Environmental Protection Agency (1980). See Tables III-1 and III-2, respectively, for specific community and noncommunity systems.

[b]Insufficient data exist to quantify water use by source. See Table III-4 for number of private wells arranged by geologic source.

Table III-4. Estimated number of permitted private domestic use water wells arranged by formation, Wind River basin, Wyoming.

Formation	Number of Wells
Quaternary deposits	1,065
Arikaree Formation	101
White River Formation	28
Wind River Formation	1,708
Wagon Bed Formation	2
Fort Union Formation	27
Lance Formation	3
Mesaverde Formation	12
Cody Shale	85
Frontier Formation	54
Muddy Sandstone	8
Thermopolis Shale	15
Cloverly Formation	22
Morrison Formation	12
Nugget Sandstone	14
Chugwater Group	29
Park City Formation	3
Phosphoria Formation	61
Goose Egg Formation	1
Tensleep Sandstone	23
Amsden Formation	1
Madison Limestone	8
Bighorn Dolomite	2
Flathead Sandstone	18
Precambrian rocks undivided	137
Unidentified sources	61
TOTAL	3,500

consumption of 180 gallons/day (Wyoming State Engineer, 1973), private domestic ground-water use is at least 3.3×10^3 acre-feet/year.

INDUSTRIAL WATER USE

Principal industries in the basin using ground and surface water are uranium, iron ore, and petroleum companies. Estimated water use for these industries is compiled in Table III-5. About 91 percent of the industrial water demand is supplied by ground water.

Uranium Industry

The uranium industry used an estimated 3.2×10^3 acre-feet of ground water during 1980, based on data supplied by the Wyoming Department of Environmental Quality and the Wyoming State Engineer's Office. This estimate is based on water use data for six active uranium companies (Western Nuclear, Pathfinder, Union Carbide, Federal American Partners, American Nuclear, and Centurian Nuclear). Sources for ground water used by the uranium industry include the White River, Wind River, Cloverly, Tensleep, and Phosphoria formations. The water is used principally for milling operations, dust suppression, and domestic purposes.

Iron Ore Industry

About 2.3×10^3 acre-feet of water was used by the U.S. Steel Corporation's Atlantic City mine during 1980 (U.S. Steel Corporation, personal communication, 1981). About 95 percent of the water demand is met by surface water from a company-owned reservoir supplied by Rock Creek.

Table III-5. Estimated water use for various industries, Wind River basin, Wyoming.[a]

Industry	1980 Estimated Water Use (ac-ft/yr)
Iron	2.3×10^3
Uranium	3.2×10^3
Petroleum	1.6×10^4

[a]Based on data from Collentine and others (1981), Wyoming State Engineer's Office (1973, 1981), U.S. Department of Agriculture and others (1980), Wyoming Oil and Gas Conservation Commission (1981), Wyoming Department of Environmental Quality (1981), U.S. Steel Corporation (personal communication, 1981).

Petroleum Industry

The petroleum industry withdrew an estimated 1.6×10^4 acre-feet of ground water during 1980 (Wyoming Oil and Gas Conservation Commission, 1981). Ground-water withdrawals by the industry are generally the result of by-product water from oil production and water developed for secondary water-flood recovery projects. According to Collentine and others (1981), ground water produced at the various oil and gas fields in the basin is principally used for secondary recovery purposes.

Ground water used by the oil and gas industry is usually produced at the stratigraphic horizon of the petroleum reservoir. For example, in the central part of the basin principal ground-water sources developed by the industry include the Frontier and Cloverly formations, whereas in the western and northern parts of the basin principal sources include the the Phosphoria, Tensleep, and Madison formations.

The reader is referred to Collentine and others (1981) for historic summaries of cumulative water-flood rates and recovery projects for individual petroleum fields in the basin.

AGRICULTURAL WATER USE

Livestock

Water consumption by livestock in the basin is estimated at 2×10^3 acre-feet/year (Wyoming Crop and Livestock Reporting Service, 1980). Estimated water consumption for the various livestock populations are listed in Table III-6.

Principal sources of water for livestock use are the Wind River Formation, Quaternary deposits, and surface water from the various

Table III-6. Estimated water consumption by livestock, Wind River basin.[a]

Livestock	Estimated Population	Average Daily Consumption/Animal (gal/day)	Average Annual Consumption/Population (ac-ft/yr)
Cattle	9.3×10^4	15	1.6×10^3
Sheep	3.8×10^4	3	2.6×10^2
Hogs	2.5×10^3	2	5.6
Horses	4.0×10^3	11	5.1×10^1
TOTAL			2×10^3

[a]Sources of data are Wyoming Crop and Livestock Reporting Service (1980); Wyoming State Engineer (1972).

rivers, creeks, and impoundments in the basin. Insufficient data exist to quantify water use by aquifer and surface-water source.

Irrigation

About 200,000 acres of land are permitted for irrigation in the basin. Annual use of ground and surface water for irrigation is about 1.4×10^5 acre-feet/year (U.S. Department of Agriculture and others, 1980; Wyoming State Engineer's Office, 1973 and various). About 2 percent of the total irrigated acres in the basin are wholly or partially irrigated with ground water (Wyoming State Engineer's Office, various). Based on average water needs for the various crops in the basin (Trelease and others, 1970) and assuming 2 percent of the total irrigated acreage is supplied by ground water, about 2.8×10^3 acre-feet/year of ground water is used for irrigation. The Wind River and Arikaree formations are the principal sources of ground water used for irrigation in the basin.

IV. AQUIFERS

IV. A Q U I F E R S

Eleven aquifers and one aquifer system are identified by this report in the Wind River basin, Wyoming. The aquifers, in ascending stratigraphic order, are the (1) Flathead, (2) Phosphoria, (3) Sundance-Nugget, (4) Cloverly, (5) Muddy, (6) Frontier, (7) Mesaverde, (8) Fort Union-Lance, (9) Wind River, (10) Arikaree, and (11) Quaternary deposits. The aquifer system is herein referred to as the Tensleep aquifer system and is comprised of the (a) Tensleep, (b) Amsden, (c) Madison, (d) Darby, and (e) Bighorn subaquifers. The aquifers were identified on the basis of (1) water-encountered reports for petroleum tests and water wells, (2) completion intervals for water wells, (3) spring locations, and (4) previous hydrogeologic investigations.

In addition to the aquifers and the aquifer system, nine regionally-continuous leaky confining layers are identified in this report. The various formations comprising the leaky confining layers are predominantly comprised of relatively impermeable massive shale, siltstone, claystone, and finely-crystalline massive limestone and dolomite.

The reader is referred to Figure II-6 (Chapter II) for the stratigraphic position of the aquifers and leaky confining layers. Figure II-6 also shows the various formations comprising the confining units. A summary of the ages, thicknesses, lithologies, and hydrologic properties of the rocks in the Wind River basin appears in Table IV-1. Aquifer test results and well yields are tabulated by formation in Table C-1 (Appendix C).

Table IV-1. Ages, thicknesses, lithologies, and hydrologic properties of the rocks exposed in the Wind River basin, Wyoming.[a]

Era	Period	Geologic Unit	Thickness (feet)	Lithologic Description	Hydrologic Properties
Cenozoic	Quaternary	alluvium and terrace deposits	0-100+	Unconsolidated, interbedded, silt, sand, and gravel.	Highly permeable and productive water-bearing deposits. Possible yields from 1 to greater than 1,000 gpm. Total dissolved solids generally range between 100 to 1,000 mg/l.
	Tertiary	Moonstone Fromation	0-1,350	Nonresistant sequence of shale, sandstone, claystone, tuff, limestone, and conglomerate. Numerous chalcedony lenses and nodules throughout unit. Unit exposed only in Granite Mountains area.	Yields water locally to springs and shallow wells along outcrop. Yields generally less than 100 gpm; no water quality data available. Comprises upper part of Arikaree aquifer.
		- Unconformity -			
	Tertiary	Arikaree Formation	0-930	Upper: well-rounded, poorly consolidated, cross-bedded, fine-to medium-grained sandstone. Some interbedded tuff, flaggy limestone, conglomerate, and arkosic sandstone. Abundant vocanic fragments. Basal: coarse, angular pebble and cobble conglomerate with poorly resistant mudstone matrix. Unit exposed only in southern part of basin.	Highly permeable and productive water-bearing unit. Large intergranular permeability and porosity. Production for wells is generally between 1 to 300 gpm, with maximum reported production of 1,500 gpm. Springs generally discharge less than 20 gpm. Saturated thickness ranges between 200 to 600 feet. Hydraulic conductivity ranges between 0.5 to 60 ft/dy. Comprises middle part of Arikaree aquifer.
		- Unconformity -			
	Tertiary	White River Formation	0-950	Calcareous, argillaceous, fine-grained sandstone with interbedded tuff and bentonite. Discontinuous, thin lenses of arkose and very coarse, poorly sorted conglomerate. Unaltered uitric ash layers common. Unit exposed only in southern part of basin.	Highly permeable and productive water-bearing unit. Good intergranular permeability and porosity. Well yields generally range between 1 to 300 gpm, with maximum reported production 850 gpm. Saturated thickness ranges between 200 to 350 feet. Comprises basal part of Arikaree aquifer.
		- Unconformity -			
	Tertiary	Wagon Bed Formation	0-700	Tuffaceous and bentonitic sandstone, siltstone, and mudstone. Poorly sorted coarse-pebble conglomerate and arkose at top and base of unit. Chert lenses and silicified mudstone lenses in upper 100 feet. Unit exposed only along southern margin of basin.	Yields water locally to springs and shallow wells. Yields less than 10 gpm. Saturated zones include sandstone and conglomerate lenses. Water qualities are poor with total dissolved solids between 1,500 to 2,500 mg/l. Not considered an aquifer.

Table IV-1. (continued)

Era	Period	Geologic Unit	Thickness (feet)	Lithologic Description	Hydrologic Properties
	Tertiary	Teepee Trail Formation	0-2,000	Tuff and tuffaceous siltstone, fine-grained sandstone, and deutrified volcanics. Exposed only in northwest part of basin.	Yields minor amounts (less than 10 gpm) of water to springs and shallow wells along outcrop. Confining layer.
	Tertiary	Aycross Formation	0-1,000	Series of shale, clay, conglomerate, volcanics, and sandstone. Exposed only in northwest part of basin.	Confining layer.
	Tertiary	Wind River Formation	250-1,030	Variegated siltstone, shale, claystone, and argillaceous sandstone with interbedded fine-grained sandstone, arkose, and arkosic sandstone. Tuffaceous and bentonitic mudstone lenses in upper 500 feet.	Major aquifer. Yields water to wells and springs throughout basin. Yields range between 1 to 3,000 gpm. Locally contains artesian zones with sufficient head to produce 200 gpm. Principal source of domestic and stock water on Wind River reservation. Principal source of industrial water in southern part of basin. Water qualities are highly variable with total dissolved solids between 100 to 5,000 mg/l.
	Tertiary	Indian Meadows Formation	0-725	Series of variegated claystone, agrillaceous sandstone, massive limestone, and poorly sorted conglomerate.	Confining layer.
		- Unconformity -			
	Tertiary	Fort Union Formation	0-8,000	Conglomerate, sandstone, shale, siltstone, and carbonaceous shale in basal part of unit; grades upward to very fine-grained clastics.	Conglomerate and sandstone zones yield water to wells. Highly productive and permeable where fractured. Water is semi-confined to confined with sufficient head to produce 10 gpm. Water qualities are poor with total dissolved solids greater than 1,000 mg/l. Basal part of unit is considered a regional confining unit. Upper part of unit contains complex series of permeable and confining layers.
Mesozoic	Cretaceous	Lance Formation	0-6,000	Massive to thin bedded sandstone, poorly sorted shale pebble conglomerate; grades upward to carbonaceous shale, siltstone, with thin lenses of bentonite and coarse-grained sandstone. Thin coal lenses in uppermost part of unit.	No known wells produce water solely from unit. Wells completed in Fort Union and Lance. Unit is highly productive and permeable in Big Horn basin (yields range between 1 to 100 gpm); water qualities are generally poor with total dissolved solids greater than 1,000 mg/l. Large development potential in Wind River basin.

Table IV-1. (continued)

Era	Period	Geologic Unit	Thickness (feet)	Lithologic Description	Hydrologic Properties
	Cretaceous	Meeteetse Formation	0-1,335	Massive to thin bedded, friable sandstone, shale, siltstone, and claystone, with thin coal and bentonite interbeds. Grades to shale, siltstone, and sandy shale eastward.	Regional confining layer.
	Cretaceous	Mesaverde Formation	550-2,000	Upper: very fine to coarse grain, massive to cross-bedded, friable sandstone. Few shale, claystone, and carbonaceous shale interbeds. Middle: interbedded carbonaceous shale, siltstone, and sandstone. Some lenticular coal beds up to 13 feet thick. Basal: very fine to medium grain, irregularly bedded to massive sandstone.	Permeable and productive water-bearing unit. Regional aquifer. Well yield data not available; however, artesian flows reported in numerous petroleum tests in central basin. Yields water to shallow stock wells in eastern basin. Water qualities poor with total dissolved solids usually greater than 1,500 mg/l.
	Cretaceous	Cody Shale	3,150-5,500	Shale, fissile, calcareous and bentonitic. Grades upward to thin bedded, fine grain sandstone with interbedded calcareous shale.	Regional confining layer.
	Cretaceous	Frontier Formation	470-1,045	Alternating sequence of sandstone and shale. Sandstone: fine to medium grain, thin bedded to massive, locally glauconitic. Shale: fissile, silty and sandy, locally carbonaceous.	Upper 2/3 of unit is regional aquifer; lower 1/3 of unit is confining layer. Water is under confined conditions with sufficient head to produce flows of 10 to 25 gpm at selected petroleum tests. Yields 5 to 150 gpm to shallow stock and domestic wells. Water qualities vary from less than 500 to greater than 3,000 mg/l total dissolved solids.
	Cretaceous	Mowry Shale	395-560	Interbedded siliceous shale and bentonite. Some claystone.	Regional confining layer.
	Cretaceous	Muddy Sandstone	20-75	Sandstone, poorly to well sorted, fine to medium grain, salt and pepper sandstone. Grades locally to siltstone and sandy shale.	Oil and water-bearing unit. Water is under confined conditions with sufficient head to produce flows of 1 to 20 gpm at selected petroleum tests. Water qualities are poor with total dissolved solids generally greater than 1,500 mg/l.
	Cretaceous	Thermopolis Shale	120-250	Fissile shale and claystone, nonresistant, with gypsum and siltstone and gypsum interbeds. Numerous fine grain, concretionary sandstone lenses.	Regional confining layer.

Table IV-1. (continued)

Era	Period	Geologic Unit	Thickness (feet)	Lithologic Description	Hydrologic Properties
	Cretaceous-Jurassic	Cloverly-Morrison formations undivided	300-570	Cloverly: Upper-sandstone, clean with lenticular chert-pebble conglomerate and thin variegated shale. Middle: variegated shale. Basal: sandstone, fine to coarse grain. Morrison: variegated claystone and shale, with thin bedded to lenticular, fine to medium grain, friable sandstone.	Cloverly: permeable and productive upper and basal sandstones. Water is under artesian conditions with sufficient head to produce flows of 1 to 25 gpm at selected petroleum tests. Yields water to stock wells along outcrops. Water qualities are generally poor with total dissolved solids greater than 1,500 mg/l. Morrison: regional confining layer. Locally contains permeable sandstone lenses. Water is under confined conditions. Yields less than 5 gpm.
	Jurassic	Sundance Formation	150-570	Upper: fine to coarse grain glauconitic sandstone with few thin shale and fossiliferous limestone interbeds. Basal: siltstone and sandstone; grade downward to oolitic limestone, dolomite, and chert pebble conglomerate.	Regional aquifer. Large intergranular permeability in sandstone and chert lenses. Yields water to shallow stock and domestic wells along outcrops (1 to 25 gpm). Water is under confined conditions. Selected petroleum tests yield-flows of 25 to 50 gpm. Water qualities are good along outcrops with total dissolved solids less than 500 mg/l. Water qualities deteriorate basinward with total dissolved solids greater than 2,000 mg/l.
		- Unconformity -			
	Jurassic	Gypsum Spring Formation	0-230	Upper: alternating sequence of siltstone, shale, limestone, dolomite, and gypsum. Basal: sandy siltstone and silty shale. Present only in western part of basin.	Regional confining layer.
		- Unconformity -			
	Jurassic	Nugget Sandstone	0-400	Upper: sandstone, fine to medium grain, calcite and silica cement, large scale cross beds. Basal: calcareous siltstone and mudstone, thin limestone, and thin to massive, very-fine grain sandstone.	Good intergranular permeability. Saturated conditions reported for numerous petroleum tests throughout basin. Water is under confined conditions. Insufficient data exists to meaningfully quantify yields and water qualities.
	Triassic	Popo Agie Formation	0-300	Interbedded resistant sandstone and siltstone, with thin claystone and irregularly-bedded limestone-pebble conglomerate.	Confining layer locally.

Table IV-1. (continued)

Era	Period	Geologic Unit	Thickness (feet)	Lithologic Description	Hydrologic Properties
	Triassic	Crow Mountain Formation	0-130	Upper: sandstone, very-fine grain, well sorted, calcareous, massive, and calcareous siltstone.	Good intergranular permeability. Yields small quantities (less than 20 gpm) of water to shallow domestic and stock wells along outcrop. No water analyses available; however, water used for domestic purposes along outcrops.
	Triassic	Alcova Limestone	0-30	Limestone, dense, finely-crystalline, laminated.	Confining layer.
	Triassic	Red Peak Formation	900-950	Sandstone, non-resistant, fine grain, with interbedded sandy and clayey siltstone, and shale.	Yields small quantities (less than 10 gpm) of water to shallow domestic and stock wells along outcrops. Water qualities are generally good with total dissolved solids less than 1,000 mg/l.
	Triassic	Dinwoody Formation	0-250	Interbedded sandy dolomitic siltstone, calcareous sandstone, and thin dolomite and limestone.	Confining layer.
		- Unconformity -			
Paleozoic	Permian	Park City Formation (Phosphoria Formation)	150-350	Interbedded dense limestone, dolomite, nonresistant siltstone and fine grain sandstone. Grades eastward to dominantly limestone, dolomite, and calcareous shale.	Comples series of permeable sandstones and impermeabl· limestone, dolomite, and siltstone. Highly productive where fractured. Well yields range up to 1,000 gpm. Water qualities are good with total dissolved solids less than 1,000 mg/l.
		- Unconformity -			
	Pennsylvanian	Tensleep Sandstone	200-600	Sandstone, resistant, massive to cross-bedded, fine grain, friable, with irregular chert layers and thin limestone and domilite near base.	Uppermost unit of the Tensleep aquifer system. Good intergranular permeability, excellent permeabilities where fractured. Saturated throughout basin. Water is under confined conditions with sufficient head to produce flows of 1 to several hundred gpm from selected wells. Water qualities along outcrops are good with total dissolved solids less than 500 mg/l. Water qualities decrease basinward with total dissolved solids greater than 2,000 mg/l.

Table IV-1. (continued)

Era	Period	Geologic Unit	Thickness (feet)	Lithologic Description	Hydrologic Properties
	Pennsylvanian	Amsden Formation	0-400	Upper: complex sequence of nonresistant shale, dense dolomite, thin cherty limestone, and thin, resistant, fine grain sandstone. Basal: Darwin Sandstone member, sandstone, fine to medium grain, cross-bedded to massive, friable, porous.	Part of Tensleep aquifer system. Darwin sandstone: permeable along joints and partings between bedding planes. Excellent permeabilities where fractured. Water is confined. Well yields range between 1 to several hundred gpm.
		- Unconformity -			
	Mississippian	Madison Limestone	200-700	Upper: limestone and dolomite, irregular, thin to massive, dense, locally cavernous, cherty. Basal: alternating sequence of limestone, dolomite, thin bedded sandstone, cherty; limestone breccia at base.	Part of Tensleep aquifer system. Poor permeabilities except where fractured. Some saturated caverns. Water-bearing throughout basin. Water is confined. Well yields range between 1 to several hundred gpm. Water qualities are good along outcrop with total dissolved solids less than 500 mg/l.
		- Unconformity -			
	Devonian	Darby Formation	0-200	Dolomite, siltstone, and shale, resistent, dense dolomite.	Part of Tensleep aquifer system. Generally considered a confining layer, but permeable along joints and fractures. Numerous joint controlled springs along Wind River Mountains.
		- Unconformity -			
	Ordovician	Bighorn Dolomite	0-300	Upper: Leigh Dolomite member, dolomite, dense and platey. Basal: Lander Sandstone member, sandstone, fine to medium grain, lenticular; contains flat-pebble conglomerate comprised of fragments of Gallatin Limestone.	Basal part of Tensleep aquifer system. Basal sandstones are permeable; also permeable along joints and fractures. Yields water to numerous springs along Wind River Mountains.
		- Unconformity -			
	Cambrian	Gallatin Limestone	0-450	Limestone, dense, thinly laminated to massive, glauconitic and oolitic, shale, silty shale, and thin sandstone interbeds.	Confining layer. Permeable along joints and fractures. Yields small quantities (less than 5 gpm) to springs along the Wind River Mountains.

Table IV-1. (continued)

Era	Period	Geologic Unit	Thickness (feet)	Lithologic Description	Hydrologic Properties
	Cambrian	Gros Ventre Formation	0-750	Limestone, shale, and calcareous shale, flat-pebble conglomerate at base.	Confining layer.
	Cambrian	Flathead Sandstone	50-500	Sandstone, fine to medium grain, resistent; grades downward to conglomerate and arkose.	Major aquifer. Permeable along partings between bedding planes, faults, fractures and joints. Small interstitial permeabilities. Water is semi-confined to confined. Yields 1 to 25 gpm to shallow stock and domestic wells. Excellent water qualities; total dissolved solids generally less than 500 mg/l. Excellent ground-water resource potential; however, relatively undeveloped because of availability of shallower ground-water sources.
		- Unconformity -			
Precambrian		undifferentiated		Complex of igneous and metamorphic rocks. Predominantly granite, granite gniess, schist, hornblende schist, aplite and basic dikes.	Permeable along joints, fractures and faults. Locally yields water to shallow wells along outcrops.

[a]Sources of data include Keefer (1965); Keefer and Rich (1957); Keefer and Van Lieu (1966); Love (1970); Love and others (1945a, b, c, 1947, 1955); Thompson and others (1949); Whitcomb and Lowry (1968), Yenne and Pipiringos (1954).

FLATHEAD AQUIFER

The Flathead aquifer is comprised of the Cambrian Flathead Sandstone and is 50 to 500 feet thick in the Wind River basin. It is not highly developed because of (1) poor accessibility in areas where the unit crops out, and (2) the availability of shallower sources of ground water in areas underlain by the unit. Eighteen wells were identified as completed in the Flathead aquifer. The locations of these wells are shown on Plate B-1.

The Flathead Formation is predominantly a pink to tan to gray fine- to coarse-grained quartzitic sandstone. The unit is thin-bedded to massive, locally crossbedded and glauconitic. The basal beds of the formation are arkosic and conglomeratic and up to 120 feet thick. The unit grades upward to shale and sandy shale.

Along the Wind River Mountains the average thickness of the Flathead Formation is about 200 feet. The unit thickens eastward to about 400 feet along the eastern part of the Owl Creek Mountains, and to about 500 feet in the Rattlesnake Hills (Keefer and Van Lieu, 1966).

Ground water in the Flathead aquifer is semi-confined to confined. Reported production for shallow stock and domestic wells is less than 25 gallons/minute (Wyoming State Engineer's Office, 1981). No production data are available for petroleum tests completed in the unit.

Intergranular permeabilities in the Flathead aquifer are small because the unit is tightly cemented. Permeabilities are significantly enhanced along partings between bedding planes and along fractures. The Flathead is most permeable where there is little secondary cementation. All reported Flathead springs discharge from partings along bedding planes (Wyoming State Engineer's Office, various; Whitcomb and Lowry, 1968).

Recharge to the Flathad aquifer occurs by (1) infiltration of precipitation into outcrops of the unit, and (2) leakage of water from Precambrian rocks. Excellent recharge potential exists at the Precambrian-Flathead contact along the Wind River and Owl Creek mountains, where annual precipitation exceeds 60 inches/year.

The ground-water resources potential of the Flathead aquifer along the east flank of the Wind River Mountains is very good. This is because (1) available recharge to the unit is large, (2) the unit is up to 300 feet thick, and (3) fracture permeabilities are expected to be large based on known tectonic structures. In addition, the Flathead Formation is a significant water-bearing unit throughout Wyoming. For example, in the Bighorn basin, artesian conditions have been encountered in the Flathead Formation with sufficient heads to produce flows of 1,000 to 2,000 gallons/minute (Wyoming State Engineer's Office, various).

TENSLEEP AQUIFER SYSTEM

The Tensleep aquifer system is comprised of the saturated, permeable parts of the Pennsylvanian Tensleep Sandstone, Pennsylvanian-Mississippian Amsden Formation, Mississippian Madison Limestone, Devonian Darby Formation, and Ordovician Bighorn Dolomite (Figure II-6). The Tensleep aquifer system is named for, but distinguished from, the Tensleep Sandstone.

With the exception of the Granite Mountains area, the Tensleep aquifer system underlies the entire basin. The various formations comprising the aquifer crop out along the Wind River Mountains, the

Owl Creek Mountains, and Rattlesnake Hills (Plate C-1). The aquifer system is up to 2,000 feet thick in the basin.

The Tensleep aquifer system is one of the most significant water-bearing units in the Wind River basin. Regardless of location, wells penetrating the system produce variable quantities of water. The water is semi-confined to confined. Selected petroleum tests have encountered confined conditions with sufficient head to produce flows of up to 200 gallons/minute from well depths exceeding 7,500 feet (Table IV-2).

Permeabilities in the Tensleep aquifer system vary according to (1) formation-lithology, (2) sedimentary structure-depositional environment, and (3) tectonic structure. Predominant lithologies comprising the system are (a) sandstone, (b) limestone, (c) dolomite, and (d) shale. In general, porosities and intergranular permeabilities in the sandstones are relatively large, whereas porosities and intergranular permeabilities are small to negligible in the limestone, dolomite, and shale.

Sedimentary structure and depositional environment affect permeabilities. For example, Emmett and others (1972) found that highly crossbedded sandstones had lower permeabilities than regular bedded sandstones in Tensleep petroleum reservoirs. Permeabilities also vary with the relative degree of grain sorting. For example, well-sorted channel sandstones have permeabilities four times larger than poorly sorted near-shore, fine-grained sandstone and siltstone deposits (Emmett and others, 1972).

Tectonic structures have the most significant effect on permeabilities in the Tensleep aquifer system. Faults, fractures, and

Table IV-2. Water-encountered reports arranged by formation for selected petroleum test wells drilled in the Wind River basin, Wyoming.[a]

Formation Drilling Company or Owner	Name of Well	Location[b]	Depth to Production Interval (top-bottom in feet)	Reported Rate of Production (gpm)
WIND RIVER FORMATION				
Burton/Hawks Inc.	5-1	3N-4E-5	8,878-8,900	1
Shell Oil Co.	34-33	4N-2E-28	2,928-2,942	1
Husky Oil Co.	16-28	4N-3E-33	3,714-3,736	7
FORT UNION FORMATION				
Gulf Oil Co.	1	3N-2E-3	5,780-5,810	1
Lomax Exploration Co.	1-9	3N-5E-9	8,878-8,900	1
Atlantic Richfield Co.	22	1S-4E-25	2,505-2,515	5
Northern Natural Gas Co.	1-18	36-93-18	6,846-6,876	5
Monsanto Co.	1-23	37-92-23	11,000-11,010	5
J.M. Huber Co.	33-1	37-92-33	6,959-6,970	1-2
Monsanto Co.	12	39-90-31	9,234-9,242	10
Monsanto Co.	1-35	39-90-35	12,404-12,420	1-2
LANCE FORMATION				
Mapco Prod. Co.	1-11	3N-5E-11	10,802-?	7
Damson Oil Co.	16-1	4N-5E-16	15,197-15,268	1
Monsanto Co.	1-23	37-92-23	11,000-11,010	5
Monsanto Co.	1-35	39-91-35	12,204-13,625	5
MESAVERDE FORMATION				
Gulf Oil Co.	1	3N-2E-3	7,145-7,250 7,970-8,040	5 10
Pan American Pet. Corp.	Beaver Creek	33-96-10	2,350-2,600	300
Pan American Pet. Corp.	Beaver Creek	33-96-11	2,122-2,210	20
N.A.	Kirby Draw	34-95-25	225-527	350
N.A.	N.A.	35-84-1	N.A.	500
Monsanto Co.	1-25	39-91-25	14,988-15,897	1-2

Table IV-2. (continued)

Formation Drilling Company or Owner	Name of Well	Location[b]	Depth to Production Interval (top-bottom in feet)	Reported Rate of Production (gpm)
MESAVERDE FORMATION (cont.)				
Monsanto Co.	1	39-91-32	15,105-16,646	5
Monsanto Co.	1-34	39-91-34	16,096-16,151	5
CODY SHALE				
Atlantic Richfield Corp.	15	1S-4E-25	4,625-4,633	15
Pan American Pet. Corp.	1	1N-2E-3	4,314-4,316	1
Pan American Pet. Corp.	91	33-96-3	3,921-4,038	20
Pan American Pet. Corp.	76	33-96-9	3,916-3,930	5
Pan American Pet. Crop.	79	33-96-9	3,942-3,963	10
Travis Oil Co.	2	34-91-36	1,900-1,912	1-2
Monsanto Co.	1-19	39-90-19	18,970-19,253	1-2
Monsanto Co.	1-21	39-90-21	18,642-18,892	1-2
Monsanto Co.	1-32	39-90-32	17,198-18,050	1-2
Moncrief Co.	17-1	39-91-17	19,355-19,365	5
FRONTIER FORMATION				
Viking Exploration, Inc.	32-16	33-91-16	2,882-2,894	10
CLOVERLY FORMATION				
Energetic, Inc, et al.	41X-20	1S-6E-20	8,860-8,868	2
Atlantic Richfield Co.	10	1S-4E-25	9,540-9,570	1-3
SUNDANCE FORMATION				
Arnell Oil Co.	A-2	33-83-1	1,386-1,448	5
NUGGET SANDSTONE				
Pan American Pet. Corp.	76	2-1-18	1,261-1,395	10
Amoco Prod. Co.	124	2-1-18	1,298-1,322	1-2
Brinkerhoff Drilling Co., Inc.	22-1	5-2-22	5,346-5,404	5

Table IV-2. (continued)

Formation Drilling Company or Owner	Name of Well	Location[b]	Depth to Production Interval (top-bottom in feet)	Reported Rate of Production (gpm)
CHUGWATER GROUP UNDIVIDED				
Gulf Oil Co.	4	4-1-32	5,602-5,614	10
Knight & Miller Oil Co.	3	33-90-13	260-270	10
PHOSPHORIA FORMATION				
Ralph Lowe	1	1S-1E-6	1,051-1,093	10
Pan American Pet. Corp.	13	2S-1E-12	3,377-3,532	2
Pan American Pet. Corp.	1	2S-1E-12	3,463-?	4
Pan American Pet. Corp.	4	2S-1E-13	2,317-?	20
Pan American Pet. Corp.	8	2S-1E-13	2,386-2,784	1
Pan American Pet. Corp.	66	2S-1E-13	3,380-?	1
Amoco Prod. Co.	108	2S-1E-13	1,808-1,945	2
Pan American Pet. Corp.	71	2S-1E-24	3,048-3,098	5
True Oil Co.	McAdams 1	2S-2E-18	2,774-2,794	25-50
Amoco Prod. Co.	107	2S-2E-18	2,992-3,034	20
Amoco Prod. Co.	124	2S-2E-30	1,424-1,472	2
Sinclair Oil & Gas Co.	1	2-1-4	6,037-6,330	3
Pan American Pet. Co.	68	2-1-17	3,250-?	5-10
Pan American Pet. Co.	54	2-1-18	3,088-3,098	2
Amoco Prod. Co.	133	2-1-18	3,182-?	20
Pan American Pet. Co.	91	2-1-19	3,051-3,290	5
Amoco Prod. Co.	215	2-1-20	3,086-?	35
Amoco Prod. Co.	217	2-1-20	3,132-?	5
Amoco Prod. Co.	310	2-1-29	3,122-?	30
Norris Oil Co.	1-McBride	3-1-33	6,367-6,630	40
Amoco Prod. Co.	135	2-1-18	2,563-?	10

Table IV-2. (continued)

Formation Drilling Company or Owner	Name of Well	Location[b]	Depth to Production Interval (top-bottom in feet)	Reported Rate of Production (gpm)
PHOSPHORIA FORMATION (cont.)				
Pan American Pet. Co.	1	5-2-8	7,066-?	5
Atlantic Richfield Co.	1	31-94-5	5,507-5,517	10
Sohio Pet. Co.	1	31-94-27	6,903-6,918	5
Atlantic Richfield Co.	22	32-95-15	7,580-7,588	35
Pasco, Inc.	27	32-95-15	7,368-7,382	2
Northwest Exploration Co.	1	32-98-32	1,048-1,362	10
Pan American Pet. Corp.	61	34-96-21	11,873-?	1-2
W.C. Kirkwood	21-12	42-107-12	2,626-2,636	120
TENSLEEP SANDSTONE				
Ralph Lowe	1	1S-1E-6	1,463-1,515	25
Pan American Pet. Corp.	110	2-1-18	3,010-3,370	120
Amoco Prod. Co.	122	2-1-18	3,170-3,174	25
Pan American Pet. Corp.	501	2-1-18	2,825-3,220	120
Amoco Prod. Co.	131	2-1-19	3,176-3,215	90
Amoco Prod. Co.	148	2-1-19	2,970-?	20
Continental Oil Co.	65	6-3-1	1,060-1,080	5
Continental Oil Co.	33	6-2-6	1,156-1,356	10
Continental Oil Co.	43	7-3-36	1,105-1,316	5
Pure Oil Co.	27	31-98-4	1,030-1,043	5
Union Oil Co.	5	31-98-4	930-952	2
Amoco Prod. Co.	18	32-95-10	7,108-7,604	100
Amoco Prod. Co.	8	32-95-15	7,280-?	75
Amoco Prod. Co.	23	32-95-15	7,256-7,570	165
Sohio Pet. Co.	3	32-95-36	8,715-8,725	50
Sohio Pet. Co.	5	32-95-36	8,548-8,558	5

Table IV-2. (continued)

Formation Drilling Company or Owner	Name of Well	Location[b]	Depth to Production Interval (top-bottom in feet)	Reported Rate of Production (gpm)
TENSLEEP SANDSTONE (cont.)				
Bagdad Oil Co.	C-1	6-2-36	1,372-1,392	10
C. F. Brehm	1	4-1-18	7,182-7,192	60
Amoco Prod. Co.	38	32-95-14	7,776-7,952	125
Amoco Prod. Co.	9	32-95-14	7,490-7,706	200
Sinclair Oil & Gas Co.	21	32-95-14	8,137-8,152	10
Pure Oil Co.	37	33-83-3	2,566-?	5
Amoco Prod. Co.	115	33-96-9	10,950-11,030	5
Amoco Prod. Co.	118	33-96-16	10,934-11,014	10
Amoco Prod. Co.	34	33-96-10	10,824-11,116	10
MADISON LIMESTONE				
Pan American Pet. Co.	66	33-96-10	11,168-11,358	1-2

[a]Sources of data include Wyoming Oil and Gas Conservation Commission (various); Petroleum Information Corp. (various); Dana (1962).

[b]Township (north) - range (west) - section, unless otherwise specified.

joints associated with deformed areas provide laterally and vertically integrated zones of large permeability. Permeabilities in highly fractured parts of the system, such as along the Wind River Mountains, are as much as several orders of magnitude larger than permeabilities in relatively undeformed central-basin areas (Table IV-3). An excellent example of fracture-enhanced permeability involves several petroleum tests situated along the axis of the Lander anticline in T. 33 N., R. 99 W., sec. 26. According to Dana (1962) several wells have encountered artesian conditions with sufficient head to produce flows of 3,000 gallons/minute from well depths of 3,700 feet.

The most productive horizons in the Tensleep aquifer system are the Tensleep Sandstone and the Madison Limestone. Both units are significant water-bearing formations throughout Wyòming. The Tensleep Sandstone and the Madison Limestone are, respectively, 200 to 600 and 200 to 700 feet thick.

The Tensleep Sandstone is highly productive throughout the basin. Well yields typically range up to several thousand gallons/minute; spring discharges typically range up to several hundred gallons/minute (Dana, 1962; Wyoming Oil and Gas Conservation Commission, various; Wyoming State Engineer's Office, various) and water-encountered reports (Wyoming Oil and Gas Conservation Commission, various) the most productive part of the unit is the uppermost 200 feet, where most highly productive wells (yields greater than 500 gallons/minute) are encountered. According to Todd (1963) permeabilities in the Tensleep Sandstone decrease with depth because of increased secondary quartz and carbonate cementation and recrystallization of quartz grains. Bredehoeft (1964) and Lawson and Smith (1966 document substantial reduction of porosity and permeability

Table IV-3. Hydrologic data arranged by formation for selected oil and gas fields, Wind River basin, Wyoming.[a]

Formation Name of Field	Location[b]	Thickness of Producing Interval (feet)	Porosity (%)	Permeability[c] (md)	Estimated Transmissivity[d] (gal/day-ft)
WIND RIVER FORMATION					
Lost Cabin	38-90	20-80	12-20	1-16	1-30
FORT UNION FORMATION					
Cooper Reservoir	35-87	35	15-20	15	10
LANCE FORMATION					
Lost Cabin	38-90	45	20	20	15
Waltman	36&37-86&87	N.A.	15	12	N.A.
MESAVERDE FORMATION					
Beaver Creek	33&34-96	70	18	23	30
Poison Spider, West	33-84	60	16	63	70
CODY SHALE					
Boone Dome	35-85	40-55	15	25-50	20-50
Government Bridge	31-82	27	10-15	18-20	10
Pilot Butte	3-1	20-40	15	33	10-25
Raderville	34&35-88&89	50	18	15-25	15-25
Poison Spider, West	33-84	25	10	1-10	1-5
FRONTIER FORMATION					
Alkali Butte	33&34-95	10	15-20	50-70	10-15
Arminto-Lox	37-86	20	17	30-40	10-15
Beaver Creek	33&34-96	40	13	70	50
Big Sand Draw	32&33-95	40	23	63	45
Clark Ranch	35-84	50	18	45-86	40-80
Powder River	36-85	95	20	45-68	80-120
Iron Creek	32-82	30	15-20	58-65	30-35
Sand Draw - Wildcat	32-95	20	10-25	70-810	25-300

Table IV-3. (continued)

Formation / Name of Field	Location[b]	Thickness of Producing Interval (feet)	Porosity (%)	Permeability[c] (md)	Estimated Transmissivity[d] (gal/day-ft)
FRONTIER FORMATION (cont.)					
Kirby Draw	33-95	57	18	60-100	60-105
Muskrat	33&34-91&92	20-60	14	60-100	20-110
Muskrat, East	33-91	21	15-20	40-80	15-30
Pilot Butte	3-1	30	18	50-80	30-45
Poison Spider, West	33-84	117	10	1	2
Sand Draw, South	31&32-94&95	90	15	1-25	1-40
Steamboat Butte	3&4-1	80	20	40-80	60-120
Big Sand Draw	32-95	20	10-25	70-810	25-300
MUDDY SANDSTONE					
Alakli Butte	33&34-95	10	15	30	5
Beaver Creek	33&34-96	15	7	10-15	3-5
Grieve	32-85	20-65	20	15-40	5-50
Government Bridge	31-82	65	15	30-50	35-60
Iron Creek	32-82	100	10	20-30	35-55
Pilot Butte	3-1	16	11	1	1
Plunkett	1S-1E	20	18	N.A.	N.A.
Poison Spring Creek	31&32-84	15	16	4	1
Ritter	31&32-84	15	15-20	5-10	1-2
Sage Spring Creek	37&38-77&78	13	15	10-20	4-8
Sage Spring Creek, North	37&38-77&78	13	15	10-20	4-8
Sand Draw, South	31&32-94&95	22	N.A.	1-10	1-4
Poison Spider	33-82&83	10-15	15	8	1-2
Wildcat	31-82	25	11-17	10-190	5-85

Table IV-3. (continued)

Formation Name of Field	Location[b]	Thickness of Producing Interval (feet)	Porosity (%)	Permeability[c] (md)	Estimated Transmissivity[d] (gal/day/ft)
CLOVERLY FORMATION - Dakota Sandstone					
Fish Creek	31-84	125	19	550-1160	1250-2640
Fish Creek	31-84	70	20	1100-1200	1400-1530
Mt. Rogers	33-94&95	60	15	350-400	380-440
Sage Creek	37&38-77&78	25	13	100-300	45-140
CLOVERLY FORMATION - Lakota Sandstone					
Beaver Creek	33&34-	40-60	15	100-300	70-330
Fish Creek	31-84	60-80	18-20	500-600	550-875
Kirby Draw	33-95	40-60	15-20	100-300	70-330
Mt. Rogers	33-94&95	70-80	20-25	300-400	380-580
Steamboat Butte	3&4-1	20-40	15	50-100	20-70
MORRISON FORMATION					
Alkali Butte	33&34-95	25	10	1-5	1-2
Big Sand Draw	32&33-95	15	10	1-10	1-3
Powder River	36-85	60	15	10-20	10-20
Poison Spider, West	33-84	30	8-20	1-6	1-3
SUNDANCE FORMATION					
Poison Spider	33-82&83	25	18	100-200	45-90
Poison Spider	33-82&83	40	20	200	145
NUGGET SANDSTONE					
Steamboat Butte	3&4-1	100-130	15	100	180-240
Wildcat	2-1-18	25	10-20	1-290	1-130
CHUGWATER GROUP undivided					
Clark Ranch	35-84	20-45	15	1-15	1-10
Rolff Lake	6-3	60-70	14	15-20	15-25
Sage Creek Anticline	1-1	20	10-15	1-10	1-4
Sheldon, Northwest	6-3	40-50	14	50-130	35-120

Table IV-3. (continued)

Formation Name of Field	Location[b]	Thickness of Producing Interval (feet)	Porosity (%)	Permeability[c] (md)	Estimated Transmissivity[d] (gal/day/ft)
DINWOODY FORMATION					
Rolff Lake, Northwest	6-3	20-30	15	1-15	1-10
PHOSPHORIA FORMATION					
Big Sand Draw	32&33-95	80-90	23	1	1
Circle Ridge	6&7-2&3	40	16	25-75	20-60
Dallas	24&32-99	30-40	10-15	50	30-35
Derby	32-98	10	13	25	5
Dubois	42-107	50	10-15	1-20	1-20
Lander-Hudson	2S.,1&2E.-99	70	20	25-50	30-60
Long Creek	31-32-94	40	15	10-20	10-20
Maverick Springs	6-2	15	15	25	10
Okie Draw	37-85	20	20	25	10
Pilot Butte	3-1	30	10-20	1	1
Rolff Lake	6-3	50	15	1	1
Riverton	1&2S-4&5E.	100	N.A.	1-10	1-20
Sand Draw, South	31&32-94&95	60-70	15	1-40	1-50
Sheldon	5-2	20	10-15	1-10	1-4
Steamboat Butte	3&4-1	60	17	5-10	5-10
Winkleman Dome	2-1	70-80	15	10-25	10-35
Wildcat	2S-2E	40	18-24	1-50	1-40
TENSLEEP SANDSTONE					
Beaver Creek	33&34-95	70 51	8 10-15	7 100-680	10 90-650
Big Sand Draw	32&33-95	150	32	10-50	30-150
Bid Sand Draw	32&33-95				
Circle Ridge	6&7-2&3	150	14	60-70	160-190

Table IV-3. (continued)

Formation / Name of Field	Location[b]	Thickness of Producing Interval (feet)	Porosity (%)	Permeability[c] (md)	Estimated Transmissivity[d] (gal/day/ft)
TENSLEEP SANDSTONE (cont.)					
Lander-Hudson	1&2E-99W	100	15	10-40	20-80
Notches	37-85	20	17-20	100-400	35-145
Dallas	24&32-99	25-30	15	100-200	45-110
Derby	4&5-98	5	15	100-250	10-25
Pilot Butte	3-1	150	15	80-100	220-275
Sand Draw, South	31&32-94&95	70-100	15	5-300	5-550
Sheldon	5-2	20-30	5-10	1-5	1-3
Steamboat Butte	3&4-1	200	14	60	220
Winkleman Dome	2-1	160	15	50-150	145-435
DARWIN SANDSTONE					
Circle Ridge	6&7-2&3	40	11	1-50	1-35
MADISON LIMESTONE					
Circle Ridge	6&7-2&3	40-50	12-15	1-10	1-10

[a]Sources of data include Wyoming Oil and Gas Conservation Commission (various); U.S. Geological Survey (various); Wyoming Geological Association, Oil and Gas Fields Symposium (1957; supplemented 1961); Petroleum Information Corp. (various).

[b]Township (north) - range (west), unless otherwise specified.

[c]md x 18.2 x 10^{-3} = gallons/day/foot^2.

[d]Transmissivity estimated using T = (K) (.0182) (b), where T = transmissivity (gal/day-ft), K = permeability (md), and b = producing thickness (feet), and assuming a water temperature of 60°F.

in the unit with increased depth in the Bighorn basin (Libra and others, 1981).

Permeabilities in the Madison Limestone are largely the result of fractures, joints, and solution cavities. Interstitial permeabilities are small to negligible because much of the unit is finely-crystalline and very dense. The most productive parts of the Madison Limestone are comprised of saturated caverns developed along solution cavities. In general, most cavern development is in the upper third of the unit.

Hydrogeologic data are limited for the Amsden Formation, Darby Formation, and Bighorn Dolomite. This is because most wells penetrating the Tensleep aquifer system encounter sufficient yields in the upper part of the system. Also, these formations are not as permeable as the overlying units. This is because the Amsden, Darby, and Bighorn formations are comprised of very dense, finely crystalline limestone and dolomite, and calcareous siltstone and shale. Permeabilities in the units are largely the result of partings between bedding planes, joints, fractures, and solution cavities. Numerous springs discharge small quantities of water (less than 10 gallons/minute) along the Wind River and Owl Creek mountains.

Approximately 200 wells completed in the Tensleep aquifer system were identified by this study. The locations of selected wells are shown on Plate B-1. Based on data for about 60 of the wells, representative aquifer parameters were calculated. The results range as follows: (1) permeability, 1 to 1,000 gallons/day/foot^2; (2) transmissivity, 10 to 4×10^4 gallons/day/foot; and (3) storage coefficient 1×10^{-3} to 8×10^{-5}.

Recharge to the Tensleep aquifer system occurs mainly by infiltration of precipitation into outcrops of the unit. Outcrop locations are shown on Plate C-1. Excellent recharge potential exists along the elevated flanks of the Wind River and Owl Creek mountains, where annual precipitation exceeds 60 inches/year, and numerous perennial streams flow across outcrops of the unit. An excellent example of surface-water recharge to the Tensleep aquifer occurs along Sinks Canyon where the Middle Popo Agie River floods sinkholes developed in the Madison Limestone.

PHOSPHORIA AQUIFER

The Permian rocks within the basin comprise one of the most complex Paleozoic systems in Wyoming. Striking lithologic variations occur from west to east across the basin, thus causing problems with accepted nomenclature and correlation. The reader is referred to Boutwell (1947), Blackwelder (1911, 1918), Condit (1924), Thomas (1934), Burk and Thomas (1956), McKelvey and others (1956), Keefer and Van Lieu (1966), for detailed investigations and summaries of the Permian system within central Wyoming. For the purposes of this report the Permian rocks within the Wind River basin are divided as follows according to location: (1) western basin - Phosphoria Formation, (2) central basin - Park City Formation, and (3) eastern basin - Goose Egg Formation.

The term Phosphoria aquifer as defined herein refers to all Permian age water-bearing rocks. The Phosphoria aquifer is a complex series of permable sandstones and relatively impermeable limestone, dolomite, and siltstone. The presence of the limestone, dolomite, and siltstone layers creates a series of confined sandstone subaquifers, which are hydraulically integrated by faults and fractures.

When defining the regional extent of the Phosphoria aquifer it is critical to understand the lateral facies changes within the Permian rocks. In general, aquifer properties deteriorate eastward because of major lithologic changes. For example, the aquifer is comprised of the Phosphoria and Park City formations, respectively, in the western and central parts of the basin. These units are predominantly comprised of sandstone, limestone, and dolomite. Reported production for selected wells completed in these units ranges from several tens to 1,500 gallons/minute. However, in the eastern part of the basin the Permian rocks consist of the Goose Egg Formation which is predominantly comprised of shale, siltstone, limestone, and gypsum. Production from wells completed in the Goose Egg Formation is generally less than 100 gallons/minute.

Phosphoria aquifer properties also deteriorate vertically because of changes in lithologies. For example, the Phosphoria and Park City formations grade downward to massive limestone, dolomite, and interbedded shale. These units are virtually impermeable, and as shown on Figure II-6 are considered confining layers between the Phosphoria aquifer and the underlying Tensleep aquifer system.

Interstitial permeabilities in the Phosphoria aquifer are generally small (less than 10 gallons/day/foot^2). Permeabilities are significantly enhanced where the aquifer is faulted and fractured, such as along the Owl Creek and Wind River mountains. Based on data for selected petroleum tests completed in structurally deformed parts of the aquifer, permeabilities and transmissivities, respectively, range from 10 to

180 gallons/day/foot^2, and 4×10^2 to 5×10^3 gallons/day/foot (Wyoming Oil and Gas Conservation Commission, various; Wyoming Geological Association, 1957).

The significance of fracture-enhanced permeabilities in the Phosphoria aquifer is evidenced by two wells located, respectively, at T. 30 N., R. 96 W., sec. 7, and T. 30 N., R. 97 W., sec. 11. Both wells are completed in faulted and fractured parts of the aquifer. The former well is about 300 feet deep and the water is under sufficient head to flow an estimated 700 gallons/minute. The latter well is about 260 feet deep and reportedly flows about 150 to 200 gallons/minute (Wyoming State Engineer's Office, various; Whitcomb and Lowry, 1968).

SUNDANCE-NUGGET AQUIFER

The Sundance-Nugget aquifer is comprised of the Jurassic Sundance Formation and the Jurassic-Triassic Nugget Sandstone and is a regional aquifer in the Wind River basin. With the exception of the Granite Mountains area, the aquifer underlies the entire basin and is 200 to 900 feet thick. Ground water in the aquifer is under semi-confined to confined conditions.

The Sundance-Nugget aquifer crops out along the Wind River and Owl Creek mountains. It is deeply buried in all other parts of the basin. Intergranular permeabilities in the unit are relatively large. Based on drill-stem test data, permeabilities range from 1 to 20 gallons/day/foot^2. Estimated transmissivities in the unit range from about 1 to 2.5×10^2 gallons/day/foot.

The Sundance-Nugget aquifer yields water to shallow domestic and stock wells along the Wind River and Owl Creek mountains. According to the Wyoming State Engineer's Office (1981) production for wells along outcrops ranges between 1 and 50 gallons/minute. Several wells are reported as under artesian conditions with sufficient head to produce up to 8 gallons/minute. Specific capacity data for the various domestic and stock wells range from about 0.1 to 35 gallons/minute/foot of drawdown.

The Sundance-Nugget aquifer is a productive unit throughout the Wind River basin. It can be easily identified in electric well logs and is almost always reported as "permeable and saturated" in petroleum drillers reports (Wyoming Oil and Gas Conservation Commission, various). For example, selected deep-basin petroleum tests have encountered sufficient heads in the Sundance and Nugget formations to produce flows of 1 to 10 gallons/minute from well depths of about 1,300 to 5,400 feet (Table IV-2).

CLOVERLY AQUIFER

With the exception of the Granite Mountains area, the Cretaceous Cloverly Formation underlies the entire basin and is 200 to 300 feet thick. The unit is comprised of fine- to coarse-grained sandstone, variegated shale, and thin, lenticular chert pebble conglomerate. The unit is informally divided into three members that are herein referred to as the (1) upper sandstone, (2) middle shale, and (3) basal sandstone. The three members correlate respectively with the Dakota Sandstone, Fuson Shale, and Lakota Sandstone. The upper and basal sandstones are the most water-bearing.

The Cloverly aquifer is overlain and underlain, respectively, by the Thermopolis Shale and the Morrison Formation, both of which are regional confining layers. The presence of the middle shale member of the Cloverly Formation creates two confined sandstone subaquifers in the Cloverly aquifer. Based on water-encountered reports for selected petroleum tests, the water in the subaquifers is under sufficient head to produce flows of 1 to 25 gallons/minute at the surface from drilling depths up to 8,000 feet (Wyoming Oil and Gas Conservation Commission, various).

Based on production records for 34 wells penetrating or completed in the Cloverly aquifer, well yields range from 1 to 350 gallons/minute (Wyoming Oil and Gas Conservation Commission, various; Wyoming State Engineer, 1981; Dana, 1962). Typical well yields are less than 50 gallons/minute. Wells with greater yield are generally associated with densely fractured and faulted areas where permeabilities in the rocks are significantly enhanced.

Permeabilities in the Cloverly aquifer are largely dependent on the degree of fracturing of the unit. In relatively unfractured areas permeabilities in the aquifer are less than 5 gallons/day/foot^2. Conversely, in faulted and folded areas where fracture densities are maximized, such as along the east flank of the Wind River Mountains, the Casper Arch and Gas Hills, permeabilities in the Cloverly aquifer range between 20 and 40 gallons/day/foot^2. Another example of fracture-enhanced permeability involves water wells drilled by Union Carbide Corporation along the west flank of the Dutton basin anticline. The wells are completed in highly fractured parts of the Cloverly aquifer and production ranges from 100 to 350 gallons/minute. Estimated permeabilities range up to 50 gallons/day/foot^2, and transmissivities range up to 4×10^3 gallons/day/foot.

The Cloverly aquifer crops out along the Casper Arch, Wind River Mountains, Owl Creek Mountains, and Gas Hills. In such areas the Cloverly aquifer yields water to shallow stock wells and small springs. Based on well permits specific capacities for the various wells range from 0.02 to 5 gallons/minute/foot. Spring discharges are generally less than 10 gallons/minute.

Excellent recharge potential to the Cloverly aquifer exists along the Wind River Mountains. Sources of recharge are infiltration of precipitation into Cloverly outcrops and infiltration of surface water from creeks and rivers that cross the unit. Major perennial streams that cross Cloverly outcrops include the Wind, Little Wind, and Popo Agie rivers, and Beaver and Sage creeks.

MUDDY AQUIFER

The Muddy aquifer underlies the entire study area and is comprised of the Cretaceous Muddy Sandstone (Figure II-6). The aquifer is 20 to 75 feet thick and comprised of poorly to well sorted, fine- to coarse-grained salt and pepper sandstone that grades locally to sandy shale. The Muddy Sandstone is a major oil and gas reservoir in the basin.

The Muddy Sandstone is saturated throughout the Wind River basin, as evidenced by water-encountered reports for petroleum tests (Table IV-2)and spring locations (U.S. Geological Survey, various; Wyoming State Engineer's Office, various; Whitcomb and Lowry, 1968). Ground water in the aquifer is under confined conditions with sufficient head to produce flows of 10 to 40 gallons/minute from well depths of 2,000 feet (Wyoming Oil and Gas Conservation Commission, various). According to the Wyoming Oil and Gas Conservation Commission, as much as 70 gallons/minute of water is produced by selected petroleum wells.

Based on drill-stem test data, permeabilities in the Muddy Sandstone are generally less than 3 gallons/day/foot^2 (Table IV-3). Permeabilities are relatively low because the sandstones comprising the aquifer are tightly cemented and often have a silty matrix. Transmissivities are generally less than 5 gallons/day/foot. The fact that the Muddy Sandstone is often artificially fractured to induce hydrocarbon flow in petroleum wells substantiates the low estimated permeabilities.

In tectonically deformed areas, such as the Rattlesnake Hills and Casper Arch, permeabilities are fracture-enhanced, as evidenced by estimated permeabilities of 10 to 25 gallons/day/foot^2. Estimated transmissivities in these areas range up to 1×10^2 gallons/day/foot. Sandstone porosities in these areas range from 15 to 36 percent (Wyoming Geological Association, 1957, 1961).

FRONTIER AQUIFER

The Cretaceous Frontier Formation is comprised of alternating sandstones, shale, and siltstone. The sandstone parts are fine- to medium-grained, thin-bedded to massive, and locally glaucontic. The shale is fissile, silty and sandy, medium-bedded to massive, and locally carbonaceous. The siltstone is massive. With the exception of the Granite Mountains area, the Frontier Formation underlies the entire Wind River basin, and crops out along the Wind River Mountains, the Owl Creek Mountains, the Gas Hills, and Casper Arch. The unit is about 500 to 1,000 feet thick.

The Frontier aquifer as defined here is comprised of a series of permeable interbedded sandstones and relatively impermeable shale and siltstone. The presence of the shale and siltstone creates a series of confined sandstone subaquifers within the unit. The aquifer is about 400 to 600 feet thick and occurs in the upper two-thirds of the Frontier Formation. The basal one-third of the Frontier Formation is a regional confining layer.

The upper two-thirds of the Frontier Formation is saturated throughout the basin, as evidenced by spring occurrences, waters encountered in petroleum tests, and stock and domestic wells. The water is under semi-confined to confined conditions.

Based on drill-stem test data for selected petroleum tests, sandstone porosities in the aquifer range from 10 to 25 percent (Table IV-3). Permeabilities range from 1 to 40 gallons/day/foot^2; transmissivities range from 1 to 3 x 10^2 gallons/day/foot (Table IV-3). Selected petroleum tests have encountered sufficient heads in the Frontier aquifer to produce flows of 10 to 25 gallons/minute from depths up to 5,000 feet (Wyoming Oil and Gas Conservation Commission, various).

The Frontier aquifer is an excellent source of ground water for shallow stock and domestic wells along the Wind River Mountains. Based on well data for 54 wells in this area, production ranges between 5 and 150 gallons/minute. Estimated transmissivities for these wells range from 1 x 10^2 to 4.5 x 10^4 gallons/day/foot. Specific capacities range from about 10 to 65 gallons/minute/foot of drawdown.

Numerous springs discharge from the aquifer along the Wind River Mountains. Maximum reported discharges are about 65 gallons/minute; however, most springs discharge less than 25 gallons/minute. The springs are typically fault- and fractured-controlled.

In the Gas Hills and Casper Arch areas, the Frontier Formation is largely comprised of siltstone, shale, and silty sandstones. In these areas the aquifer is poorly developed because of relatively small permeabilities. Stock wells generally produce less than 15 gallons/minute in these areas. Specific capacities range from about 0.01 to 2 gallons/minute/foot of drawdown.

Recharge to the Frontier aquifer occurs by (1) infiltration of precipitation into outcrops, (2) infiltration of surface water where streams cross the unit, and (3) leakage of water from adjacent units. The largest potential recharge areas are along the Wind River and Owl Creek mountains. Excellent recharge potential exists in the southwest part of the basin where the Popo Agie River, Little Popo Agie River, and Beaver Creek flow across several miles of exposed Frontier sandstones.

MESAVERDE AQUIFER

The Mesaverde aquifer underlies much of the Wind River basin and is comprised of the Cretaceous Mesaverde Formation. The Mesaverde Formation is a complex and variable sequence of sandstone, siltstone, shale, carbonaceous shale, and coal, and is 550 to 2,000 feet thick. The unit crops out along the Owl Creek Mountains in the northwest part of the basin and along the Casper Arch and Gas Hills in the eastern and central areas. The Mesaverde Formation also forms a relatively small but conspicuous northwest-trending ridge in the western part of the basin.

The Mesaverde aquifer is divided into two permeable sandstone units separated by a relatively impermeable shale and siltstone unit. The presence of the impermeable unit creates two confined subaquifers within the Mesaverde aquifer that are hydraulically connected by faults and fractures.

The upper permeable sandstone subaquifer is herein referred to as the Teapot horizon. The Teapot horizon is comprised of very fine- to coarse-grained, massive to crossbedded, moderately porous and friable sandstone and is 50 to 450 feet thick. The Teapot horizon correlates with the productive Pine Ridge Sandstone horizon in the Laramie, Shirley, and Hanna basins (Richter, 1981). The Teapot is easily recognized because the unit forms conspicuous dip slopes often covered by dense stands of pine trees.

The Teapot horizon is saturated throughout the basin based on water-encountered reports for petroleum tests (Table IV-2), production intervals in water wells, and spring locations. Wells completed in the Teapot horizon produce 5 to 500 gallons/minute; springs discharge up to 100 gallons/minute. Based on drill-stem test data permeabilities in the Teapot horizon range between 20 and 150 gallons/day/foot^2. Porosity averages about 20 percent. Based on one pump test the transmissivity of the Teapot horizon in the Kirby Draw is 4.5×10^2 gallons/day/foot.

The middle part of the Mesaverde Formation is comprised of siltstone, massive to thin-bedded shale, carbonaceous shale, and thin-bedded discontinuous dirty sandstone. Wells penetrating this unit generally do not encounter significant quantities of ground water. This unit is 200 to 400 feet thick.

The lower permeable unit in the Mesaverde aquifer is subdivided into two saturated sandstone horizons, the Parkman and Fales sandstones. In the east and east-central parts of the basin the two units are separated by shales and siltstones comprising the Wallace Creek tongue of the Cretaceous Cody Shale (Hares and others, 1946; Rich, 1958; Barwin, 1961).

The Parkman and Fales sandstones are characteristically very fine to medium-grained, irregularly bedded to massive and crossbedded, well cemented to moderately friable. According to Keefer (1972) individual beds range from a few feet to 250 feet thick. Permeabilities in the units are generally less than 20 gallons/day/foot^2. This is because the sandstones are well cemented with calcareous and ferruginous cement. Estimates of transmissivity range from 5 to 70 gallons/day/foot. Wells completed in the Parkman and Fales sandstone produce less than 100 gallons/minute.

Permeabilities in the Mesaverde aquifer are enhanced where the unit is faulted and fractured. For example, several unnamed fault-controlled springs discharge 20 to 100 gallons/minute from the unit southeast of Riverton, Wyoming, near the head of Kirby Draw.

Fracture-enhanced permeability has a significant influence on waterflood recovery efforts in the Sand Draw-Beaver Creek areas. For example, the Beaver Creek gas field, Madison and Second Cody units, are situated on a gently dipping, faulted anticline. Both units produce ground water from the Mesaverde aquifer for secondary recovery. Selected water wells in the field produce up to 300 gallons/minute.

Recharge to the Mesaverde aquifer occurs largely by (1) direct infiltration of precipitation into Mesaverde outcrops, and (2) infiltration of surface water from streams that cross Mesaverde outcrops. Recharge by precipitation largely occurs in the Casper Arch, Gas Hills, and Owl Creek Mountain areas. Large surface-water recharge potential exists where the Wind, Little Wind, and Popo Agie rivers cross permeable Mesaverde sandstone exposures.

The Mesaverde aquifer has not been developed for municipal and community use because few towns or public facilities are situated near Mesaverde outcrops. Towns underlain by the Mesaverde Formation do not utilize the aquifer because of the availability of surface water and shallow ground-water supplies.

FORT UNION-LANCE AQUIFER

The Fort Union-Lance aquifer is comprised of the basal Fort Union Formation and the upper Lance Formation. The aquifer underlies the entire basin, with the exception of the Granite Mountains area. Insufficient data exist to estimate the saturated thickness of the aquifer. The Fort Union and Lance formations crop out in the Gas Hills and Rattlesnake Hills, and along the flanks of the Wind River and Owl Creek mountains. The units are deeply buried in the central and northern parts of the basin with drilling depths ranging from 6,000 to 12,000 feet (Table IV-2).

Permeable horizons in the Fort Union-Lance aquifer are comprised of fine- to coarse-grained massive sandstone and conglomeratic channel sandstone. The permeable units are confined by massive to thin-bedded siltstone and carbonaceous shale. Petroleum test wells penetrating the Fort Union-Lance aquifer have encountered sufficient head to produce flows of 10 to 15 gallons/minute from depths up to 8,000 feet.

Based on drill-stem test data permeabilities in the Fort Union-Lance aquifer are generally less than 15 md or about 10 gallons/day/foot^2. Porosity ranges from 15 to 20 percent. Estimates of transmissivity range between 10 and 200 gallons/day/foot. Interstitial permeabilities in the aquifer are relatively small; however, enhanced fracture permeability exists in tectonically deformed parts of the basin.

The Fort Union-Lance aquifer supplies water to shallow domestic and stock wells along outcrops of the unit in the Gas Hills and Casper Arch areas. Locations of selected wells are shown on Plate B-1. Well yields are typically less than 20 gallons/minute. However, selected petroleum tests along the Casper Arch have encountered flows up to 350 gallons/minute from the unit (Wyoming Oil and Gas Conservation Commission, various).

WIND RIVER AQUIFER

The Wind River aquifer is comprised of the Tertiary Wind River Formation. The unit underlies the entire Wind River basin and is 250 to 1,030 feet thick. The Wind River Formation is comprised of argillaceous sandstone, variegated siltstone, shale, and claystone, and interbedded fine-grained sandstone and arkose.

The Wind River aquifer is a major source of ground water for domestic, agricultural, and industrial wells within the basin. Based on well data from the Wyoming State Engineer's Office (1981) there are 1,708 permitted wells completed in the Wind River Formation. Locations are shown on Plate B-1. About 60 percent of these wells are located within the Wind River Reservation, 30 percent are in the Gas Hills-Rattlesnake Hills area, and the remaining 10 percent are scattered elsewhere within the basin.

Permeable horizons in the Wind River Formation are generally restricted to sandstone, conglomerate, and arkosic sandstone units. Intergranular permeabilities in the sandstone range up to 2,500 gallons/day/foot^2. Although some sandstone units can be correlated across the basin, most sandstones are lenticular and discontinuous, and separated by less permeable shale and siltstone. The presence of the shales and siltstones create a series of semi-confined and confined sandstone subaquifers within the Wind River Formation.

Production for wells completed in the Wind River Formation varies according to facies changes within the unit. In general, permeabilities and well production increase westward with increased predominance of sandstone lithologies. For example, in the eastern parts of the basin the unit is comprised of argillaceous sandstone, siltstone, and shale, and as a result permeabilities are small and well yields are less than 50 gallons/minute. In the central part of the basin the unit is comprised of arkosic sandstone, sandstone, and siltstone, and well yields range up to 300 gallons/minute. In the western part of the basin, the Wind River Formation is comprised mainly of clean lenticular sandstone, channel sandstone, conglomerate, and interbedded shales. Well production in this area ranges up to 1,500 gallons/minute (Robinove, 1958; Morris and others, 1959).

As previously stated, the most permeable and productive part of the Wind River aquifer is situated in the western third of the basin. Based on pump test data for selected wells near Riverton and Lander transmissivities range from 3×10^3 to 4.2×10^4 gallons/day/foot, whereas storage coefficients range between 1×10^{-4} and 2.1×10^{-5} (Morris and others, 1959; Wyoming State Engineer's Office, 1981). Estimated hydraulic conductivities range up to about 50 feet/day.

Confined ground-water conditions have been encountered in the Wind River aquifer in the Lander, Riverton, Ethete, and Shoshoni areas. According to Robinove (1958), Morris and others (1959), and the Wyoming State Engineer (1981) flows up to 300 gallons/minute from well depths of 400 feet have been reported for the various wells. Most of the artesian wells are situated along highly fractured anticlines where permeabilities are fracture-enhanced.

Numerous springs discharge from the Wind River Formation in the eastern and central parts of the basin. They usually discharge less than 10 gallons/minute; however, maximum discharges of 80 to 120 gallons/minute have been reported for springs in the Gas Hills area (Wyoming Department of Environmental Quality, various). Most springs discharge from intergranular pore spaces in permeable sandstones and are typically perched above less permeable shales. In general, spring discharges are highly variable, being dependent on seasonal recharge.

With the exception of the southeastern part of the basin, regional ground-water flow in the Wind River aquifer is toward the Wind River and Boysen Reservoir. In the southeastern part of the basin regional ground-water flow is toward the east with flow converging on Alcova and Pathfinder reservoirs.

Recharge to the Wind River aquifer occurs mainly by infiltration of precipitation into Wind River Formation outcrops. Additional recharge occurs by infiltration of irrigation water and leakage of water from adjacent units. Insufficient data exist to allow meaningful estimates of recharge to the aquifer.

ARIKAREE AQUIFER

The Arikaree aquifer as defined herein is comprised of the Moonstone, Arikaree, and White River formations. The rocks comprising these units were originally assigned to the Split Rock Formation and its subdivisions by Love (1961), but that name is now abandoned (Denson, 1965). The Arikaree aquifer underlies the southern part of the Wind River basin, principally the Granite Mountains area. The unit attains a maximum thickness of about 2,500 feet near Muddy Gap and Split Rock, Wyoming.

The Arikaree aquifer is the principal source for ground water in the southern part of the basin. About 200 domestic and stock wells are completed in the aquifer. Locations for selected wells are shown on Plate B-1.

Much of the Arikaree aquifer is elevated and dissected in the southwest part of the Granite Mountains area, and in such locations the aquifer is unconfined. However, in the Split Rock syncline the aquifer is structurally depressed and laterally continuous, and in such areas the aquifer is semi-confined.

Based on elevations of water levels for selected wells and elevations of springs, regional ground-water flow in the Arikaree aquifer is eastward and flow converges on the Sweetwater River and tributary canyons.

The upper part of the Arikaree aquifer is comprised of the Pliocene Moonstone Formation, which is up to 1,350 feet thick in the area; however, only the basal 800 feet is saturated. The unit consists largely of coarse- to medium-grained sandstone, pumicite, tuff, conglomerate, claystone, and gravel.

Wells completed in the upper part of the Arikaree aquifer generally yield less than 100 gallons/minute, but yields up to 500 gallons/minute have been reported for selected wells along the Sweetwater River, near Jeffrey City, Wyoming. Estimated permeabilities and transmissivities, respectively, range between 10 and 180 gallons/day/foot^2, and 1×10^1 to 6×10^2 gallons/day/foot. Ground water in the Moonstone Formation is usually unconfined.

The middle part of the Arikaree aquifer consists of the Miocene Arikaree Formation. The unit crops out extensively between the southern border of the study area and the Sweetwater River. The Arikaree Formation is predominantly comprised of fine- to medium-grained tuffaceous sandstone with thin flaggy limestone, tuff, conglomerate, and arkose interbeds. Maximum saturated thickness of the unit is about 1,000 feet.

The Arikaree Formation is the most productive horizon in the Arikaree aquifer. It is not uncommon for wells completed in this horizon to produce 1,000 gallons/minute with less than 50 feet of drawdown. These wells have total drilling depths less than 250 feet. Based on pump test data permeabilities in the Arikaree Formation range from 10 to 450 gallons/day/foot^2. Calculated transmissivities range up to 4.5×10^5 gallons/day/foot.

Numerous springs discharge from the Arikaree Formation in the Southeast part of the Wind River basin. They are perched above relatively impermeable claystone and shale, and generally discharge less than 20 gallons/minute. Most springs discharge along partings between bedding planes.

The basal part of the Arikaree aquifer includes the upper 500 to 600 feet of the White River Formation. The unit is comprised of calcareous fine- to medium-grained sandstone with tuff, bentonite, and fine-pebble conglomerate.

QUATERNARY DEPOSITS

Unconsolidated alluvium, colluvium, and terrace deposits of Recent age underlie all major flood plains in the Wind River basin. The unconsolidated material consists mainly of thin to medium beds of clay, silt, fine- to coarse-grained sand, fine- to coarse-pebble conglomerate, gravel, and boulders. The deposits range from 5 to 200 feet thick, but are generally less than 40 feet thick (McGreevy and others, 1969; Morris and others, 1959). They have excellent development potential as productive aquifers because permeabilities are large and because in many places the entire thickness is saturated.

Ground water in the Quaternary deposits is unconfined. Water-table conditions are dependent on seasonal recharge and vary widely throughout the year. Recharge to the deposits occurs by (1) infiltration of precipitation into outcrops, (2) discharge from bedrock units, (3) stream loss, and (4) irrigation. Maximum recharge occurs in March and July.

About 1,100 wells are completed in alluvium along the Wind, Little Wind, and Popo Agie rivers, and along Beaver, Muskrat, Muddy, and Fivemile creeks. The locations of selected wells are shown on Plate B-1. Based on pump test data, permeabilities in the alluvium range from 10 to 1,300 gallons/day/foot^2 (McGreevy and others, 1969; Dana, 1962; Wyoming State Engineer's Office, 1981). Transmissivities range up to 2.5 x 10^5 gallons/day/foot. According to the Wyoming State Engineer's Office (1981), well yields range from 5 to 5,500 gallons/minute.

Excellent ground-water resources potential exists for saturated colluvial deposits along the Owl Creek and Wind River mountains. For the purposes of this report, glacial deposits are included as colluvium. As shown on Plate B-1, about 50 wells are completed in colluvial deposits near Dubois, Wyoming. Such wells typically produce from 5 to 150 gallons/minute (Wyoming State Engineer's Office, 1981). Permeabilities in the deposits range up to 200 gallons/day/foot^2. According to Morris and others (1959) and McGreevy and others (1969) porosities range up to 45 percent.

Terrace deposits along major surface-water drainages are the thickest Quaternary units in the basin, ranging up to about 200 feet. Water-bable conditions are highly variable in the terrace deposits, being directly dependent on seasonal recharge. It is not uncommon for static water levels to vary as much as 50 feet in deep terrace wells, whereas some shallow terrace wells "dry up" during late summer and early fall.

Most terrace deposits are elevated and well drained; however, reported production rates for selected terrace wells in the Riverton-

Lander areas range up to 150 gallons/minute (Wyoming State Engineer's Office, 1981; Dana, 1962). Based on pump test data for selected wells, permeabilities in the deposits range up to 1,000 gallons/day/foot^2, whereas transmissivities range up to 3×10^4 gallons/day/foot.

V. GROUND-WATER CIRCULATION

V. GROUND-WATER CIRCULATION

Ground water moves in response to hydraulic gradients. Hydraulic gradients develop naturally and are inclined from areas of recharge to points of discharge.

Principal factors influencing ground-water circulation are (1) recharge rates and (2) permeabilities. Obviously, if available recharge to an aquifer is small, the amount of ground water that will flow through the aquifer or be taken into storage by the aquifer will be proportionately small. Similarly, if permeabilities in the aquifer are small, ground-water flow rates will be small.

FACTORS INFLUENCING PERMEABILITY

Permeabilities in the rocks in the Wind River basin are significantly enhanced by fractures, which are generally associated with tectonic structures. Consequently, ground-water resource evaluation in the basin requires information on the type, distribution, and intensity of fracturing associated with the various structures.

Folds, faults, and associated fractures are hydraulically important because they establish vertically and horizontally integrated zones of large permeability. Although fractures associated with folds and faults are localized, their permeabilities are several orders of magnitude larger than adjacent unfractured rocks. As a result, ground-water flow rates are significantly greater in the saturated units along the structures. The fact that yields from wells situated in tectonically deformed areas are typically greater than from wells completed in relatively undeformed areas of the same aquifers substantiates the previous statement. It is also a fact that most major springs in the basin are associated with tectonic structures.

The regional structure of the basin is shown on Plate A-1. As shown, the rocks along the Wind River and Owl Creek mountains are severely faulted and folded. Ground-water circulation in these fractured rocks is significantly enhanced because the faults and folds increase permeabilities. The ground-water resources potential in these rocks is excellent because (1) permeabilities are enhanced, and (2) available recharge is large because the mountains are principal recharge areas.

By comparison, relatively few folds and faults dissect the rocks in the central part of the basin. As a result, ground-water circulation in these rocks is relatively small because fracture permeabilities and interstitial permeabilities are negligible. Few large-capacity wells (yields greater than 500 gallons/minute) exist in the central part of the basin.

REGIONAL GROUND-WATER CIRCULATION

Potentiometric data are insufficient to allow construction of meaningful water level maps for all of the permeable units in the basin. However, based on potentiometric indicators such as static water levels encountered in water wells, elevations of springs, and estimated potentiometric levels based on petroleum drill-stem tests, ground-water circulation in the Lower Cretaceous rocks is generally basinward, as shown on Figure V-1. An exception to the previous statement involves the Granite Mountains area, where ground-water flow is

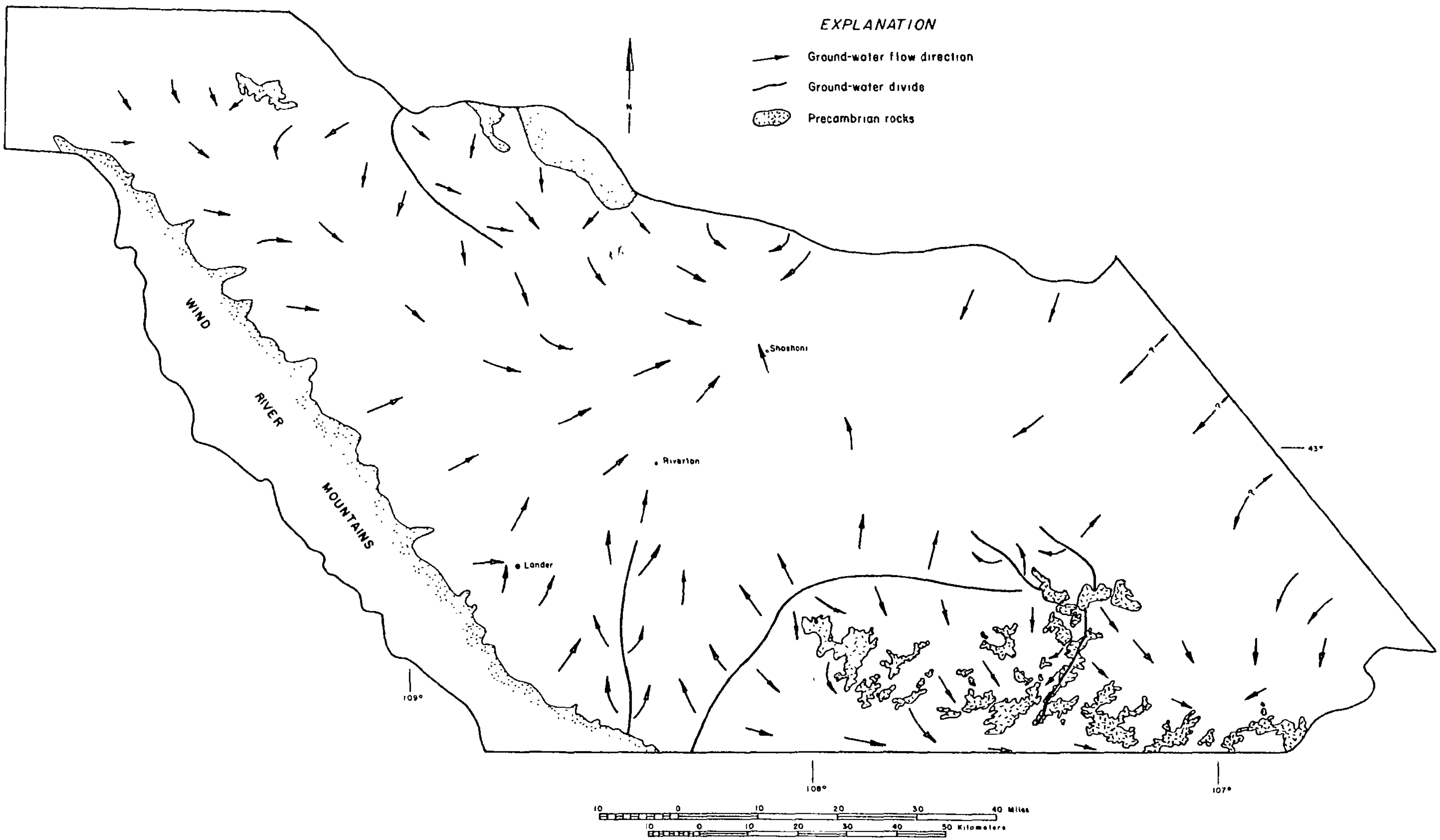


Figure V-1. Generalized ground-water flow directions in the Lower Cretaceous rocks, Wind River basin, Wyoming.

toward the Split Rock syncline which separates the basin from the Washakie-Red Desert basin. With the exception of the Quaternary deposits and the Arikaree aquifer, ground-water flow directions shown on Figure V-1 can be used to approximate flow directions in the various aquifers in the basin. This is because the aquifers have similar recharge-discharge areas and are influenced by similar structural controls.

According to Whitcomb and Lowry (1968), ground-water flow in the eastern part of the basin is eastward toward the Casper Arch. Hodson and others (1973) indicate that ground-water flow occurs eastward from the basin, across the Casper Arch, and drains to the Powder River basin. Insufficient potentiometric data exist to adequately document ground-water drainage from the Wind River basin to the Powder River basin; therefore, flow direction arrows shown on Figure V-1 for the Casper Arch area are questionable.

GROUND-WATER CIRCULATION IN THE QUATERNARY DEPOSITS AND ARIKAREE AQUIFER

Saturated Quaternary deposits and the Arikaree aquifer are areally limited units. For example, saturated Quaternary deposits are geographically confined to surface drainage areas, whereas the Arikaree aquifer is situated only in the southern part of the basin. Locally, the units are extensively developed for ground-water use, and as a result numerous potentiometric data exist.

Ground-water flow directions in the Quaternary deposits are mainly toward major surface drainages, lakes, and reservoirs. In the southern part of the basin the water flows toward the Sweetwater River and Alcova and Pathfinder reservoirs. In the east and east-central part of the basin the water drains toward Conant, Muskrat, and Poison creeks, all of which drain to Boysen Reservoir. In the west and west-central part of the basin the water drains toward the Wind, Little Wind, and Popo Agie rivers.

As shown on Figure V-2, ground-water flow in the Arikaree aquifer is southward and eastward. The water drains largely to springs and seeps along Pathfinder and Alcova reservoirs and to the Sweetwater River.

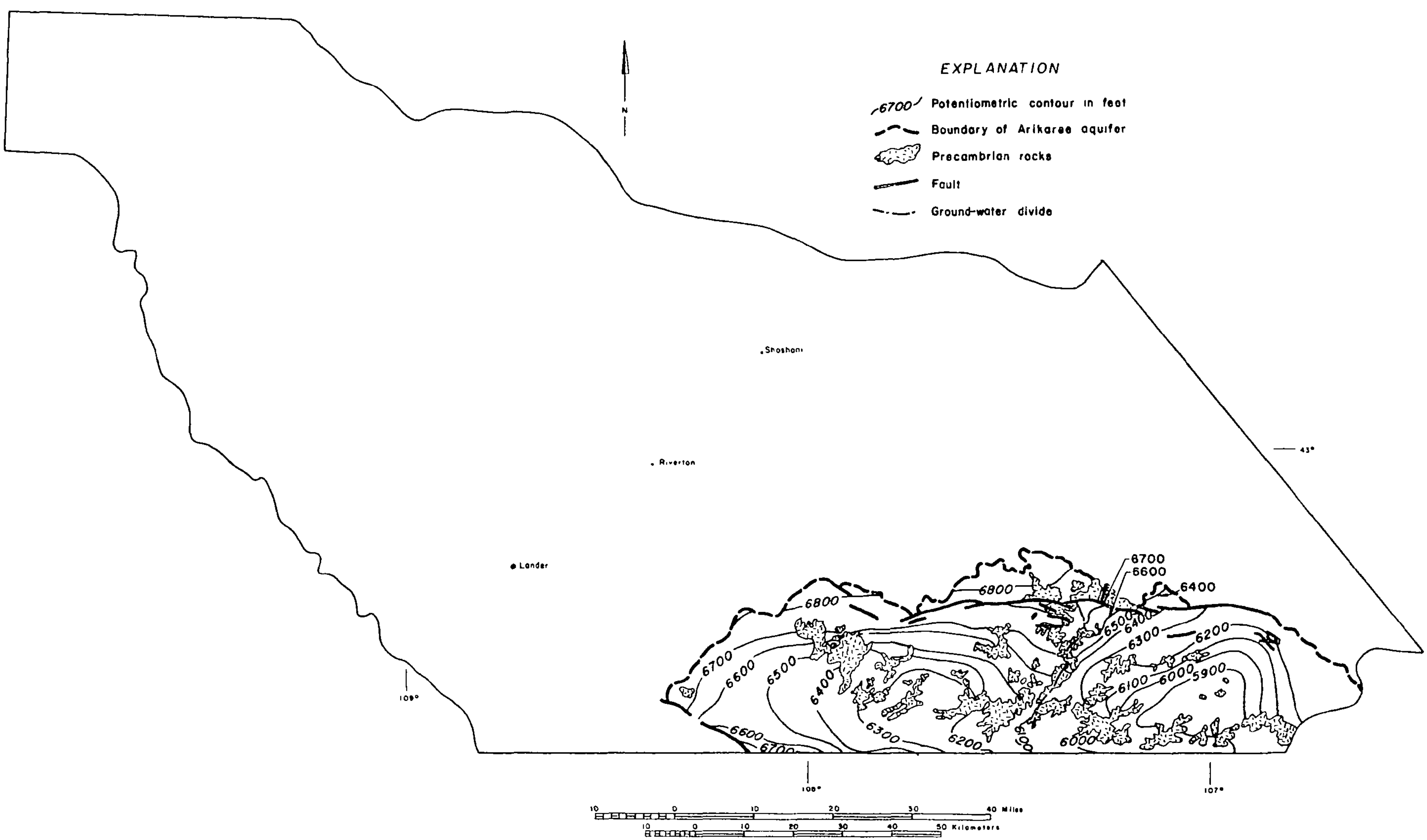


Figure V-2. Potentiometric surface contours for the Arikaree aquifer, Wind River basin, Wyoming.

VI. WATER QUALITY

VI. WATER QUALITY

Water analyses for approximately 600 wells and springs were evaluated to determine the quality and chemical character of the ground water in the various aquifers in the Wind River basin. The analyses were selected to include: (1) a diversity of geographic sources for the ground water, (2) a number of different stratigraphic and structural settings for the wells and springs, and (3) most of the major springs in the basin.

The results of selected chemical analyses are presented in Appendix B. The various ground waters are classified by type based on the relative proportions of major ions (Piper, 1944). The chemical analyses provide qualitative insights into: (1) approximate source rocks for the ground water, (2) evolution of ground-water quality and therefore direction of ground-water flow in the geologic section, and (3) relative residence times of the ground water.

Sources of the water quality analyses used in this report are: Wyoming Water Resources Research Institute, Wyoming State Engineer, Whitcomb and Lowry (1968), Crawford and Davis (1962), Crawford (1940), and U.S. Environmental Protection Agency (1980).

REGIONAL WATER QUALITY

In general, ground waters with total dissolved solids less than 500 mg/l are encountered in outcrops of the various saturated units along the elevated flanks of the Wind River, Owl Creek, and Granite mountains. These are principal recharge areas where residence times for ground water are relatively short and flow rates are great. The relatively faster and greater flow rates along mountain flanks result because of steep hydraulic gradients and because permeabilities in the rocks are significantly enhanced by fractures. Water qualities deteriorate basinward mainly because of (1) long residence times, (2) small flow rates, (3) dissolution of soluble salts from the aquifer matrix and from adjacent confining layers, and (4) leakage of poor quality waters from adjacent units. In general, total dissolved solids concentrations increase as ground-water flow length increases.

Excellent potential exists for encountering ground waters with less than 1,000 mg/l total dissolved solids along the east flank of the Wind River Mountains and the Granite Mountains. For the purposes of this report, the east flank of the Wind River Mountains includes the area extending about 15 miles east of the Precambrian-Paleozoic contact and parallel to the length of the range. The flank is comprised of Cambrian to Cretaceous rocks. In general, good quality water is encountered in all of the permeable units.

The potential for low dissolved solids waters in the Granite Mountains area is excellent. In particular, the Split Rock syncline is an enormous source area for good quality waters.

Water qualities in the central basin and Casper Arch areas are poor (total dissolved solids greater than 1,500 mg/l). This is because (1) residence times for the water are generally greater, (2) permeabilities are small, and (3) the rocks are comprised mainly of shale, siltstone, and dirty sandstone.

FLATHEAD AQUIFER

Insufficient data exist to meaningfully evaluate the chemical qualities of ground water in the Flathead aquifer. This is because 13 of the 16 chemical analyses obtained during this study included only dissolved solids, sulfate, and nitrate. The three remaining analyses included most primary and secondary drinking water standards. Based on these three analyses ground water in the Flathead aquifer is predominantly calcium-bicarbonate and sodium-sulfate-bicarbonate rich. All 16 analyses are for waters from shallow outcrop wells and springs.

In general, water qualities in the Flathead aquifer are very good. Total dissolved solids analyses for all 16 samples are less than 425 mg/l, whereas sulfate and nitrate (NO_3-N) analyses are, respectively, below 250 and 5 mg/l.

TENSLEEP AQUIFER SYSTEM

The results of 28 chemical analyses for ground waters in the Tensleep aquifer are compiled on Table B-1. Twenty-five analyses are from wells and springs in the Tensleep Sandstone, whereas the remaining three analyses are from Madison Limestone wells. No complete analyses were available for waters from the Bighorn, Darby, or Amsden formations.

As shown on Figure VI-1, ground waters in the Tensleep aquifer system are of three predominant types: (1) calcium-magnesium-bicarbonate, (2) calcium-magnesium-sulfate, and (3) sodium-sulfate. There is an obvious correlation between total dissolved solids, water type, and well depth. Low total dissolved solids concentrations

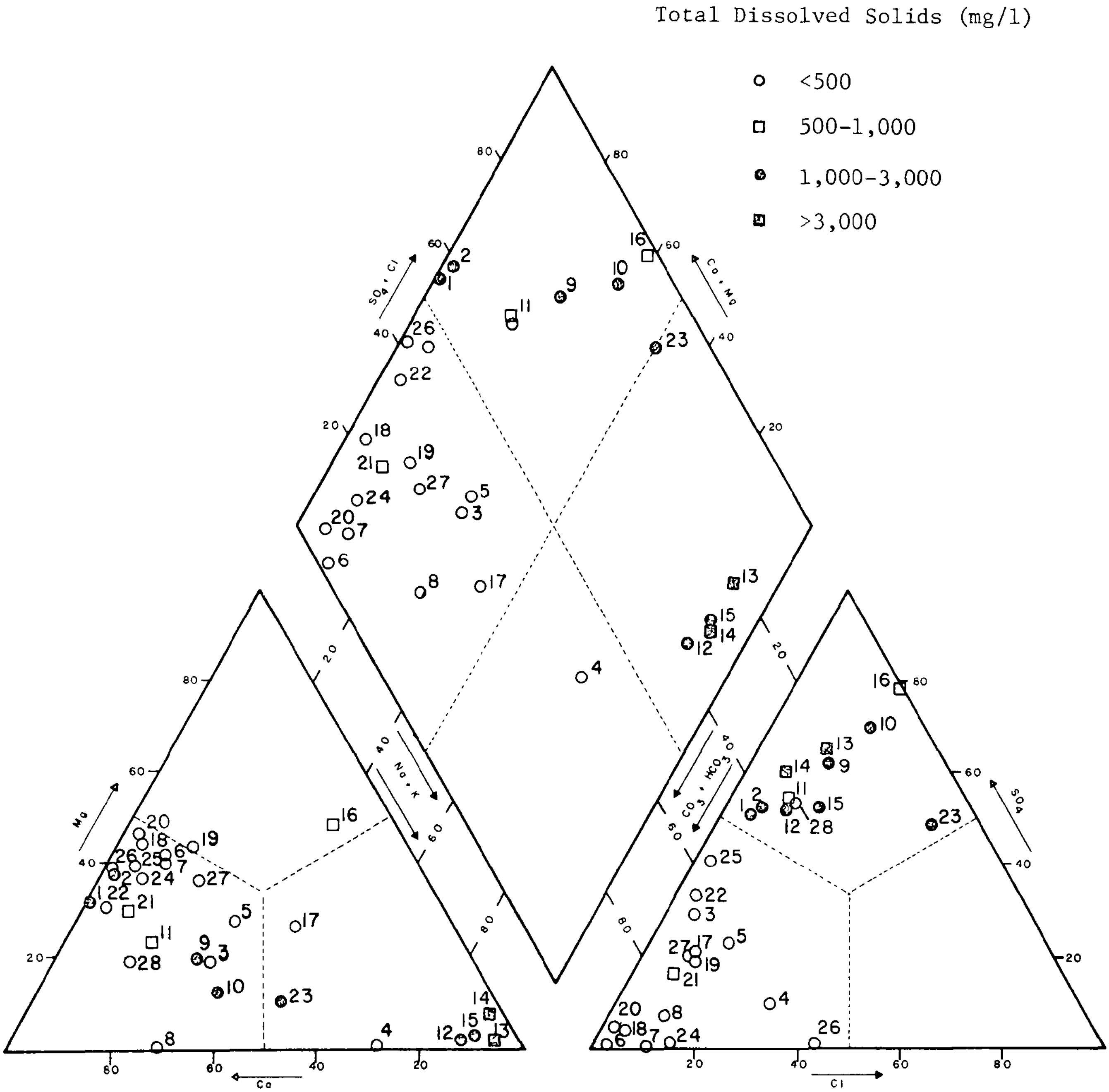


Figure VI-1. Trilinear diagram showing chemical characteristics of ground waters from selected wells and springs that discharge from the Tensleep aquifer system, Wind River basin, Wyoming. Numbered data points correspond to sample numbers on Table B-1.

(less than 500 mg/l) are almost always encountered in wells and springs along outcrops of the aquifer. This water is moderately hard (less than 180 mg/l $CaCO_3$) with calcium, magnesium, and bicarbonate the dominant ionic species. Maximum well depths in which calcium-magnesium-bicarbonate water is encountered is about 3,000 feet. Basinward, and with increased well depths, total dissolved solids concentrations increase to more than 3,000 mg/l. In the deep basin waters, sulfate replaces bicarbonate as the dominant anion in solution, and sodium replaces magnesium and calcium as the dominant cation. There is also a minor increase in chloride ions as total dissolved solids increase.

The areal distribution of sampling locations is shown on Plate C-1. Insufficient data exist to construct total dissolved solids contours for the entire basin. However, an inferred 1,000 mg/l contour line can be constructed along the east flank of the Wind River Mountains. Maximum drilling depths to the top of the aquifer west of the contour line are about 3,500 feet. Reasonable explanations for the relatively good quality water are: (1) the area is a principal recharge zone, and (2) permeabilities in the rocks are significantly enhanced by faults and fractures and so ground-water flow rates are great.

Tensleep aquifer system waters are distinguishable from the overlying Phosphoria aquifer waters on the basis of sodium and sulfate concentrations. Based on water quality data on Table B-1, Phosphoria waters contain 5 to 10 times as much sodium and sulfate as Tensleep waters. In areas where the two aquifers are hydraulically connected by faults and fractures representative waters contain intermediate concentrations of sodium-potassium and sulfate.

PHOSPHORIA AQUIFER

Water analyses for the Phosphoria aquifer are compiled on Table B-1, and the results are plotted on the trilinear diagram in Figure VI-2. All of the analyses are for oil-field waters at minimum drilling depths of about 2,500 feet. Ground waters in the Phosphoria aquifer are predominantly mixed cation-bicarbonate type.

Based on data presented on Figure VI-2, ground waters in the Phosphoria aquifer with total dissolved solids concentrations less than 500 mg/l contain mixed cation concentrations, whereas bicarbonate is the dominant anion. As the total dissolved solids increase (500 to >1,000 mg/l) relative sulfate concentrations increase and sodium becomes the dominant cation. Sample 2 (Figure VI-2) is exceedingly rich in sodium and chloride ions, unlike any other sampled Phosphoria waters.

Total dissolved solids concentrations and sampling locations for ground waters in the Phosphoria aquifer are shown on Plate C-2. Insufficient data exist to construct total dissolved solids contours for the entire basin. However, based on available data total dissolved solids concentrations increase basinward and with drilling depth.

There is also a correlation between total dissolved solids concentrations and structural deformation of the aquifer. For example, samples 3, 4, 9, 11, and 19-23 are from wells situated along the axes of faulted anticlines where permeabilities are significantly enhanced by fractures. These samples contain total dissolved solids concentrations less than 950 mg/l. It is reasonable to expect that the increased permeabilities allow for greater flow rates through the aquifer, therefore creating a flushing effect and decreasing relative residence

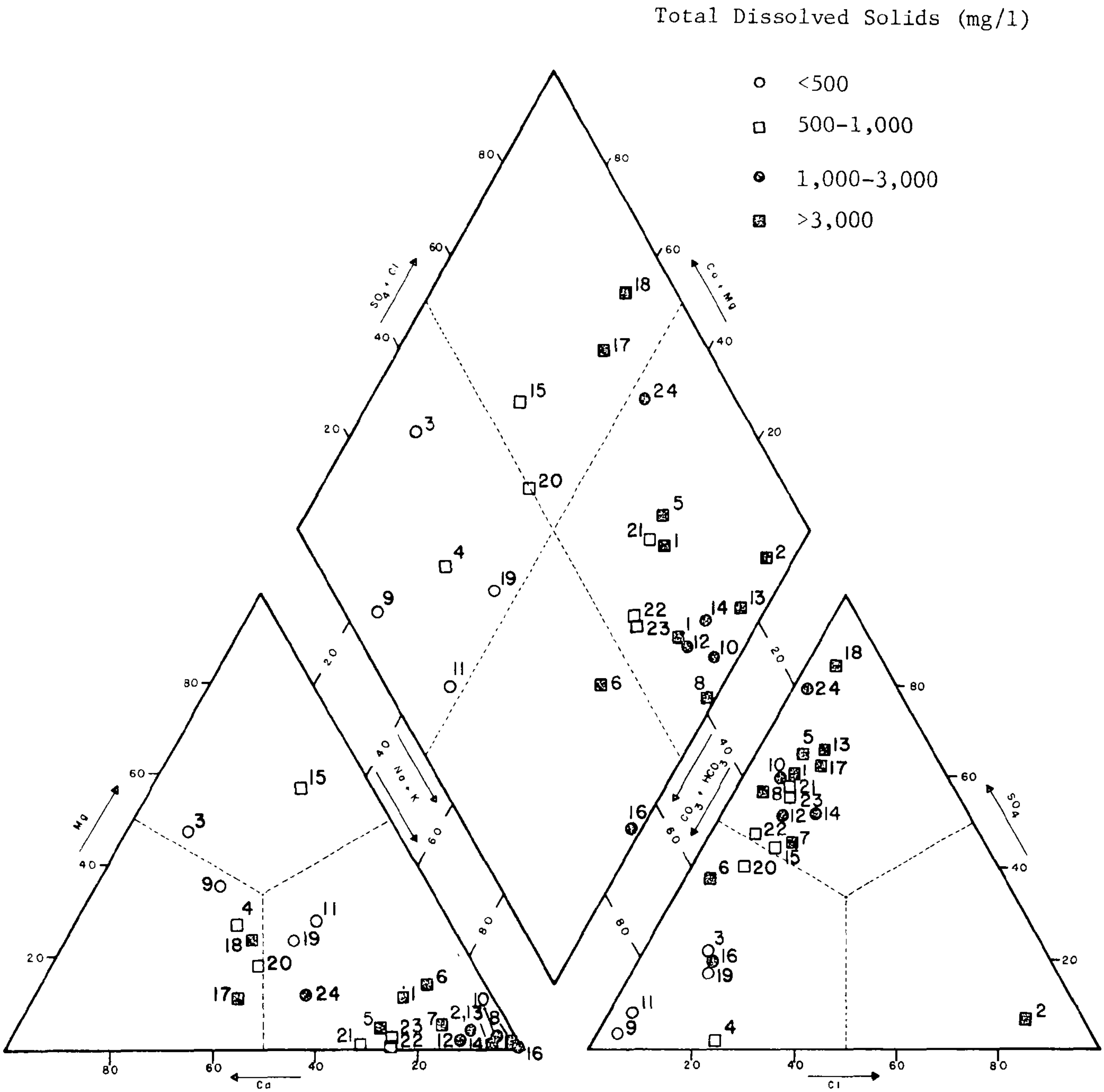


Figure VI-2. Trilinear diagram showing chemical characteristics of ground waters from selected wells and springs that discharge from the Phosphoria aquifer, Wind River basin, Wyoming. Numbered data points correspond to sample numbers on Table B-1.

times of the ground water. Conversely, samples 5, 12, 13, 14, and 16 are for wells located in relatively undeformed areas, and total dissolved solids concentrations range from 1,683 to 3,797. The relatively large concentrations are most likely the result of (1) long residence times, (2) small flow rates-low permeabilities, and (3) dissolution of soluble salts from the aquifer matrix.

SUNDANCE-NUGGET AQUIFER

Water analyses for one Sundance Formation sample and two Nugget Sandstone samples are compiled on Table B-1. Insufficient data exist to meaningfully quantify water qualities in the aquifer. Based on available data the waters are predominantly sodium-sulfate-bicarbonate. Total dissolved solids concentrations range between 799 and 2,945 mg/l. Increased dissolved solids are correlative with sodium and sulfate enrichment (Table B-1).

Although the Sundance and Nugget formations are saturated and permeable, according to Richter (1981), Feathers and others (1981), and Crawford (1940) the units are generally not considered sources of low dissolved solids water (less than 1,000 mg/l). Possible exceptions are areas where total dissolved solids concentrations less than 500 mg/l are reported for selected springs and shallow wells.

In areas adjacent to the Wind River basin, such as the Sweetwater basin to the south and the central Casper Arch to the east, ground waters in the Sundance-Nugget aquifer are sodium-chloride-sulfate rich. According to Crawford (1940) total dissolved solids concentrations in the aquifer in the Sweetwater basin range between 8,000 and 50,000 mg/l. Based on data from the Wyoming Oil and Gas Conservation Commission, (various) oil-field waters from the aquifer in the central Casper Arch area contain dissolved solids ranging from 1,000 to 2,200 mg/l. According to Feathers and others (1981) ground waters in the aquifer in the Salt Creek area of the Powder River basin contain dissolved solids averaging about 10,000 mg/l.

CLOVERLY AQUIFER

Chemical analyses for Cloverly aquifer ground waters are compiled on Table B-1, and the results are plotted on the trilinear diagram in Figure VI-3. Based on data shown in Figure VI-3, five of the samples are sodium-sulfate water, three of the analyses are sodium-bicarbonate water, and two are sodium-chloride water. Total dissolved solids concentrations range from about 450 to 30,000 mg/l.

Cloverly aquifer waters containing less than 1,000 mg/l total dissolved solids are predominantly sodium-bicarbonate and sodium-sulfate-bicarbonate type. As dissolved solids increase (1,000 to 3,000 mg/l), sulfate generally replaces bicarbonate and the waters are a sodium-sulfate type. Waters containing dissolved solids greater than 3,000 mg/l are a sodium-chloride type.

In general, water qualities are good (total dissolved solids less than 1,000 mg/l) in areas where the aquifer (1) crops out, and (2) is intensely faulted and fractured, and at drilling depths less than 2,500 feet. Water qualities deteriorate basinward and with drilling depths exceeding 2,500 feet regardless of fracture-enhanced permeabilities. The areal distribution of sampling locations and total dissolved solids concentrations are shown on Plate C-3.

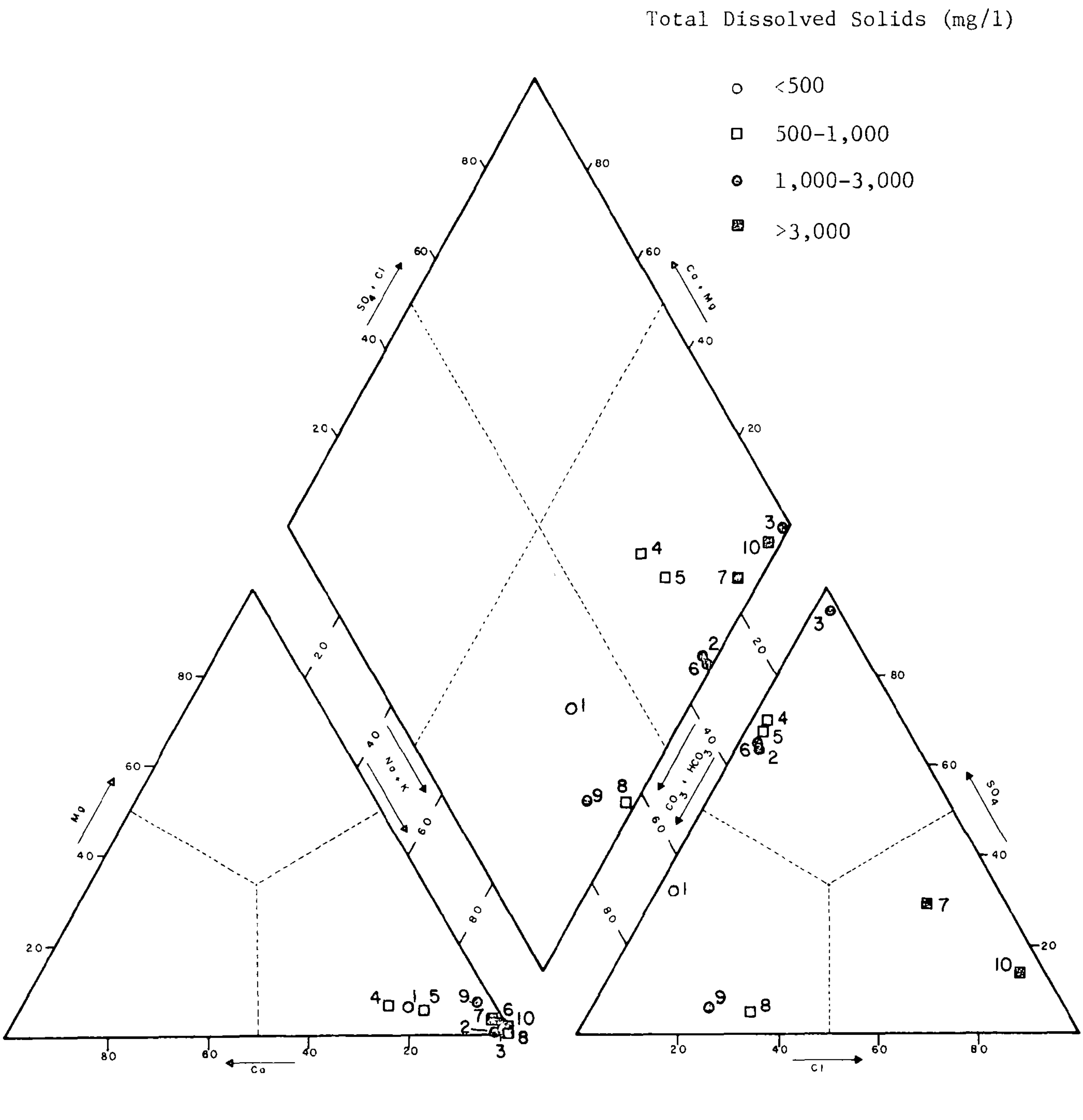


Figure VI-3. Trilinear diagram showing chemical characteristics of ground waters from selected wells and springs that discharge from the Cloverly aquifer, Wind River basin, Wyoming. Numbered data points correspond to sample numbers on Table B-1.

Samples 7 and 10 contain 10 to 30 times more total dissolved solids than the other 10 samples (29,990 and 11,719 mg/l, respectively). The large dissolved solids concentrations are mainly attributable to large sodium and chloride concentrations. Both samples are from oil and gas tests and may be contaminated by various drilling fluids, or obtained from hydraulically isolated zones within the aquifer.

MUDDY AQUIFER

Twenty-five chemical analyses for ground waters from the Muddy Sandstone are compiled in Table B-1. Unfortunately, the analyses include only bicarbonate, sulfate, chloride, and total dissolved solids, and as a result the analyses cannot be plotted on trilinear diagrams and classified by water type.

Based on total dissolved solids concentrations, water qualities in the Muddy aquifer are poor. Dissolved solids in 17 of 25 samples exceeded 3,000 mg/l, and the remaining 8 samples ranged between 1,000 and 3,000 mg/l. Based on available data, large total dissolved solids concentrations (greater than 5,000) are associated with substantial increases in chloride and bicarbonate ions.

Sampling locations and total dissolved solids concentrations are shown on Plate C-4. Insufficient data exist to construct meaningful dissolved solids contours for the Muddy aquifer. However, as shown on Plate C-4, dissolved solids concentrations are relatively large in both outcrop and structurally depressed parts of the basin.

In general, water qualities in the Muddy aquifer are poor throughout the various structural-hydrologic basins in Wyoming. According to Richter (1981), Crawford and Davis (1962), and Crawford (1940), Muddy aquifer waters generally contain dissolved solids greater than 2,000 mg/l. The waters are predominantly sodium-chloride and sodium-chloride-bicarbonate type. According to Crawford (1940) shale and silt in the aquifer matrix is the major source for sodium and chloride ions.

Muddy aquifer waters are distinguishable from waters in the overlying Frontier Formation on the basis of sodium and chloride concentrations. Muddy aquifer waters generally contain sodium and chloride concentrations greater than 1,500 mg/l, whereas the respective ion concentrations in Frontier waters are generally less than 800 and 1,000 mg/l (Richter, 1981; Crawford and Davis, 1962; Crawford, 1940).

FRONTIER AQUIFER

Water qualities in the Frontier aquifer are highly variable as evidenced by total dissolved solids concentrations ranging from less than 500 to about 14,000 mg/l. As shown on Plate C-5, dissolved solids concentrations are usually less than 2,000 mg/l along or near outcrops of the aquifer. Dissolved solids concentrations increase basinward and with drilling depths to the aquifer.

Chemical analyses for 50 Frontier aquifer waters are compiled on Table B-1, and the results for representative samples are shown on the trilinear diagram in Figure VI-4. As shown on Figure VI-4, Frontier aquifer waters are comprised of three types: (1) sodium-sulfate, (2) sodium-bicarbonate-sulfate, and (3) sodium-chloride. Sodium is the dominant cation for all samples regardless of total dissolved solids concentrations, whereas dominant anions vary with location, drilling depths, and dissolved solids. For example: (1) samples 14 and 19

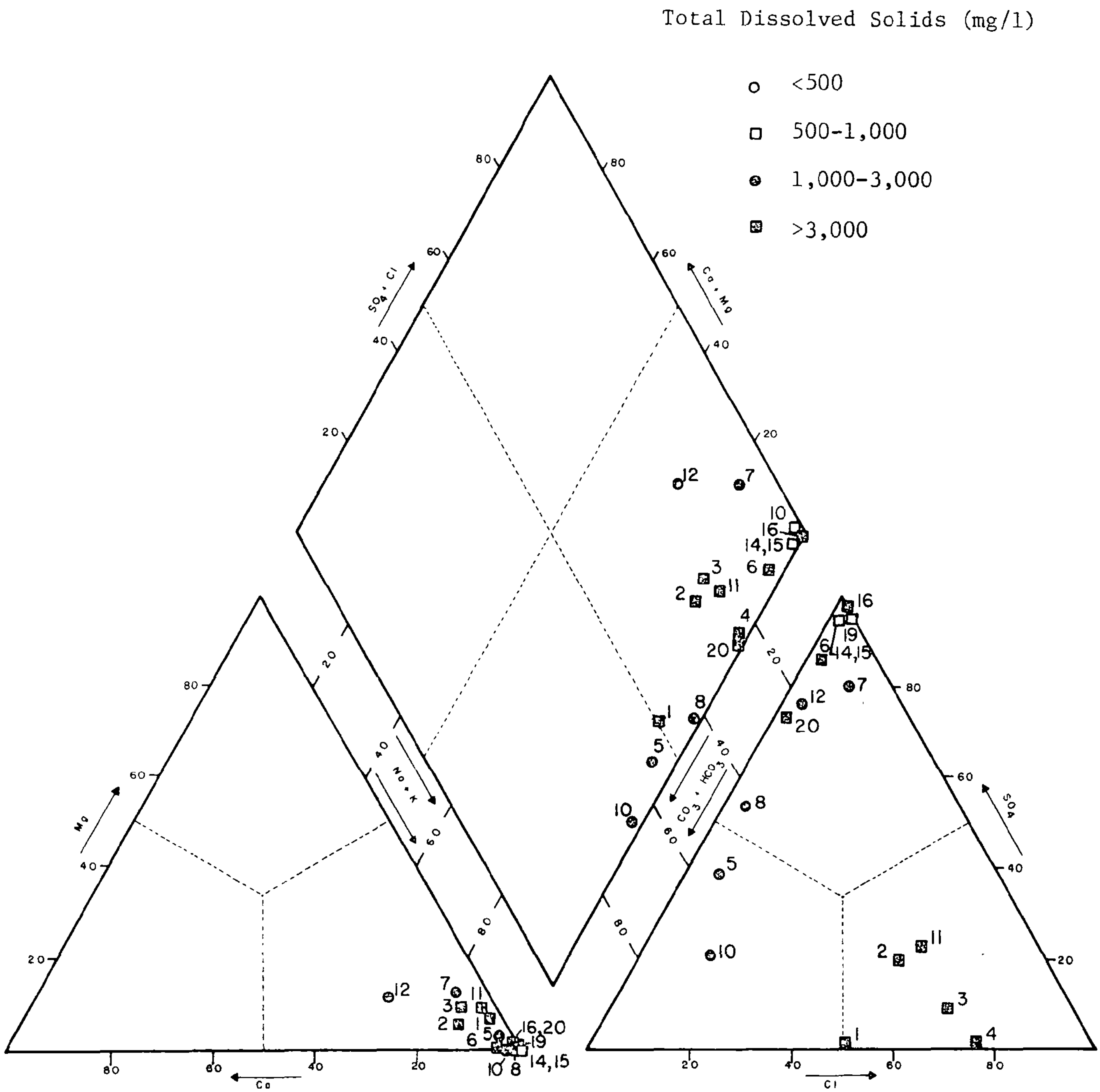


Figure VI-4. Trilinear diagram showing chemical characteristics of ground waters from selected wells and springs that discharge from the Frontier aquifer, Wind River basin, Wyoming. Numbered data points correspond to sample numbers on Table B-1.

(Figure VI-4) contain dissolved solids concentrations less than 1,000 mg/l and sulfate is the dominant anion. Both samples are from shallow wells located on Frontier Formation outcrops. (2) Samples 5, 7, 8, 10, and 12 (Figure VI-4) contain dissolved solid concentrations ranging between 1,000 and 3,000 mg/l. These samples increase in bicarbonate ions with increased drilling depths. (3) Samples 1, 2, 3, 4, and 11 (Figure VI-4) are from deep, central basin oil-field tests and dissolved solids concentrations exceed 4,300 mg/l. Chloride is the dominant anion in these samples.

Three factors influence major ion water chemistries in the Frontier aquifer: (1) lithology, (2) residence time for the ground water, and (3) leakage of poor quality waters from underlying units. For example, the Frontier Formation is comprised largely of shales and claystone and as a result ground waters with long residence times will dissolve soluble salts from the argillaceous rocks. Also, based on the fact that hydraulic heads increase with depth in the Frontier and underlying formations, there is a possibility of vertical leakage of poor quality waters from the underlying Mowry Shale.

MESAVERDE AQUIFER

Only two chemical analyses for Mesaverde aquifer waters were available for this study (Table B-1), and the results are plotted on the trilinear diagram in Figure VI-5. Based on available data, ground water in the Mesaverde aquifer is of the sodium-sulfate-bicarbonate type (Figure VI-5). The gross chemical character of the water is most likely controlled by dissolution of calcite, dolomite, and gypsum from

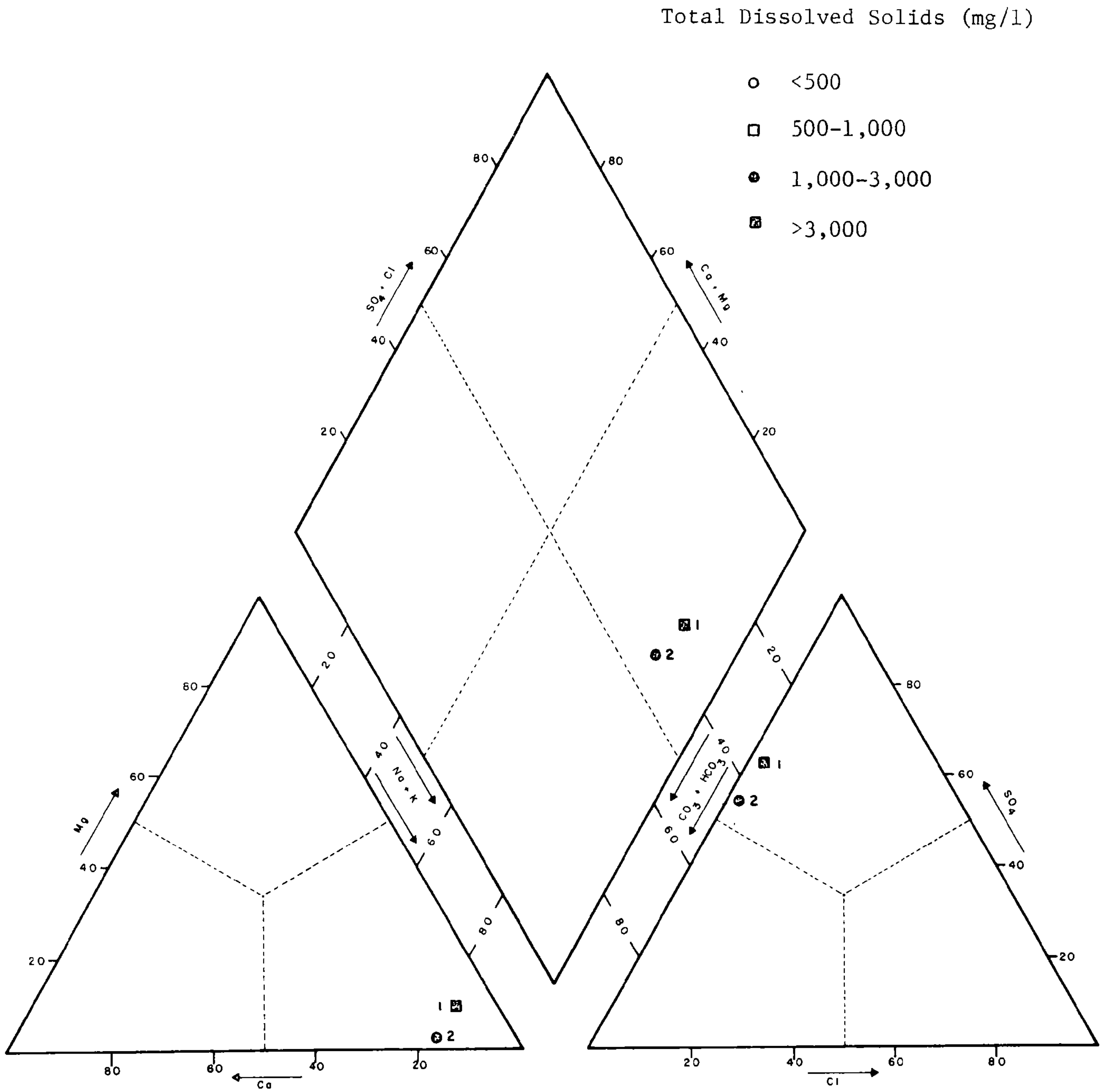


Figure VI-5. Trilinear diagram showing chemical characteristics of ground waters from selected wells and springs that discharge from the Mesaverde aquifer, Wind River basin, Wyoming. Numbered data points correspond to sample numbers on Table B-1.

the aquifer matrix with cation exchange of sodium for calcium and magnesium (Crawford, 1940).

According to Crawford (1940), Feathers and others (1981), Richter (1981), and Libra and others (1981) water qualities in the Mesaverde aquifer are poor throughout Wyoming. Total dissolved solids concentrations are generally above 1,500 mg/l; however, Richter (1981) reports several Mesaverde springs and seeps with dissolved solids less than 500 mg/l.

FORT UNION-LANCE AQUIFER

Water qualities in the Fort Union-Lance aquifer are highly variable as is evident from total dissolved solids concentrations ranging from about 500 to 20,500 mg/l. As shown on Plate C-6, low dissolved solids waters (less than 1,000 mg/l) are encountered along outcrops of the aquifer. Dissolved solids increase basinward and with drilling depths to the aquifer.

Chemical analyses for 11 Fort Union-Lance aquifer waters are compiled on Table B-1. The results of the analyses are plotted on the trilinear diagram in Figure VI-6. As shown on Figure VI-6, Fort Union-Lance aquifer waters are comprised of three types: (1) sodium-sulfate, (2) sodium-chloride, and (3) sodium-bicarbonate. Based on data presented in Figure VI-6, there is a correlation between increased total dissolved solids concentrations and particular ionic species. For example, lower dissolved solids water are generally sodium-bicarbonate and sodium-sulfate rich, whereas relatively high dissolved solids waters are sodium-chloride rich. There is also correlation between geographic location and increased chloride concentrations. For

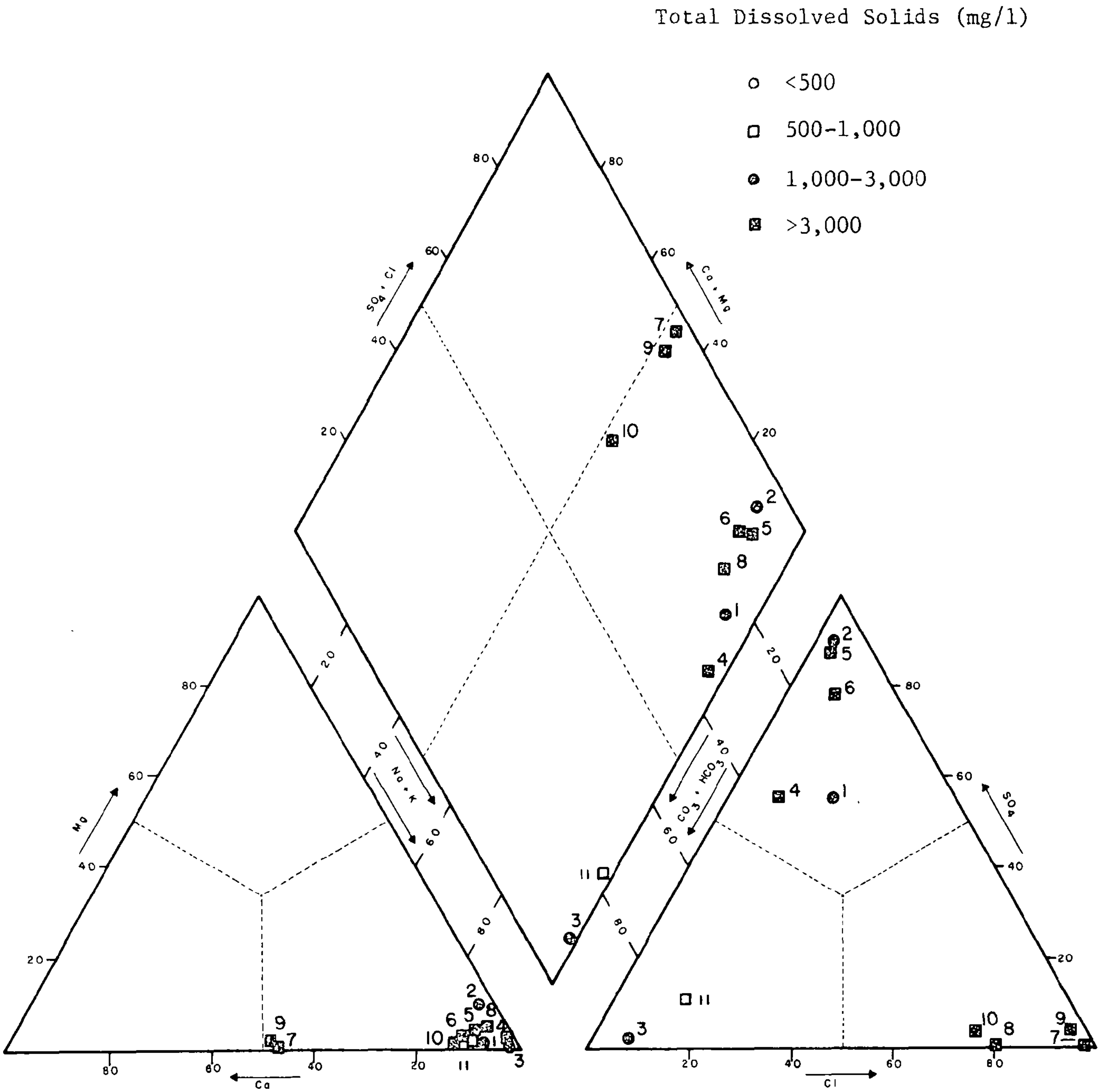


Figure VI-6. Trilinear diagram showing chemical characteristics of ground waters from selected wells and springs that discharge from the Fort Union-Lance aquifer, Wind River basin, Wyoming. Numbered data points correspond to sample numbers on Table B-1.

example, samples 7, 8, 9, and 10 are sodium-chloride rich, and all of the samples are for wells located in T. 39 N., R. 91 W. No other sodium-chloride waters were encountered in the aquifer elsewhere in the basin.

Principal factors influencing major ion water chemistries in the Fort Union-Lance aquifer are (1) lithology and (2) sedimentary environments. According to Crawford (1940) and Whitcomb and Lowry (1968), channel sandstones cemented with silica and calcium-bicarbonate cement generally contain low dissolved solids water (less than 500 mg/l). Wells completed in saturated coals generally yield waters with dissolved solids less than 1,000 mg/l (Whitcomb and others, 1966; Crist and Lowry, 1966). Conversely, wells completed in saturated silty and shaley sandstones almost always produce waters with dissolved solids greater than 1,000 mg/l. Also, many of the saturated sandstones comprising the aquifer are lenticular and discontinuous, therefore allowing for mixing of poor quality waters from saturated siltstones and shales.

WIND RIVER AQUIFER

Chemical analyses for 131 Wind River aquifer waters are compiled on Table B-1. The results of representative samples from various springs, drilling depths, and geographic locations, are plotted on the trilinear diagram in Figure VI-7. Selected sample locations are shown on Plate C-7. The large number of analyses for Wind River aquifer waters, relative to waters from other aquifers, reflects the aquifer's increased development and use.

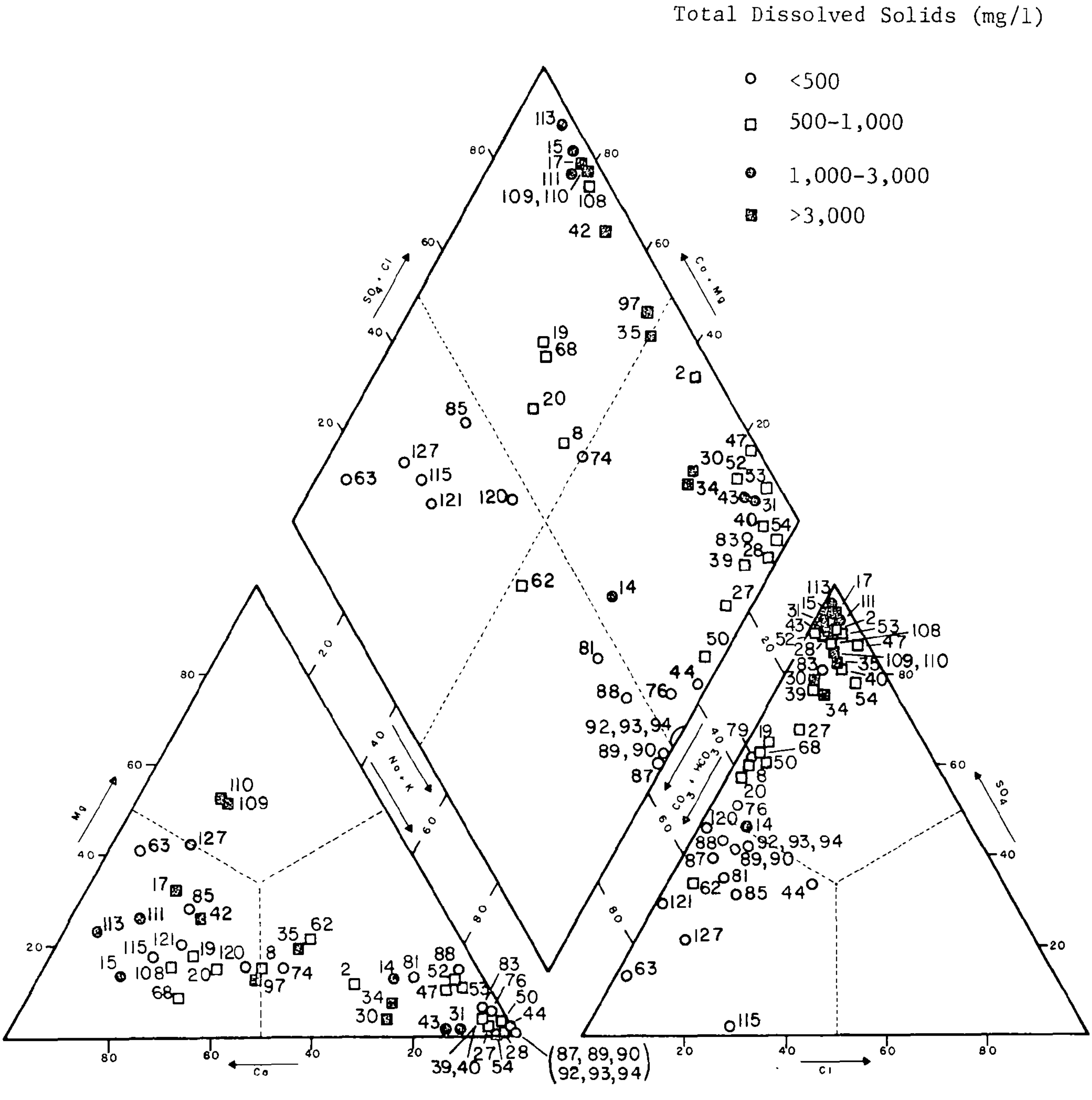


Figure VI-7. Trilinear diagram showing chemical characteristics of ground waters from selected wells and springs that discharge from the Wind River aquifer, Wind River basin, Wyoming. Numbered data points correspond to sample numbers on Table B-1.

In general, cation concentrations in the Wind River aquifer are mixed (Figure VI-7), regardless of total dissolved solids concentrations and drilling depths (however, data are limited to maximum drilling depths of about 1,000 feet). There is also no correlation between major cation water chemistries and whether the sample was taken from a deep-basin well or a spring. However, there is correlation between major anion water chemistries and total dissolved solids concentrations. For example, the dominant anion in low dissolved solids waters (less than 800 mg/l) is bicarbonate, whereas the dominant anion in waters with dissolved solids greater than 2,000 mg/l is sulfate. Bicarbonate and sulfate ions are mixed in waters with dissolved solids ranging between 800 and 2,000 mg/l. Chloride concentrations are very low.

As shown on Figure VI-7, water type varies according to total dissolved solids. Table VI-1 summarizes the relationship between water type and dissolved solids.

Principal factors influencing water qualities in the Wind River aquifer are (1) lithology and (2) recharge mechanisms. The aquifer is comprised of discontinuous, lenticular sandstone, conglomerate, siltstone, claystone, and shale, and therefore it is reasonable to expect variations in water qualities according to the lithology in which the well or spring is located. An excellent example of the influence of lithology on water quality involves the north-central part of the basin. In this area the Wind River aquifer is comprised largely of silty, shaley, coarse-grained sandstones and the water type is predominantly sodium-sulfate and calcium sulfate with dissolved solids

Table VI-1. Relationship between water type and total dissolved solids for ground waters in the Wind River aquifer, Wind River basin, Wyoming.

Total Dissolved Solids Concentrations (mg/l)	Water Type (dominant type listed first)
<500	1. calcium-magnesium-bicarbonate
	2. sodium-bicarbonate-sulfate
500-1,000	1. sodium-sulfate
	2. calcium-sulfate
1,000-3,000	1. calcium-magnesium-sulfate
	2. sodium-sulfate
>3,000	1. calcium-sulfate
	2. sodium-sulfate
	3. magnesium-sulfate

ranging from about 1,000 to 4,400 mg/l. By comparison, in the northeast corner of the basin the Wind River Formation is largely comprised of a relatively clean sandy conglomerate and the water is of the calcium-magnesium-bicarbonate type with total dissolved solids concentrations generally less than 600 mg/l.

As an example of the influence of recharge mechanisms on water quality, Morris and others (1959) found that total dissolved solids concentrations in selected wells in the Riverton irrigation district increase substantially during irrigation seasons as a result of infiltration of soluble salts leached from fertilizers and by leaching of gypsum and epsomite from overlying Quaternary deposits.

ARIKAREE AQUIFER

The results of 17 chemical analyses for ground waters in the Arikaree aquifer are compiled on Table E-1. Representative analyses are plotted on the trilinear diagram in Figure VI-8. The chemical qualities of the water are very good with total dissolved solids typically less than 600 mg/l. Based on available data the quality of the water is generally very good throughout the entire aquifer and is independent of well depth and geographic location.

As shown on the trilinear diagram in Figure VI-8, ground waters in the Arikaree aquifer are calcium-bicarbonate and sodium-sulfate rich. There is no discernable relationship between variations in total dissolved solids concentrations and any particular group of major anions or cations.

As shown on Plate C-8, the Arikaree aquifer exists only in the southern part of the Wind River basin. Prospects for developing

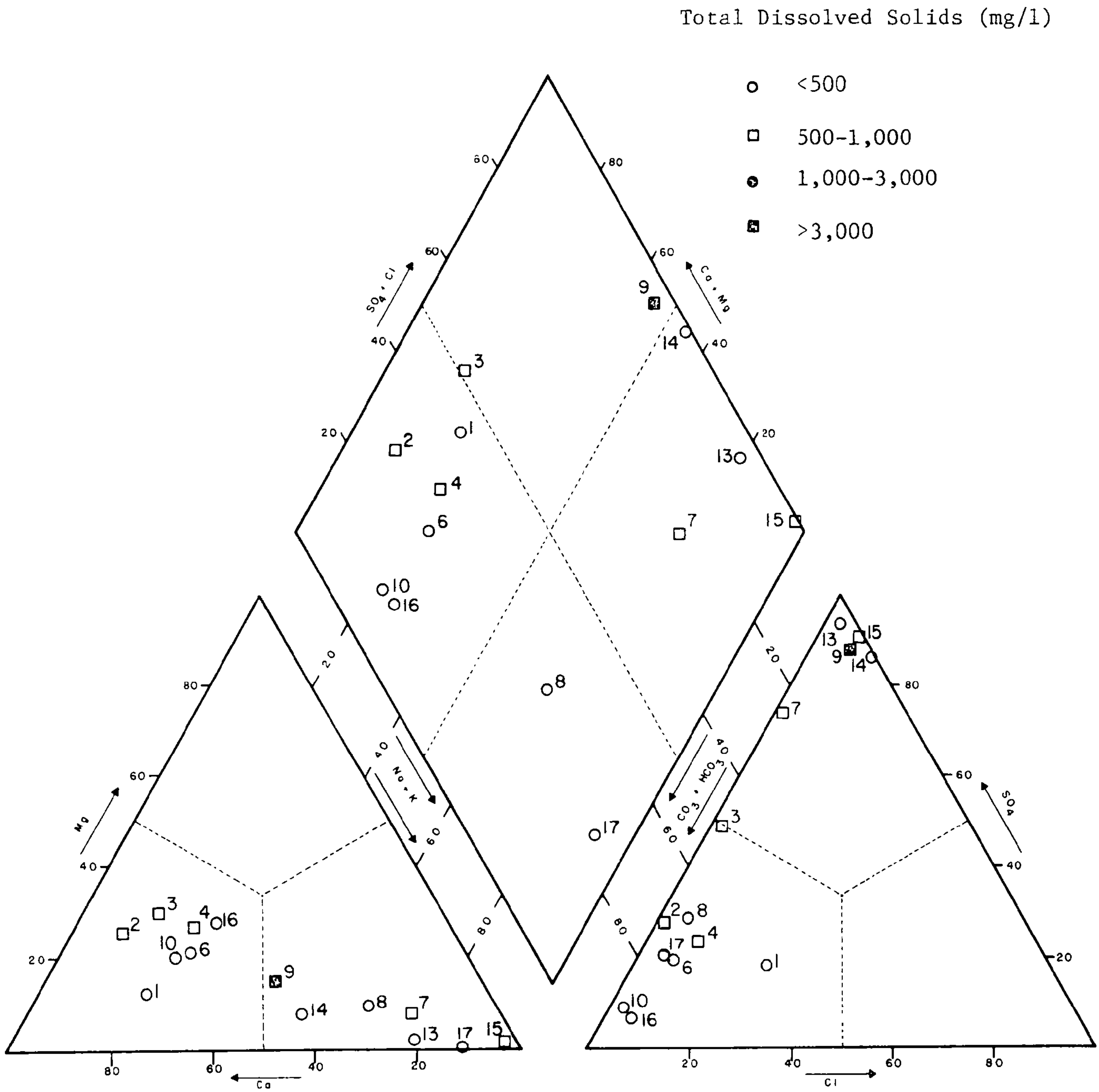


Figure VI-8. Trilinear diagram showing chemical characteristics of ground waters from selected wells and springs that discharge from the Arikaree aquifer, Wind River basin, Wyoming. Numbered data points correspond to sample numbers on Table B-1.

potable ground-water supplies in the aquifer are excellent, thus making the Arikaree aquifer one of the most significant water-bearing units in the area.

Reasonable explanations for the very good water qualities in the aquifer are: (1) interstitial permeabilities in the unit are large, thus providing a large flow-rate potential for ground water, and (2) the aquifer is comprised of relatively clean calcium-carbonate and silica-cemented sandstones.

QUATERNARY DEPOSITS

Saturated Quaternary deposits in the Wind River basin include glacial, terrace, and alluvial units. The most areally extensive Quaternary deposits are alluvium; however, the thickest are glacial deposits. Chemical analyses for saturated Quaternary deposits are listed on Table B-1, and the results are plotted on the trilinear diagram in Figure VI-9.

Glacial Units

Insufficient data exist to show the results of chemical analyses for glacial unit waters on the trilinear diagram on Figure VI-9. This is because available chemical analyses are for total dissolved solids concentrations only.

Based on available data, total dissolved solids concentrations in glacial unit waters are less than 600 mg/l. The locations of sampling points are shown on Plate C-9. In general, water qualities are very good because of (1) shallow flow, (2) short residence times, and (3) large flow rates.

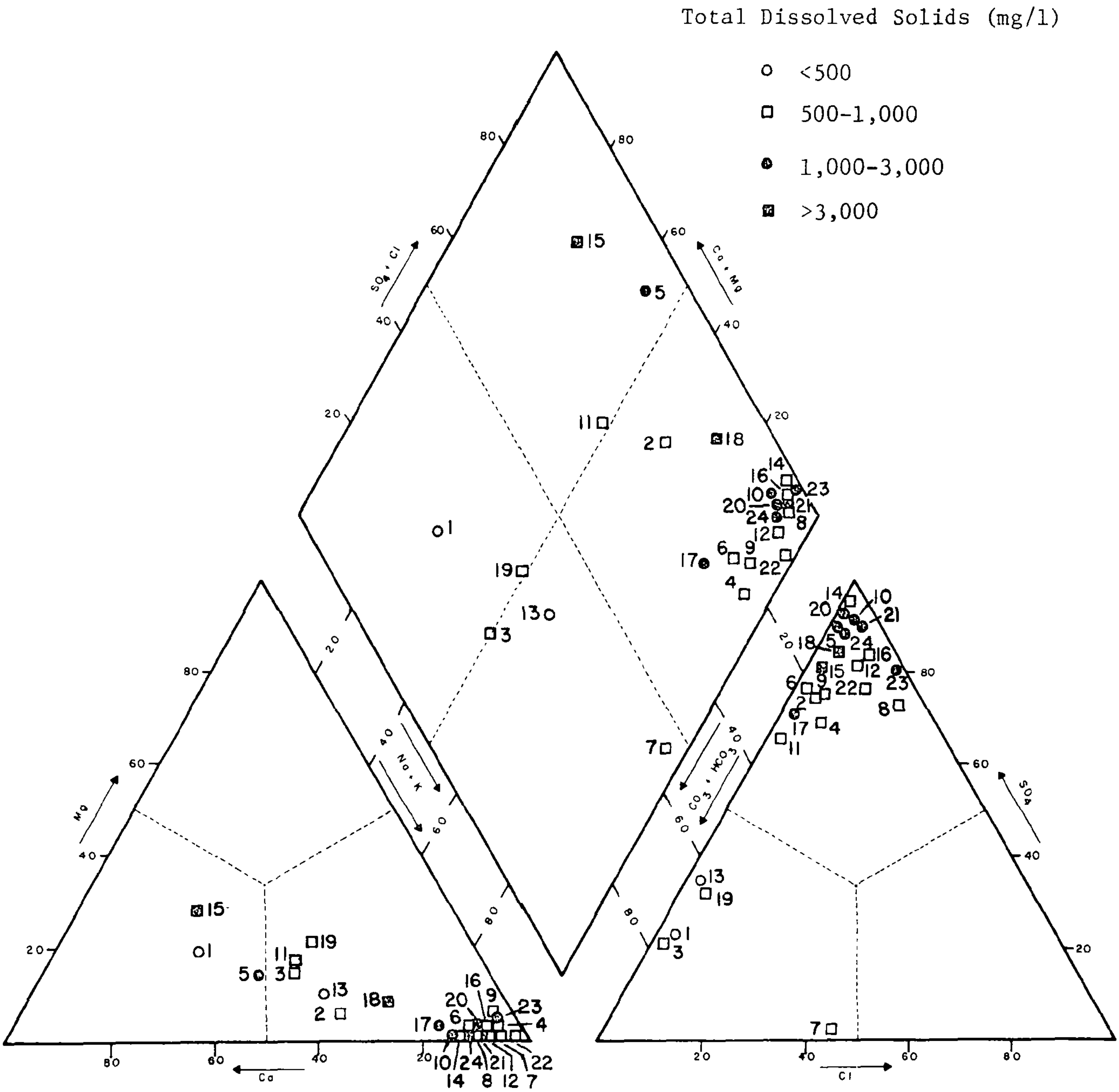


Figure VI-9. Trilinear diagram showing chemical characteristics of ground waters from selected wells and springs that discharge from Quaternary deposits, Wind River basin, Wyoming. Numbered data points correspond to sample numbers on Table B-1.

Alluvial and Terrace Units

Water qualities in alluvial and terrace units vary greatly in the Wind River basin. The chemical variations can occur over relatively short geographic distances, with well depth, and time of year. Principal factors influencing water qualities are (1) lithology, (2) recharge mechanisms, and (3) evapotranspiration rates.

As shown on Figure VI-9, sulfate is the predominant anion in most alluvial and terrace waters. A reasonable explanation for the relatively large concentrations of sulfate ions is simply concentration of soluble salts by the water. Concentration of soluble sulfates can readily occur in alluvial and terrace waters because of the abundance of epsomite and gypsum in the host aquifer.

Sodium is the predominant cation in most alluvial and terrace waters (Figure VI-9). However, a few samples are mixed cation, and a few others are enriched in calcium ions.

As shown on Figure VI-9, principal water types in the alluvial and terrace units are (1) sodium-sulfate, (2) calcium-magnesium-bicarbonate, and (3) calcium-sulfate. There is no clear correlation between water type and total dissolved solids concentrations for most of the samples; however, the following general correlations exist. (1) All calcium-magnesium-bicarbonate waters contain dissolved solids less than 1,000 mg/l. (2) Calcium-sulfate waters contain dissolved solids greater than 2,500 mg/l.

As shown on Plate C-9, total dissolved solids concentrations vary greatly over short geographic distances. For example, in the Lander area it is common for dissolved solids to vary by several orders of magnitude within an area of one square mile. Such variations make geographic characterization of major ion water chemistries nearly impossible. However, water qualities vary with well depth. This is largely the result of (1) lithology and (2) recharge mechanisms. The relationship between well depth, lithology, and total dissolved solids concentrations is summarized on Table VI-2.

The variations in water qualities with well depth are particularly interesting. Water qualities deteriorate with well depths to about 100 feet; however, at about 100 feet water qualities improve (Table VI-2). In general, relatively low to moderate dissolved solids concentrations (400-1,500 mg/l) are found in deep terrace wells (101 to 200 feet); whereas high dissolved solids waters are found at intermediate drilling depths (41 to 100 feet). Morris and others (1959) state that this situation is a result of recharge sources to the units. Recharge to the basal terrace deposits within the Wind River Indian Reservation is by vertical leakage of low dissolved solids, calcium-magnesium-bicarbonate waters from the underlying Wind River Formation, whereas recharge to the upper parts of the units is largely from irrigation and precipitation. Prior to irrigation and rainy seasons, most terraces are well drained and have greatly lowered water tables. When the irrigation season begins the irrigation water leaches soluble salts within the terrace and thereby increases total dissolved solids concentrations.

Morris and others (1959) also observed seasonal variations in water qualities. For example, total dissolved solids and sulfate concentrations increase noticeably during early spring and then decrease steadily during the summer, fall, and winter. Morris and

Table VI-2. Relationship between well depth, lithology, and total dissolved solids for selected alluvial and terrace wells, Wind River basin, Wyoming.[a]

Well Depth (feet)	Principal Lithologies	Total Dissolved Solids (mg/l)
1-15	Wind-blown sand and silt	<500
16-40	Sandy siltstone, clay, dirty sandstone	500-1,000
41-100	Coarse-grained dirty sandstone, shale, and sandy siltstone	>1,500
101-200[b]	Conglomerate and sandstone	400-1,500

[a]Data are for 27 wells within Wind River Indian Reservation.

[b]Based on eight wells completed in terrace units.

others attribute the increase to leaching of soluble salts from alluvial and terrace units during irrigation season, followed by a "flushing effect" of the salts. Similar variations in water qualities in alluvial aquifers as a result of irrigation have been described in Swenson and Swenson (1957) and Libra and others (1981).

Changes in major ion water chemistries have been observed along major surface drainages. Six- to ten-fold increases in total dissolved solids concentrations have been observed in waters from alluvial wells along Muddy Creek, Fivemile Creek, and Wind River. It is reasonable to expect that this is the result of leaching of soluble salts from upstream sediments as a result of irrigation and precipitation runoff and then subsequent recharge to the alluvium by the surface water along downstream reaches.

PRIMARY DRINKING WATER STANDARDS

Primary drinking water standards established by the U.S. Environmental Protection Agency (1976) are summarized in Table VI-3. Insufficient data exist to allow thorough evaluation for all primary standards in the various water-bearing units in the Wind River basin; however, based on available chemical analyses, fluoride and nitrate concentrations often equal or exceed standard levels. Figure VI-10 shows the (1) sampling location, (2) source of ground water, and (3) concentration in mg/l for areas where fluoride and nitrate concentrations exceed primary standards.

As shown on Figure VI-10, fluoride concentrations exceeding 2.0 mg/l are encountered in the Wind River, Frontier, Phosphoria, and Tensleep aquifers. The concentrations range from 2.2 to 5.8 mg/l. About 20 samples from the Wind River Formation exceed 2.0 mg/l. Most of the samples are from wells situated along major surface water drainages within the Wind River Indian Reservation.

Nitrate concentrations exceeding 10 mg/l (NO_3-N) are encountered in the Arikaree, Wind River, Fort Union, and Frontier formations in various parts of the basin (Figure VI-10). The concentrations range from 11 to 265 mg/l. Thirty-seven Wind River Formation samples exceeded nitrate standards, most from wells within the Wind River Indian Reservation. It is reasonable to believe that the relatively large nitrate concentrations are related to agricultural activities because all of the samples are from principal irrigation districts.

Table VI-3. Primary and secondary drinking water standards established by U.S. Environmental Protection Agency (1976).

Constituent	Primary Drinking Water Standard[a]	Secondary Drinking Water Standard[a]
Arsenic	0.05	
Barium	1.	
Cadmium	0.01	
Chloride		250
Chromium	0.05	
Coliform Bacteria	1 colony/100 ml[b]	
Color		15 color units
Copper		1.
Corrosivity		Noncorrosive[c]
Fluoride	2.0[d]	
Foaming Agents		0.5
Iron		0.3
Lead	0.05	
Manganese		0.05
Mercury	0.002	
Nitrate (as N)	10.	
Odor		3 threshold odor units
Organic Chemicals-Herbicides		
2,4-D	0.1	
2,4,5-TP	0.01	
Organic Chemicals-Pesticides		
Endrin	0.0002	
Lindane	0.004	
Methoxychlor	0.1	
Toxaphene	0.05	
pH		6.5-8.5 units
Radioactivity		
Ra-226 + Ra-228	5 pCi/l	
Gross Alpha Activity	15 pCi/l[e]	
Tritium	20,000 pCi/l	
Sr-90	8 pCi/l	
Selenium	0.01	
Silver	0.05	
Sodium		f
Sulfate		250
Total Dissolved Solids		500

Table VI-3. (continued)

Constituent	Primary Drinking Water Standard[a]	Secondary Drinking Water Standard[a]
Turbidity	1 turbidity unit[g]	
Zinc		5.

[a]All concentrations in mg/l unless otherwise noted.

[b]The standard is a monthly arithmetic mean. A concentration of 4 colonies/ 100 ml is allowed in one sample per month if less than 20 samples are analyzed or in 20 percent of the samples per month if more than 20 samples are analyzed.

[c]The corrosion index is to be chosen by the State.

[d]The fluoride standard is temperature-dependent. This standard applies to locations where the annual average of the maximum daily air temperature is 58.4°F to 63.8°F.

[e]The standard includes radiation from Ra-226 but not radon or uranium.

[f]No standard has been set, but monitoring of sodium is recommended.

[g]Up to five turbidity units may be allowed if the supplier of water can demonstrate to the State that higher turbidities do not interfere with disinfection.

SOURCE: U.S. Environmental Protection Agency, 1976.

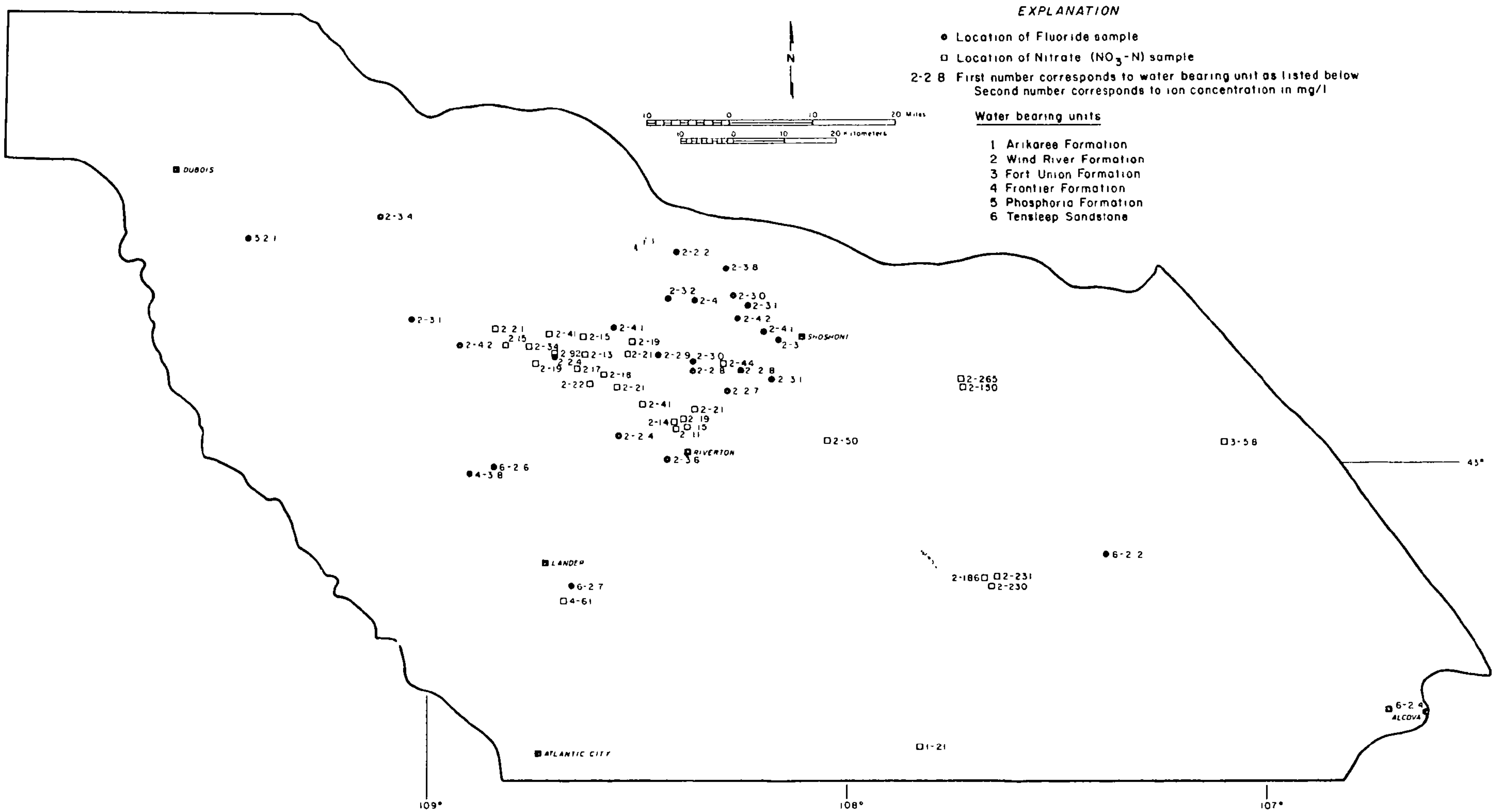


Figure VI-10. Map showing locations of ground-water samples where fluoride and nitrate concentrations exceed U.S. Environmental Protection Agency (1976) primary drinking water standards.

SECONDARY DRINKING WATER STANDARDS

Secondary drinking water standards are summarized on Table VI-3. Secondary standards of interest to this study include total dissolved solids, chloride, and sulfate. Although these constituents are not considered toxic, they are thought to be undesirable in excessive quantities in drinking water. In many areas, however, because no better drinking water is available residents have adjusted to drinking highly mineralized water.

Secondary drinking water standards are exceeded in various water analyses for all of the saturated units in the basin. The reader is referred to Table B-1 for specific chemical analyses, sources of ground water, and sample locations.

Total Dissolved Solids

Total dissolved solids concentrations in ground waters in the basin are shown on Plates C-1 through C-9. Ground waters containing total dissolved solids concentrations less than 500 mg/l are generally limited to outcrop areas of the various aquifers along the flanks of the Wind River Mountains, Owl Creek Mountains, and Gas Hills. Dissolved solids concentrations increase basinward.

Chloride

Chloride concentrations in ground waters in the basin exceeding secondary drinking water standards (250 mg/l) are associated with waters containing total dissolved solids concentrations greater than 2,500 mg/l. Based on data presented in Table B-1, chloride concentrations are relatively large in the Muddy Sandstone (where 80 percent of the available analyses contained chloride concentrations exceeding

250 mg/1), the Frontier Formation (60) percent), the Fort Union Formation (45 percent), and the Cloverly Formation (25 percent). About 13 percent of the Wind River and Phosphoria analyses contain chloride concentrations exceeding secondary drinking water standards. Chloride concentrations in analyses for all other formations listed in Table B-1 are less than 5 percent.

Sulfate

Sulfate concentrations exceeding the secondary drinking water standard (250 mg/1, Table VI-3) are associated with ground waters containing greater than 1,000 mg/1. Table VI-4 summarizes the results of chemical analyses by formation in which sulfate concentrations exceed 250 mg/1.

RADIONUCLIDE ANALYSES

The physiological effects of various concentrations of radionuclide species in ground-water supplies is an increasing concern of the U.S. Environmental Protection Agency as well as the general public. The EPA has, admittedly, taken a conservative approach that radionuclide species such as radium-226, gross alpha, gross beta, and uranium (U_3O_8) in excessive concentrations are harmful and increase the risk of cancer. Primary drinking water standards have been established for radium-226 (5.0 pCi/1) and gross alpha (15 pCi/1). No standards have been established for uranium (U_3O_8) and gross beta.

Analysis for radium-226, gross alpha, and gross beta contain an error limit that generally indicates the 95 percent confidence interval of the analysis. Large error limits are usually due to either (1) instrument insensitivity at low concentrations, or (2) particle

Table VI-4. Results of chemical analyses arranged by formation in which sulfate concentrations exceed U.S. Environmental Protection Agency (1976) secondary drinking water standards.

Formation	Number of Available Analyses[a]	Percent of Analyses Exceeding 250 mg/l Sulfate (SO_4)
Quaternary deposits	24	79
Arikaree	17	18
Wind River	131	70
Fort Union	11	45
Mesaverde	2	100
Frontier	50	28
Muddy	25	12
Cloverly	12	67
Nugget	3	67
Phosphoria	24	71
Tensleep	25	36
Madison	3	33

[a]Analyses presented in Table B-1.

absorption in samples containing high dissolved solids. Where the confidence interval is large relative to the given absolute value, interpretation of results is difficult.

Few radium-226 and gross alpha chemical analyses exist for ground waters in the Wind River basin. This is because the analyses are expensive and public awareness of the analyses is limited. In order to generate a radionuclide data base, the Wyoming Water Resources Research Institute collected 22 water samples during the course of this study to quantify radionuclide species in the various water-bearing units. The results of the analyses are reported in Table VI-5. It should be noted, however, that the analyses are for site-specific areas and are not indicative of radionuclide concentrations throughout an entire aquifer or water-bearing unit.

Based on data presented in Table VI-5, gross alpha concentrations exceed primary drinking water standards for analyses 2, 3, 6, 7, 8, and 9. In particular, gross alpha concentrations for samples 6, 7, and 8 are unusually large. It is also interesting to note that samples 6 and 8 are very large with respect to radium-226. Typically, large concentrations of gross alpha are associated with concentrations of radium-226, uranium (U_3O_8), or both. According to Bob Tauver (personal communication, EPA Region 8, 1981) the gross alpha concentrations could be the result of thorium-230 decay.

Hem (1970, p. 212) states that uranium (U_3O_8) is present in most natural waters in concentrations ranging between 0.001 and 0.01 mg/l. Based on this fact, a thorough search was conducted to identify areas in the basin where uranium concentrations exceeded this limit. As

Table VI-5. Radionuclide concentrations in ground waters from selected wells and springs, Wind River basin, Wyoming.[a]

Key No.[b]	Source of Water	Location[c]	Date of Collection	Uranium (U_3O_8) (mg/1)	Ra-226 (pCi/1)	Gross Alpha (pCi/1)	Gross Beta (pCi/1)
	Arikaree Formation	29-88-17 cd	5-10-81	0.007	0.65±0.2	5±2	14±4
	Arikaree Formation	29-87-35 db	5-10-81	0.010	0.34±0.19	6±2	9±2
	Wind River Formation	33-89-7 bb	4-23-81	N.D.	0±1.9	0±6	15±7
1	Wind River Formation	1N-4E-27 ad	4-30-81	0.052	0±0.08	10±4	14±5
	Wind River Formation	36-86-19 cd	4-24-81	N.D.	0.2±0.2	0±3	8±3
	Fort Union Formation	36-86-36	4-28-81	N.D.	0.1±0.1	0±3	5±5
2	Mesaverde Formation	37-87-24 ca	4-28-81	N.D.	0.1±0.1	0±20	10±21
	Cody Shale	33-99-19 ac	4-30-81	N.D.	0±0.1	1±3	0±5
	Frontier Formation	2-02-31 cb	4-30-81	0.010	1.1±0.2	1±2	4±5
3	Frontier Formation	34-100-33 ba	5-01-81	N.D.	0±0.1	0±15	8±21
	Thermopolis Shale	33-100-24 bc	5-01-81	N.D.	0±0.1	0±7	9±12
	Cloverly Formation	33-89-15	4-23-81	N.D.	0.64±0.2	1±1	13±2
	Cloverly Formation	33-90-22 db	4-23-81	0.001	0.3±0.2	0±7	0±8
	Morrison Formation	33-100-26 db	5-01-81	0.005	0±0.1	1±1	0±2
4	Nugget Sandstone	33-100-22 cb	4-30-81	0.019	0±0.1	12±2	8±2
5	Chugwater Formation	33-100-21 ca	4-30-81	0.019	0±0.1	1±2	2±4
6	Park City Formation	30-96-7 bb	5-01-81	N.D.	21±0.9	128±67	138±93
7	Tensleep Sandstone	33-100-18 bd	4-30-81	N.D.	0.2±0.2	44±4	158±6

Table VI-5. (continued)

Key No.[b]	Source of Water	Location[c]	Date of Collection	Uranium (U_3O_8) (mg/l)	Ra-226 (pCi/l)	Gross Alpha (pCi/l)	Gross Beta (pCi/l)
8	Tensleep Sandstone	33-89-18 cb	4-23-81	0.002	6.8±0.5	19±4	24±4
	Tensleep Sandstone	41-107-16 bd	4-29-81	N.D.	0±0.1	2±0	4±1
9	Madison Limestone	33-100-29 da	4-30-81	0.003	1.2±0.2	13±2	9±2
	Precambrian	29-100-12 bb	5-01-81	0.003	0±0.2	2±1	4±2

[a]Samples analyzed by Chemical and Geological Laboratories, Casper, Wyoming.

[b]Reference number referred to in text.

[c]Township (north) - range (west) - section, quarter-section, quarter-quarter-section (unless otherwise noted). U.S. Geological Survey well and spring numbering system shown in Appendix A.

shown on Figure VI-11, numerous water-bearing units contain uranium concentrations exceeding 0.01 mg/l.

Samples 1, 4, and 5 (Table VI-5) contain uranium concentrations of 0.052, 0.019, and 0.019 mg/l. Sample 1 is from a well completed in a known uranium deposit near Riverton, Wyoming. Sample 5 is from a spring situated at the base of a uranium-bearing arkose in the Chugwater Formation, whereas sample 4 is from a perched spring located along the Nugget Sandstone-Chugwater Formation contact.

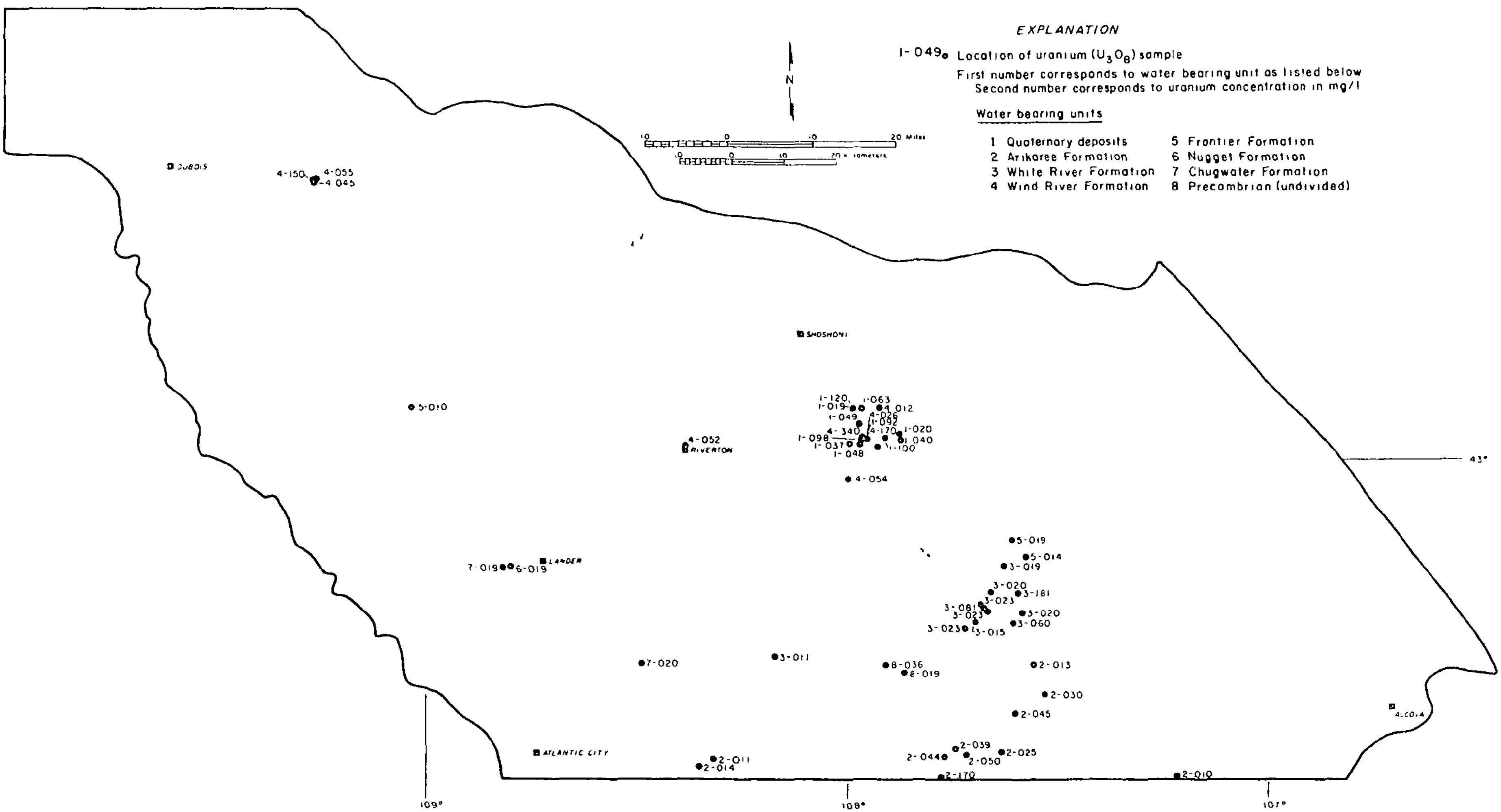


Figure VI-11. Map showing locations of ground-water samples where uranium (U_3O_8) concentrations exceed 0.010 mg/l.

VII. R E F E R E N C E S

VII. REFERENCES

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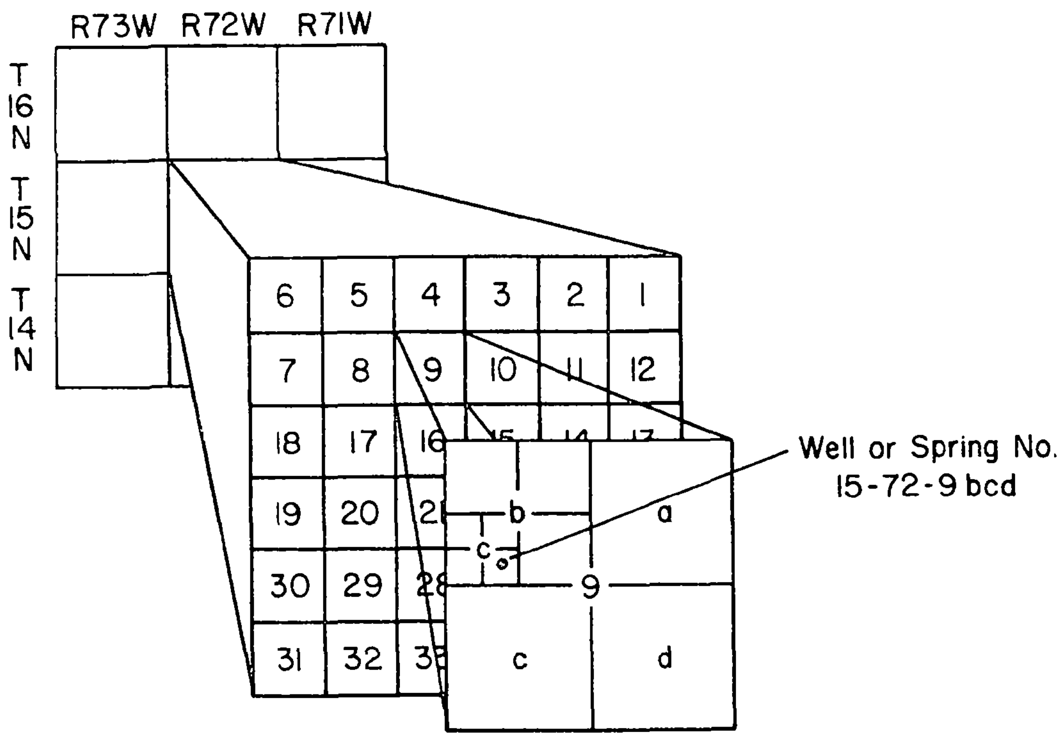
APPENDIX A

WELL AND SPRING NUMBERING SYSTEM

WELL AND SPRING NUMBERING SYSTEM

Water wells, oil and gas test wells, and spring cited in this report are numbered according to the U.S. Geological Survey system that specifies that location of the site based on the Federal land subdivision system. An example is shown below.

In this example, 15-72-9 bcd, 15 refers to the township, 72 to the range, and 9 to the section in which the well is located. The lower-case letters that follow the section number identify a smaller tract of land within the section. The first letter (b in this example) denotes a 160-acre tract, commonly called a quarter section. The second letter (c) denotes a 40-acre tract, commonly called a quarter-quarter section. The third letter (d) denotes an 10-acre tract or a quarter-quarter-quarter section. The letters a, b, c, and d indicate respectively the northeast, northwest, southwest, and southeast tracts of the respective subdivision.



APPENDIX B

CHEMICAL ANALYSES FOR SELECTED WELLS AND SPRINGS, WIND RIVER BASIN, WYOMING

Table B-1. Chemical analyses for wells and springs in the Wind River basin, Wyoming.[a]

No.[b]	Source Well Name or Owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp. (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Total Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[e]	Lab pH
	QUATERNARY DEPOSITS																			
1	N.A.	1N-2E-3	10-15-48	USGS	9.4	48	11	28	2	202	47	5	.3	.8	.07	24	256	165	435	8.0
2	N.A.	1N-3E-16	10-19-48	USGS	10	81	8.2	171	4	157	426	17	.3	1.2	.12	15	830	236	1200	7.5
3	N.A.	1N-4E-3	10-20-48	USGS	11.1	64	15	98	.8	388	84	7	.6	19	.20	26	500	221	784	7.9
4	N.A.	2N-5E-30	10-21-48	USGS	11.1	10	.1	248	.4	163	376	28	1.2	.8	.4	10	734	25	1210	8.0
5	N.A.	2N-2E-4	9-17-49	USGS	9.4	370	70	403	6.4	263	1780	20	.2	17	.3	10	2790	1210	3140	7.3
6	N.A.	2N-3E-10	10-19-49	USGS	9.4	23	3.4	250	3.6	152	448	7.6	1.4	0	.25	11	864	72	1240	7.4
7	N.A.	2N-4E-2	10-20-48	USGS	10	13	1.7	343	2.4	561	3.2	258	2.8	.4	.66	16	933	40	1610	7.9
8	N.A	2N-5E-2	10-20-48	USGS	10	14	1.5	261	.8	34	444	97	2.8	.2	.43	16	872	41	1360	7.7
9	N.A.	2N-6E-7	9-17-49	USGS	11.1	8	10	235	4.8	138	400	18	.8	.3	.24	8.8	752	61	1090	7.2
10	N.A.	3N-1E-21	10-14-48	USGS	11.1	46	2	458	4.4	85	1000	12	.7	.3	.08	13	1580	123	2060	7.5
11	N.A.	3N-2E-7	8-14-50	USGS	12.8	108	32	173	N.A.	294	480	12	N.A.	24	N.A.	N.A.	974	401	1390	7.5
12	N.A.	3N-2E-10	10-18-48	USGS	10	6	.6	174	5.2	44	320	26	1.4	.4	.1	14	612	18	913	7.5
13	N.A.	3N-2E-14	12-5-50	USGS	9.4	37	6.7	71	1.2	214	94	4	N.A.	1.1	.09	11	376	120	519	7.7
14	N.A.	3N-2E-26	10-18-48	USGS	11.7	46	.1	445	7.6	22	988	18	.7	.2	.22	13	1530	116	2160	7.1
15	N.A.	3N-2E-27	12-5-50	USGS	9.4	488	167	282	5.3	256	2190	24	.7	13	.15	12	3310	1910	3500	7.1
16	N.A.	3N-3E-16	10-18-48	USGS	10	12	.1	217	1.2	34	394	36	2	0	.27	17	716	30	1100	8.0
17	N.A.	3N-4E-29	9-17-49	USGS	9.4	74	7.9	473	4.8	416	848	17	1.1	.7	.28	9.2	1640	217	2190	7.8
18	N.A.	3N-5E-33	10-16-48	USGS	8.3	206	41	735	3.2	330	1760	58	1.1	44	.34	19	3030	682	3830	7.6
19	N A.	3-1-24	9-17-49	USGS	12.2	70	29	124	3.2	405	175	16	1.4	15	.31	32	696	294	964	8.2
20	N.A.	3N-2E-5	8-14-50	USGS	14.4	33	.5	459	1.3	78	990	8.5	.8	.8	.1	10	1540	85	2180	7.5
21	N.A.	4N-2E-29	8-14-50	USGS	10	31	.1	548	1.8	64	1090	48	1.1	.3	.1	12	1770	78	2560	8.2
22	N.A.	4N-3E-13	10-26-51	USGS	10.6	5.5	.1	256	.6	32	435	49	2	.4	.35	10	802	14	1270	9.5
23	N.A.	4N-4E-20	10-26-51	USGS	11.1	31	.9	556	.9	34	1020	160	3.2	.3	.22	8	1800	81	2740	7.2
24	N.A.	4-1-31	11-14-51	USGS	N.A.	71	4.1	716?		138	1520	37	1.2	1	.21	7.4	2430	194	3380	7.5
	ARIKAREE FORMATION																			
1	Jeffrey City	29-92-10	7-19-73	WDA	N.A.	50	5.5	15	5.6	122	29	33	0.4	4.2	.01	42	264	148	373	N.A.
2	C. Anderson	29-92-10	8-18-77	WDA	N.A.	N.A.	N.A.	37	N.A.	290	86	N.A.	N.A.	21	N.A.	N.A.	520	N.A.	N.A.	N.A.
3	Jeffrey City Liquors	29-92-10	5-13-77	WDA	N.A.	N.A.	N.A.	110	N.A.	190	140	N.A.	N.A.	4.8	N.A.	N.A.	580	N.A.	N.A.	N.A.
4	Shaw	29-94-5	7-31-79	WDA	N.A.	N.A.	N.A.	104	N.A.	N.A.	300	N.A.	N.A.	0.3	N.A.	N.A.	912	420	N.A.	N.A.
5	Harvey	29-94-6	9-3-75	WDA	N.A	N.A.	N.A.	N.A.	N.A.	N.A.	23	N.A.	N.A.	6.8	N.A.	N.A.	596	150	N.A.	N.A.
6	Sanford Cattle Co.	30-86-35	6-16-67	USGS	9	56	13	27	5.7	228	48	11	0.8	N.A.	.03	35	310	192	480	7.8
7	Sanford Cattle Co. #1	30-85-27	5-20-66	USGS	11	33	6.2	167	1.3	151	340	3.4	1.3	0.1	1.5	14	682	108	970	8
8	Dumbell Ranch	30-86-18	4-28-66	USGS	9	43	7.8	80	1.2	255	85	9.9	2	0.7	N.A.	28	422	140	588	7.8
9	Sanford Cattle Co. #2	30-85-27	6-20-66	USGS	10	580	122	758	6.1	197	3010	183	0.4	0.2	2.7	11	5080	1950	5380	8.2
10	Matador Cattle Co.	31-98-27	7-10-67	USGS	8	36	8	14	4	171	13	2.1	0.3	Tr	.02	27	186	122	306	7.4
11	Cotter Ferguson Mine	32-90-10	6-15-77	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	510	N.A.	N.A.	7.6

Table B-1. (continued)

No.[b]	Source Well Name or Owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp. (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Total Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[e]	Lab pH
	ARIKAREE FORMATION (contd.)																			
12	Cotter Ferguson Mine	32-90-11	7-15-77	N.A.	N.A.	N.A.	N.A.	N.A.		N.A	N.A.	N.A.	N.A.	N.A	N.A.	N.A.	360	N.A.	N.A.	7.6
13	Camron spring	32-90-11	7-15-77	N.A.	N.A.	16	1	73	10	N.A.	77	N.A.	0.1	0.1	N.A.	N.A.	392	32	N.A.	8.9
14	Cotter Ferguson Mine	32-90-27	9-19-78	N.A.	8	32	4	48	8	N.A.	57	6	0.3	0.07	0.1	N.A.	258	N.A.	380	7.9
15	Cotter Ferguson Mine	32-90-11	1-22-79	N.A.	7.8	5.1	1.4	200	8.4	N.A	3.7	29	0.8	0.01	0.5	N.A.	533	N.A.	970	8.4
16	N.A.	31-95-31	7-21-65	USGS	10	35	7.3	17	3.4	180	5.8	5.3	0.3	3.8	0.02	44	211	119	318	7.3
17	unnamed spring	32-90-11	10-3-63	USGS	10	7.8	0.1	79	7.2	206	23	2.4	0.3	1.5	0.16	53	276	20	362	7.9
	WIND RIVER FORMATION																			
1	PMW-3	32-90-3	6-25-77	N.A.	N.A.	N.A.	N.A.	N.A.		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	530		N.A	10.8
2	PMW-8	32-90-3	9-14-77	N.A.	N.A.	81	22	215	16	N.A.	427	11	0.8	<0.5	0.2	N.A.	890	287	1280	7.8
3	PMW-9	32-90-3	9-20-77	N.A.	N.A.	91	22	220	14	N.A.	452	10	0.8	<0.5	0.6	N.A.	937	347	1400	7.8
4	PMW-10	32-90-3	9-22-77	N.A.	N.A.	97	25	210	14	N.A.	470	10	0.7	<0.5	0.6	N.A.	938	335	1450	7.9
5	PMW-15	32-90-3	6-7-78	N.A.	N.A.	89	24	220	18	N.A.	458	11	0.41	<0.6	1.4	N.A.	864	307	1250	N.A.
6	PB-3	32-90-11	11-30-78	N.A.	12.3	51	6.4	170	11	200	411	12	0.78	<0.1	0.4	N.A.	823	N.A	1210	7.9
7	PC-2	32-90-3	1-22-79	N.A.	10	65	20	180	13	205	469	11	0.67	<0.1	0.4	N.A.	872	N.A.	1380	7.9
8	PF-2	32-90-3	11-30-78	N.A	9.8	79	17	86	12	224	291	5	0.48	<0.1	0.3	N.A.	628	N.A.	960	7.7
9	PG-1	32-90-10	1-10-79	N.A	12.9	81	N.A.	N.A.	N.A.	168	N.A.	N.A.	N.A	<0.1	<0.1	N.A.	N.A.	N.A	1190	7.9
10	Pathfinder 4-1	32-90-2	5-7-79	N.A	N.A.	64	9	54	3.1	274	486	15	1	0.08	0.3	N.A.	829	N.A	1290	7.7
11	Pathfinder 34024	32-90-7	1-31-77	N.A.	N.A.	89	11	69	N.A.	N.A.	287	5	.27	0.05	N.A.	N.A.	684	N.A.	N.A	N.A.
12	Pathfinder WGH-3	32-90-8	4-6-79	N.A.	N.A.	96	10	70	18	251	313	5	.9	0.01	0.17	N.A.	700	N.A.	990	7.2
13	Pathfinder WGH-1	32-90-18	12-8-78	N.A.	N.A.	236	32	98	27	236	316	7	.75	0.07	0.3	N.A.	925	N.A.	1260	7.9
14	Pathfinder T1-6	33-90-22	4-10-79	N.A.	N.A.	116	55	564	28	293	237	23	0.8	0.79	1.04	N.A.	2380	N.A.	3070	7.7
15	Pathfinder 502	33-90-22	6-8-57	N.A.	N.A.	278	33	68	10	7	214	9	0.3	Tr	N.A.	N.A.	1370	829	1600	5.3
16	Pathfinder 502	33-90-22	5-8-79	N.A.	N.A.	61	9	48	3	35	1190	25	0.8	0.03	0.1	N.A.	2710	N.A.	3110	–
17	Pathfinder 502	33-90-22	2-14-80	N.A.	N.A.	424	86	260	24	61	1825	24	0.44	7.48	0.84	N.A.	3142	N.A.	3000	6.5
18	Pathfinder	33-90-28	1-14-64	N.A.	N.A.	295	70	27	13	257	780	45	0.4	Tr	N.A.	N.A.	1510	1025	1750	7
19	Pathfinder	33-90-28	11-19-62	N.A.	N.A.	151	29	74	15	252	403	15	0.4	23	N.A.	N.A.	834	496	1193	7.7
20	Pathfinder 154	33-90-28	11-15-64	N.A.	N.A.	106	20	65	14	242	285	5	0.3	0.6	N.A.	N.A.	652	347	921	7.6
21	Pathfinder 647	33-90-32	11-19-62	N.A.	N.A.	240	23	72	12	296	598	8	0.2	0.2	N.A.	N.A.	1144	694	1480	7.5
22	Pathfinder 4L	33-90-35	4-24-75	N.A.	N.A.	N.A.	12	N.A.	N.A.	N.A.	580	9	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
23	Pathfinder 7B	33-90-35	6-1-78	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	14	0.8	0.05	0.1	N.A.	N.A.	N.A.	N.A.	N.A.
24	Adobe Oil & Gas	N.A.	3-7-78	D.M.	N.A.	108	33	67	10	195	374	10	1	0.59	1	N.A.	698	405	885	6.8
25	Adobe Oil & Gas	N.A.	3-8-78	D.M.	N.A.	274	23	11	9	329	506	12	0.37	0.01	1	N.A.	997	778	1235	7.3
26	Union Carbide MW-1	N.A.	3-20-79	D.M.	7.2	398	508	399	Tr	N.A	4641	670	1	N.A.	N.A.	N.A.	7486	5	8400	2.8
27	N.A.	2N-5E-30	10-21-48	USGS	N.A.	10	0.1	248	0.4	163	376	28	1.2	0.8	0.40	10	756	25	1210	8.0
28	N.A.	2N-5E-7	9-17-49	USGS	N.A.	8	10	235	4.8	138	400	18	0.8	0.3	0.24	8.8	754	61	1090	7.2

Table B-1. (continued)

No.[b]	Source Well Name or Owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp. (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Total Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[e]	Lab pH
	WIND RIVER FORMATION (contd.)																			
29	N.A.	2N-6E-19	10-20-48	USGS	N.A.	26	4.6	284	0.8	126	440	94	1.6	1.4	0.22	13	934	84	1480	8.2
30	N.A.	3N-1E-9	11-1-66	USGS	N.A.	201	20	759	2.8	445	1770	67	0.4	0.1	0.16	18	3060	582	3800	7.9
31	N.A.	3N-1E-21	10-14-48	USGS	N.A.	46	2	458	4.4	85	1000	12	0.7	0.3	0.08	13	1580	123	2060	7.5
32	N.A.	3N-1E-21	9-17-49	USGS	N.A.	81	24	86	3.2	284	195	21	1.2	34	0.28	14	601	301	867	7.8
33	N.A.	3N-1E-21	10-14-48	USGS	N.A.	282	73	414	2.4	414	1380	46	1.4	9.8	0.22	28	2440	1000	3030	7.2
34	N.A.	3N-1E-25	9-17-49	USGS	N.A.	320	59	966	6.4	512	2120	163	2.4	92	0.33	14	3910	817	4840	7.8
35	N.A.	3N-1E-36	10-14-48	USGS	N.A.	450	167	748	5.6	342	2760	153	0.7	0.3	0.18	13	4470	1810	4790	7.7
36	N.A.	3N-2E-5	8-14-50	USGS	N.A.	33	0.5	459	1.3	78	990	8.5	0.8	0.8	0.10	10	1540	85	2180	7.5
37	N.A.	3N-2E-6	6-18-51	USGS	N.A.	N.A.	N.A.	253	2.6	134	400	290	N.A.	N.A.	0.12	N.A.	N.A.	391	1830	7.8
38	N.A.	3N-2E-6	6-19-51	USGS	N.A.	N.A.	N.A.	362	3.7	164	945	330	N.A.	N.A.	0.30	N.A.	N.A.	808	2810	7.7
39	N.A.	3N-2E-7	10-29-60	USGS	N.A.	8	Tr	210	0.4	88	345	21	2	Tr	N.A.	16	647	20	974	8.5
40	N.A.	3N-2E-10	10-18-48	USGS	N.A.	6	0.6	174	5.2	44	320	26	1.4	0.4	0.10	14	570	18	913	7.5
41	N.A.	3N-2E-26	10-18-48	USGS	N.A.	46	0.1	445	7.6	22	988	18	0.7	0.2	0.22	13	1530	116	2160	7.1
42	N.A.	3N-2E-27	12-5-50	USGS	N.A.	488	167	282	5.3	256	2190	24	0.7	13	0.15	12	3310	1910	3500	7.1
43	N.A.	3N-2E-20	10-18-48	USGS	N.A.	70	2.6	579	7.2	119	1290	15	0.6	0.3	0.04	15	2040	185	2720	7.5
44	N.A.	3N-3E-6	10-26-51	USGS	N.A.	0.9	0.1	97	0.2	74	42	38	1.6	0.4	0.21	21	270	3	446	9.7
45	N.A.	3N-3E-16	10-18-48	USGS	N.A.	12	0.1	217	1.2	34	394	36	2.0	Tr	0.27	17	696	30	1100	8.0
46	N.A.	3N-3E-24	10-20-48	USGS	N.A.	460	179	714	10	175	2980	69	1.2	0.8	0.98	16	4520	1880	5160	7.9
47	N.A.	3N-3E-26	10-19-48	USGS	N.A.	27	0.1	332	4.0	23	664	59	1.0	0.3	0.12	11	1110	68	1660	7.1
48	N.A.	3N-4E-29	9-17-49	USGS	N.A.	74	7.9	473	4.8	416	848	17	1.1	0.7	0.28	9.2	1640	217	2190	7.8
49	N.A.	3N-5E-33	10-16-48	USGS	N.A.	206	41	735	3.2	330	1760	58	1.1	44	0.34	19	3030	682	3830	7.6
50	N.A.	3N-6E-15	10-27-60	USGS	N.A.	4.8	1.0	179	0.6	168	234	12	3.0	0.7	N.A.	10	530	16	847	8.3
51	N.A.	4N-1E-11	11-2-66	USGS	N.A.	149	15	1500	6.3	212	3250	77	1.2	0.1	0.07	6.9	5110	435	6300	7.8
52	N.A.	4N-1E-18	11-2-66	USGS	N.A.	36	2.9	582	0.2	131	1190	14	0.4	0.1	0.05	11	1910	102	2670	8.0
53	N.A.	4N-2E-29	8-14-50	USGS	N.A.	31	0.1	548	1.8	64	1090	48	1.1	0.3	0.10	12	1770	78	2560	8.2
54	N.A.	4N-3E-13	10-26-51	USGS	N.A.	5.5	0.1	256	0.6	32	435	49	2	0.4	0.35	10	791	14	1270	9.5
55	N.A.	4N-3E-34	10-26-51	USGS	N.A.	7.5	0.1	264	0.2	43	500	35	1.8	0.4	0.24	12	842	19	1320	7.2
56	N.A.	4N-3E-36	10-29-60	USGS	N.A.	320	224	520	8.2	254	2510	56	1	Tr	N.A.	28	3790	1720	6180	7.7
57	N.A.	4N-4E-20	10-26-51	USGS	N.A.	31	0.9	556	0.9	34	1020	160	3.2	0.3	0.22	8	1800	81	2740	7.2
58	N.A.	4N-4E-23	6-26-51	USGS	N.A.	14	0.7	380	0.6	78	415	260	4	0.3	0.15	6.8	1120	38	1870	7.5
59	N.A.	4N-4E-23	10-19-48	USGS	N.A.	186	69	354	6	285	1150	34	0.8	Tr	0.14	13	1960	748	2490	7.5
60	N.A.	5N-4E-21	10-26-66	USGS	N.A.	34	8.0	819	3	72	1370	335	2.2	0.1	0.19	5.7	2610	118	3810	7.5
61	N.A.	5N-5E-33	10-26-66	USGS	N.A.	52	7.9	1070	3	76	1800	416	3.8	0.1	0.23	4.9	3390	162	4730	7.9
62	N.A.	3N-1W-24	9-17-49	USGS	N.A.	70	29	124	3.2	405	175	16	1.4	15	0.31	32	680	294	964	8.2
63	N.A.	3N-3W-4	11-4-65	USGS	N.A.	39	17	6.6	0.8	190	23	1	0.5	0.7	0.01	23	205	168	340	7.8
64	N.A.	4N-1W-4	10-31-66	USGS	N.A.	9.6	1.9	261	1	140	406	51	1.4	0.1	0.09	5.4	808	32	1280	8.3
65	N.A.	4N-1W-25	12-19-66	USGS	N.A.	32	3.2	342	1.8	50	763	15	0.5	0.5	0.03	1.8	1190	93	1770	8.5

Table B-1. (continued)

No.[b]	Source Well name or owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Total Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[e]	Lab pH
	WIND RIVER FORMATION (cont.)																			
66	N.A.	6N-3W-33	10-31-66	USGS	N.A.	11	0.1	294	0.4	90	438	86	3.4	0.1	0.17	6.2	883	28	1380	8.0
67	N.A.	1S-3E-2	11-4-64	USGS	N.A.	27	5	80	1	211	58	Tr	N.A.	N.A.	2	N.A.	N.A.	N.A.	540	7.3
68	N.A.	1S-3E-7	11-3-66	USGS	N.A.	102	15	56	2	180	258	8.6	0.7	0.9	0.06	12	543	315	797	7.8
69	N.A.	1S-3E-10	10-29-64	USGS	N.A.	1	2	175	1	211	125	14	N.A.	Tr	0.12	N.A.	N.A.	N.A.	569	8.8
70	N.A.	1S-3E-10	10-27-64	USGS	N.A.	3	3	155	Tr	153	157	11	1	Tr	0.18	N.A.	N.A.	N.A.	569	8.2
71	N.A.	1S-3E-13	11-12-64	USGS	N.A.	28	4	190	1	211	285	12	N.A.	Tr	0.12	N.A.	N.A.	88	983	8.2
72	N.A.	1S-3E-13	11-19-64	USGS	N.A.	148	16	310	3	241	873	37	1	8	0.12	N.A.	N.A.	438	2210	7.9
73	N.A.	1S-3E-14	11-19-64	USGS	N.A.	163	5	580	1	85	1640	36	0.8	0.7	0.09	N.A.	N.A.	430	3380	7.8
74	N.A.	1S-3E-17	11-3-65	USGS	N.A.	59	12	73	2.1	162	208	8.2	0.9	0.3	0.10	17	461	196	696	7.8
75	N.A.	1S-3E-23	11-19-64	USGS	N.A.	146	39	130	1	226	501	57	0.4	Tr	0.05	N.A.	N.A.	525	1350	7.7
76	N.A.	1S-3E-23	5-18-45	USGS	N.A.	1.5	2.2	150	N.A.	166	155	9	0.5	Tr	N.A.	N.A.	416	12	688	N.A.
77	N.A.	1S-3E-24	11-19-64	USGS	N.A.	5	2	175	1	122	239	14	1.1	Tr	0.09	N.A.	N.A.	23	879	8.6
78	N.A.	1S-4E-4	9-30-64	USGS	N.A.	2	1	139	1	223	139	4	1.1	0.04	N.A.	7	426	N.A.	670	8.5
79	N.A.	1S-4E-18	10-16-64	USGS	N.A.	424	58	521	3	305	1960	43	N.A.	Tr	0.36	N.A.	N.A.	2590	3730	7.6
80	N.A.	1S-4E-18	10-26-64	USGS	N.A.	4	2	150	1	156	132	11	1.2	Tr	0.14	N.A.	N.A.	19	697	8.8
81	N.A.	1N-1E-3	8-31-66	USGS	N.A.	16	9.7	96	2.5	204	103	20	0.6	0.2	0.19	1.8	350	100	610	8.0
82	N.A.	3N-1E-16	10-19-48	USGS	N.A.	81	8.2	171	4.0	157	426	17	0.3	1.2	0.12	15	802	236	1200	7.5
83	N.A.	3N-1E-17	11-8-65	USGS	N.A.	4.2	0.4	148	0.4	52	251	15	2.4	Tr	0.33	11	461	12	743	8.4
84	N.A.	4N-1E-3	10-20-48	USGS	N.A.	64	15	98	0.8	388	84	7	0.6	19	0.2	26	508	221	784	7.9
85	N.A.	4N-1E-12	10-21-48	USGS	N.A.	42	14	21	0.8	145	68	20	0.4	0.5	0.3	19	249	162	385	8.3
86	N.A.	4N-1E-24	10-21-48	USGS	N.A.	5	2.2	226	0.8	85	368	39	2.0	0.4	0.38	12	703	22	1090	8.3
87	N.A.	4N-1E-27	10-21-60	USGS	N.A.	1.6	1.0	126	1.6	184	107	9	0.6	0.6	N.A.	13	360	8	574	8.5
88	N.A.	4N-1E-27	10-22-48	USGS	N.A.	6.5	0.3	142	0.4	191	125	9.9	0.4	0.8	0.22	13	401	17	664	8.6
89	N.A.	4N-1E-27	9-3-54	USGS	N.A.	1.5	0.1	142	1.7	185	117	9	0.4	Tr	N.A.	11	386	4	613	8.9
90	N.A.	4N-1E-27	12-3-65	USGS	N.A.	0.8	0.2	136	0.9	204	122	11	0.6	Tr	0.1	12	384	3	627	8.2
91	N.A.	4N-1E-32	10-15-48	USGS	N.A.	8.5	0.2	155	2.8	131	220	16	3.6	0.2	0.34	9.5	482	22	768	8.2
92	N.A.	4N-1E-34	10-27-51	USGS	N.A.	2.9	0.1	160	0.5	192	161	13	0.4	0.6	0.16	11	453	7	725	8.7
93	N.A.	4N-1E-34	12-2-65	USGS	N.A.	1.2	1.7	165	1.4	187	174	11	0.8	Tr	0.13	7.5	465	10	769	8.[illegible]
94	N.A	4N-1E-34	12-2-65	USGS	N.A.	0.8	0.1	132	0.9	165	99	8.9	0.7	Tr	0.07	8.3	353	2	470	8.7
95	N.A.	4N-1E-34	10-26-51	USGS	N.A.	23	1.1	125	0.7	191	96	10	0.6	0.5	0.24	12	351	10	562	8.6
96	N.A.	1N-2E-24	9-15-65	USGS	N.A.	94	14	15	3.1	334	47	3	0.4	1.7	0.05	26	368	293	586	8
97	N.A.	NN-2E-4	9-17-49	USGS	N.A.	370	70	403	6.4	236	1780	20	0.2	17	0.30	10	2790	1210	3140	7.3
98	N.A.	2N-2E-15	10-18-48	USGS	N.A.	37	5.9	167	18	386	140	23	1.0	0.6	0.08	14	600	116	916	7.9
99	N.A.	2N-2E-17	10-18-48	USGS	N.A.	34	1.5	148	1.2	186	232	6.5	0.5	Tr	0.12	25	542	91	825	7.7
100	N.A.	2N-2E-18	11-1-60	USGS	N.A.	59	7.8	72	2.0	190	170	4.0	0.8	0.7	N.A.	0	429	179	658	8.0
101	N.A.	3N-2E-10	10-19-48	USGS	N.A.	23	3.4	250	3.6	152	448	7.6	1.4	Tr	0.25	11	824	72	1240	7.4
102	N.A.	3N-2E-19	9-17-49	USGS	N.A.	14	0.6	235	4.0	35	456	41	1.2	0.6	0.48	10	782	38	1130	7.3
103	N.A.	3N-2E-26	9-17-49	USGS	N.A.	62	0.5	579	4.8	28	1250	82	1.2	41	0.52	10	2050	157	2770	6.9

Table B-1. (continued)

No.[b]	Source Well Name or Owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp. (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[e]	Lab pH
	WIND RIVER FORMATION (contd.)																			
104	N.A.	4N-2E-2	10-20-48	USGS	N.A.	13	1.7	343	2.4	561	3.2	258	2.8	0.4	0.66	16	926	40	1610	7.9
105	N.A.	4N-2E-10	9-17-49	USGS	N.A.	16	0.4	260	4.8	34	456	92	1.2	0.3	0.46	10	858	42	1280	6.8
106	N.A.	4N-2E-17	10-20-48	USGS	N.A.	12	1.3	350	21	625	224	20	1.0	4.4	0.24	12	972	36	1470	8.3
107	N.A.	5N-2E-2	10-20-48	USGS	N.A.	14	1.5	261	0.8	34	444	97	2.8	0.2	0.43	16	854	41	1360	7.7
108	Union Carbide MW-2	N.A.	2-27-79	D.M.	8.3	138	23	57	13	N.A.	389	29	1	N.A.	N.A.	N.A.	772	126	1300	5.7
109	Union Carbide MW-3	N.A.	3-6-79	D.M.	8.6	718	800	480	31	N.A.	4767	363	2	N.A.	N.A.	N.A.	7827	641	9800	6.6
110	Union Carbide MW-3	N.A.	3-7-79	D.M.	10.6	714	800	500	29	N.A.	4759	373	1	N.A.	N.A.	N.A.	7938	663	7400	6.1
111	Union Carbide MW-4	N.A.	3-19-79	D.M.	8.3	288	77	67	19	N.A.	1146	39	1	N.A.	N.A.	N.A.	1757	23	2500	5.7
112	Union Carbide MW-6	N.A.	3-20-79	D.M.	8.9	695	104	59	20	N.A.	1807	134	2	N.A	N.A.	N.A.	3076	106	4200	6.4
113	Union Carbide MW-7	N.A.	3-20-79	D.M.	8.6	579	117	49	31	N.A.	1928	49	1	N.A.	N.A.	N.A.	2931	5	N.A.	3.9
114	Union Carbide MW-8	N.A	3-19-79	D.M.	8.6	375	449	447	62	N.A.	5962	245	1	N.A.	N.A.	N.A.	9705	5	8400	3.9
115	Union Carbide MW-9	N.A.	3-15-79	D.M.	N.A.	55	9	17	7	N.A.	388	108	1	N.A.	N.A.	N.A.	354	5	N.A	3
116	Union Carbide MW-10	N.A.	3-20-79	D.M.	8.5	686	133	394	27	N.A.	2699	625	2	N.A.	N.A.	N.A.	4391	5	5800	4.4
117	Union Carbide MW-10	N.A.	4-5-79	D.M.	8.3	667	126	263	24	N.A.	2213	901	2	N.A.	N.A.	N.A.	4025	308	5790	6.5
118	Union Carbide MW-16	N.A.	3-6-79	D.M	8.3	785	177	700	37	N.A.	2032	893	1	N.A.	N.A.	N.A.	5760	5	6500	3.2
119	Union Carbide MW-17	N.A.	3-20-79	D.M.	8.3	474	103	117	210	N.A.	1262	130	1	N.A.	N.A.	N.A.	2554	196	3500	7.4
120	Union Carbide MW-18	N.A.	3-2-79	D.M.	8.3	27	5	24	4	N.A.	120	98	1	N.A.	N.A.	N.A.	175	40	300	6.6
121	Union Carbide MW-19	N.A.	3-14-79	D.M	9.1	74	18	34	7	N.A.	271	75	1	N.A.	N.A.	N.A.	438	75	720	6.5
122	Union Carbide MW-20	N.A.	3-12-79	D.M.	9.9	615	467	252	22	N.A.	3005	380	1	N.A.	N.A.	N.A.	5187	519	6000	6.6
123	Union Carbide MW-205	N.A.	3-20-79	D.M.	5	669	920	600	39	N.A.	5354	105	2	N.A.	N.A.	N.A.	8436	636	9600	6.6
124	N.A.	1S-5E-11	11-5-65	USGS	17	150	39	340	7.4	469	782	77	1.2	0.3	0.33	16	1710	534	2320	8.0
125	N.A.	1N-5E-12	12-3-65	USGS	N.A.	51	22	92	5.4	177	270	7.1	1.6	Tr	0.10	19	590	219	869	8.1
126	N.A.	33-90-32	1-15-65	USGS	8.8	144	22	65	14	271	366	4.3	0.2	230	N.A.	26	777	N.A.	1808	7
127	N.A.	N.A.	8-17-65	USGS	10	31	20	10	4.2	159	36	11	N.A.	N.A.	N.A	14	205	160	430	7.5
128	N.A.	N.A.	1-15-64	USGS	27	106	20	65	14	232	285	4.8	0.3	265	N.A.	21	652	N.A.	921	7
129	N.A.	35-90-2	7-27-65	USGS	10	150	39	25	5.4	101	504	7.1	0.6	N.A.	N.A.	10	834	534	1200	7.8
130	N.A.	36-94-36	9-28-65	USGS	10	88	36	720	4.1	201	1620	16	0.9	50	N.A.	5	2560	368	3500	N.A.
131	N.A.	37-91-23	10-18-60	USGS	N.A.	47	1.5	540	1.4	34	1150	21	2	265	N.A.	6	1910	N.A.	2690	8.2
	FORT UNION FORMATION																			
1	N.A.	1S-2E-9	5-18-45	USGS	N.A.	15	12	598	N.A.	390	730	182	1.2	4.3	N.A.	N.A.	1750	87	1760	8.4
2	N.A.	1S-2E-10	11-14-51	USGS	N.A.	71	4.1	716	N.A.	138	1520	37	1.2	1.0	0.21	7.4	2430	275	1720	8.6
3	Seaboard Oil Co.	36-94-31	7-18-55	CGL	N.A.	1	Tr	1241	N.A.	2590	37	98	N.A.	N.A.	N.A.	N.A.	2894	N.A.	N.A.	8.4
4	Seaboard Oil Co.	36-94-31	6-20-55	CGL	N.A.	16	28	2212	N.A.	2000	2625	265	N.A.	N.A.	N.A.	N.A.	6264	N.A.	N.A.	8.3
5	Seaboard Oil Co.	36-94-31	6-20-55	CGL	N.A.	130	32	2746	N.A	610	5407	130	N.A	N.A.	N.A.	N.A.	8817	N.A	N.A	8.4
6	Seaboard Oil Co.	34-92-8	N.A.	CGL	N.A.	89	22	1112	N.A	390	2064	160	N.A	N.A	N.A	N.A	3639	N.A.	N.A	8.3

Table B-1. (continued)

No.[b]	Source Well Name or Owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp. (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Total Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[c]	Lab pH
	FORT UNION FORMATION (contd.)																			
7	Monsanto Co.	39-91-25	6-30-80	CGL	N.A.	3311	21	4241	200	381	30	12400	N.A.	N.A.	N.A.	N.A	20390	N.A.	N.A.	5.6
8	Monsanto Co.	39-91-35	6-9-80	CGL	N.A.	85	7	2779	50	1525	21	3600	N.A.	N.A.	N.A.	N.A.	7293	N.A	N.A	7.3
9	Monsanto Co.	39-91-35	6-9-80	CGL	N.A.	2269	20	2779	250	549	24	8250	N.A.	N.A.	N.A.	N.A.	13862	N.A	N.A.	6.9
10	Monsanto Co.	39-91-35	6-30-80	CGL	N.A	275	5	2518	49	1708	49	3400	N.A.	N.A.	N.A.	N.A.	7137	N.A.	N.A.	6.6
11	Unnamed spring	36-86-36	4-28-81	CGL	9	8	1	317	1	532	Tr	78	5.8	Tr	N.A.	N.A.	767	24	1200	8.6
	MESAVERDE FORMATION																			
1	Clark Oil Prod. Co.	33-86-36	8-12-77	CGL	N.A.	65	18	726	18	817	1000	90	N.A.	N.A.	N.A.	N.A.	3219	N.A.	N.A.	8
2	Unnamed spring	37-87-24	4-28-81	CGL	10	20	8	830	4	955	920	164	.86	.23	N.A.	N.A.	2646	83	3450	8.6
	FRONTIER FORMATION																			
1	Midwest Refining Co.	3-1-27	N.A.	MRC	N.A.	24	57	1698	N.A.	2472	N.A.	1395	N.A.	N.A.	N.A.	N.A	4383	N.A	N.A.	N.A
2	Alkali Butte #1	33-95-1	N.A	CGL	N.A.	N.A.	N.A.	243	N.A.	4560	29	5929	N.A.	N.A.	N.A.	N.A.	13776	N.A.	N.A.	N.A
3	Alkali Butte #1	34-95-36	N.A.	CGL	N.A.	N.A.	N.A.	106	N.A.	1515	19	2609	N.A	N.A.	N.A.	N.A	6028	N.A.	N.A.	N.A.
4	Sand Draw #2	32-95-9	N.A.	CGL	N.A.	18	Tr	2384	N.A.	1586	50	2750	N.A.	N.A.	N.A.	N.A.	5982	N.A.	N.A.	N.A
5	N.A.	1N-1E-33	10-30-57	USGS	N.A.	0.4	0.3	772	3.5	951	500	57	N.A.	N.A.	3.8	N.A.	1800	N.A.	2530	9.1
6	N.A.	8N-2E-7	7-22-46	USGS	N.A.	10	8.1	1510	N.A.	516	2700	52	2.8	10	N.A.	N.A.	4600	58	5660	8.4
7	N.A.	4N-4E-14	11-4-65	USGS	N.A.	33	11	680	2.4	166	1230	116	1.6	1	2	7.4	2170	126	3170	7.9
8	N.A.	1S-1W-8	5-19-45	USGS	N.A.	1	1.3	435	N.A.	430	430	20	3.8	Tr	N.A.	N.A.	1170	8	1800	N.A.
9	N.A.	2N-1W-7	5-10-63	USGS	N.A.	N.A.	N.A.	680	N.A.	N.A.	N.A.	N.A.	0.95	N.A.	N.A.	N.A.	2350	25	N.A.	8.6
10	Sohio #4	32-95-36	8-8-55	CGL	N.A.	1	Tr	868	N.A.	1355	317	150	N.A.	N.A.	N.A.	N.A.	2146	N.A.	N.A.	8.6
11	Pan Canadian Pet. Co.	36-94-25	2-4-76	CGL	N.A.	100	139	2790	49	2928	850	2600	N.A.	N.A.	N.A.	N.A.	7970	N.A.	N.A.	8.1
12	N.A.	4N-4E-16	7-23-46	CGL	N.A.	114	41	445	N.A.	332	1060	30	0.8	1.6	N.A.	N.A.	1930	N.A.	N.A.	N.A
13	Hedges	32-99-9	8-23-74	WDA	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	123	N.A.	N.A.	1.1	N.A.	N.A.	432	296	N.A.	N.A
14	Knight	32-99-10	4-25-78	WDA	N.A.	N.A.	N.A.	74	N.A.	N.A.	410	N.A.	N.A.	6.2	N.A	N.A	808	350	N.A.	N.A.
15	Hedges	32-99-9	6-15-79	WDA	N.A.	N.A.	N.A.	190	N.A.	N.A.	170	N.A.	N.A	1.0	N.A.	N.A.	488	25	N.A.	N.A
16	Clark	32-99-9	4-27-78	WDA	N.A.	N.A.	N.A.	269	N.A.	N.A.	2080	N.A.	N.A.	61	N.A.	N.A.	4000	1930	N.A.	N.A.
17	States	32-99-9	8-10-76	WDA	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	500	N.A.	N.A.	N.A
18	Wanner	32-99-10	11-6-75	WDA	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	38	N.A.	N.A.	0.3	N.A.	N.A.	420	350	N.A.	N.A
19	Davis	32-99-9	5-17-79	WDA	N.A.	N.A.	N.A.	370	N.A.	N.A.	620	N.A.	N.A.	Tr	N.A.	N.A.	751	11	N.A.	N.A
20	N.A.	32-95-9	N.A.	CGL	N.A.	16	5	2252	N.A.	1518	26	2600	N.A.	N.A.	N.A.	N.A.	5640	N.A.	N.A.	N.A.
21	K. Martinsen	32-99-10	6-27-77	WDA	N.A.	N.A.	N.A.	17	N.A.	N.A.	20	N.A.	N.A.	Tr	N.A.	N.A.	392	270	N.A.	N.A.
22	B. Ilams	33-99-28	6-30-74	WDA	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	1745	N.A	N.A.	1.7	N.A.	N.A.	2820	N.A.	N.A.	N.A.
23	B. Ilams	33-99-27	12-5-77	WDA	N.A.	N.A.	N.A.	25	N.A.	N.A.	94	N.A.	N.A.	0.13	N.A.	N.A.	460	410	N.A.	N.A.
24	Kotunok	33-99-29	11-10-75	WDA	N.A	N.A.	N.A	N.A.	N.A.	N.A	470	N.A.	N.A.	N.A.	N.A.	N.A.	1980	1000	N.A.	N.A.
25	N.A.	6-3-27	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1328	55	80	N.A.	N.A.	N.A.	N.A.	1369	N.A.	N.A.	N.A.

Table B-1. (continued)

No.[b]	Source Well Name or Owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp. (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Total Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[e]	Lab pH
	FRONTIER FORMATION (contd)																			
	N.A.	6-3-27	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1260	55	81	N.A.	N.A.	N.A.	N.A.	1331	N.A.	N.A.	N.A.
	N.A.	6-3-35	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1239	Tr	78	N.A.	N.A.	N.A.	N.A.	1215	N.A.	N.A.	N.A.
	N.A.	4-1-29	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	4062	130	2300	N.A.	N.A.	N.A.	N.A.	7530	N.A.	N.A.	N.A.
	N.A.	3-1-14	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1554	26	2786	N.A.	N.A.	N.A.	N.A.	5982	N.A.	N.A.	N.A.
	N.A.	3-1-14	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	6392	40	3591	N.A.	N.A.	N.A.	N.A.	11536	N.A.	N.A.	N.A.
	N.A.	3-1-14	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	4192	16	3700	N.A.	N.A.	N.A.	N.A.	9748	N.A.	N.A.	N.A.
	N.A.	3-1-15	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	3500	Tr	3900	N.A.	N.A.	N.A.	N.A.	9439	N.A.	N.A.	N.A.
	N.A.	3-1-15	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	3300	25	2891	N.A.	N.A.	N.A.	N.A.	7667	N.A.	N.A.	N.A.
	N.A.	3-1-16	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1304	98	1800	N.A.	N.A.	N.A.	N.A.	4246	N.A.	N.A.	N.A.
	N.A.	3-1-33	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	3108	Tr	1400	N.A.	N.A.	N.A.	N.A.	5010	N.A.	N.A.	N.A.
	N.A.	3-1-34	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	2269	Tr	1300	N.A.	N.A.	N.A.	N.A.	4113	N.A.	N.A.	N.A.
	N.A.	2-1-27	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	4611	20	1631	N.A.	N.A.	N.A.	N.A.	8743	N.A.	N.A.	N.A.
	N.A.	37-86-35	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1700	Tr	3150	N.A.	N.A.	N.A.	N.A.	6665	N.A.	N.A.	N.A.
	N.A.	34-91-36	1962	CGL	N.A.	N.A	N.A.	N.A.	N.A.	2431	207	578	N.A.	N.A.	N.A.	N.A.	3379	N.A.	N.A.	N.A.
	N.A.	34-91-36	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	2945	141	598	N.A.	N.A.	N.A.	N.A.	3763	N.A.	N.A.	N.A
	N.A.	34-89-1	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	2360	761	6500	N.A.	N.A.	N.A.	N.A.	13877	N.A.	N.A.	N.A.
	N.A	34-89-1	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	3760	4	2540	N.A.	N.A.	N.A.	N.A.	7458	N.A.	N.A	N.A.
	N.A.	34-89-30	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1354	721	700	N.A.	N.A.	N.A.	N.A.	3394	N.A.	N.A.	N.A.
	N.A.	33-96-14	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1960	16	5900	N.A.	N.A.	N.A.	N.A.	11445	N.A.	N.A.	N.A.
	N.A.	33-96-21	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	2095	50	3235	N.A.	N.A.	N.A.	N.A.	7220	N.A.	N.A.	N.A.
	N.A.	33-95-21	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	2096	30	2633	N.A.	N.A.	N.A.	N.A.	6053	N.A.	N.A.	N.A.
	N.A.	33-92-1	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1733	20	3381	N.A.	N.A.	N.A.	N.A.	7111	N.A.	N.A.	N A.
	N.A.	33-92-3	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1970	Tr	3920	N.A.	N.A.	N.A.	N.A.	8174	N.A.	N.A.	N.A.
	N.A.	33-84-11	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	510	21	2989	N.A.	N.A.	N.A.	N.A.	5375	N.A.	N.A.	N.A.
	N.A.	32-95-26	1962	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	4720	46	3040	N.A.	N.A.	N.A.	N.A.	9165	N.A.	N.A.	N.A.
	MUDDY SANDSTONE																			
	N.A.	32-85-22	N.A.	USGS	N.A.	N.A.	N.A.	N.A.	N.A.	4470	Tr	2800	N.A.	N.A.	N.A.	N.A.	8493	N.A.	N.A	N.A.
	N.A.	32-85-22	N.A.	USGS	N.A.	N.A.	N.A.	N.A.	N.A.	5120	69	2680	N.A.	N.A.	N.A.	N.A.	8938	N.A.	N.A.	N.A.
	Hancock	32-99-22	3-17-78	USGS	N.A.	N.A.	N.A.	212	N.A.	N.A.	640	N.A.	N.A.	0.4	N.A.	N.A.	1640	760	N.A.	N.A.
	N.A.	32-85-15	N.A.	USGS	N.A.	N.A.	N.A.	N.A.	N.A.	4904	5	2620	N.A.	N.A.	N.A.	N.A.	8550	N.A.	N.A.	N.A.
	N.A.	32-85-16	N.A.	USGS	N.A.	N.A.	N.A.	N.A.	N.A.	5960	35	2780	N.A.	N.A.	N.A.	N.A.	9786	N.A.	N.A.	N.A.
	N.A.	32-86-13	N.A.	USGS	N.A.	N.A.	N.A.	N.A.	N A.	2904	16	2220	N.A.	N.A.	N.A.	N.A	6191	N.A	N.A.	N.A.
	N.A.	32-85-14	N.A.	USGS	N.A	N.A	N.A	N.A	N.A.	1915	Tr	1560	N.A.	N A.	N.A.	N.A.	4226	N A	N.A.	N.A.
	N.A.	32-86-15	N.A	USGS	N.A	N A	N.A.	N.A	N.A.	1777	Tr	460	N.A	N A	N.A	N A	2298	N A	N.A.	N.A.
	N.A.	33-98-19	N.A.	USGS	N.A.	N.A.	N.A.	N A.	N.A.	170	772	14	N.A.	N.A.	N.A.	N.A.	1310	N.A.	N.A.	N.A.
	N.A.	33-87-16	N.A.	USGS	N.A.	N.A.	N.A.	N.A.	N.A.	1763	56	25	N.A.	N.A.	N.A.	N.A.	1658	N.A.	N.A.	N.A.

Table B-1. (continued)

No.[b]	Source Well Name or Owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp. (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Total Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[e]	Lab pH
	MUDDY SANDSTONE (contd.)																			
	N.A.	33-87-8	12-19-73	USGS	N.A.	N.A.	N.A.	N.A.	N.A.	3018	49	1780	N.A.	N.A.	N.A.	N.A.	5625	N.A.	N.A.	N.A.
	N.A.	33-87-7	N.A.	USGS	N.A.	N.A.	N.A.	N.A.	N.A.	2548	24	2200	N.A.	N.A.	N.A.	N.A.	5876	N.A.	N.A.	N.A.
	N.A.	34-87-15	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	990	44	26150	N.A.	N.A.	N.A.	N.A.	43789	N.A.	N.A.	N.A.
	N.A.	5-2-23	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	3580	61	690	N.A.	N.A.	N.A.	N.A.	4338	N.A.	N.A.	N.A.
	N.A.	4-1-19	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	2293	235	3006	N.A.	N.A.	N.A.	N.A.	7292	N.A.	N.A.	N.A.
	N.A.	4-1-32	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1998	16	3518	N.A.	N.A.	N.A.	N.A.	7553	N.A.	N.A.	N.A.
	N.A.	3-1-27	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	7368	4	830	N.A.	N.A.	N.A.	N.A.	7781	N.A.	N.A.	N.A.
	N.A.	3-1-27	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	4740	11	935	N.A.	N.A.	N.A.	N.A.	5669	N.A.	N.A.	N.A.
	N.A.	33-87-3	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	4510	8	3760	N.A.	N.A.	N.A.	N.A.	10115	N.A.	N.A.	N.A.
	N.A.	32-86-14	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1915	Tr	1560	N.A.	N.A.	N.A.	N.A.	4226	N.A.	N.A.	N.A.
	N.A.	32-85-12	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	4150	Tr	2700	N.A.	N.A.	N.A.	N.A.	8058	N.A.	N.A.	N.A.
	N.A.	31-82-20	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1455	914	104	N.A.	N.A.	N.A.	N.A.	2786	N.A.	N.A.	N.A.
	N.A.	31-82-26	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	2031	62	200	N.A.	N.A.	N.A.	N.A.	2175	N.A.	N.A.	N.A.
	N.A.	31-82-27	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1768	21	295	N.A.	N.A.	N.A.	N.A.	2055	N.A.	N.A.	N.A.
	N A.	31-82-35	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	1892	115	250	N.A.	N.A.	N.A.	N.A.	2204	N.A.	N.A.	N.A.
	CLOVERLY FORMATION																			
1	Pathfinder	33-98-15	7-16-64	N.A.	N.A.	23	6.9	120	7.0	288	111	6	1.2	1.0	0.42	N.A.	445	86	694	7.6
2	Pathfinder	33-90-15	1-15-64	N.A.	N.A.	5.1	Tr	395	2.0	336	533	17	1.5	Tr	N.A.	14	1150	13	1760	8.5
3	Pathfinder	33-90-22	4-25-75	N.A.	N.A.	1.9	0.4	390	1.9	N.A.	571	12	1.6	0.6	0.6	N.A.	1150	6.9	N.A.	8.6
4	Pathfinder	33-90-23	1-15-64	N.A.	N.A.	47	8.5	198	5.4	192	405	10	0.4	1.0	N.A.	N.A.	792	153	1180	6.9
5	Pathfinder	33-90-28	9-19-61	N.A.	N.A.	36	7.8	232	5.6	219	390	9	0.5	1.4	N.A.	N.A.	806	122	1230	6.8
6	N.A.	N.A.	1-1-64	USGS	25	5	Tr	396	2	336	533	17	1.5	Tr	N.A	N.A.	1150	N.A.	N.A.	8.5
7	Pan Canadian Pet. Co.	36-94-25	6-23-76	CGL	N.A.	309	36	10821	718	5392	2250	13200	N.A.	N.A.	N.A.	N.A.	29990	N.A.	N.A.	7.9
8	Clark Oil Prod. Co.	33-86-36	8-.2-79	CGL	N.A.	3	2	359	5	537	38	144	N.A.	N.A.	N.A.	N.A.	887	N A	N A.	8.7
9	Sohio Co.	31-82-35	11-15-55	CGL	N.A.	15	32	856	N.A.	1390	115	250	N.A.	N.A.	N.A.	N.A.	2204	N.A.	N.A.	8.6
10	Alkali Butte #2	N.A.	N.A.	CGL	N.A.	N.A.	N.A.	4682	N.A.	600	705	4682	N.A.	N.A.	N.A.	N.A.	11719	N.A.	N.A.	N A.
11	N.A.	32-86-15	N.A.	USGS	N.A.	N.A.	N.A.	N.A.	N.A.	534	712	8	N.A.	N.A.	N.A.	N.A.	1529	N.A.	N.A.	N.A.
12	N.A	34-88-20	N.A.	CGL	N.A.	N.A.	N.A.	N.A.	N.A.	2118	67	132	N.A.	N.A.	N.A.	N.A.	2158	N.A.	N.A.	N.A.
	NUGGET SANDSTONE																			
1	Pan Canadian Pet. Co.	36-94-25	4-13-76	CGL	N.A.	10	3	1059	10	891	1100	240	N.A.	N.A.	N.A.	N.A.	2945	N.A	N.A.	8.6
2	Atkins	33-100-21	5-19-76	WDA	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	1430	N.A	N.A.	2.8	N.A.	N.A.	2090	1450	N.A.	N.A.

Table B-1. (continued)

No.[b]	Source Well Name or Owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp. (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Total Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[e]	Lab pH
	SUNDANCE FORMATION																			
	Unnamed spring	32-99-34	10-14-65	USGS	10	1.8	0.4	297	0.8	380	239	6.6	2.3	0.8	0.79	10	799	6	1300	9.1
	PHOSPHORIA FORMATION																			
1	Gulf Oil & Mineral	N.A.	6-4-79	CGL	N.A.	260	114	1190	92	366	2290	810	N.A.	N.A.	N.A.	N.A.	4936	N.A.	N.A.	7.7
2	Pan Canadian Pet. Co.	36-94-26	6-15-76	CGL	N.A.	583	60	13226	995	4148	2100	16000	N.A.	N.A.	N.A.	N.A.	37167	N A.	N A.	8.4
3	Sohio #1	33-99-26	11-16-55	CGL	31	69	51	25	N.A.	370	100	33	N.A.	N.A.	N.A.	N.A.	447	N.A.	N.A	8.1
4	Sohio #1a	33-99-26	10-25-55	CGL	34	91	34	83	N.A.	508	12	84	N.A	N A	N.A.	N.A.	554	N.A	N.A	7 2
5	Sohio #4	32-95-36	9-6-55	CGL	31	289	39	932	N.A.	890	1827	140	N.A	N.A.	N.A.	N.A.	3713	N.A.	N.A.	8.4
6	Sohio	33-99-26	11-16-55	CGL	33	114	107	924	N.A.	1890	963	60	N.A.	N.A.	N.A.	N.A.	3158	N.A.	N.A.	8.3
7	Sohio	33-99-26	10-25-55	CGL	N.A.	187	49	1449	N.A.	1220	1181	280	N.A.	N.A.	N.A.	N.A.	4466	N.A	N.A.	9.3
8	Sohio	33-99-26	10-25-55	CGL	N.A.	16	5	1245	N.A.	1290	1535	80	N.A.	N.A.	N.A.	N.A.	3516	N.A.	N.A.	8.1
9	Sohio	33-99-26	10-6-55	CGL	N.A.	60	34	43	N.A.	440	10	8	N.A.	N.A.	N.A.	N.A.	372	N.A	N.A	7.6
10	Sohio	33-99-26	10-6-55	CGL	N.A.	28	10	1034	N.A.	710	1024	80	N.A.	N.A	N.A.	N.A.	2886	N.A	N.A.	9.1
11	Sohio	33-99-36	10-6-55	CGL	N.A.	41	26	83	N.A.	424	29	8	N.A.	N.A.	N.A.	N.A.	396	N A	N.A	7.5
12	Sohio 4a	32-95-36	9-19-55	CGL	N.A.	81	10	832	N.A.	710	798	110	N.A.	N.A.	N.A.	N.A.	2472	N.A.	N.A	9.0
13	Sohio	32-95-36	9-19-55	CGL	N.A.	49	19	1331	N.A.	570	1361	180	N.A.	N.A.	N.A.	N.A.	3797	N.A	N.A	9.5
14	Sohio	32-95-36	9-19-55	CGL	N.A.	37	12	550	N.A.	490	683	160	N.A.	N.A.	N.A.	N.A.	1683	N A.	N.A	7.8
15	Sohio	33-99-26	11-16-26	CGL	N.A.	34	92	84	N.A.	240	207	38	N.A	N.A.	N.A.	N.A.	682	N.A.	N.A.	8.4
16	Sohio	32-95-36	8-8-55	CGL	N.A.	1	Tr	868	N.A.	1355	317	150	N.A.	N.A.	N.A.	N.A.	2146	N.A.	N.A	8.6
17	N.A.	5N-6W-14	9-30-64	USGS	10	409	68	557	18	734	1560	219	2 1	Tr	0.48	9 4	3210	1300	3920	N.A.
18	N.A.	5N-6W-35	10-1-65	USGS	9	447	171	469	7.6	367	2320	76	1.1	0.1	0.06	14	3690	1820	4230	8.2
19	Lander #2	34-99-30	N.A.	CGL	N.A.	59	27	93		385	81	43	N.A.	N.A.	N.A.	N.A.	492	N.A	N.A.	N.A.
20	Lander #5	33-99-4	N.A.	CGL	N.A.	109	28	117		390	256	38	N.A	N.A.	N.A.	N.A.	740	N A	N.A.	N.A
21	Derby Dome #1	31-98-4	N.A.	CGL	N.A.	50	N.A.	125		205	312	25	N.A.	N.A.	N.A.	N.A.	673	N.A.	N.A.	N.A.
22	Derby Dome #2	31-98-4	N.A.	CGL	N.A.	42	N.A.	140		220	192	20	N.A.	N.A.	N.A.	N.A.	502	N.A.	N.A	N.A.
23	Derby Dome #5	31-98-4	N.A.	CGL	N.A.	56	N.A.	193		230	328	30	N.A.	N.A.	N.A.	N.A.	940	N.A	N.A.	N.A
24	Derby Dome #2	32-98-29	N.A.	CGL	N.A.	220	43	373		355	1178	12	N.A.	N.A	N.A	N A	2000	N.A.	N.A.	N.A.
	TENSLEEP SANDSTONE																			
1	Maverick Springs #1	6-2-23	N.A.	MRC	N.A.	340	N.A.	N.A.	682	617	40	N.A.	N.A.	N.A.	N.A.	N.A.	1448	N.A.	N.A.	N.A.
2	Maverick Springs #1	6-2-26	N.A.	MRC	N.A.	224	87	15	N.A.	457	569	3.6	N.A.	N.A.	N.A.	N.A.	1051	N.A.	N.A.	N.A.
3	Lander #7	2S-2E-30	N.A.	CGL	N.A.	48	12	34	N.A.	190	68	6	N.A.	N.A.	N.A.	N.A.	247	N.A.	N.A.	N.A.
4	Lander #8	2S-2E-30	N.A.	CGL	N.A.	38	Tr	111	N.A.	245	30	67	N.A.	N.A.	N.A.	N.A.	375	N.A.	N.A.	N.A.
5	Dallas Dome #1	32-99-13	N.A.	CGL	N.A.	48	20	41	N.A.	220	67	29	N.A.	N.A.	N.A.	N.A.	314	N.A.	N.A.	N.A.
6	Derby Dome #12	31-98-4	N.A.	CGL	N.A.	42	24	10	N.A.	270	Tr	3	N.A.	N.A.	N.A.	N.A.	212	N.A.	N.A.	N.A.

Table B-1. (continued)

No.[b]	Source Well Name or Owner	Location[c]	Date of Collection	Analyzing Agency[d]	Temp. (°C)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	B	SiO_2	Total Dissolved Solids	Hardness ($CaCO_3$)	Specific Conductance[c]	Lab pH
	TENSLEEP SANDSTONE (contd.)																			
7	Derby Dome #2	31-98-4	N.A.	CGL	N.A.	38	20	9	N.A.	220	N.A.	12	N.A.	N.A.	N.A.	N.A.	198	N.A.	N.A.	N.A.
8	Derby Dome #2	31-98-9	N.A.	CGL	N.A.	44	N.A.	22	N.A.	160	12	10	N.A.	N.A.	N.A.	N.A.	167	N.A.	N.A.	N.A.
9	Pathfinder	33-98-18	7-16-64	N.A.	N.A.	158	40	93	N.A.	222	482	79	N.A.	N.A.	N.A.	N.A.	1060	559	1430	7
10	Pathfinder	33-90-24	1-15-64	UI	N.A.	208	38	170	514	144	710	143	0.4	N.A.	N.A.	N.A.	1440	699	1920	6.8
11	unnamed spring	1S-1W-2	8-18-53	USGS	41	162	41	49	N.A.	290	362	41	2.6	0.1	N.A.	34	801	573	1180	7.3
12	Sohio #4	32-95-36	9-19-55	CGL	31	81	10	832	N.A.	710	798	110	N.A.	N.A.	N.A.	N.A.	2472	N.A.	N.A.	9
13	Sohio #3	32-95-36	8-19-55	CGL	33	49	19	1331	N.A.	570	1361	180	N.A.	N.A.	N.A.	N.A.	3797	N.A	N.A.	9.5
14	Sohio #1	33-99-26	11-16-55	CGL	30	16	39	1119	N.A.	1070	1634	112	N.A.	N.A.	N.A.	N.A.	3447	N.A.	N.A.	8.1
15	Sohio #4a	32-95-36	10-19-55	CGL	31	37	12	550	N.A.	490	683	160	N.A.	N.A.	N.A.	N.A.	1683	N.A.	N.A.	7.8
16	Sohio #1a	33-99-26	11-16-55	CGL	31	34	92	84	84	N.A.	207	38	N.A.	N.A.	N.A.	N.A.	682	N.A.	N.A.	8.4
17	N.A.	33-99-35	8-17-65	CGL	36	36	19	15	68	180	45	12	2.7	Tr	0.04	21	245	171	410	7.0
18	N.A.	33-100-18	8-17-65	CGL	14	47	25	4.9	0.7	268	8.2	5.3	0.2	1.2	0.01	8.5	233	219	430	7.2
19	N.A.	33-100-25	3-17-65	CGL	28	31	20	10	4.2	159	36	11	0.7	Tr	0.03	14	205	160	347	7.5
20	N.A.	33-101-13	8-17-65	CGL	10	44	25	2	1.6	254	8.2	3.5	0.3	1.1	0.01	8.8	220	213	413	7.4
21	unnamed spring	42-107-32	9-21-65	CGL	30	123	38	17	7.0	479	84	23	1.2	Tr	0.11	18	547	464	937	6.8
22	N.A.	33-88-10	9-4-75	USGS	10	55	17	2.5	2.2	166	73	4	2.2	N.A.	90	9.4	248	210	450	7.6
23	N.A.	30-82-24	9-3-75	USGS	43	130	21	170	10	103	380	240	2.4	N.A.	180	36	1040	410	9600	7.8
24	N.A.	34-88-31	6-10-75	USGS	12	42	18	4.3	4	200	24	3.6	N.A.	0.6	N.A.	11	204	180	N.A.	N.A.
25	N.A.	42-94-26	10-12-70	USGS	N.A.	92	41	10	1.6	298	170	3.1	2.2	N.A.	N.A.	12	479	398	730	8.2
	MADISON LIMESTONE																			
	N.A.	30-99-13	4-8-65	USGS	N.A.	93	37	3	1	275	7	117	N.A.	1	N.A.	N.A.	397	N.A.	N.A.	7
	N.A.	33-99-35	8-17-65	USGS	36	36	19	15	6.8	180	45	12	0.7	N.A.	N.A.	21	240	171	460	7
	N.A.	2N-1W-18	12-13-62	USGS	N.A.	178	34	46	N.A.	293	360	50	N.A.	N.A.	N.A.	N.A.	930	N.A.	N.A.	7.4

[a]Chemical analyses are in milligrams per liter.

N.A. - not available

[b]Numbers correspond to data points on trilinear diagrams (Chapter IV) for water-bearing units.

[c]Township-north, range-west, section; unless otherwise noted.

[d]WDA - Wyoming Department of Agriculture, Division of Laboratories, Laramie, Wyoming
USGS - U.S. Geological Survey
DM - Dames and Moore Consultants
CGL - Chemical and Geological Laboratories, Casper, Wyoming
MRC - Midwest Refining Company, Casper Wyoming
UI - Utah International

[e]Micromhos per centimeter^2 at 25°C.

APPENDIX C

HYDROLOGIC DATA ARRANGED BY FORMATION FOR SELECTED WELLS IN THE WIND RIVER BASIN, WYOMING

Table C-1. Hydrologic data arranged by formation for selected wells in the Wind River basin, Wyoming.

Formation Well Name or Owner	Location	Test Date	Duration (hrs)	Saturated Thickness (ft)	Yield (gpm)	Drawdown (ft)	Estimated Transmissivity (gpd/ft)	Estimated Permeability (gpd/ft^2)	Specific Capacity	Storage Coefficient
QUATERNARY DEPOSITS										
Quiver, N.	1N-1E-34 aa	4-25-61	N.A.	21	10	1	2×10^4	9.5×10^2	10	N.A.
USGS	1N-1E-34 bc	6-28-66	N.A.	25	60	15	8×10^3	3.2×10^2	4	N.A.
Trumball, C.	1N-1E-35 ad	4-13-61	N.A.	20	5	1	1×10^4	5×10^2	5	N.A.
Coggles, A.	1N-1E-35 bb	4-28-65	N.A.	20	10	1	2×10^4	9.5×10^2	10	N.A.
Rhodes, R.	1N-1E-36 cc	5-31-61	N.A.	20	4	1	8×10^3	4×10^2	4	N.A.
USGS	1N-2E-6 aa	6-6-66	N.A.	50	25	4	1.3×10^4	2.5×10^2	6.3	N.A.
N.A.	1N-4E-31 dc	11-6-65	N.A.	9	15	13	2.4×10^3	2.7×10^2	1.2	N.A.
Ward, S.	1N-1W-5 ac	7-16-63	N.A.	40	5	14	8×10^2	2×10^1	0.4	N.A.
Ward, A.	1N-1W-5 ac	7-17-63	N.A.	35	5	13	8×10^2	2.3×10^1	0.4	N.A.
Clare, D.	1N-1W-31 cb	10-16-63	N.A.	20	10	5	4×10^3	2×10^2	2	N.A.
McAdams, B.	1N-1W-32 dd	5-28-63	N.A.	40	10	5	4×10^3	1×10^2	2	N.A.
Enos, F.	1N-2W-25 cb	6-22-63	4	25	10	2	1×10^4	4×10^2	5	N.A.
Stagner, B.	1N-2W-25 db	9-10-63	4	25	15	7	4.2×10^3	1.7×10^2	2.1	N.A.
Peahrora, S.	1N-2W-26 ad	6-21-63	1	25	10	4	5×10^3	2×10^2	2.5	N.A.
LeClair, E.	1N-2W-26 cb	6-28-63	3	19	15	5	6×10^3	3.2×10^2	3	N.A.
Compton, A.	1N-2W-26 dd	6-19-63	7	20	10	3	6.6×10^3	3.3×10^2	3.3	N.A.
Tyler, J.	1N-2W-35 ad	6-11-63	5	30	10	4	5×10^3	1.7×10^2	2.5	N.A.
Teran, B.	1N-2W-35 ad	6-11-63	4	35	18	7	5.2×10^3	1.5×10^2	2.6	N.A.
Dick, J.	1N-2W-36 cb	6-8-63	4	35	16	6	5.4×10^3	1.5×10^2	2.7	N.A.
Harris, F.	1N-2W-31 cd	7-18-63	2	35	15	2	1.5×10^4	4.3×10^2	7.5	N.A.
Harris, F.	1N-2W-31 cd	7-18-63	2	35	15	1	3×10^4	8.6×10^2	15	N.A.
USGS	4N-4W-cd	8-20-66	24	30	195	3	1.3×10^5	4.3×10^3	65	N.A.
USGS	4N-4W-22 ab	6-15-66	24	30	144	6	4.8×10^4	1.6×10^3	24	N.A.
St. Helens Church	4N-4W-24 cb	N.A.	N.A.	50	20	3	1.3×10^4	2.7×10^2	6.7	N.A.
Chavez, L.	1S-1W-3 cc	5-21-63	4	20	20	4	1×10^4	5×10^2	5	N.A.
Brown, B.	1S-1W-4 ab	5-22-63	2	20	15	9	3.4×10^3	1.7×10^2	1.7	N.A.
Herford, V.	1S-1W-4 ad	5-1-63	0.5	20	15	9	3.4×10^3	1.7×10^2	1.7	N.A.
Henan, G.	1S-1W-4 bc	5-1-63	0.5	20	20	5	8×10^3	4×10^2	4	N.A
McAdams, L.	1S-1W-4 cb	5-4-63	0.5	30	20	6	6.6×10^3	2.2×10^2	3.3	N.A.
Hill, G.	1S-1W-4 cc	5-3-63	2	40	12	2	1.2×10^4	3×10^2	6	N.A.
Fort Washakie	1S-1W-4 cd	7-11-63	1	25	10	7	2.8×10^3	1.1×10^2	1.4	N.A.
USGS	1S-1W-4 da	7-25-66	1	45	25	4	1.3×10^4	2.8×10^2	6.3	N.A.
Twitchell, G.	1S-1W-4 da	5-24-63	7	25	15	5	6×10^3	2.4×10^2	3	N.A.
Padia, P.	1S-1W-5 ab	4-28-63	3	115	12	3	8×10^3	7×10^1	4	N.A.
Nicol, F.	1S-1W-5 db	N.A.	4	40	6	3	4×10^3	1×10^2	2	N.A.
Soonup, C.	1S-1W-6 ad	6-10-63	6	43	10	15	1.4×10^3	3.3×10^1	0.7	N.A.
Engavo, N.	1S-1W-6 ca	4-20-63	4	20	10	4	5×10^3	2.5×10^2	2.5	N.A.
Murphy, R.	1S-1W-6 cd	N.A.	0.5	58	5	31	4×10^2	0.7×10^1	0.2	N.A.
Gould, T.	1S-1W-6 dd	4-22-63	1	15	12	4	6×10^3	4×10^2	3	N.A.
Tyler, M.	1S-1W-7 dc	4-5-63	2	42	12	5	4.8×10^3	1.1×10^2	2.4	N.A.
Meyers, P.	1S-1W-7 dd	4-8-63	3	30	15	3	1×10^4	3.3×10^2	5	N.A.
St. Clair, E.	1S-1W-8 aa	N.A.	N.A.	50	20	5	8×10^3	1.6×10^2	4	N.A.
Burnett, R.	1S-1W-8 ab	5-20-63	N.A.	21	11	2	1.1×10^4	5.2×10^2	5.5	N.A.
Day, G.	1S-1W-8 ad	N.A.	N.A.	15	9	1	1.8×10^4	1.2×10^3	9	N.A.

Table C-1. (continued)

Formation Well Name or Owner	Location	Test Date	Duration (hrs)	Saturated Thickness (ft)	Yield (gpm)	Drawdown (ft)	Estimated Transmissivity (gpd/ft)	Estimated Permeability (gpd/ft^2)	Specific Capacity	Storage Coefficient
QUATERNARY DEPOSITS (continued)										
Washakie, A.	1S-1W-8 da	4-9-63	1	35	40	1	8×10^4	2.3×10^3	40	N.A.
Pogoree, J.	1S-1W-8 dc	4-6-63	2	20	25	3	1.7×10^4	8.3×10^2	8.3	N.A.
Lebeau, M.	1S-1W-8 cc	N.A.	4	35	7	1	1.4×10^4	4×10^2	7	N.A.
Chingman, F.	1S-1W-9 bd	N.A.	1	31	10	10	2×10^3	6.4×10^1	1	N.A.
Coshen, W.	1S-1W-9 da	N.A.	1	22	15	3	1×10^4	4.5×10^2	5	N.A.
Wise, F.	1S-1W-10 bc	5-15-63	N.A.	20	20	7	5.8×10^3	2.9×10^2	2.9	N.A.
Moon, M.	1S-1W-10 cb	5-10-63	5	45	20	6	6.6×10^3	1.5×10^2	3.3	N.A.
Coulston, L.	1S-1W-10 cb	7-1-64	3	50	10	6	3.4×10^3	6.8×10^1	1.7	N.A.
Weed, S.	1S-1W-10 cd	7-1-63	3	31	15	8	3.8×10^3	1.2×10^2	1.9	N.A.
Ute, A.	1S-1W-16 bc	4-10-63	1	18	12	1	2.4×10^4	1.3×10^3	12	N.A.
Wagon, S.	1S-1W-18 ba	N.A.	2	21	15	11	2.8×10^3	1.3×10^2	1.4	N.A.
Robertson, T.	1S-1W-18 bc	4-13-63	4	27	10	10	2×10^3	7.4×10^1	1	N.A.
Posey, M.	1S-1W-19 bb	4-1-63	6	15	20	10	4×10^3	2.7×10^2	2	N.A.
Hugo, W.	1S-1W-1 cc	4-16-63	1	27	15	1	3×10^4	1.1×10^3	15	N.A.
Shoyo, D.	1S-1W-1 db	6-8-63	N.A.	51	20	4	1×10^4	2×10^2	5	N.A.
Wagon, J.	1S-1W-1 dc	4-18-63	2	21	12	2	1.2×10^4	5.7×10^2	6	N.A.
Tillman, D.	1S-1W-1 dc	N.A.	3	15	6	3	4×10^3	2.7×10^2	2	N.A.
Perry, L.	1S-1W-13 dd	4-3-63	4	61	7	31	4×10^2	0.7×10^1	0.2	N.A.
St. Stevens Mission	1S-4W-9 cd	N.A.	1	47	50	2	5×10^4	1.1×10^3	25	N.A.
Miller, L.	1S-3E-34 da	N.A.	4	85	5	57	2×10^2	0.2×10^1	0.1	N.A.
WIND RIVER FORMATION										
Cook, C.	1N-4E-21 dd	11-8-64	24	200	16	57	6×10^2	0.3×10^1	0.3	N.A.
City of Riverton	1N-4E-26 ca	N.A.	48	70	400	70	1.1×10^4	1.6×10^1	5.7	1×10^{-3}
City of Riverton	1N-4E-27 ac	N.A.	48	33	400	49	1.6×10^4	5×10^1	8.2	2.1×10^{-3}
City of Riverton 1	1N-4E-35 bb	3-16-51	48	156	N.A.	N.A.	9×10^3	N.A.	N.A.	N.A.
City of Riverton 2	1N-4E-35 bb	3-16-51	48	190	N.A.	N.A.	1×10^4	N.A.	N.A.	N.A.
City of Riverton 3	1N-4E-34 ad	3-16-51	48	40	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
City of Riverton 4	1N-4E-27 dd	3-16-51	48	8	190	0.7	6.9×10^3	8.6×10^2	271	1.1×10^{-4}
City of Riverton 5	1N-4E-27 dc	3-16-51	48	8	200	0.5	1×10^4	1.3×10^3	400	2.1×10^{-4}
City of Riverton 6	1N-4E-27 cd	3-16-51	48	N.A.	200	0.5	1×10^4	N.A.	N.A.	2.0×10^{-4}
City of Riverton 7	1N-4E-34 ba	3-16-51	48	8	200	0.5	1×10^4	1.3×10^3	400	1.9×10^{-4}
City of Riverton 8	1N-4E-34 bb	3-16-51	51	8	200	0.5	1×10^4	1.3×10^3	400	N.A.
City of Riverton 9	1N-4E-34 bb	3-16-51	48	8	200	0.5	1×10^4	1.3×10^3	400	2.0×10^{-4}
City of Riverton 10	1N-4E-34 ca	3-16-51	48	8	200	0.5	1×10^4	1.3×10^3	400	1.6×10^{-4}
USGS 11	1N-4E-33 dd	3-16-51	48	8	200	0.5	1×10^4	1.3×10^3	400	1.3×10^{-4}
Wyo. Game and Fish	2S-2E-4 dd	N.A.	N.A.	460	15	140	2×10^2	4.3×10^{-1}	0.1	N.A.
Mount Hope Church	2S-2E-18 ad	N.A.	N.A.	435	20	200	2×10^2	4.6×10^{-1}	0.1	N.A.
Saunders, L.	2S-2E-31 ad	8-22-66	4	230	10	30	6×10^2	0.3×10^1	0.3	N.A.
Montgomery, R.	2S-4E-12 dd	11-1-50	3	210	5	50	2×10^2	9.5×10^{-1}	0.1	N.A.
Pince, C.	3S-2E-3 bd	N.A.	8	210	5	75	2×10^2	9.5×10^{-1}	0.1	N.A.
City of Pavillion	3S-2E-7 cd	N.A.	7	500	45	220	4×10^2	8×10^{-1}	0.2	3.6×10^{-4}
Henry, R.	3S-2E-8 bc	N.A.	24	110	6	30	4×10^2	0.4×10^1	0.2	N.A.

Table C-1. (continued)

Formation Well Name or Owner	Location	Test Date	Duration (hrs)	Saturated Thickness (ft)	Yield (gpm)	Drawdown (ft)	Estimated Transmissivity (gpd/ft)	Estimated Permeability (gpd/ft^2)	Specific Capacity	Storage Coefficient
WIND RIVER FORMATION (continued)										
Stearns, T.	3S-2E-33 ab	N.A.	24	485	25	16	3.2×10^{3}	0.7×10^{1}	1.6	N.A.
Mason, C.	3S-3E-36 ad	8-3-52	3	50	40	19	4.2×10^{3}	8.4×10^{1}	2.1	N.A.
City of Shoshoni	3S-6E-15 bc	12-1-51	24	495	300	194	3.2×10^{3}	0.6×10^{1}	1.6	4.2×10^{-4}
White, B.	4N-2E-29 ad	11-2-52	2	220	5	37	2.7×10^{2}	0.1×10^{1}	0.1	N.A.
Over, A.	4N-3E-5 dc	N.A.	N.A.	325	2	85	4×10^{1}	1.2×10^{-1}	0.02	N.A.
Darrington, E.	4N-3E-8 aa	N.A.	N.A.	500	10	3	6.6×10^{3}	1.3×10^{1}	3.3	N.A.
Rungle, L.	4N-3E-9 dd	N.A.	N.A.	225	2	29	4×10^{1}	1.8×10^{-1}	0.02	N.A.
Mohlman, R.	4N-3E-11 ac	N.A.	N.A.	347	2	120	4×10^{1}	1.2×10^{-1}	0.02	N.A.
Smith, M.	4N-3E-17 cc	N.A.	N.A.	135	2	15	2.6×10^{2}	0.2×10^{1}	0.13	N.A.
Fisher, H.	4N-3E-20 ab	N.A.	N.A.	112	40	25	1.3×10^{3}	1.1×10^{1}	0.63	N.A.
Trook, A.	4N-3E-21 dc	N.A.	2	329	10	118	1.6×10^{2}	4.9×10^{-1}	0.08	N.A.
Walters, M.	4N-3E-24 da	N.A.	3	490	5	255	4×10^{1}	8×10^{-2}	0.02	N.A.
Harmon, K.	4N-3E-35 ab	N.A.	3	317	1	255	8	3×10^{-2}	0.004	N.A.
Newell, F.	4N-3E-35 ad	N.A.	1	315	3	212	2×10^{1}	6×10^{-2}	0.01	N.A.
Ward, S.	1N-1W-5 ac	7-16-63	2	35	5	14	7.2×10^{1}	2.1×10^{1}	0.36	N.A.
Ward, A.	1N-1W-5 ac	7-17-63	2	30	5	13	7.8×10^{1}	2.6×10^{1}	0.39	N.A.
Quiver, R.	1N-1W-31 ad	6-3-63	4	90	10	60	3.4×10^{2}	0.4×10^{1}	0.17	N.A.
Clare, D.	1N-1W-31 cb	10-16-63	1	22	10	5	4×10^{3}	1.8×10^{2}	2	N.A.
McAdams, B.	1N-1W-32 dd	5-28-63	N.A.	35	10	5	4×10^{3}	1.1×10^{2}	2	N.A.
Amboh, N.	2N-2W-17 bc	7-23-63	N.A.	60	15	12	2.6×10^{3}	4.3×10^{1}	1.3	N.A.
Guina, J.	2N-2W-21 cd	7-26-63	N.A.	60	15	13	2.6×10^{3}	4.3×10^{1}	1.3	N.A.
Hankass, V.	2N-2W-26 ac	7-17-63	N.A.	40	6	20	6×10^{2}	1.5×10^{1}	0.3	N.A.
Roberts, D.	2N-2W-28 bc	7-18-63	N.A.	120	10	26	7.8×10^{2}	0.7×10^{1}	0.39	N.A.
Frank, V.	4N-3W-32 dc	N.A.	N.A.	100	20	40	1×10^{3}	1×10^{3}	0.5	N.A.
Urbigkit, R.	4N-4W-16 ad	N.A.	N.A.	130	7	10	1.4×10^{3}	1.1×10^{1}	0.7	N.A.
Blackburn, J.	1S-3E-13 da	9-11-64	3	80	10	40	5×10^{2}	0.6×10^{1}	0.25	N.A.
Eldridge, M.	1S-3E-14 aa	N.A.	4	40	50	25	4×10^{3}	4×10^{2}	2	N.A.
Frazier, L.	1S-3E-15 cb	N.A.	3	120	15	42	7.2×10^{2}	0.6×10^{1}	0.36	N.A.
Arapahoe Council	1S-3E-23 bc	N.A.	4	120	16	93	3.4×10^{2}	0.3×10^{1}	0.17	N.A.
Arapahoe School	1S-3E-23 bd	N.A.	24	250	25	150	3.4×10^{2}	0.1×10^{1}	0.17	N.A.
ARIKAREE FORMATION										
Sun Land & Cattle Co.	29N-87W-35 bd	4-23-59	N.A.	80	20	35	1.1×10^{3}	1.4×10^{1}	0.57	N.A.
McIntosh, B.	29N-90W-9 ab	9-15-78	N.A.	80	20	21	1.9×10^{3}	2.4×10^{1}	0.95	N.A.
Smith, M.	29-91-18 ba	4-27-79	N.A.	30	10	2	1×10^{4}	3.3×10^{2}	5	N.A.
Veach, R.	29N-91W-18 bb	5-1-79	N.A.	60	10	15	1.3×10^{3}	2.2×10^{1}	0.67	N.A.
Irvin, W.	29N-92W-10 cc	4-1-55	N.A.	30	7	12	1.2×10^{3}	3.8×10^{2}	0.58	N.A.
Green Mt. Mobile Park	29N-92W-14 bc	8-1-77	N.A.	200	145	4	7.2×10^{4}	3.6×10^{2}	36	N.A.
Green Mt. Village	29N-92W-14 bc	8-1-77	N.A.	250	175	5	7×10^{4}	2.8×10^{2}	35	N.A.
McIntosh, B.	29N-92W-33 cd	5-15-29	N.A.	250	10	1	2×10^{4}	8×10^{1}	10	N.A.
Huntsman, N.	29N-94W-5 da	6-14-79	N.A.	30	12	2	1.2×10^{4}	4×10^{2}	6	N.A.

Table C-1. (continued)

Formation / Well Name or Owner	Location	Test Date	Duration (hrs)	Saturated Thickness (ft)	Yield (gpm)	Drawdown (ft)	Estimated Transmissivity (gpd/ft)	Estimated Permeability (gpd/ft^{2})	Specific Capacity	Storage Coefficient
ARIKAREE FORMATION (continued)										
Sanford Ranches	30N-85W-27 ba	N.A.	N.A.	200	5	1	1 x 10^{4}	5 x 10^{1}	5	N.A.
Rusco, Inc.	30N-86W-29 db	5-10-53	N.A.	25	10	2	1 x 10^{4}	4 x 10^{2}	5	N.A.
Rusco, Inc.	30N-87W-15 ab	11-5-56	N.A.	20	10	1	2 x 10^{4}	1 x 10^{3}	10	N.A.
Jamerman, C.	30N-91W-31 bb	10-1-51	N.A.	10	25	3	1.7 x 10^{4}	1.7 x 10^{3}	8.33	N.A.
Holy Cross Cattle Co.	30N-92W-35 ad	4-15-69	N.A.	15	15	1	3 x 10^{4}	2 x 10^{3}	15	N.A.
Graham, E.	30N-93W-21 dd	N.A.	N.A.	20	25	3	1.7 x 10^{4}	8.3 x 10^{2}	8.33	N.A.
Myers, A.	30N-94W-20 cb	11-1-57	N.A.	30	12	2	1.2 x 10^{4}	4 x 10^{2}	6	N.A.
Contryman, M.	30N-95W-27 ac	11-20-77	N.A.	40	10	1	2 x 10^{4}	5 x 10^{2}	10	N.A.
FORT UNION-LANCE FORMATIONS UNDIVIDED										
Lazy YK Cattle Co.	34N-93W-19 dd	11-12-73	N.A.	200	6	180	6.7 x 10^{1}	3.3 x 10^{1}	0.03	N.A.
Lazy K Cattle Co.	34N-93W-20 aa	6-28-60	N.A.	300	9	200	1 x 10^{2}	5 x 10^{-1}	0.05	N.A.
Miles, J.	35N-89W-29 dc	4-12-63	N.A.	325	10	241	8 x 10^{1}	2.5 x 10^{-1}	0.04	N.A.
Miles, J.	35N-89W-32 ab	11-22-69	N.A.	300	10	195	1 x 10^{2}	3.3 x 10^{-1}	0.05	N.A.
M & D Land Co.	33N-86W-20 cd	N.A.	N.A.	100	5	81	1.2 x 10^{2}	0.1 x 10^{1}	0.06	N.A.
MESAVERDE FORMATION										
Arapahoe Ranch	6N-2E-32 ab	4-28-65	N.A.	90	15	2	1.5 x 10^{4}	1.7 x 10^{2}	7.5	N.A.
Rochelle Sheep Camp	37N-87W-24 ac	10-7-59	N.A.	110	5	50	2 x 10^{2}	0.2 x 10^{1}	0.1	N.A.
CIG Exploration	37N-87W-36 bd	N.A.	N.A.	500	10	300	6 x 10^{1}	1.2 x 10^{-1}	0.03	N.A.
CODY SHALE										
Lindaur, H.	1N-1E-3 bb	N.A.	N.A.	80	20	291	1.4 x 10^{2}	0.2 x 10^{1}	0.07	N.A.
Quiver, R.	1N-1W-31 ad	6-3-63	N.A.	90	2	60	6 x 10^{1}	6.7 x 10^{-1}	0.03	N.A.
Abeyta, G.	1S-1W-29 cc	8-13-65	N.A.	90	3	13	4.8 x 10^{2}	4.6 x 10^{1}	0.23	N.A.
Eicholtz, R.	1S-1W-30 bd	N.A.	N.A.	200	5	800	2 x 1p^{1}	1 x 10^{-1}	0.01	N.A.
Nicholas, W.	33N-99W-19 ca	11-25-61	N.A.	350	120	200	1.2 x 10^{3}	0.3 x 10^{1}	0.6	N.A.
Calvert, F.	33N-99W-22 ac	9-30-63	4	240	13	120	2.2 x 10^{2}	9.2 x 10^{-1}	0.11	N.A.
Calvert, F.	33N-99W-22 bc	10-18-63	6	200	8	180	8 x 10^{1}	4 x 10^{-1}	0.04	N.A.
Nicholls, D.	33N-99W-27 bb	11-2-78	3	30	12	18	1.3 x 10^{3}	4.4 x 10^{1}	0.67	N.A.
FRONTIER FORMATION										
St. Michael Mission	1N-1E-33 bb	N.A.	N.A.	50	20	18	2.2 x 10^{3}	4.4 x 10^{1}	1.1	N.A.
Crowheart School	4N-4W-14 cc	11-4-65	28	400	10	100	2 x 10^{2}	5 x 10^{-1}	0.1	N.A.
Burnett, R.	4N-4W-25 da	N.A.	N.A.	212	4	145	6 x 10^{1}	2.8 x 10^{-1}	0.03	N.A.
Fike, J.	6N-3W-2 bc	N.A.	N.A.	120	3	60	1 x 10^{2}	8.3 x 10^{-1}	0.05	N.A.
Roberts Mission	1S-1W-8 cc	N.A.	N.A.	452	1	312	6	1.3 x 10^{-2}	0.003	N.A.
Hollings, D.	1S-1W-25 dc	7-20-65	N.A.	N.A.	4	47	1.8 x 10^{2}	N.A.	0.09	N.A.
Shoyo, H.	1S-2W-1 db	6-6-63	N.A.	50	5	32	3.2 x 10^{2}	0.6 x 10^{1}	0.16	N.A.

Table C-1. (continued)

Formation Well Name or Owner	Location	Test Date	Duration (hrs)	Saturated Thickness (ft)	Yield (gpm)	Drawdown (ft)	Estimated Transmissivity (gpd/ft)	Estimated Permeability (gpd/ft^2)	Specific Capacity	Storage Coefficient
FRONTIER FORMATION (continued)										
Van Hess, R.	1S-1E-15 ab	8-13-65	N.A.	38	3	12	5×10^{2}	1.3×10^{1}	0.25	N.A.
Huchinson, B.	1S-1E-16 ac	N.A.	N.A.	70	3	41	1.4×10^{2}	0.2×10^{1}	0.07	N.A.
Meyers, M.	2S-1E-7 dd	N.A.	N.A.	350	10	185	1×10^{2}	2.9×10^{-1}	0.05	N.A.
Meyers, E.	2S-1E-7 dd	N.A.	N.A.	250	10	200	1×10^{2}	0.4×10^{1}	0.05	N.A.
Knifer, D.	33N-99W-19 cd	8-28-75	N.A.	200	25	1	5×10^{4}	2.5×10^{2}	25	N.A.
Sims, L.	33N-99W-20 dd	12-31-79	N.A.	200	15	70	4.2×10^{2}	0.2×10^{1}	0.21	N.A.
Brown, W.	33N-100W-2 aa	5-1-79	3	100	10	60	3.4×10^{2}	0.3×10^{1}	0.17	N.A.
CLOVERLY-MORRISON FORMATIONS UNDIVIDED										
Weber, J.	33N-99W-23 cd	2-12-60	N.A.	25	5	15	6.7×10^{2}	2.7×10^{1}	0.33	N.A.
Best, M.	33N-100W-11 bc	N.A.	N.A.	100	25	100	5×10^{2}	0.5×10^{1}	0.25	N.A.
Hallett, A.	33N-100W-24 cb	6-24-78	N.A	N.A.	20	185	2.2×10^{2}	N.A.	0.11	N.A.
Spear, K.	33N-100W-24 ad	3-1-62	N.A.	N.A.	4	1	8×10^{3}	N.A.	4	N.A.
Hitshew, D	33N-100W-24 cd	5-1-62	N.A.	N.A.	10	1	2×10^{4}	N.A.	10	N.A.
Marker, V.	30N-82W-18 bc	11-20-65	N.A.	35	15	12	2.5×10^{3}	7.1×10^{1}	1.25	N.A.
Foote, M.	30N-83W-26 ca	5-24-76	N.A.	100	8	140	1.2×10^{2}	0.1×10^{1}	0.06	N.A.
Volker, E.	30N-83W-26 ca	10-1-56	N.A.	80	7	90	1.6×10^{2}	0.2×10^{1}	0.08	N.A.
Adamson, M.	30N-83W-26 bd	5-26-78	N.A.	60	5	100	1×10^{2}	0.2×10^{1}	0.05	N.A.
SUNDANCE-NUGGET FORMATIONS UNDIVIDED										
British-American Oil	3N-1W-5 ba	N.A.	N.A.	N.A.	6	N.A.	N.A.	N.A.	N.A.	N.A.
N.A.	6N-2W-22 cb	N.A.	N.A.	140	15	N.A.	N.A.	N.A.	N.A.	N.A.
Weed, H.	1S-2W-24 ad	3-29-63	N.A.	40	10	3	6.7×10^{3}	1.7×10^{2}	3.3	N.A.
Lafferty, J.	1S-2W-26 ad	3-30-63	N.A.	56	9	2	9×10^{3}	1.6×10^{2}	4.5	N.A.
Lewis, J.	33N-100W-22 dc	6-18-66	N.A.	60	10	41	4.8×10^{2}	0.8×10^{1}	0.24	N.A.
Richardson, E.	33N-100W-22 bc	7-1-69	N.A.	100	28	35	1.6×10^{3}	1.6×10^{1}	0.8	N.A.
Davis, D.	33N-100W-22 bc	4-15-68	N.A.	100	15	60	5×10^{2}	0.5×10^{1}	0.25	N.A.
Dent, H.	33N-100W-22 bc	8-27-70	N.A.	200	20	47	8.6×10^{2}	0.4×10^{1}	0.43	N.A.
Karhu, J.	33N-100W-22 bc	5-26-76	N.A.	100	12	51	4.8×10^{2}	0.5×10^{1}	0.24	N.A.
TENSLEEP SANDSTONE										
Sjostrom, R.	33N-100W-18 bb	N.A.	N.A.	400	100	1	2×10^{5}	5×10^{2}	100	N.A.
Town of Lander	33N-100W-25 ac	1-6-42	48	400	539	10	1.1×10^{4}	2.7×10^{1}	5.4	N.A.
Brodie, J.	33N-101W-35 aa	5-20-69	3	20	18	2	1.8×10^{4}	9×10^{2}	9	N.A.
Cole, R.	32N-101W-1 dd	N.A.	N.A.	50	10	5	4×10^{3}	8×10^{1}	2	N.A.
Canyon Devl. Co.	32N-100W-9 ac	8-2-78	N.A.	35	12	8	3×10^{3}	8.6×10^{3}	1.5	N.A.
Lucky Mc Uranium Co.	33N-100W-22 aa	8-21-57	24	N.A.	150	260	1.2×10^{3}	N.A.	0.58	N.A.
Pathfinder Mines	33N-90W-22 bc	6-1-68	24	N.A.	80	281	5.6×10^{2}	N.A.	0.28	N.A.
Lucky Mc Uranium Co.	33N-90W-23 ac	6-4-57	24	N.A.	200	301	1.3×10^{3}	N.A.	0.66	N.A.

Table C-1. (continued)

Formation Well Name or Owner	Location	Test Date	Duration (hrs)	Saturated Thickness (ft)	Yield (gpm)	Drawdown (ft)	Estimated Transmissivity (gpd/ft)	Estimated Permeability (gpd/ft^2)	Specific Capacity	Storage Coefficient
MADISON LIMESTONE										
Arapahoe Ranch	6N-4E-14 bb	4-28-63	N.A.	740	41	16	5.1×10^{3}	0.7×10^{1}	2.6	N.A.
N.A.	7N-1E-30 ba	3-1-61	2	306	25	3	1.7×10^{4}	5.4×10^{1}	8.3	N.A.
Arapahoe Ranch	7N-5E-22 b	3-3-65	N.A.	740	5	16	6.2×10^{2}	8.4×10^{-1}	0.31	N.A.
N.A.	6N-2E-26 db	9-17-64	N.A.	400	125	2030	1.2×10^{2}	6×10^{-2}	0.06	N.A.
N.A.	1S-1W-2 aa	N.A.	N.A.	N.A.	230	1	4.6×10^{5}	N.A.	230	N.A.
Strube Const. Co.	33N-100W-29 ad	N.A.	N.A.	250	25	200	2.6×10^{2}	0.1×10^{1}	0.13	N.A.
Scheer, L.	33N-101W-21 cb	N.A.	N.A.	180	15	30	1×10^{3}	0.6×10^{1}	0.5	N.A.
Allen, L.	39N-89W-4 dd	5-2-57	N.A.	150	300	1	6×10^{5}	4×10^{3}	300	N.A.
BIGHORN DOLOMITE										
Pan American	2N-1W-18 cc	N.A.	N.A.	422	173	1285	2.6×10^{2}	6×10^{-1}	0.13	N.A.
Chadwick, F.	33N-101W-34 bb	9-24-77	N.A.	80	25	10	5×10^{3}	6.3×10^{1}	2.5	N.A.
Wyo. Rec. Comm.	32N-100W-18 dd	N.A.	N.A.	50	25	6	8.3×10^{3}	1.7×10^{2}	4.2	N.A.

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