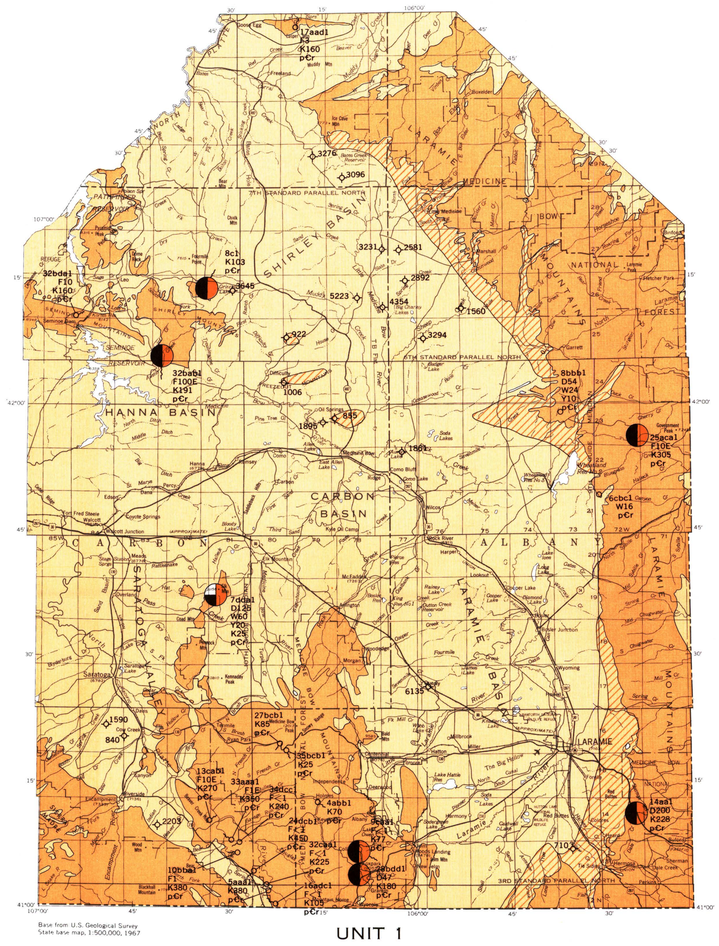


UNIT 1

OCCURRENCE OF WATER

Rocks of Unit 1 will yield water only where there is permeability due to weathering and (or) fracturing. Weathering generally does not greatly affect the rocks deeper than 100 feet, and openings that result from fractures tend to decrease in both size and number with depth; therefore, little additional water is obtained by deep drilling.

QUALITY OF WATER

Water samples for analysis were collected only in the outcrop area; wells outside the outcrop area are not known to yield water from Unit 1. The relatively insoluble character of the rocks results in water with low dissolved-solids content.

The concentration of dissolved solids is generally less than 500 mg/l (milligrams per liter); calcium and bicarbonate are the main constituents. In general, the water is of excellent quality for domestic, stock, and irrigation purposes. Pollution may be a problem in some areas where water may move through fractures directly to a well from contaminated sources such as septic tanks and corrals.

POTENTIAL FOR DEVELOPMENT

Wells that yield about 5 gpm (gallons per minute) can be developed throughout the outcrop area; however, because of the variation in permeability and thickness of permeable material, many wells drilled in random exploration would be unsuccessful. Weathered material is relatively thin in areas of high relief because of the rapid rate of erosion; therefore, steep valley sides and narrow ridges should be avoided in selecting well sites. The best areas for exploration are the broad interstream divides, valley bottoms, concave slopes, and other areas of low relief. Valley bottoms may have thick weathered zones. In addition, the material beneath the valley may be more permeable because the valley may occur along lines of fractures.

Davis and Turk (1964), in a study of wells in rocks similar to those in this unit, suggest that domestic wells should be less than 250 feet deep and wells of larger production should be less than 600 feet deep because the decrease in permeability with depth increases the unit cost of water with depth. They further state (p. 11) that the optimum depth of domestic wells, in many places, will be less than 100 feet.

EXPLANATION

Area where unit crops out

Area where unit occurs in the subsurface

Area where unit can be penetrated by drilling 1000 feet or less. (See text)

Area where unit is not present

SYMBOLS FOR DATA POINTS

Well | Spring | Well or spring for which chemical analysis is given | Oil well for which analysis of water produced with oil is given | Oil well, or oil test, showing depth to top of unit, in feet

12 abc 1, section number segment of well or spring number. *Well and springs referred to in this report are numbered according to their location within the Federal system of land subdivision. The first segment of the number is the township (north); the second number segment is the range (west); the third number segment the section, which is followed by a first letter designating quarter section, a second letter, if shown, designating quarter-quarter section, etc. (a–NE¼, b–NW¼, c–SW¼, d–SE¼). Well 30-80-10 dbc 2, for example, is in the SW¼ of the NW¼ of the SE¼ of section 10, Township 30 North, Range 80 West. The number 2 indicates that this is the second well inventoried in the quarter-quarter-quarter section.*

D100, depth of well in feet.

W+51, depth to water below, or head of water above (+), land surface, in feet.

F10, natural flow of spring or artesian well, in gallons per minute.

Y100, yield of well by pumping, in gallons per minute; generally not the maximum yield possible.

K700, specific conductance of water, in micromhos per centimeter at 25°C.

E, estimated

?, questionable

QUALITY OF WATER

Cations: Magnesium (Mg), Calcium (Ca), Sodium (Na)

Anions: Bicarbonate (HCO_3), Sulfate (SO_4), Chloride (Cl)

Center of diagrams are color coded to indicate the major cation, or anion, in milliequivalents per liter. If no single cation, or anion, is dominant but two or more are nearly equal, those that are equal are shown.

GEOLOGIC SOURCE

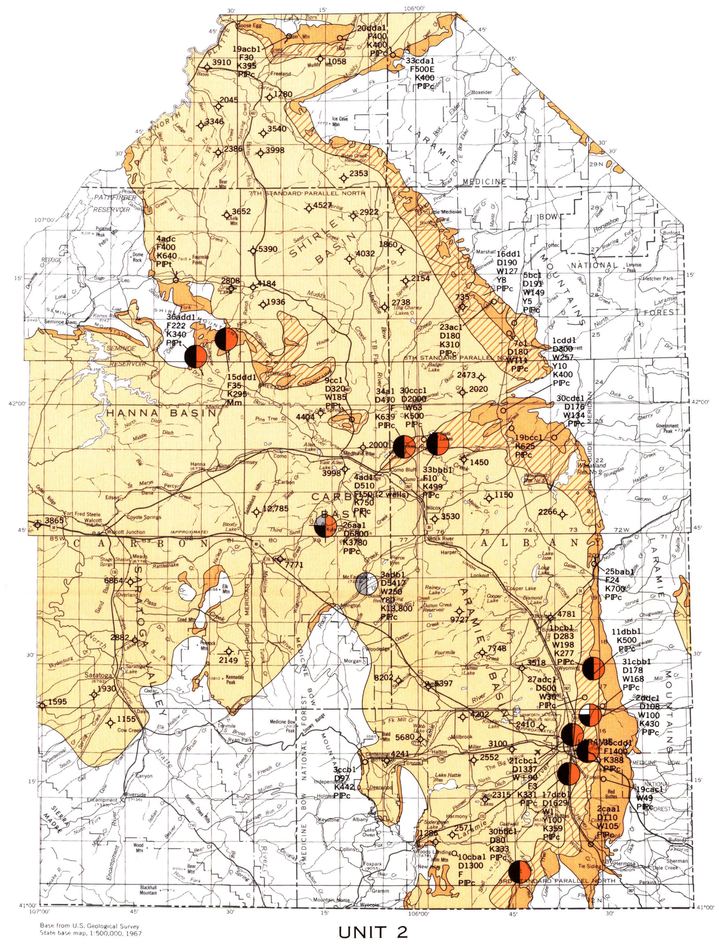
If geologic source is not indicated, the exact source of water is uncertain. Water is from one or more formations in the unit.

Unit 4
- Kcv–*Cloverly Formation*
- Jm–*Morrison Formation*
- Js–*Sundance Formation*

Unit 3
- Tkc–*Chugwater Group*
- Ps–*Satanka Shale*
- TRge–*Goose Egg Formation*

Unit 2
- PPPc–*Casper Formation*
- PPPt–*Tensleep Sandstone*
- Mm–*Madison Limestone*

Unit 1
- pCr–*Precambrian rocks*



UNIT 2

OCCURRENCE OF WATER

Water occurs in intergranular openings in sandstone, arkose, and conglomerate; however, in many places, these rocks are well cemented and little of the original intergranular openings remain. Water also occurs in zones where the permeability has been increased by fracturing and solution. Because strata of Unit 2 are massive and brittle, they fracture when subjected to stress and, therefore, the rocks may be very permeable in the vicinity of folds and faults. Solution by circulating ground water is common in the limestone of the unit and would be most apt to occur in the vicinity of folds and faults.

QUALITY OF WATER

In or near the outcrop and in areas of high permeability where ground-water circulation is good, the water has a dissolved-solids concentration of less than 500 mg/l. The water is predominantly a calcium bicarbonate type.

Crawford (1953, p. 133) listed 23 analyses of water from the Tensleep Sandstone in oil fields where the rocks of this unit are distant from the outcrop and at great depth. The water from these areas is a sodium sulfate or sodium chloride type and has a dissolved-solids concentration greater than 3,000 mg/l. The two deep wells, one of which is a producing oil well, sampled for this investigation support Crawford's data.

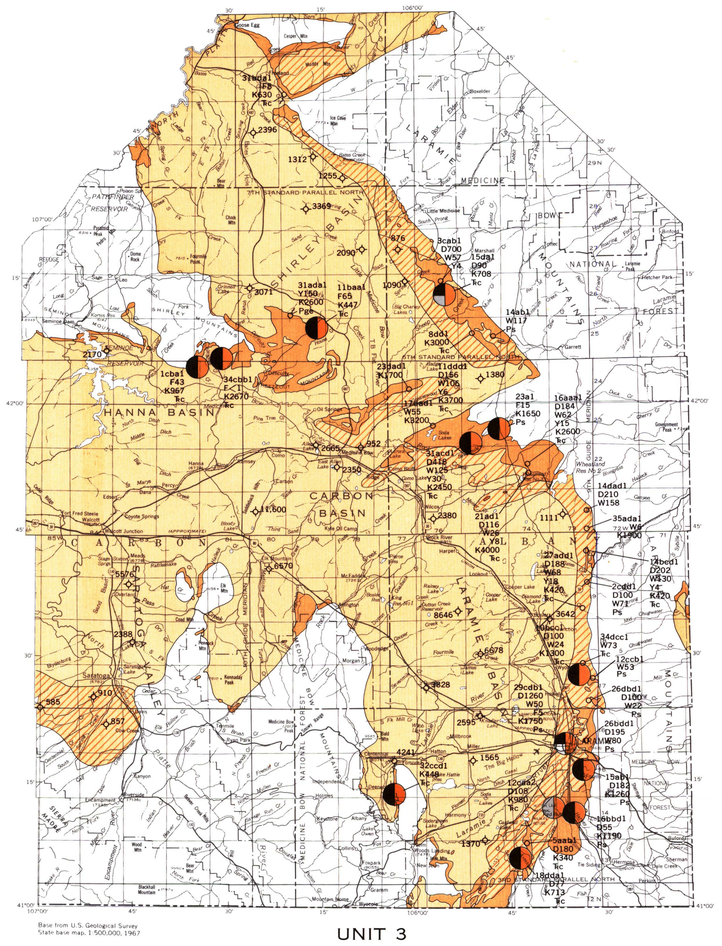
POTENTIAL FOR DEVELOPMENT

Well yields in the order of 50 to 100 gpm can be developed nearly everywhere the full section of the unit is saturated. Yields of wells penetrating only part of the unit will be proportionally smaller. Where the unit is fractured, wells yielding as much as 1,000 gpm can be developed.

Water from several wells that reportedly tap only Unit 2 was similar in quality to that in Unit 3, which is of poorer quality; this suggests that part or all of the water was from rocks of Unit 3. Wells drilled into Unit 2 will yield better quality water if they are constructed to exclude water from the overlying Unit 3.

Summary of lithology and distribution.

Subdivision		Lithology	Distribution
Cloverly Formation (Kcv)		Sandstone and gray to purple shale. Sandstone conglomeratic in places.	The formation averages about 100 feet thick in the area.
Morrison Formation (Jm)		Shale and claystone, variegated red and green; fresh-water limestone and sandstone.	The formation is 200 to 300 feet thick in most of the area; thickens to the south.
Sundance Formation (Js)		Sandstone, siltstone, and shale with small amount of limestone.	The formation thins from about 230 feet in the Freezeout Mountains to 54 feet at Red Mountain (Pipiringos, 1968, p. D8).
Nugget Sandstone		Sandstone, red and gray, and pale red to red siltstone and shale.	The formation is present near Seminoe Dam but is absent eastward in the Shirley and Freezeout Mountains (Pipiringos, 1968, p. D16–D18). Thickness of the formation in the area probably does not exceed 50 feet.
Chugwater Group (Tkc)	Jelm Formation	Shale, sandstone, and siltstone; colors are dominantly reddish brown except in the upper part of the formation where light-colored, massive, crossbedded sandstone is present.	The formation ranges in thickness from 360 feet near Seminoe Dam to 25 feet near Casper (Pipiringos, 1968, p. 13), and averages about 200 feet thick. The formation is absent south of Saratoga.
	Alcova Limestone	Limestone, thin-bedded; forms resistant hogback and dip slopes.	The Alcova Limestone is about 20 feet thick near the town of Alcova and 14 feet thick in the Freezeout Mountains. The formation is absent at Flattop anticline and is not known to occur in the southern part of the area.
	Red Peak Formation	Siltstone and silty claystone, very fine grained sandstone and sandy siltstone, red.	The formation is about 600 to 700 feet thick.
	Goose Egg Formation and equivalents	Shale and siltstone, red, with interbedded limestone and gypsum. In the Laramie area, the Forelle Limestone and Satanka Shale(Ps) are equivalent to rocks in the lower part of the Goose Egg. Rocks equivalent to the upper part of the Goose Egg are poorly exposed (Maughan, 1964, p. 55) and are mapped as part of the Chugwater Group.	The formation is 380 feet thick near the Goose Egg Post Office (Burk and Thomas, 1956, p. 5) but thins southward to about 250 feet of equivalent strata at Red Mountain near the State line in the Laramie Basin.
Casper Formation (PPPc)		Sandstone, limestone, dolomite, shale, and arkose. Includes arkosic Fountain Formation which is nearly 600 feet thick at the State line in the Laramie Basin but wedges out to the north and interfingers with the Casper Formation (Pederson, 1953, p. 23). The Tensleep Sandstone(PPPt), which is laterally continuous with and lithologically similar to the Casper, is also included.	The rocks are 500 feet thick in most of the central part of Albany County and western Carbon County; elsewhere, they are generally 600 to 800 feet thick.
Amsden Formation		Shale, red; sandy shale; and cherty carbonates.	The formation is about 100 feet thick in the southwestern part of the area but is absent in the Laramie, Shirley, Carbon, and Hanna Basins (Agatston, 1954, p. 552).
Madison Limestone (Mm)		Limestone, gray, cherty; massive in upper part; arkosic conglomeratic sandstone in lower part.	The formation is nearly 500 feet thick in the northwestern part of the area but thins southeastward and is absent south of a line extending approximately from the Wheatland Reservoir no. 2 through the town of Elk Mountain.
Cambrian rocks		Sandstone, dark red, quartzitic; conglomeratic in lower part.	The rocks occur only as erosional remnants and, possibly, a wedge extending into the area a short distance from the northwest (Maughan, 1963, p. 26).
Precambrian rocks (pCr)		Chiefly granitic and metasedimentary rocks.	Present, either at the surface or in the subsurface throughout the area.



UNIT 3

OCCURRENCE OF WATER

Permeability sufficient for saturated rock to yield water to wells is widespread only in the sandstone in the upper part of Unit 3. Permeability resulting from fractures and solution does occur locally, however, and large yields of water are obtained where these more permeable rocks are in hydraulic connection with the underlying Unit 2. For this reason, large springs that rise in the outcrop area of Unit 3 are included in Unit 2. Permeability due to fractures and solution is illustrated by conditions near Como Bluff (T. 23 N., R. 77 W.). In this area the rocks have been sharply folded and faulted, and several large springs and small perennial lakes occur. The flow of the individual springs was not measured; however, the flow of Rock Creek increases by about 6 cfs (cubic feet per second) in the reach traversing the area underlain by rocks of Unit 3. This represents natural ground-water discharge to the stream.

QUALITY OF WATER

Dissolved solids in the ground water sampled from this unit ranged from 200 to 3,000 mg/l. The lower concentrations were in samples collected either in the outcrop area where the water has been in contact with the rocks a relatively short time or where there is a hydraulic connection with the underlying unit. The water is generally a calcium sulfate type.

POTENTIAL FOR DEVELOPMENT

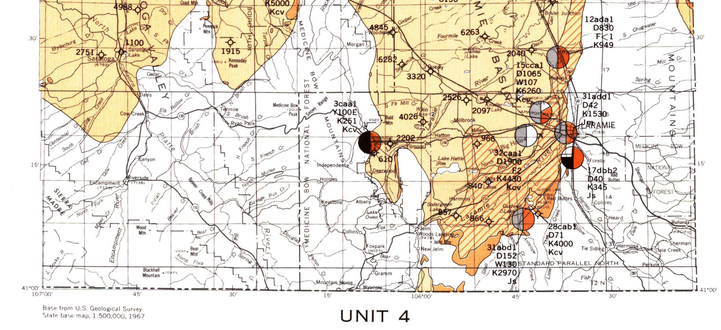
Wells that yield 5 to 10 gpm can be developed nearly everywhere the rocks are present. Large yields are rare but yields in the order of 1,000 gpm have been developed where fracturing or solution has increased the permeability of these rocks. Conditions suitable for large yields depend to a large extent on hydraulic connection with Unit 2. Development for many uses will be restricted because of the high sulfate concentration. Water with a dissolved-solids concentration of less than 750 mg/l is obtained only from shallow wells and springs in the outcrop area. There is no information about the quality of water at depth in Unit 3 because successful deep wells are not known.

Chemical analyses of water

[Results in milligrams per liter except temperature, specific conductance, and pH. Analyses by U.S. Geological Survey]

	Well number	Geologic source	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue at 180°C)	Hardness as ($CaCO_3$)	Specific conductance (micromhos at 25°C)	pH
UNIT 1	13–78– 9caa1	pCr	10– 1–68	6	16	0.03	7.8	2.1	3.7	1.0	41	0	3.3	0.4	0.1	0.2	0.00	58	28	77	6.7
	28bdd1	pCr	10– 1–68	5	12	.60	28	6.1	3.9	1.0	112	0	3.1	.9	.1	.1	.00	136	95	180	7.5
	14–72–14aa1	pCr	1–10–69	.....	9.5	.....	27	6.4	5.6	1.9	55	0	12	15	.3	41	.12	162	94	228	6.6
	19–81– 7dda1	pCr	8– 8–67	3	11	.04	1.6	1.0	1.6	.0	13	0	.0	.7	.0	.1	.05	40	8	25	6.5
	23–72–25aca1	pCr	8–23–68	9	20	.02	38	8.3	7.7	1.6	135	0	20	6.4	.3	5.0	.04	192	130	305	7.0
	25–82–32bab1	pCr	6–27–67	11	21	.12	26	3.0	6.3	1.2	110	0	.8	1.1	.2	1.6	.04	120	78	191	8.1
	26–81– 8c1	pCr	9–10–60	11	39	.23	11	3.9	4.1	.4	50	0	9.4	.0	.2	1.4	.02	75	44	103	6.9
UNIT 2	13–74–30bbc1	PPPc	10– 4–68	.....	13	.....	54	6.9	6.7	0.8	210	0	7.9	1.8	0.8	0.0	0.01	170	163	333	7.7
	15–73–17dcb1	PPPc	1–10–69	13	8.8	0.06	31	24	8.3	1.3	180	0	37	2.4	.3	7.0	.01	214	176	359	7.6
	16–73– 2ddc1	PPPc	4–26–43	.....	.....	.....	32	33	.....	.....	234	0	32	10	.4	4.5	.09	.....	216	330	.....
	21cbc1	PPPc	5–31–69	.....	10	.....	32	21	4.9	1.6	174	0	26	2.9	.2	5.1	.00	182	167	331	8.0
	35cdd1	PPPc	4–22–43	.....	.....	.....	44	25	.....	.....	230	8	11	2.0	.4	3.5	.....	.....	213	388	.....
	17–73– 1bcb1	PPPc	4–29–43	.....	.....	.....	42	12	.....	.....	180	0	3.0	1.0	.0	3.5	.....	.....	154	277	.....
	19–78– 3adb1	PPPc	8–13–68	.....	26	.....	630	43	2,740	166	182	0	2,160	3,720	3.9	1.1	.36	[3]9,580	1,750	13,800	7.0
	21–79–26aa1	PPPc	7–16–68	21	37	1.3	378	43	448	75	118	0	1,590	350	2.9	.1	.65	[3]2,980	1,120	3,780	7.5
	23–76–33bbb1	PPPc	8–22–68	13	9.2	.03	48	20	21	3.8	196	0	60	17	.6	.1	.08	284	203	499	7.8
	77–34a1	PPPc	9–28–65	11	10	.05	61	28	25	3.5	175	0	137	35	.6	.0	.00	422	267	639	8.0
	25–81–15dd1	Mm	7–10–68	6	6.1	.08	46	12	1.0	.4	185	2	5.8	.6	.1	2.3	.01	170	164	295	8.3
	82–36add1	PPPt	7–17–67	13	12	.02	51	11	4.0	.9	213	0	6.6	.0	.2	2.4	.00	194	174	340	8.1
UNIT 3	13–74–18dda1	Tkc	10– 3–68	9	16	.....	84	29	24	1.1	136	0	220	30	0.6	1.2	0.08	456	330	713	7.6
	14–73–16bbd1	Ps	10– 4–68	.....	11	.....	183	19	70	2.1	181	0	474	22	3.8	1.6	.30	902	536	1,190	8.0
	74–12caa2	Tkc	10– 4–68	.....	10	.....	46	34	125	3.2	190	0	322	32	.5	.1	.35	662	255	980	7.7
	15–73–34b1	Ps	4–23–43	.....	.....	.....	225	49	[4]9.0	.....	252	0	542	7	.0	2.5	.04	[3]959	763	1,260	7.6
	77–32ccd1	Tkc	10– 2–68	7	14	.....	59	20	7.1	1.3	188	0	82	1.5	1.1	.1	.03	314	228	448	7.8
	16–73–29cbd1	Ps	5–22–67	8	12	4.5	196	90	98	3.0	154	0	929	12	.6	.2	.27	[3]1,420	861	1,750	7.6
	17–73–10bcc1	Tkc	4–29–43	.....	.....	.....	155	87	.....	.....	150	0	613	13	.7	10	.09	.....	744	1,300	.....
	23–75–23a1	Ps	9–12–68	8.0	23	.02	232	88	35	3.0	156	0	840	25	1.0	3.7	.21	[3]1,330	942	1,660	7.6
	31acd1	Tkc	8–12–68	9	17	.04	459	116	44	4.2	116	0	1,530	26	1.0	2.6	.40	[3]2,260	1,620	2,450	7.5
	24–82– 1cba1	Tkc	7–17–67	9	14	.00	160	37	7.2	1.4	225	0	355	1.4	.5	.9	.00	734	551	967	7.8
	25–79–11baa1	Tkc	7–31–68	8	9.1	.06	57	20	8.6	1.8	250	0	33	1.8	.2	1.2	.01	264	225	447	7.8
	81–34cbb1	Tkc	7–17–67	9	14	.13	471	159	40	2.8	152	0	1,680	8.2	.9	4.9	.10	[3]2,460	1,830	2,670	7.3
	26–76–15da1	Tkc	8–21–68	.....	11	.....	53	25	56	3.6	199	0	175	9.9	.5	7.5	.14	442	234	708	7.8
UNIT 4	14–74–31abd1	Js	10– 3–68	10	1.2	.....	5.4	0.1	680	3.0	0	62	1,310	51	2.1	0.1	0.48	[3]2,120	14	2,970	9.5
	15–73–17dbb2	Js	1–10–69	.....	9.1	.....	29	24	8.0	1.3	180	0	31	2.2	.3	7.7	.01	200	170	345	7.8
	78– 3caa1	Kcv	11– 4–68	8	26	0.09	38	5.1	6.0	1.4	148	0	10	.9	.4	.1	.01	168	116	251	7.5
	16–73–31add1	Jm	11– 7–66	.....	7.8	1.1	45	49	224	3.8	235	0	555	25	1.2	.0	.31	[3]1,030	314	1,530	7.9
	74–15cca1	Kcv	6–24–48	.....	14	.30	17	15	1,600	7.6	1,530	0	1,090	805	2.8	.0	.90	[3]4,320	104	6,260	7.6
	32caa1	Kcv	11–22–68	18	32	1.0	126	37	770	8.4	96	0	465	1,140	4.2	.3	.41	[3]2,630	468	4,430	7.2
	17–74–12da1	?	10–30–68	11	20	.15	.8	.0	235	.6	508	18	25	28	3.2	.5	.15	576	2	949	8.6
	20–73–21abb1	?	10–29–68	8	13	.07	85	8.0	37	1.8	250	0	106	5.8	.6	5.6	.27	418	245	610	8.1
	80–21cc1	Kcv	10– 1–65	36	23	.17	.0	.0	65	1.6	164	0	3.3	3.5	.7	.0	.04	178	0	.....	8.1
	21–79–26aa2	Js	7–16–68	15	30	.17	1.0	.9	746	4.2	1,140	39	302	187	6.8	.1	3.6	[3]1,890	6	2,870	8.5
	24–75– 9ac1	Kcv	9–12–68	.....	7.1	.40	7.0	2.6	410	2.1	334	0	540	64	1.6	1.2	.33	[3]1,200	28	1,800	8.2
	80–19add1	Js	7–14–67	21	11	.06	39	27	135	2.1	228	0	298	7.4	.6	.0	.11	624	211	976	7.9
	25–75–19aa1	Js	8–28–68	8	7.4	.03	156	49	378	5.7	79	0	1,280	39	1.0	.0	.18	[3]1,960	594	2,620	7.0
	26–76–33ca1	Kcv	8–22–68	.....	4.7	.05	24	18	50	3.3	133	0	133	3.5	.4	1.4	.10	310	131	508	7.9
	80–22baa1	Kcv	7–29–68	12	9.0	2.4	14	5.5	102	1.8	250	0	62	2.5	.4	.4	.04	326	58	540	7.9
	29–81– 5bbb1	Kcv	9–14–66	24	12	.06	1.4	.1	184	.2	350	4	98	11	1.6	.0	.34	484	4	779	8.3
	31–79– 8ccd1	Kcv	8–10–67	7	19	.74	10	1.0	2.3	.3	34	0	6.0	.7	.1	3.2	.01	70	30	88	6.6

[1] Calculated from constituents.
[2] Na+K calculated.



UNIT 4

OCCURRENCE OF WATER

A number of areally extensive sandstone beds in the unit will yield water to wells. Some sandstone is only moderately cemented, but, at some localities, it may be highly cemented and, therefore, contains water only in fractures.

QUALITY OF WATER

The quality of water in this unit varies widely. Dissolved solids range from approximately 100 mg/l to about 4,000 mg/l. The water with the lower dissolved solids occurs in the Cloverly Formation. The water is generally is a sodium bicarbonate or sodium sulfate type. The low calcium content of the water, even in parts of the outcrop area, reflects a base-exchange environment.

POTENTIAL FOR DEVELOPMENT

Wells yielding from 5 to 10 gpm can be developed nearly everywhere the sandstones are saturated; maximum yields will generally be less than 50 gpm. A number of holes drilled for oil exploration in this unit have been converted to water wells.

SCALE 1:750 000

10 0 10 20 30 40 MILES

10 0 10 20 30 40 50 60 KILOMETERS

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1973—W72059

WATER RESOURCES OF THE LARAMIE, SHIRLEY, HANNA BASINS AND ADJACENT AREAS, SOUTHEASTERN WYOMING

By
Marlin E. Lowry, Samuel J. Rucker, IV, and Kenneth L. Wahl

1973