Ground-Water Resources of North Park and Middle Park Colorado—A Reconnaissance

By PAUL T. VOEGELI, Sr.

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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GROUND-WATER RESOURCES OF NORTH PARK AND MIDDLE PARK, COLORADO—A RECONNAISSANCE

By Paul T. Voegeli, Sr.

ABSTRACT

North and Middle Parks are in north-central Colorado and include an area of about 3,000 square miles. These parks occupy a large synclinal basin, which is bounded on the west by the Park Range and on the east by the Front Range. Both parks are major catchment areas for large river systems. North Park is in the Atlantic watershed and is drained by way of the North Platte River. Middle Park is in the Pacific watershed and is drained by way of the Colorado River.

The mountain ranges surrounding the parks consist chiefly of rocks of Precambrian age, which contain little ground water. The sedimentary rocks in the synclinal trough range in age from Permian to Recent in North Park and from Pennsylvanian to Recent in Middle Park. The sedimentary rocks are of marine and continental origin and have been acted upon by many different structural forces; as a result, the geology is complex. The hydrologic setting is equally complex. Sufficient ground water for domestic and stock purposes may be found in most parts of the parks.

Alluvium and the Coalmont Formation are the principal aquifers in North Park; alluvium is the principal aquifer in Middle Park. Other formations are capable of yielding some water; however, they are not considered to be aquifers because of their small extent, great depth of burial, or probability of being drained.

The aquifers are recharged principally by infiltration of water from streams and by percolation of precipitation.

Ground water is discharged through wells, springs, and seeps. As the parks are semiclosed ground-water basins, little ground water moves out of them.

The chemical quality of ground water from the many different rock types is generally good, and the water is suitable for most uses.

INTRODUCTION

LOCATION

North and Middle Parks are intermontane basins in the Rocky Mountains in north-central Colorado. North Park, an area of about 1,200 square miles, is the headwater area of the Platte River and includes most of Jackson County; Middle Park, an area of about 1,800 square miles, is the headwater area of the Colorado River and includes most of Grand County and all Summit County (fig. 1). The two parks form a single structural basin about 90 miles long and 35 miles wide; the longer axis trends approximately northward.

PURPOSE AND SCOPE

The primary purpose of this investigation was to obtain information on the occurrence of ground water, a basic knowledge required for the proper management of this part of the State's water resources. Another purpose was to better acquaint residents in the area with the occurrence of ground water, so that supplies for domestic, public, and stock uses might be developed with a minimum of cost and effort. Potential sites for the artificial recharge of otherwise dry formations were investigated as part of a statewide program now in progress.

The investigation included 6 weeks of fieldwork in September and October 1959 and 4 weeks in May and June 1960. Studies were made of the water-bearing properties of appropriate geologic formations, and information was obtained on 185 water wells and springs.

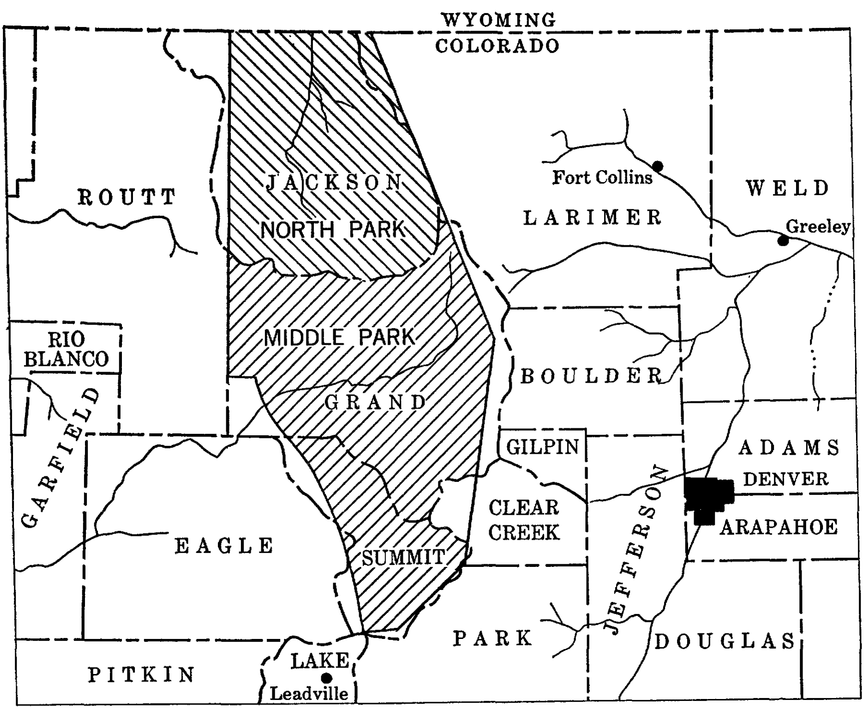

FIGURE 1.—Location of North Park and Middle Park.

Twenty-nine samples of water were collected for chemical analysis. The report describes the general occurrence of ground water, the areas having water and those lacking available ground water, the general nature of the aquifers and their ability to store and yield water, the chemical quality of the water samples in relation to the uses of ground water, and the outlook for future development of ground-water resources.

PREVIOUS INVESTIGATIONS

The earliest geologic investigation of North Park was made in 1874 by A. R. Marvine of the Hayden Survey. Marvine died as a result of the hardship and exposure during the fieldwork in North Park, and only a small part of this work was published in the Hayden geologic atlas (Hayden, 1877). Hague (Hague and Emmons, 1877), of the King Survey, made a hasty reconnaissance of North Park in the middle seventies. In 1911, Beekly (1915) studied the coal resources and general geology. Since 1911, different parts of North Park have been studied in detail; however, most of these investigations have been limited to small areas.

The geology of Middle Park is not well known, nor has it been investigated extensively since the work of the Hayden Survey (Marvine, 1874). Local investigations by mining and engineering interests have been made, and a few (generally unpublished) theses on the subject have been written. Several reconnaissances have been made: one of the northwest corner of Middle Park (Grout, Worcester, and Henderson, 1913), and one of the Granby anticline (Lovering, 1930). At the present time (1963), the U.S. Geological Survey is mapping several quadrangles in detail.

No previous areal ground-water studies have been made in the parks.

ACKNOWLEDGMENTS

The writer is grateful to the ranchers and other residents of the parks who provided basic well information and allowed well measurement and testing. Special thanks are extended to the late John Barnard, Sr., of Middle Park and to C. E. Burr of North Park, who provided information on their wells and the water resources in their respective regions. The municipal officials of Grandby and Walden supplied helpful information on the occurrence of ground water in and near their towns. The Continental Oil Co., Sinclair Oil and Gas Co., and the Texas Co. made available logs of seismograph shotholes in North Park. Thanks are extended to the representatives of the U.S. Forest and National Park Services, who provided information on their wells and on the occurrence of ground water in their areas of responsibility.

SYSTEM OF NUMBERING WELLS IN COLORADO

The wells and logs described in this report are located by a numbering system based on the U.S. Bureau of Land Management system of land subdivision. The number shows the location of the well or log by township, range, section, and position within the section. A graphical illustration of this method of well location is shown in figure 2. The first letter indicates the quadrant of the base line and principal meridian—B indicates the northwest quadrant, C the southwest quadrant. The first numeral indicates the township, the second indicates the range, and the third indicates the section in which the well is situated. Lowercase letters following the section number locate

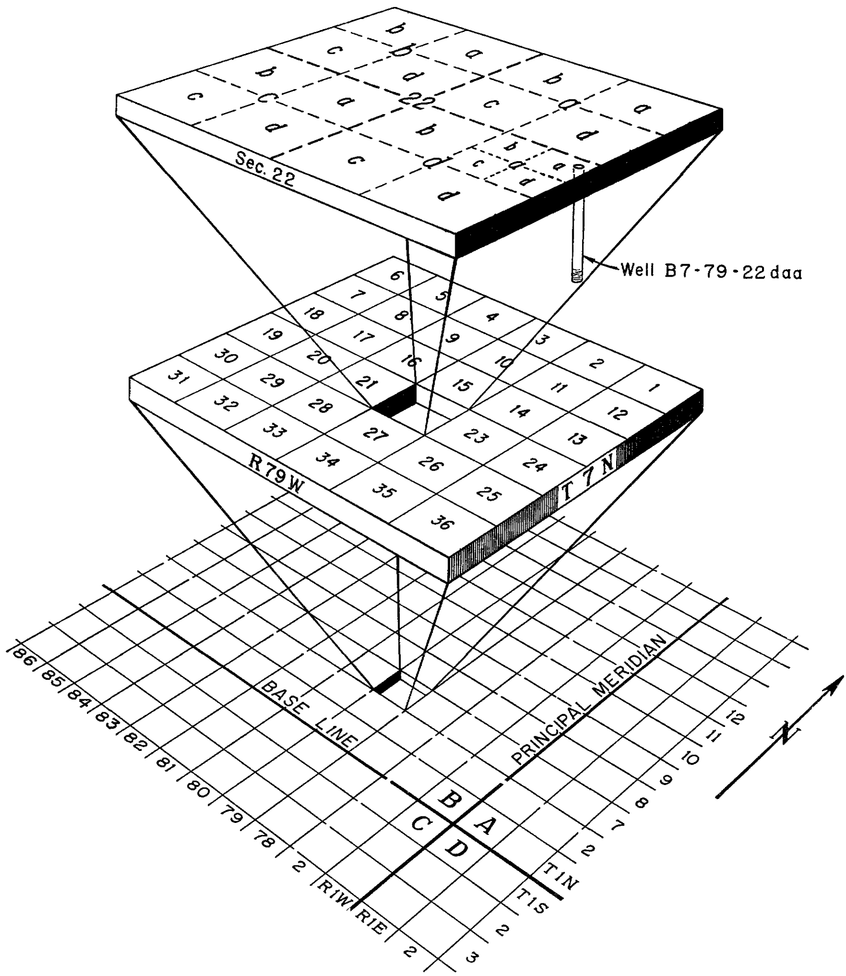

FIGURE 2.—System of numbering wells and test holes in Colorado.

the well within the section. The first letter denotes the quarter section, the second letter denotes the quarter-quarter section, and the third letter denotes the quarter-quarter-quarter section. The letters are assigned in a counterclockwise direction, beginning with "a" in the northeast quarter of the section. Letters are assigned to each quarter-quarter section and each quarter-quarter-quarter section in the same manner. If more than one well occurs in a quarter-quarter-quarter section, consecutive numbers beginning with 2 are added to the letters. For example, B7–79–22daa2 indicates a well in the northeast quarter of the northeast quarter of the southeast quarter of sec. 22, T. 7 N., R. 79 W., and shows that this is the second well inventoried in the quarter-quarter-quarter section. The capital letter B indicates the township is north of the base line and that the range is west of the principal meridian.

GEOGRAPHY

NORTH PARK

North Park is an extensive natural depression surrounded by high picturesque mountain ranges. The area is bounded on the east by the Front Range, which consists of the formidable Medicine Bow and Never Summer Mountains, on the west by the Park Range, on the south by the Rabbit Ears Range, and on the north by several high mountains and associated lesser peaks. Maximum relief in the area is about 5,000 feet. The lowest altitude, about 7,550 feet, is in the northern part of the park where the North Platte River enters Wyoming. The high peaks surrounding North Park range in altitude from 11,000 to 13,000 feet.

The floor of North Park seems flat when viewed from a high point. When viewed from the floor, however, local relief is rather pronounced; and the flatness of the floor is broken by ridges, small hills, and mesas. The most prominent topographic feature on the floor is Owl Ridge, which rises nearly 1,500 feet above the floor. This hogbacklike ridge extends north-northwestward across the center of the park and terminates near the flood plain of the North Platte River. Sheep Mountain, Delaney Butte, and Sentinel Mountain also rise appreciably above the floor of the park.

MIDDLE PARK

Middle Park occupies an extensive natural depression surrounded by high mountains. The area is bounded on the west by the Park Range, on the east by the Never Summer Mountains and Front Range, on the north by the Rabbit Ears Range, and on the south by the confluence of the Park Range and the western part of the Front Range. Unlike the flat-floored basin of North Park, Middle Park is divided topographically into a series of valleys and subbasins.

Maximum relief is about 5,500 feet. The lowest altitude, about 7,300 feet, is in the western part of the park where the Colorado River enters Gore Canyon. The high peaks surrounding Middle Park range in altitude from 10,000 to 13,000 feet.

ECONOMIC DEVELOPMENT

NORTH PARK

Population.—The population of North Park in 1960 was about 1,800. Walden, the largest town, is the only incorporated community. It had a population of 809 in 1960. Other communities are Cowdrey, Gould, Coalmont, and Rand. (See pl. 1.) The density of the rural population is less than one per square mile.

Agriculture and industry.—The chief sources of income in North Park are the raising of beef cattle and sheep and the production of wild hay. North Park leads Colorado in the production of wild hay. The average size of ranches is about 3,500 acres.

Oil and other mineral resources, also, are important in the economy. Several oil fields are in production, and, in 1960, coal was mined at Coalmont for rail shipment. Fluorspar mining has been active periodically since 1918.

Over the years, the Colorado State Forest, in the southeastern part of North Park, has produced about 10 million board feet of cut lumber.

MIDDLE PARK

Population.—The population of Middle Park in 1960 was about 5,600. The major towns and their 1960 populations are Breckenridge (393), Dillon (814), Fraser (253), Frisco (316), Hot Sulphur Springs (237), Granby (503), Grand Lake (170), and Kremmling (576). During the summer, Middle Park attracts many tourists and weekend vacationers, and the population temporarily increases many fold. The density of the rural population is about $1\frac{1}{2}$ per square mile.

Agriculture and industry.—The raising of beef cattle and sheep and the production of wild hay are the major agricultural activities. The average size of ranches is about 1,400 acres.

Mining was at one time an important part of the economy of southern Middle Park. Now, recreation is a large source of income. Middle Park provides many year-round attractions for the tourists and others seeking outdoor living—boating, skiing, fishing, and hunting.

IMPORTANCE OF WATER TO ECONOMIC DEVELOPMENT

Water is a major natural resource in North and Middle Parks. The economic development of the parks depends on the continued availability of water for domestic, stock, and irrigation supplies. Surface water has been and will continue to be the principal source of supply to meet an ever-increasing water demand to support a growing economy. Ground water will continue to play a major role in areas remote from surface-water sources, where small supplies are needed for domestic and stock use. In a few areas, ground water may be used with surface water to augment and regulate the total water supply.

Although surface water in the area seems to be unlimited, the quantity available is relatively small because much of the water has been awarded by decisions of the courts to users outside the parks. Ground water, also, is not abundant, except in a few places.

CLIMATE

The climate of North and Middle Parks is typified by pleasant warm days and cool nights in the summer and cold days and nights during the winter. June through September are generally the warmest months; and December through February, the coldest. The average monthly temperature at six stations in the parks is shown in table 1.

On the floor of North Park, annual precipitation is about 9 inches; in the lower altitude of Middle Park, it ranges from 13 to 18 inches. Precipitation in the surrounding mountains is considerably greater. Precipitation is greatest during the summer, as shown in table 1.

DRAINAGE

North Park is drained by the North Platte River, which flows northward into Wyoming. Near the Wyoming border, the river has an annual discharge of about 300,000 acre-feet. Water from the North Platte and its numerous tributaries is diverted in many places during the growing season for the irrigation of about 130,000 acres of hay meadows. Many of the streams are perennial, owing to constant supplies of melt water derived from high snowfields in the surrounding mountains. In some areas perennial flow is sustained by spring discharge.

No natural outlet for drainage exists in the northwestern part of the area east of Sheep Mountain, and the surface water collects in large depressions, forming lakes. The two largest of these are Lakes John and Boettcher.

TABLE 1.—*Average monthly temperature and precipitation in North and Middle Parks, Colo.*

[Data from publications of the U.S. Weather Bur.]

Locality	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average annual	Altitude of station (feet)	Years of record
Temperature (°F)															
Dillon [1]	15.0	17.3	22.7	32.9	42.0	49.4	55.1	53.8	47.8	38.4	25.2	18.2	34.8	8,794	48
Fraser	12.9	15.7	22.0	33.0	41.9	49.6	55.1	53.2	46.5	36.5	23.2	15.8	33.8	8,560	48
Grand Lake	13.4	18.4	24.9	35.4	44.4	51.5	57.8	56.3	49.8	40.2	26.8	18.8	36.5	8,288	6
Green Mountain Dam	15.3	20.8	27.3	38.4	47.7	54.7	60.9	59.4	52.9	42.3	28.8	20.5	39.1	7,740	18
Hot Sulphur Springs	14.7	17.7	25.5	36.0	47.3	55.8	60.4	60.2	51.5	41.3	26.2	17.7	37.9	7,800	7
Walden	15.9	18.2	25.5	36.5	45.9	53.9	59.5	58.6	51.3	40.4	28.1	24.8	37.7	8,099	18
Precipitation (inches)															
Breckenridge	1.73	2.33	2.45	2.67	1.99	1.19	2.35	2.04	1.47	1.48	1.59	2.05	23.34	9,559	8
Dillon [1]	1.41	1.51	2.13	2.21	1.73	1.22	1.94	1.71	1.12	1.14	1.22	1.30	18.64	8,794	54
Fraser	1.37	1.44	1.59	1.83	1.67	1.38	1.64	1.53	1.04	1.00	1.16	1.08	16.73	8,560	52
Grand Lake	1.56	1.30	1.17	1.90	1.33	1.18	1.81	1.56	1.25	.92	.84	1.33	16.15	8,288	6
Hot Sulphur Springs	.74	.77	.96	1.14	1.27	.96	1.48	1.21	1.92	.86	.78	.62	12.71	7,800	8
Walden	.43	.55	.84	1.18	1.08	.93	.81	1.06	.89	.54	.45	.37	9.13	8,099	19

[1] Station at former town of Dillon, near Dillon damsite.

The Colorado River drains Middle Park. Before major amounts of water were diverted across the mountains, the river at Kremmling had an annual discharge of about 1,300,000 acre-feet. Some water is diverted for local irrigation; however, about 23 percent of the water originating in Middle Park is diverted to the eastern slope of the Front Range for use by the city and county of Denver and the Colorado–Big Thompson project of the U.S. Bureau of Reclamation. The principal tributaries of the Colorado River in Middle Park are the Williams Fork, Blue and Fraser Rivers, and Troublesome and Big Muddy Creeks.

GROUND-WATER ENVIRONMENT AND AVAILABILITY

The occurrence and availability of ground water in North and Middle Parks are similar. In both areas the most readily available source of ground water is from the alluvium of streams. Complex geology and hydrology also are common features. Where feasible, each area is discussed separately, however, because of individual differences that affect occurrence and availability.

NORTH PARK

Most of North Park is underlain by formations consisting principally of shale and other fine-grained materials having low permeability. Sandy zones in some of the shaly formations contain small amounts of water. Many of the sandy zones are small and discontinuous, and locating them by test drilling may be costly and difficult. Formations such as the Pierre and Benton Shales have few sandy zones and are nearly impermeable.

Some rocks in North Park contain small quantities of water in amounts adequate for domestic and stock supplies. These include local glacial, landslide, and talus deposits, permeable zones in the North Park Formation of late Miocene age, sandstone zones in rocks older than the Coalmont Formation of Paleocene and Eocene age, and the granite, schist, and gneiss of Precambrian age. The glacial deposits, although of relatively small volume, are capable of fairly large yields to wells locally. Water issues from springs along the contact of the North Park Formation, which is composed of continental deposits, of Miocene age and the Coalmont Formation of Paleocene and Eocene age on the flanks of Owl Ridge. Springs discharging from Precambrian rocks provide some domestic and stock water in the areas bordering the park floor. The capability of these rocks to yield quantities adequate for domestic and stock supply varies widely throughout North Park. The secondary sources should be considered when attempting to develop a domestic or stock supply;

however, first consideration should be given to the sources of water in the alluvium and Coalmont Formation.

Water in the alluvium of the streams can be readily developed, but its potential is limited to supplying water for domestic and stock use.

The Coalmont Formation underlies much of North Park and in some parts of the park is the only potential source of ground water. In several places, discontinuous sandy zones in the Coalmont yield small quantities of water to wells; but the subsurface extent and exact location of the sandy zones are unknown, and the full water-yielding potential of this unit remains to be tested.

MIDDLE PARK

Large quantities of ground water can be obtained in a few small areas in Middle Park, but most of the park is underlain by rocks that are capable of yielding only meager supplies of water. The relative impermeability of the materials inhibits or precludes the entrance of water. Some of the formations consist of material in which water could be stored; however, many of the formations are drained or can be reached only by deep drilling. Most of the formations in Middle Park in many places have steeply inclined beds and are faulted. In small, local areas, formations not generally capable of storing water have been broken and fractured and may contain some water in the fractures. Where the Precambrian rocks are broken or fractured, water may issue from springs. The Jurassic and Cretaceous rocks are generally poor sources of water. Some water is available from the Dakota Sandstone in places where it is sufficiently thick and has not been drained. In the Tertiary sedimentary rocks, some water is available from fractured zones and in places where sandstone, sand, gravel, or boulders are the predominant constituents. Wells in undrained terrace deposits are capable of yielding water in quantities sufficient for domestic and stock supplies.

The alluvium of the various streams is the principal source of ground water in Middle Park. In most places the alluvium is capable of yielding at least enough water for domestic use.

STRATIGRAPHY AND STRUCTURE

NORTH PARK

North Park is underlain by a thick sequence of sedimentary rocks ranging in age from Permian to Recent. The sequence of these rocks is well known from exposures in the area and on the flanks of the park and from the logs of deep oil prospects. The age designations, thickness, physical character, and water-supply characteristics of the principal geologic units in North Park are shown in table 2. The distribution of the alluvium and the outcrops of bedrock units in North and Middle Parks is shown on the generalized geologic map (pl. 1).

The sedimentary rocks of North Park occupy a large synclinal trough between the uplifted masses of granite and other types of Precambrian rock of the Medicine Bow–Never Summer Ranges on the east and the Park Range on the west. The north end of the syncline is cut off abruptly by the east-trending Independence Mountain fault, and the south end of the syncline is crossed by the Rabbit Ears Range. The rocks of North Park also have been deformed by faults, folds, and anticlines. Most of the anticlines have been faulted.

The diversified structural patterns in North Park have presented many complex problems to those in search of petroleum and will present similar problems to those seeking ground water. The geologic map (pl. 1) does not show details of the complex geology and should be used only as a general reference in selecting well sites.

MIDDLE PARK

Middle Park is underlain by a thick sequence of sedimentary rocks ranging in age from Pennsylvanian to Recent. The sequence of the rocks is fairly well known; however, their areal limit, relation, thickness, and detailed lithologic character are only generally known. The principal geologic units in Middle Park capable of yielding readily available water are Tertiary or younger in age. The age designation, thickness, physical character, and water-supply potential of the principal geologic units are shown in table 3. The distribution of the surficial deposits and the outcrops of bedrock units are shown on plate 1.

The large synclinal trough in North Park extending into Middle Park is filled with sedimentary rocks of Mesozoic and Tertiary age. These rocks are exposed in the northern part of the Middle Park in parts of Rabbit Ears Range. The regional and local structural features of Middle Park are complex. To point out the complex structural features of the park, a description by Tweto (1957, p. 25) follows:

> Structural features within the major Middle Park syncline divided the southern part of the Park into three geologically dissimilar units. An eastern area, lying between the flank of the Front Range and the Vasquez Mountains, is characterized by a thick section of Middle Park formation, a zone of sharp overlap of this formation against older rocks, and by the Vasquez thrust fault, which is accompanied locally by tight folds. A central area, extending from the northern end of the Vasquez Mountains at Byers Canyon westward to the vicinity of Troublesome Creek, is an area of upwarp marked by outcrops of Precambrian rocks and a thin sedimentary section. In a third area, extending from Troublesome Creek to the flank of the Park Range, shales of Cretaceous age near the western flank of the main syncline are overridden by Precambrian rocks of the Williams Range thrust fault. The Middle Park formation is absent or inconspicuous in this area.

TABLE 2.—*Generalized section of geologic formations in North Park*

System	Series	Subdivision	Thickness (feet)	Physical character	Water supply
Quaternary	Recent	Alluvium	0-80± (Averages<25)	Sand, gravel, clay, and silt.	Principal source of readily developed ground water in area. Yields adequate quantities of water of generally good quality to domestic and stock wells.
	Recent and Pleistocene	Landslides and talus	0–100	Sand, gravel, clay, and boulders.	Yields some water to springs and seeps.
		Terrace deposits	0–6	Sand and gravel.	In a very few places yields water to springs and seeps.
	Pleistocene	Glacial deposits	0–150	Sand, gravel, clay, and boulders.	Yields adequate quantities of water to domestic and stock wells.
Tertiary	(Units in subdivision may not be in order of age.)	Continental deposits undifferentiated (may include White River Formation of Oligocene age)	0–400±	White sandstone, conglomerate, reddish-brown and green shale, white tuffaceous siltstone, and claystone.	Yields water to springs and seeps.
		Undifferentiated intrusive and extrusive rocks		Quartz monzonite, andesite porphyry, obsidian porphyry, basalt, andesite, and rhyolite.	Does not yield water to wells in North Park.
	Miocene	North Park Formation	0–2, 000	Calcareous sandstone and conglomerate; contains some siltstone, clay, volcanic ash, and tuff.	Yields water to wells in northwestern and central parts of North Park.
	Eocene and Paleocene	Coalmont Formation	6, 000–9, 000	Sandstone, shale, coal beds, and conglomerate.	In some areas, yields adequate quantities of water of generally good quality to domestic and stock wells. In other areas, yield and chemical quality of water are poor.
Cretaceous	Upper Cretaceous	Pierre Shale	3, 000–4, 500	Dark-green and black shale; contains thin beds of sandstone.	Does not yield water to wells in North Park.
		Niobrara Formation	400–900	Calcareous gray and dark-gray shale; contains thin beds of limestone.	Do.
		Benton Shale	500–650	Shale, sandy shale, sandstone, and thin limestone.	Do.

	Lower Cretaceous	Dakota Sandstone	165–320	Sandstone and conglomerate interbedded with thin shale.	Some water might be obtained near the outcrop.
Jurassic	Upper Jurassic	Morrison Formation	400–500	Varicolored shale and marl; contains thin layers of limestone and sandstone.	Does not yield water to wells in North Park.
		Sundance(?) Formation	100–150	Sandstone; contains minor amounts of siltstone and limestone in upper part.	Some water might be obtained near the outcrop. In most of area, formation is at great depth.
Triassic and Permian		Chugwater Formation	600–800	Red silty shale and sandstone.	Does not yield water to wells in North Park.
Permian		Forelle Limestone	0–50	Pink to light-gray limestone.	Do.
		Satanka(?) Shale	0–50	Red silty shale.	Do.
Precambrian				Metamorphoric and igneous rocks consisting chiefly of schist, gneiss, and granite.	Yields water of good quality to springs.

TABLE 3.—*Generalized section of geologic formations in Middle Park*

System	Series	Subdivision	Thickness (feet)	Physical character	Water supply
Quartenary	Recent	Alluvium	0– 100±	Gravel, sand, silt, and clay.	Principal source of readily developed water. Yields adequate quantities for domestic and stock supply nearly everywhere. Locally yields moderate to large quantities.
	Recent and Pleistocene	Landslides and talus	1– 100	Sand, gravel, and boulders.	Yields water to springs and seeps.
		Terrace deposits	1– 100±	Boulders, gravel, sand, and silt.	Yields water to wells, where not drained.
	Pleistocene	Glacial deposits	0– 200±	Boulders, gravel, sand, silt, and clay.	Yields water to wells and springs.
Tertiary	(Units in subdivision may not be in order of age.)	Continental deposits undifferentiated (may include White River Formation of Oligocene age)	0–1,000±	Boulders, gravel, sand, silt, clay, sandstone, siltstone, and shale.	Yields water to wells.
		Undifferentiated intrusive and extrusive rocks		Trachyte porphyry, monzonite porphyry, scoria, breccia, andesite, and basalt.	Not known to yield water to wells.
		Lakebed deposits	200–1,000±	Mudstone conglomerate lenses, dark shale, tuff, clay, and sand.	Yields water to a few wells.
	Paleocene	Middle Park Formation	2,500–5,000	Lower part consists of breccia, agglomerate, and conglomerate; upper part consists of conglomerate, sandstone, and shale.	Yields water to springs.
Cretaceous	Upper Cretaceous	Pierre Shale	200–5,000	Dark-gray to brown or greenish-brown shale; contains sandy zones.	Yields water to a few wells where formation has been fractured.
		Niobrara Formation	400– 500	Consists of basal limestone unit overlain by calcareous shale, thin-bedded limestone and interbedded shale and dark-gray calcareous shale.	Does not yield water to wells.
		Benton Shale	0– 300±	Dark fissile shale and a sandy zone near the top.	Do.

	Lower Cretaceous	Dakota Sandstone	140– 400	Consists of three units: a lower light-gray to white sandstone and local basal conglomerate; a middle dark shale; and an upper white to light-gray sandstone.	Yields water to a few domestic and stock wells.
Jurassic	Upper Jurassic	Morrison Formation	25– 400	Variegated clay-shale and mudstone and sandstone.	Yields water to a few wells and springs.
Pennsylvanian and Permian		Undifferentiated	0–9, 000	Limestone, dolomite, coarse conglomerate, cobbles, fine-to coarse-grained sandstone, siltstone, and shale.	Does not yield water to wells.
Precambrian				Metamorphic and igneous rocks consisting chiefly of schist, gneiss, and granite.	Yields water of good quality to springs.

The many types of structural features in Middle Park influence the occurrence of ground water. The geologic structure in many areas eliminates the possibility of obtaining ground water that normally would be available if the formations had remained undisturbed. In many places, formations capable of yielding water dip steeply and can be reached only by deep drilling. In some places, faults have severed water-bearing formations, and drainage of the formation has resulted.

HYDROLOGY

The wide variety of geologic conditions in North and Middle Parks results in a wide variety of ground-water occurrences. In many places, such as in the alluvium, ground water is under water-table conditions. The water occupies a part or all of the permeable soil or rock, and its surface is not confined by impermeable material. In places where the water-bearing formation is confined by overlying materials that are relatively impermeable, the water table is absent, and the water is under artesian conditions. Artesian water occurs in parts of the Coalmont Formation in North Park and in parts of the Dakota Sandstone and undifferentiated Tertiary deposits in Middle Park.

The aquifers of North Park and Middle Park are recharged by local precipitation. Water may be added to the permeable formations directly from precipitation, or it may enter the formation elsewhere from streams, irrigation canals, or irrigated fields.

Ground water is discharged by wells and springs, and through seepage into streams. Some water is also discharged by evapotranspiration in places where the water table is close to the land surface.

Little ground water moves out of the parks, owing to the general impermeability of the rocks that surround each area.

QUALITY OF WATER

Twelve ground-water samples from North Park and 17 from Middle Park were collected and analyzed to (1) provide general information on the chemical quality of water in the formations presently being tapped by wells and (2) to evaluate the suitability of the water for domestic and stock use. The results of the analyses are shown in tables 4 and 7. The location of the sampling points is shown on plate 2.

Concentrations of dissolved constituents are given in parts per million (ppm); a part per million is the weight of a constituent in a million unit weights of water. Thus, a water sample containing 1 ppm iron (Fe) contains 1 pound of iron in a million pounds of water.

The analyses of the water samples collected in North Park indicate that most of the water is of a quality suitable for domestic and stock use, although some water contains undesirable amounts of iron and one sample had an excessive content of fluoride. The water from well B9–79–16cbc, tapping the Coalmont Formation, was the only water sampled in North Park that exceeded the suggested limits for dissolved-solids content (U.S. Public Health Service, 1962). The relatively poor quality of this water may be attributed to local conditions in the Coalmont. Water similar in quality to that from well B9–79–16cbc may be found elsewhere in the Coalmont Formation in North Park, but water of good quality is more likely to be found.

The analyses of the water samples collected in Middle Park indicate that most of the water is of a quality suitable for domestic and stock use. The water from spring B2–79–32abb was the only water that contained more than 1,000 ppm dissolved solids. In places, water in the glacial deposits reportedly contains iron in excess of the standards established for domestic use.

Water in the alluvium of the parks should be similar in quality to that in the adjoining rivers and streams.

The chemical quality of ground water in the parks for the most part meets the nationwide standards for potable water established by the U.S. Public Health Service (1962). The American Water Works Association has adopted these standards as recommended limits for public water supplies. Standards for some of the chemical constituents are listed in the following table:

Allowable limits for public water supply

Constituent	*Concentration (ppm)*
Iron	0.3
Manganese	.05
Chloride	250
Sulfate	250
Fluoride	[1] 1.5
Dissolved solids	[2] 500

[1] Latest recommended control limits (1962) give lower, optimum, and upper control limits for fluoride based on the annual average of maximum daily air temperatures as follows:

Annual average of maximum daily air temperatures (° F)	Recommended control limits (fluoride concentrations, in ppm)		
	Lower	Optimum	Upper
50.0–53.7	0.9	1.2	1.7
53.8–58.3	.8	1.1	1.5
58.4–63.8	.8	1.0	1.3

[2] 1,000 ppm permitted if no other supply is available.

PRINCIPAL AQUIFERS

NORTH PARK

ALLUVIUM

The alluvial deposits of North Park, because of their wide areal distribution and general capability to provide at least minimum quantities of water for domestic and stock wells, are considered to be the major source of ground water in the area.

The alluvium, derived from the park floor and surrounding mountains, consists chiefly of sand and gravel in a matrix of silt and other fine-grained material.

During the formation of the drainage system of North Park, the streams had little opportunity to cut deeply into bedrock or to form wide, deep alluvial valleys, owing to the semiclosed drainage of the park. Although many of the stream deposits occupy large areas, the average thickness of the alluvium is generally less than 25 feet. Areas where the thickness is greater than 25 feet are not extensive. Selected logs of wells, test holes, and seismograph shotholes, describing the thickness and character of the alluvium, are given in table 6.

Large yields from wells in the alluvium do not seem possible. The permeability of the alluvium in many places is high; however, because the zone of saturation is thin, high sustained yields to wells cannot be expected. Locally, yields greater than 300 gpm (gallons per minute) might be possible; however, they may be expected only in exceptionally favorable areas where the thickness of saturated sand and gravel exceeds 25 feet.

During this study a pumping test was made of a well (B9-79-21bcc2) tapping the alluvium of the Michigan River at Walden; the test was made on October 5-6, 1959. The pertinent data and results are given in the following table:

Well B9-79-21bcc2 [1]

Depth of well	feet	35
Depth to bedrock	do	12
Depth to water below land surface	do	4
Total saturated thickness	do	8
Duration of pumping	hours	24
Average pumping rate	gallons per minute	113
Drawdown	feet	20
Coefficient of transmissibility [2]	gallons per day per foot	20,000
Coefficient of permeability [3]	gallons per day per square foot	2,500

[1] Well-numbering and location system described on p. G4.

[2] Coefficient of transmissibility is the quantity of water passing through a section of the aquifer 1 mile wide under a hydraulic gradient of 1 foot per mile. Computation is based on nonequilibrium method of Theis (1935). The coefficient of transmissibility also is equal to the coefficient of permeability multiplied by the saturated thickness.

[3] Coefficient of permeability is the quantity of water passing through a section 1 foot high and 1 mile wide under a gradient of 1 foot per mile.

On the basis of pumping tests and other observations, underflow in the alluvium of the Michigan River near Walden is estimated to be 500,000 gpd or 1½ acre-feet per day. The hydrologic and geologic characteristics of the alluvium of the Michigan River seem to be similar to those of the alluvium of other rivers and streams in the park, which may have similar abilities to yield water to wells.

The alluvium is recharged by water from streams and by irrigation water applied to hay meadows in the valleys.

COALMONT FORMATION

The Coalmont Formation of Paleocene and Eocene age is a lesser source of ground water in North Park than the alluvium. The formation, consisting of shale, sandstone, coal beds, and conglomerate, is capable in some areas of providing water to domestic and stock wells. The thickness and the limits of subsurface distribution of constituent materials in the Coalmont Formation differ greatly from place to place.

The small amount of water in the Coalmont is generally in the sandstone and sandy zones. The texture, color, and other physical characteristics of the sandstone and sandy zones differ greatly from place to place and within short distances. Beekly (1915) discussed in detail the diversity of the constituents of the sandstone and other strata of the Coalmont Formation.

The few wells that tap the formation generally penetrate only a small part of the total thickness. Records of these wells show that the water-bearing capacity of the deposits differs greatly from place to place. The available records and geologic study (Beekly, 1915) are insufficient to be used as bases for predictions of the probable success or failure of proposed well sites in unexplored areas. The Coalmont provides water of a quality suitable for domestic and stock use near Rand and in parts of T. 7 N., R. 79–80 W. In these areas, development of wells in the Coalmont has been more extensive than elsewhere in the park. The Coalmont has been tapped in other areas in the park, but individual wells are miles apart.

The formation is probably not capable of yielding large quantities of water to wells anywhere in the area. Yields of wells tapping the Coalmont Formation are generally less than 10 gpm. Some wells tapping the formation penetrate only a few sandstone layers or sandy zones and yield little or no water. Low yield of these unsuccessful wells may be attributed mainly to a lack of permeable zones.

The permeability of the water-bearing zones in the Coalmont Formation is generally unknown. One pumping test was made during the present investigation; the test, on July 6–7, 1960, was of well B10–79–

32ddd, 3.5 miles north of Walden. The results of that test are shown in the following table:

Well B10–79–32ddd

Depth of well	feet	97
Depth to water below land surface	do	8
Duration of pumping	hours	26
Average pumping rate	gallons per minute	6.3
Drawdown	feet	10.8
Specific capacity [1]		.58
Coefficient of transmissibility	gallons per day per foot	900

[1] Yield of well, in gallons per minute per foot of drawdown.

WATER UTILIZATION AND RECOVERY

The principal use of ground water in North Park is for domestic and stock supply. Large-capacity wells capable of yielding water in quantities required for irrigation do not exist. The location of selected wells and springs is shown on plate 2. Records of selected wells and springs are given in table 5. Of the less than 200 wells in North Park, most are less than 50 feet deep and tap the shallow alluvium. A few have been drilled into the Coalmont Formation to depths greater than 200 feet.

MIDDLE PARK

ALLUVIUM

The alluvium, including the terrace deposits of the streams, is the best source of readily developed ground water in Middle Park, although the area of such deposits is small.

The deposits derived from the hills and mountains in and adjacent to the park consist chiefly of sand, gravel, and included boulders, silt, and other fine-grained material. Their thickness ranges from zero to about 100 feet. Where the gradient of the streams is not great, deposits capable of storing usable quantities of water occur. Where the streams have steep gradients and have cut deeply into bedrock, few water-bearing deposits of alluvium exist.

The alluvial deposits of the Colorado, Blue, and Fraser Rivers are the principal alluvial sources of ground water in Middle Park. In many places the alluvium and associated terrace deposits of these rivers are saturated with usable quantities of water, whereas in other places the materials are thin and are not capable of yielding much water. Yields of as much as 400 gpm have been measured from wells drilled into the alluvium of the Blue River near the Dillon damsite.

One aquifer test was made in 1960 of the alluvium of the Fraser River at Granby, and in 1956 several tests were made of the alluvium of the Blue River at the Dillon damsite. A summary of the results of the aquifer test at Granby is given in the following table:

Well B1–76–6bab

Depth of well below land surface feet	14
Depth to water below land surface do	5.4
Duration of pumping hours	24
Average pumping rate gallons per minute	100
Drawdown feet	3.6
Specific capacity gallons per minute per foot	28
Coefficient of transmissibility gallons per day per foot	12,000

A summary of the results of the aquifer tests in September–October 1956 at Dillon are shown below:

Well C5–77–18bbc1

Depth of well feet	75.2
Depth to bedrock do	73.5
Depth to water below land surface do	14
Total saturated thickness do	59.5
Duration of pumping hours	136
Average pumping rate gallons per minute	400
Drawdown feet	10
Specific capacity gallons per minute per foot	40
Coefficient of transmissibility [1] gallons per day per foot	200,000
Average coefficient of permeability gallons per day per square foot	4,000
Specific yield [2] percent	20

[1] Computation is based on nonequilibrium method of Theis (1935) and the Thiem (1906) method for water-table conditions.

[2] The quantity of water that a given volume of the aquifer will yield to wells under the pull of gravity if it is first saturated and then allowed to drain.

WATER UTILIZATION AND RECOVERY

Ground water in Middle Park is used principally for domestic, stock, and commercial (motel, cafe, and resort) supplies. Most of the ground water used is pumped from wells; however, springs are the principal source of ground water in some places. The location of selected wells and springs is shown on plate 2, and records of these wells and springs are given in table 8. About 300 wells of all types are in the park. Most of them are less than 100 feet deep and tap either alluvium or glacial deposits. A few have been drilled to depths greater than 200 feet. One of the deepest in Middle Park is on the Yust Ranch, south of Kremmling. This flowing artesian well, in the NE¼ sec. 30, T. 1 S., R. 80 W., reportedly is 1,485 feet deep.

OUTLOOK FOR THE FUTURE

NORTH PARK

Although ground water in North Park is not abundant, quantities necessary to maintain the growing economy of the area seem to be available. Alluvium will continue to be the principal source of readily

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available ground water. The Coalmont Formation in some areas will continue to be a source of water, with the probability of yet unproven areas being developed. The prospects for developing irrigation wells are not promising. Some irrigation wells might be drilled locally, but the yields of the wells would probably be barely adequate. The geologic and hydrologic features of North Park are such that wells for irrigation or as a supplemental source to surface water is generally not possible.

MIDDLE PARK

Middle Park, also, has few ground-water resources, although it has more than North Park. The search for and development of ground water in much of Middle Park are difficult, owing to the complex geology and hydrology. Except in the alluvium downstream from the Dillon damsite, near Granby, along the North Fork of the Colorado River, and in a small area in the upper part of the Williams Fork in Tps. 2–3 S., Rs. 77–8 W., where at least moderate quantities of ground water seem to be available, aquifers in Middle Park generally yield only small quantities of water. The alluvium should be given first consideration in attempting to obtain a ground-water supply. The occurrence of water in the bedrock units of the park is little known; however, on the basis of past experience with the bedrock units, the search for ground water in these rocks should be attempted only with careful field examination and subsurface testing.

The chemical quality of ground water in Middle Park is generally good, and the water is usable for most purposes.

The availability of water in the alluvium of Middle Park depends greatly on the amount of surface-water recharge. In many places in Middle Park, water levels in alluvial valleys respond directly to surface-water availability. If the recharge to the alluvium is reduced by upstream diversion of surface water, ground water in the lower parts of stream valleys may be depleted.

Doubling or tripling the number of wells in Middle Park should have no adverse effect on wells now in use. The natural conditions for developing large-capacity wells do not exist in most of the park.

SELECTED REFERENCES

Beekly, A. L., 1915, Geology and coal resources of North Park, Colorado: U.S. Geol. Survey Bull. 596, 121 p.

Burbank, W. S., and others, 1935, Geologic map of Colorado: U.S. Geol. Survey, 2 sheets. Scale 1:250,000.

Eschman, D. F., 1955, Glaciation of the Michigan River Basin, North Park, Colorado: Jour. Geology, v. 63, no. 3, p. 197–213.

——— 1957, Late Cenozoic history of the Michigan River Basin, North Park, Colorado, *in* Rocky Mtn. Assoc. Geologists Guidebook 9th Ann. Field Conf., North and Middle Parks Basin, Colorado, 1957: p. 32–35.

Gorton, K. A., 1953, Geology of the Cameron Pass area, Grand, Jackson, and Larimer Counties, Colorado, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 87–98.

Grout, F. F., Worcester, P. G., and Henderson, Junius, 1913, Reconnaissance of the geology of the Rabbit Ears region, Routt, Grand, and Jackson Counties, Colorado: Colorado Geol. Survey Bull. 5, pt. 1, 57 p.

Hague, Arnold, and Emmons, S. F., 1877, Descriptive geology: U.S. Geol. Explor. 40th Parallel (King), v. 2, p. 112–129.

Hail, W. J., Jr., and Leopold, E. B., 1960, Paleocene and Eocene age of the Coalmont formation, North Park, Colorado: U.S. Geol. Survey Prof. Paper 400–B, p. 260–261.

Hail, W. J., Jr., and Lewis, G. E., 1960, Probable late Miocene age of the North Park formation in the North Park area, Colorado: U.S. Geol. Survey Prof. Paper 400–B, p. 259–260.

Hayden, F. V., 1869, Trip to Middle Park: U.S. Geol. and Geog. Survey Terr., 3d Ann. Rept., p. 181–186.

——— 1877, Geological and geographical atlas of Colorado: U.S. Geol. and Geog. Survey Terr.

Heaton, R. L., 1940, Geological aspects of the Colorado–Big Thompson project: Mines Mag. [Colorado], v. 30, no. 5, p. 257–264.

Ives, R. L., 1938, Glacial geology of the Monarch Valley, Grand County, Colorado: Geol. Soc. America Bull., v. 49, no. 7, p. 1045–1066.

Lovering, T. S., 1930, The Granby anticline, Grand County, Colorado: U.S. Geol. Survey Bull. 822–B, p. 71–76, pl. 6.

——— 1934, Geology and ore deposits of the Breckenridge mining district, Colorado: U.S. Geol. Survey Prof. Paper 176, 64 p.

Marvine, A. R., 1874, Report on the Middle Park Division: U.S. Geol. and Geog. Survey Terr. (Hayden), 7th Ann. Rept. (for 1873), p. 83–192.

Miller, J. C., 1934, Geology of the north and south McCallum anticlines, Jackson County, Colorado: U.S. Geol. Survey Circ. 5, 27 p.

Montagne, John de la, 1957, Cenozoic structural and geomorphic history of northern North Park and Saratoga Valley, Colorado and Wyoming, *in* Rocky Mtn. Assoc. Geologists Guidebook 9th Ann. Field Conf., North and Middle Parks Basin, Colorado, 1957: p. 36–41.

Montagne, John de la, and Barnes, W. C., 1957, Stratigraphy of the North Park formation in the North Park area, Colorado, *in* Rocky Mtn. Assoc. Geologists Guidebook 9th Ann. Field Conf., North and Middle Parks Basin, Colorado, 1957: p. 55–60.

Osterwald, F. W., and Dean, B. G., 1957, Tectonics of north-central Colorado, *in* Rocky Mtn. Assoc. Geologists Guidebook 9th Ann. Field Conf., North and Middle Parks Basin, Colorado, 1957: p. 13–17.

Ransome, F. L., 1911, Geology and ore deposits of the Breckenridge district, Colorado: U.S. Geol. Survey Prof. Paper 75, 187 p.

Singewald, Q. D., 1951, Geology and ore deposits of the upper Blue River area, Summit County, Colorado: U.S. Geol. Survey Bull. 970, 74 p.

Steven, T. A., 1954, Geology of the Northgate fluorspar district, Colorado: U.S. Geol. Survey Mineral Inv. Field Studies Map MF–13.

——— 1956, Cenozoic geomorphic history of the Medicine Bow Mountains near the Northgate fluorspar district, Colorado: Colorado Sci. Soc. Proc., v. 17, no. 2, p. 35–55.

Steven, T. A., 1957, Sentinel Mountain-Dean Peak faulted anticline, North Park, Colorado, *in* Rocky Mtn. Assoc. Geologists Guidebook 9th Ann. Field Conf., North and Middle Parks Basin, Colorado, 1957: p. 82–84.

Theis, C. V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geohpys. Union Trans., 16th Ann. Meeting, pt. 2, p. 519–524.

Thiem, Gunter, 1906, Hydrologische Methoden [Hydrologic methods]: Leipzig, J. M. Gebhardt, 56 p.

Tweto, O. L., 1957, Geologic sketch of southern Middle Park, Colorado, *in* Rocky Mtn. Assoc. Geologists Guidebook 9th Ann. Field Conf., North and Middle Parks Basin, Colorado, 1957: p. 18–31.

U.S. Public Health Service, 1962, Drinking water standards: Public Health Service Pamph. 956, 61 p.

Ward, D. E., 1957, Geology of the middle fork of the Michigan River, Jackson County, Colorado, *in* Rocky Mtn. Assoc. Geologists Guidebook 9th Ann. Field Conf., North and Middle Parks Basin, Colorado, 1957: p. 70–73.

BASIC DATA

TABLE 4.—*Analyses of water from selected wells and springs in North Park*

[Dissolved constituents given in parts per million]

Geologic source: K, Cretaceous rocks; Tc, Coalmont Formation; Tnp, North Park Formation; QTu, Quaternary and Tertiary deposits undifferentiated; Qg, glacial deposits; Qt, terrace deposits; Qal, alluvium.
Use: D, domestic; In, industrial; N, none; PS, public supply; S, stock.

Location	Geologic source	Date of collection	Depth of well (feet)	Temperature (°F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
B6-77- 3bbb	Qg	10-15-59	92	44	[1] 0.00	13	2.9	6.8	0.8	52
B6-78-30cca	Tc	10-16-59	149	--------	.13	27	6.8	48	1.6	198
B7-79-22cdc [3]	Tc	9- 4-59	211	47	.09	9.6	1.0	72	1.2	202
B7-80- 5bbd [4]	Tc	11-10-59	75	44	.03	2.0	.1	68	.4	136
12ac [5]	Qt	9-10-59	----------	64	[1].06	56	13	38	1.8	300
B8-80-15cac [3 5]	QTu	9- 3-59	----------	54	.00	40	3.9	7.3	3.4	148
B9-79-16cbc [6]	Tc	7- 7-60	168	48	10	32	11	510	5.4	794
21bcc [6]	Qal	10- 4-59	27.6	48	[1].00	46	13	19	1.2	232
B9-81-31dcd	K(?)	9- 8-59	600-700	108	[1].04	13	2.9	90	6.8	258
B10-79-32ddd [6]	Tc	7- 7-60	97	51	.67	4.0	.5	125	.8	267
B10-80-11bdb [3]	Qal	9- 2-59	81	--------	.06	13	4.9	93	1.6	242
B12-80-29bcc	Tnp	9- 3-59	65	45	[1].01	85	26	14	4.0	342

Location	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum)	Hardness (as $CaCO_3$)		Specific conductance, in micromhos at 25°C	pH	Use
						Calcium magnesium	Noncarbonate			
B6-77- 3bbb	9.9	4.0	0.1	0.0	64	44	2	119	7.1	[2] D
B6-78-30cca	21	8.0	.5	6.1	216	95	0	368	7.8	PS
B7-79-22cdc [3]	15	2.0	.3	.0	200	28	0	332	8.2	D
B7-80- 5bbd [4]	17	4.0	.3	1.2	170	5	0	288	8.5	S
12ac [5]	20	9.0	.5	.8	287	193	0	506	7.7	S
B8-80-15cac [3 5]	7.4	2.0	.3	1.5	139	116	0	257	7.8	D, In
B9-79-16cbc [6]	377	135	.2	.4	1,460	125	0	2,360	7.0	[2] D
21bcc [6]	19	2.0	.3	.4	215	168	0	390	7.4	PS
B9-81-31dcd	24	6.0	.7	.0	270	44	0	464	6.6	[7] D
B10-79-32ddd [6]	47	7.0	2.2	.0	318	12	0	552	7.8	N
B10-80-11bdb [3]	42	6.0	.3	.0	280	52	0	478	8.2	D
B12-80-29bcc	46	10	.5	11	364	319	38	642	7.5	S

[1] In solution at time of analysis.
[2] Excluding drinking-water supply.
[3] Contains 0.00 ppm manganese.
[4] Contains 0.000 ppm selenium.
[5] Spring.
[6] Contains 0.00 ppm arsenic.
[7] Used in heating ranch house.

TABLE 5.—*Records of selected wells and springs in North Park*

Well or spring number: Well- and spring-numbering system described on p. 4.
Type of well: DD, dug and drilled; Dr, drilled, Du, dug.
Depth of well: Measured depths are given in feet; reported depths are given in feet followed by "R".
Type of casing: C, concrete; M, metal—iron or steel.
Geologic source: pє, Precambrian; K, Cretaceous deposits; Tc, Coalmont Formation; Tnp, North Park Formation; QTu, Quaternary and Tertiary deposits undifferentiated; Qg, glacial deposits; Qt, terrace deposits; Qal, alluvium.
Distance to water level below land surface: Measured distances to water are given in feet and tenths; reported distances to water are followed by "R".
Land-surface altitude at well or spring: Altitudes interpolated from U.S. Geol. Survey topographic quadrangle maps.
Pump and power: Cy, cylinder; J, jet; N, none; T, turbine; E, electric; G, gasoline; H, hand; W, windmill.
Use: D, domestic; I, irrigation; In, industrial; N, none, PS, public supply; S, stock.
pH: Field measurement of pH.
Specific conductance: Field measurement of specific conductance.
Remarks: CWCB, data from records of the Colorado Water Conservation Board; Lg, log of well given in table 6; WS, chemical analysis of water given in table 4.

Well or spring No.	Owner or operator	Year completed	Type	Depth below land surface (feet)	Casing: Diameter (inches)	Casing: Type	Geologic source	Distance to water level below land surface (feet)	Date of measurement	Land-surface altitude at well or spring (feet)	Pump and power	Use	Temperature (°F)	pH	Specific conductance (micromhos)	Remarks
B6-77- 3bbb	H. W. Kenney	1946	Dr	92R	6	M	Qg	28.5	10-15-59	8,910	J, E	D	44	6.2	140	WS.
B6-78- 6abd	O. C. Daugherty	1957	Dr	125R	6	M	Tc	54.7	10-14-59	8,580	Cy, W	S	45	8.4	350	
30cca	Rand School Dist. 5.		Dr	149R	6	M	Tc	63.2	10-16-59	8,630	J, E	D, PS		7.6	425	WS.
30cca2	do		Dr	150	4	M	Tc	58.8	do	8,630	N	N				
30ddc			Dr	62R	6	M	Tc	19R		8,630	Cy, W	D	47	6.0	260	
B6-79- 4	Stephens Bros	1956	Dr	50R	6	M	QTu	18R	6-22-56			S				CWCB, Lg, reported yield 55 gpm with negligible drawdown.
B6-80-13	Hill's Land & Cattle Co.	1956	Dr	100R	6	M	Tc	13R	10-25-56			S				CWCB, Lg, reported yield 72 gpm with 12 ft drawdown.
B6-81-26	E. V. Murphy	1956	Dr	43R	4	M	Qal, Tc	5.7R	6-20-56			D				CWCB, Lg, reported yield 44 gpm with 8 ft drawdown.
B6-82-15	E. H. Gombus		Dr	34R	6	M	Qal	20R				D				CWCB, Lg, reported yield 2 gpm.
B7-77-24	State of Colorado	1956	Dr	17.5R	5	M	Qg	5R	6-12-56			PS				CWCB, Lg, reported yield 7 gpm.
24	Fred Bockman	1956	Dr	47R	5	M	Qg	10R	6-14-56			D				CWCB, Lg, reported yield 25 gpm with 10 ft drawdown.

TABLE 5.—*Records of selected wells and springs in North Park*—Continued

Well or spring No.	Owner or operator	Year completed	Type	Depth below land surface (feet)	Casing: Diameter (inches)	Casing: Type	Geologic source	Distance to water level below land surface (feet)	Date of measurement	Land-surface altitude at well or spring (feet)	Pump and power	Use	Temperature (°F)	pH	Specific conductance (micromhos)	Remarks
B7-78- 6ca	U.S. Government.						QTu			8,300		S, I	45	8.0	400	Spring, reported to yield 1,800 gpm.
31add	O. C. Daugherty						Tnp			8,500		S	46	7.4	325	Spring, yield 1 gpm.
B7-79- 5dbc	Amos Allard	1956	Dr	55	4	M	Qal, Qt, Tc(?).	8.2	9-10-59	8,220	N	S				
16aad	C. E. Burr	1957	Dr	95R	4	M	Tc(?)	6.1	9- 9-59	8,260	Cy, H	D	43	7.2	315	
21ccc	do		Du	16.5			Qal	4.3	9- 4-59	8,340	Cy, G	S				
21dac	do		Dr	41			Qal	4.6	8-26-59	8,320	Cy, E	S				
21dad	do		Dr	125R	5	M	Tc	4.9	do	8,320	T, E	S	44	7.6	350	Lg.
21dad2	do	1956	Dr	135R			Tc	3.1	9- 4-59	3,320	T, E	S	44	7.9	300	
22cbc	do		Dr	28			Qal, Tc	3.5	do	8,320	Cy, E	S	42	7.7	425	
22ccd	do	1956	Dr	95R	5	M	Tc	5.7	8-26-59	8,320	Cy, E	S	43	7.2	370	Lg.
22ccd2	do		Du	20R			Qal	5.3	do	8,320	N	N				
22cdc	do	1956	Dr	211R	5	M	Tc	4.6	do	8,320	T, E	D	47	8.6	350	Lg, WS.
B7-80- 5bbd	John Peterson	1954	Dr	75	7	M	Tc	30.8	11-10-59	8,120	Cy, W	S	44	9.2	310	WS.
12ac	Amos Allard						Qt			8,250		S		7.6	520	Spring, WS.
B7-81- 3	Ordway Mellen	1956	Dr	212R	6-5	M	Tc	12R	10- -56			D				CWCB, Lg, reported yield 1 gpm with 188 ft drawdown.
14	Wamsley Cattle Co.	1956	Dr	75R	6	M	Qal, Tc	12R	7-25-56			D				CWCB, Lg, reported yield 39 gpm.
14₁	do	1956	Dr	74R	8-6	M	Qal, Tc	4R	10- 5-56			D				CWCB, Lg, reported yield 17 gpm with 2 ft drawdown.
B7-82-21ddd	U.S. Forest Service.	1956	Dr	62R	6	M	Qg	32.5	10-17-59	8,490	Cy, H	D	45	7.4	650	Lg.
B8-79- 9	H. E. Hampton	1956	Dr	60R	10	M	Tc	17R	10- -56			I				CWCB, Lg, reported yield 63 gpm with 3 ft drawdown.
28ccd	Amos Allard	1956	Dr	36	5	M	Qal, Tc(?)	4.3	9-10-59	8,000	N	N				
32dbd	do	1956	Dr	52R	5	M	Tnp	6.9	9- 9-59	8,200		D, S		7.6	325	
B8-80-15cac	U.S. Government.						QTu			8,160		D, In		7.7	270	Spring, WS.
21bbd	do		Dr	197	7	M	Tnp	123.1	11-10-59	8,300	Cy, W	S	47	7.6	300	Estimated yield 3 gpm.
29acd	John Peterson	1956	Dr	30	6	M	Tc	10R		8,070		D				Lg, reported yield 6 gpm.

B9-78-29aab							Tc			8,280		S	45	7.6	600	Spring, estimated yield ½ gpm.
B9-79-16cbc	Robert Corkle	1956	Dr	168R	6	M	Tc	26.4	7- 7-60	8,100	J, E	D	48	7.4	2,300	WS.
21bcc	Town of Walden	1959	Du	27.6	36-18	M	Qal	1.6	10- 2-59	8,060	T, E	PS	48		400	Lg, WS, measured yield 60 gpm with 21 ft drawdown after 48 hrs pumping.
21bcc2	do	1959	Du	35	18	M	Qal	0.9	do	8,060	T, E	PS				Lg, measured yield 105 gpm with 20 ft drawdown after 24 hrs pumping.
21cbb	do		Du	27.4	156	C	Qal	10R		8,060	T, E	PS				Reported yield 150 gpm for 6 hrs with drawdown to well bottom.
28bb	Marand	1954	Dr	845R	8-7	M	Tc	270R	10-16-54	8,110	N	N				CWCB, Lg, well drilled for town of Walden, well no longer used by town, owing to poor yield.
B9-80-28	Platte Cattle Co.	1956	Dr	33R	6	M	Qal	6R	8- 8-56							CWCB, Lg, reported yield 3 gpm with 2 ft drawdown.
B9-81-31dcd	Irvin Brands		Dr				K			8,270	N	D	108	6.1	450	Flowing well, WS, estimated yield 350 gpm, water used for heating ranch house.
B10-79-32ddd	U.S. Government		Dr	97	8	M	Tc	7.5	9- 8-59	8,020	N	N	51	8.6	575	WS, well pumped at 6.3 gpm for 26.5 hrs with drawdown of 10.8 ft.
32ddd2	do		Dr	46	5	M	Tc	10.2	do	8,030	N	N				
B10-80-11bac	Big Horn Ranch						Qal			7,880	Cy, E	S	48	6.8	975	
11bda	do			20			Qal	8.5	9- 2-59	7,880	Cy, E	S	48	6.8	715	
11bdb	do	1958	Dr	81R			Qal	15R		7,880	E	D		8.5	590	Lg, WS.
11bdb2	do			40R			Qal			7,880		D		7.7	480	
B11-79-20		1956	Dr	72R	6-5	M	Qal, K	34R	6- -56			S				CWCB, Lg, reported yield 5 gpm.
20bc	Robert Lundgren.	1956	Dr	31R	6	M	Qal, K(?)	6R	6- 7-56			D				CWCB, Lg, reported yield 10 gpm.
B11-80-3ba	E. A. Stanton		Dr	61R	6	M	Qal, pЄ	Dry								CWCB, Lg.
B12-80-21dbd	State Line Ranch.						pЄ					S	46	6.8	160	Spring.
29abd			Dr	120R	5	M	Tnp	85.4	9- 2-59	7,980	Cy, H	N				
29bcc	State Line Ranch.		DD	65R	20	M	Tnp	61.3	9- 3-59	7,980	Cy, W	S	45	7.2	640	WS.

TABLE 6.—*Drillers' logs of selected wells, tests, and seismograph shotholes, North Park*

[Formational names have been added to the logs by the author. Depth, in feet below land surface. [S] indicates log of seismograph shotholes; [T] indicates log of test hole]

	Thickness (feet)	*Depth (feet)*
B11–79–20		
Topsoil	8	8
Alluvium: Gravel	6	14
Cretaceous(?) deposits (bedrock):		
Clay	13	27
Shale, black, contains bentonite streaks	22	49
Shale	23	72
B11–79–20bc		
Topsoil	2	2
Alluvium: Gravel and boulders	11	13
Cretaceous deposits (bedrock):		
Bentonite	1	14
Sandrock (Dakota(?) Sandstone)	17	31
B11–80–3ba		
Topsoil	3	3
Undifferentiated Precambrian metamorphic rocks (bedrock):		
Flint rock	19	22
Clay	12	34
Granite, about 70 percent decomposed	27	61
B–11–80–35ccc [S]		
Coalmont Formation (bedrock):		
Shale and sandstone ledges	65	65
Shale	15	80
Sandstone, hard	10	90
Shale, sandy	20	110
B11–81–35dcc [S]		
Coalmont Formation (bedrock):		
Sandstone	20	20
Shale, sandy	15	35
Sandstone	25	60
Shale, sandy	10	70
B10–78–31adb [S]		
Alluvium: Sand and gravel	30	30
Coalmont(?) Formation (bedrock):		
Shale, sandy, blue	30	60
Sandrock	20	80
Shale, blue	70	150
B10–79–3bbb [S]		
Alluvium: Sand and gravel	54	54
Pierre Shale (bedrock): Shale, blue	66	120

TABLE 6.—*Drillers' logs of selected wells, tests, and seismograph shotholes, North Park*—Continued

B10–79–10bcc [S]	*Thickness (feet)*	*Depth (feet)*
Alluvium: Sand and gravel streaks	20	20
Pierre shale (bedrock): Shale, blue	80	100

(Driller reports much water at 20 ft.)

B10–79–25cab [S]		
Alluvium: Sand and gravel	18	18
Coalmont Formation (bedrock):		
Clay, sandy	17	35
Shale, blue and gray	85	120
Shale and ledges	30	150

B10–79–33ccc [S]		
Shale (soil)	6	6
Terrace deposits: Gravel	4	10
Coalmont Formation (bedrock):		
Shale, sandy	21	31
Sandstone stringers	9	40
Shale, sandy	30	70

B10–80–11bdb		
Alluvium:		
Sand, gravel, and boulders	40	40
Clay	10	50
Gravel and sand	6	56
Shale, loose (clay)	6	62
Gravel and sand	18	80
Open cavity	1	81

B10–80–27dcd [S]		
Alluvium: Gravel	15	15
Coalmont Formation (bedrock):		
Sandstone	15	30
Shale	40	70

B9–79–7ddd [S]		
Alluvium: Gravel and boulders	45	45
Coalmont Formation (bedrock): Shale, blue	155	200

B9–79–8cdc [S]		
Alluvium: Gravel	15	15
Coalmont Formation (bedrock): Shale, blue	185	200

B9–79–21bcb [T]		
Topsoil	1	1
Alluvium: Gravel, coarse to very coarse, rounded to well-rounded, and coarse to very coarse sand; contains pebbles as much as 1 in. in diameter; becomes coarser near base	11	12
Coalmont Formation (bedrock): Clay, sandy, yellow to brown	8	20

TABLE 6.—*Drillers' logs of selected wells, tests, and seismograph shotholes, North Park*—Continued

B9-79-21bcb2 [T]	*Thickness (feet)*	*Depth (feet)*
Fill: Sand, fine to medium; contains light-brown clay and gravel	6	6
Alluvium:		
Gravel, coarse, rounded to well-rounded, and coarse to very coarse sand; contains pebbles less than 1 in. in diameter	9	15
Sand, fine to medium, round to subround, white to gray (driller reports sand caves)	5	20
Coalmont Formation (bedrock):		
Clay, sandy, blue	4	24
Sandstone, very fine to fine (driller reports hard drilling)	1	25

B9-79-21bcc		
Topsoil	1	1
Alluvium:		
Gravel, very coarse, and some pebbles; contains coarse to very coarse sand	9	10
Sand, coarse to very coarse	2	12
Gravel, coarse to very coarse; contains very coarse sand and cobbles 4 in. in diameter; becomes more sandy near base	7	19
Coalmont Formation (bedrock):		
Sand, fine to medium, poorly cemented, blue to black; contains some clay	3	25
Sand, fine, white with black specks; consists chiefly of quartz and ferromagnesium minerals	5	30

Sandstone at 30 ft.

B9-79-21bcc2		
Soil, sandy	1.5	1.5
Alluvium:		
Sand and gravel, fine to coarse	3.5	5
Gravel, medium to coarse, and sand	3.5	8.5
Sand, coarse to very coarse, subangular	.5	9
Gravel, medium to very coarse; contains cobbles and boulders	3	12
Clay, very sandy, micaceous, yellow	2	14
Coalmont Formation (bedrock):		
Sandstone, shaly; contains carbonaceous fragments and dark mica flakes	2	16
Shale, silty, micaceous, gray	6	22
Shale, silty, sandy, micaceous, gray; contains abundant white and tan inclusions of gypsum at 26–30 ft	8	30
Sandstone, fine, clayey, light-gray	1	31
Shale, sandy; contains thin streaks of hard sandstone	3	34
Sandstone, very fine to fine, light-gray; contains abundant mica	1	35

TABLE 6.—*Drillers' logs of selected wells, tests, and seismograph shotholes, North Park*—Continued

	Thickness (feet)	Depth (feet)
B9-79-28bb		
Coalmont Formation (bedrock):		
Shale, sandy	3	3
Shale	22	25
Shale, sandy	255	280
Shale	10	290
Coal	5	295
Shale, sandy	441	736
Sand, coarse, and small gravel	104	840
Shale, sandy	5	845
B9-79-30acd [S]		
Coalmont Formation (bedrock): Shale, blue	200	200
B9-80-9abb [S]		
Alluvium: Gravel	21	21
Coalmont Formation (bedrock): Sandstone and ledges	179	200
B9-80-16baa [S]		
Alluvium: Gravel and boulders	52	52
Coalmont Formation (bedrock):		
Sandstone	89	141
Shale, blue	59	200
B9-80-19dda [S]		
Alluvium: Gravel and boulders	58	58
Coalmont Formation (bedrock): Shale, blue	142	200
B9-80-21bdb [S]		
Alluvium: Gravel	25	25
Coalmont Formation (bedrock): Shale, blue	175	200
B9-80-28		
Topsoil	4	4
Alluvium: Granite boulders	12	16
Coalmont Formation (bedrock):		
Shale	14	30
Gravel and sand	3	33
B8-79-9		
Coalmont Formation (bedrock):		
Sandy soil and rock	18	18
Sandrock	5	23
Shale and rock	14	37
Sandrock	5	42
Shale	18	60
B8-80-1dad [S]		
Coalmont Formation (bedrock):		
Sandstone	41	41
Shale, blue	99	140

TABLE 6.—*Drillers' logs of selected wells, tests, and seismograph shotholes, North Park*—Continued

	Thickness (feet)	*Depth (feet)*
B8-80-6ccc S		
Alluvium: Boulders and gravel	35	35
Coalmont Formation (bedrock):		
Sandstone and hard ledges	80	115
Shale, blue	40	155
B8-80-15dca S		
Tertiary deposits, undifferentiated: Gravel	20	20
Coalmont Formation (bedrock): Shale, blue	180	200
B8-80-27aca S		
North Park Formation (bedrock): Sand and gravel	200	200
B8-80-29acd		
Coalmont Formation (bedrock):		
Shale	18	18
Sandrock	2	20
Shale	10.5	30.5
B8-80-30bca S		
Alluvium: Sand and gravel	31	31
Coalmont Formation (bedrock): Shale, blue	169	200
B8-81-16baa S		
Alluvium:		
Gravel	30	30
(No sample)	10	40
Gravel	10	50
B8-81-17aaa S		
Alluvium: Sand and gravel	18	18
Coalmont Formation (bedrock): Shale	52	70
B7-77-24		
Topsoil	4	4
Glacial deposits:		
Granite boulders	15	19
Clay	20	39
Water sand	2	41
B7-77-24		
Topsoil	4	4
Glacial deposits:		
Boulders	5	9
Clay	1	10
Clay and large granite boulders	7.5	17.5
(Hole bottomed at 17.5 ft in red rock.)		
B7-79-21dad		
Alluvium: Clay and gravel	20	20
Coalmont Formation (bedrock):		
Clay	20	40
Sand	20	60
Clay, sandy	60	120

TABLE 6.—*Drillers' logs of selected wells, tests, and seismograph shotholes, North Park*—Continued

	Thickness (feet)	*Depth (feet)*
B7-79-22ccd		
Topsoil	1	1
Alluvium: Sand and gravel	9	10
Coalmont Formation (bedrock):		
Clay, yellow	15	25
Clay, sandy, blue	40	65
Sand slate (sandy shale)	6	71
Sandstone	1	72
Slate (shale)	1	73
Sandstone	2	75
Sand slate (sandy shale)	10	85
Sand	5	90
Slate, blue (blue shale)	5	95
B7-80-33aca s		
Alluvium: Sand and gravel	20	20
Coalmont Formation (bedrock): Shale and sand	60	80
B7-79-22cdc		
Soil	3	3
Alluvium: Clay and gravel	4	7
Coalmont Formation (bedrock):		
Clay, yellow	13	20
Clay, sandy, blue	25	45
Sand	5	50
Slate, blue (blue shale)	1	51
Sand slate (sandy shale)	2	53
Slate, streaky, blue (blue shale)	55	108
Sand slate (sandy shale)	3	111
Slate (shale)	5	116
Sand slate (sandy shale)	44	160
Slate (shale)	10	170
Sand slate, streaky (sandy shale)	41	211
B7-81-3		
Coalmont Formation (bedrock):		
Clay; contains water	25	25
Shale	66	91
Sandrock, hard	8	103
Shale	57	160
Sandrock, hard	6	166
Shale	56	212
B7-81-14		
Alluvium:		
Clay	14	14
Clay and gravel	11	25
Coalmont Formation (bedrock):		
Clay and shale	37	62
Shale	13	75

TABLE 6.—*Drillers' logs of selected wells, tests, and seismograph shotholes, North Park*—Continued

	Thickness (feet)	*Depth (feet)*
B7-81-14$_1$		
Topsoil and rock	8	8
Alluvium:		
Gravel	2	10
Clay and rock	16	26
Coalmont Formation (bedrock): Shale	48	74
B7-81-23dac S		
Coalmont Formation (bedrock):		
Shale, sandy, brown	87	87
Sandstone	6	93
Shale, sandy, brown	18	111
Shale, sandy, gray and black	51	162
B7-82-21ddd		
Topsoil	3	3
Glacial deposits: Granite boulders	17	20
Upper Cretaceous deposits (bedrock): Shale, blue	42	62
B6-79-4		
Quaternary and Tertiary deposits, undifferentiated:		
Granite boulders	5	5
Clay and boulders	21	26
Bentonite	.5	26.5
Water sands containing much gravel	23.5	50
B6-80-8aaa S		
Coalmont Formation (bedrock):		
Sand	5	5
Sandstone	10	15
Shale, sandy	65	80
Shale	25	105
Shale, sandy	25	130
Sandstone, hard	7	137
Shale, sandy	32	169
B6-80-13		
Coalmont Formation (bedrock):		
Clay, sandy	30	30
Sandrock, soft, blue	7	37
Shale, blue	9	46
Sandrock	46	92
Shale, blue	3	95
Sandrock	5	100
B6-81-26		
Alluvium: Granite boulders	20	20
Coalmont Formation (bedrock): Shale and water-bearing sand	23	43

TABLE 6.—*Drillers' logs of selected wells, tests, and seismograph shotholes, North Park*—Continued

B6-82-15

	Thickness (feet)	*Depth (feet)*
Topsoil and clay	5	5
Alluvium:		
Clay and gravel	11	16
(No sample)	7	23
Boulders	11	34

TABLE 7.—*Analyses of water from selected wells and springs in Middle Park*

[Dissolved constituents given in parts per million]

Geologic source: J, Jurassic rocks; K, Cretaceous rocks; TKmp, Middle Park Formation; Tlb, Tertiary lakebed deposits; Tu, Tertiary deposits undifferentiated; Qg, glacial deposits; Qt, terrace deposits; Qal, alluvium.
Use: D, domestic; Irr, irrigation; N, none; PS, public supply; S, stock; TW, test well.

Location	Geologic source	Date of collection	Depth of well (feet)	Temperature (°F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
B1-76- 6bab	Qal	7- 9-60	14	51	0.11	42	6.8	9.5	6.6	132
32dab	J(?)	7- 8-60	68	50	.10	22	1.9	4.1	2.0	78
B1-80-30aa [2]	K	11-11-59	1,147	75	3.8	17	5.1	20	3.4	48
32cc [3]	K	do		52	1.3	56	13	23	4.8	238
B2-76- 3cad [4]	Tlb	10- 9-60	180	64	.1	49	3.6	5.2	3.7	165
32ddc	Qt	6-24-60	87	47	.42	30	3.9	27	1.6	150
B2-77-35add [5]	Qt	6-23-60	112		.25	46	9.7	22	1.2	210
35bba [3]	TKmp	6-24-60		43	.00	62	17	13	1.6	231
B2-79-32abb [3] [6]	Tlb	do		79	[1] .03	14	3.9	600	12	1,120
B3-76-26bdd	Qg	1956	150			8.8	1.0	100	2.2	263
26dba [7]	Tu, K	10- 8-60	312	57	.09	10	3.6	250	3.7	600
B4-75-31bcd [8]	Qg	10- 4-60	24	45	.22	4.2	1.1	1.8	.6	17
B4-76-24dda	Qt	11-13-62	91	41	.18	10	1.0	[9]	[9]	42
C2-76-3bbc	Qg	8-11-60	60	39		27	3.9	7.0	1.5	106
C5-77-18bbc1	Qal	10- 2-56	75	42						
19cd	Qal	11-12-59	20		.35	26	5.1	7.6	1.0	92
C5-78-12dca	Qal	do	27		.18	40	8.3	7.2	1.6	118
C7-77-18cd [3]	Qg	do		39	.62	16	3.4	5.1	.6	66

Location	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum)	Hardness (as $CaCO_3$) Calcium magnesium	Hardness (as $CaCO_3$) Noncarbonate	Specific conductance, in micromhos at 25° C	pH	Use
B1-76- 6bab	32	5.0	0.1	13	180	133	25	327	6.8	N
32dab	7.4	2.0	.1	1.5	79	63	0	153	6.3	D, S
B1-80-30aa [2]	64	2.0	.5	.7	137	63	24	238	6.5	D, S
32cc [3]	41	4.0	1.2	0.0	261	193	0	478	6.9	S
B2-76- 3cad [4]	6.2	3.5	.2	6.3	192	138	3	290	7.5	D
32ddc	12	2.0	.2	14	165	91	0	293	7.5	S
B2-77-35add [5]	21	2.0	.1	8.5	214	155	0	389	7.1	D
35bba [3]	61	.5	.1	.6	270	224	35	465	7.4	D, Irr
B2-79-32abb [3] [6]	82	240	1.0	.6	1,500	51	0	2,540	7.3	S
B3-76-26-bdd	13	3.0	3.0	1.4	262	26	0	454	8.1	D
26dba [7]	48	14	12	1.0	645	41	0	1,030	8.2	D
B4-75-31bcd [3]	3.4	.8	.2	.4	26	15	1	37	6.3	N
B4-76-24dda	10	2.0	.3	.6	63	29	0	86	7.1	TW
C2-76- 3bbc	10	1.5	.3	.2	113	83	0	182	7.2	D
C5-77-18bbc1		2.1						211		TW
19cd	22	2.2	.1	1.7	111	86	10	199	6.6	D
C5-78-12dca	48	1.5	.2	.8	166	134	37	298	7.1	D
C7-77-18cd [3]	8.7	2.0	.1	.0	68	54	0	120	7.4	PS

[1] In solution at time of analysis.
[2] Contains 0.002 ppm selenium.
[3] Spring.
[4] Contains 0.1 ppm aluminum, 3.6 ppm phosphate, 32 ppm silica.
[5] Contains 0.00 ppm selenium.
[6] Contains less than 0.01 ppm selenium.
[7] Contains 0.6 ppm aluminum, 3.2 ppm phosphate, 19 ppm silica.
[8] Contains 0.2 ppm aluminum, 2.5 ppm phosphate, 6.9 ppm silica.
[9] Contains 9.2 ppm sodium and potassium.

TABLE 8.—*Records of selected wells and springs in Middle Park*

Well or spring number: Well- and spring-numbering system described on p. G4.
Type of well: DD, dug and drilled; Dr, drilled; Du, dug.
Depth of well: Measured depths are given in feet; reported depths are given in feet followed by R.
Type of casing: CB, concrete block; C, concrete; M, metal—iron or steel; R, rock.
Geologic source: p€, Precambrian; J, Jurassic deposits; K, Cretaceous deposits; Kp, Pierre Shale; TKmp, Middle Park Formation; O, Oligocene deposits; Tlb, Tertiary lakebed deposits; Tu, Tertiary deposits undifferentiated; QTu, Quaternary and Tertiary deposits undifferentiated; Qg, glacial deposits; Qt, terrace deposits; Qal, alluvium.
Distance to water level below land surface: Measured distances to water are given in feet and tenths; reported distances to water are followed by "R".
Land-surface altitude at well or spring: Altitudes interpolated from U.S. Geol. Survey topographic quadrangle maps.
Pump and power: C, centrifugal; Cy, cylinder; J, jet; N, none; T, turbine; E, electric; G, gasoline; H, hand.
Use: C, commercial; D, domestic; I, irrigation; In, industrial; N, none; PS, public supply; S, stock; TW, test well.
pH: Field measurement of pH.
Specific conductance: Field measurement of specific conductance.
Remarks: CWCB, data from records of the Colorado Water Conservation Board; Lg, log of well given in table 9; WS, chemical analysis of water given in table 7.

Well or spring No.	Owner or operator	Year completed	Type	Depth below land surface (feet)	Casing		Geologic source	Distance to water level below land surface (feet)	Date of measurement	Land-surface altitude at well or spring (feet)	Pump and power	Use	Temperature (°F)	pH	Specific conductance (micromhos)	Remarks
					Diameter (inches)	Type										
B1-76- 6abb	Town of Granby	1963	Dr	48	6	M	Qal	3.5	5-22-63	7,960	N	PS	45	7.0	230	Lg, well pumped at 43 gpm for 24 hrs with drawdown of 5.0 ft. Pump to be installed.
6abb2	do	1963	Dr	49	12	M	Qal	2.5	7-9-63	7,960	N	PS	46	7.0	260	Well pumped at 138 gpm for 3 hrs with drawdown of 22 ft. Pump to be installed.
6bab	do		Du	14	54	C	Qal	5.4	6-24-60	7,960	N	N	51	6.2	345	WS, well pumped at 100 gpm for 24 hrs with drawdown of 3.5 ft.
32ad	U.S. Forest Service.		Du	14R			J(?)				J, E	PS				CWCB, Lg.
32dab	Francis Acord	1955	Dr	68R	6	M	J(?)	20R		8,640	T, E	D, S	50	6.4	160	WS.
B1-78-10aba	On highway right-of-way.						J			7,760		N	44	7.6	200	Spring.
18bb	Marie Mitchell	1960	Dr	60R	6-5	M		35R		7,520	J, E	C				CWCB.
B1-79- 2cc	Kirkley Land and Cattle Assn.	1958	Dr	40R	6	M	Qt	20R			J, E	D				CWCB, Lg.

B1-80- 8db	W. E. Rayner	1960	Dr	60R	6	M	Qt				J, E	D				Do.
20bb	T. A. Engle	1960	Dr	37R	6	M	Qal	10R		7,350	J, E	D				CWCB, reported yield of 24 gpm with neglibible drawdown.
30aa	F. E. Yust	1958	Dr	1,485R	5	M	K			7,450		D, S	75	6.0	240	Flowing well, Lg, WS, reported to flow 60 gpm.
32cc	do						K			7,430		S	52	6.2	500	Spring, WS, estimated yield of 150 gpm.
B2-76- 3cad	Circle H. Corral		Dr	180R			Tlb					D	64	7.5	300	WS.
3dcd	Scanlock Subdivision.		Dr	180R	6-5	M		90R				D				CWCB.
10ba	Albert Selak	1955	Dr	80R	6	M	Tu	60R				D				CWCB, Lg.
11abb	K. Goss	1955	Dr	110R	6-5	M	Tu	70R								CWCB.
11abc	G. Pharo	1955	Dr	90R	6-5	M	Tu	60R				D				CWCB, Lg.
11aca	D. Bethel	1956	Dr	75R	6-5	M	Tu, K	40R			J, E	D				CWCB, reported yield of 8 gpm with drawdown of 20 ft.
11ba	National Park Service.	1958	Dr	320R			K, J	10R				N				Lg, well has been back-filled because of insufficient yield.
21ba	A. C. Blayney	1959	Dr	25R	6	M		10R			J, E	D				CWCB.
31bc	R. W. McDougell.	1959	Dr	25R	6	M	Qt	20R			J, E	D				CWCB, Lg.
31cb	John Kittel	1959	Dr	32R	6	M		9R			C, G					CWCB.
32ddc	Hazel P. Champier.		Dr	87R	6	M	Qt	11.4	6-24-60	8,030	T, E	S	47	7.6	305	Lg, WS, yields 15 gpm with drawdown of 23 ft after 10 minutes pumping.
32ddc2	do						Qt			8,040			49	7.4	250	Spring.
35ccc	Little H-O Ranch.	1958	Dr	438R	6-5½	M	K(?)					D				CWCB.
B2-77- 2b	R. Schoenberger	1955	Dr	52R	6-5	M	Kp(?)	20R				D				CWCB, Lg.
2ca	do	1960	Dr	2,068	10-7	M	K(?)	200R		8,160	N	S				CWCB, Lg, reported to yield 2 gpm.
27bc	J. W. Gimbel, Jr.			50R	6⅝	M	Qal	28R			J, E					CWCB, Lg, reported to yield 20 gpm.
35add	John Barnard, Sr., Estate.		Dr	112R	7	M	Qt	50.0	6-23-60	7,920	J, E	D		7.0	400	Lg, WS.
35bba	do						TKmp			8,060		D, S, I	43	7.4	495	Spring, WS.
B2-79-32abb	U.S. Bureau of Land Management.						Tlb			7,720		S	79	7.4	2,400	Spring, WS.
B3-75- 5bdb	J. Lockhart	1959	Dr	116R	6	M	Qg	10R								CWCB, Lg.
6a	R. L. Coons	1958	Dr	94R		M	Qg	9R				D				CWCB, Lg, reported to yield 10 gpm with drawdown of 85 ft.
6a2	Wayne Killian	1958	Dr	93R		M	Qg					D				CWCB, Lg, reported to yield 20 gpm with drawdown of 20 ft.
6cc	John Bell		Dr	30R	6-5	M	Qg					D				CWCB, Lg, reported to yield 2½ gpm for 3 hrs with drawdown of 24 ft.

TABLE 8.—*Records of selected wells and springs in Middle Park*—Continued

Well or spring No.	Owner or operator	Year completed	Type	Depth below land surface (feet)	Casing: Diameter (inches)	Casing: Type	Geologic source	Distance to water level below land surface (feet)	Date of measurement	Land-surface altitude at well or spring (feet)	Pump and power	Use	Temperature (°F)	pH	Specific conductance (*micromhos*)	Remark
B3-75- 6cc2	William Bell	1956	Dr	231.5R	6-5	M	Qg					C				CWCB, Lg, reported to yield 15 gpm for ¾ hr with drawdown of 2 ft.
6cc3	F. A. Peterson	1956	Dr	70R	6⅝-5	M	Qg(?)	30R				D				CWCB, reported to yield 6 gpm for 8 hrs with drawdown of 10 ft.
6cc4	W. E. Young	1956	Dr	60R	6⅝-5	M	Qg	60R				D				CWCB, reported to yield 7 gpm for 8 hrs with drawdown of 10 ft.
6cc5	L. J. Pritchard	1956	Dr	20R	6	M	Qg	8R				D				CWCB, reported to yield 3 gpm for 1 hr with drawdown of 2 ft.
6ddb	National Park Service.						Qg					D		6.6	165	Water contains iron in excess of 7.5 ppm.
9b	T. W. Anderson and others.	1956	Dr	73R	6⅝	M	Qg	73R				D				CWCB, Lg, reported to yield 10 gpm for 5 hrs with drawdown of 5 ft.
B3-76- 1aa	J. Y. and R. T. Matthews.	1959	Dr	182	6	M	Qg	40R				D				CWCB, Lg, reported to yield 5.5 gpm with drawdown of 100 ft.
1ad	J. Val Rose	1957	Dr	47R		M	Qg	40R			J, E	D				CWCB.
12aa	Buckingham	1955	Dr	75R	6-5	M	Qg	45R				D				Do.
12ac	E. Ashby	1958	Dr	61.5R		M		21R				D				CWCB, reported to yield 7 gpm.
12dbd	Charles Keirsey	1958	Dr	75R		M	Qg									CWCB, Lg, reported to yield 8 gpm with drawdown of 25 ft.
13b	Carl Adler	1958	Dr	60R	6⅝	M	Qg									CWCB, Lg, reported to yield 25 gpm.
13b2	N. Rougen	1955	Dr	51R	6	M	Qg	25R				D				CWCB, reported to yield 6 gpm.

13b3	J. E. Wilson	1955		37R	6–5	M	Qg	15R				D				CWCB, reported to yield 6 gpm with drawdown of 10 ft.
13b4	G. S. Holman	1959	Dr	40R	6	M	Qg	3R				D				CWCB, reported to yield 10 gpm with drawdown of 36 ft.
13b5	H. G. Smith	1959	Dr	50R	6	M	Qg	8R				D				CWCB, reported to yield 4 gpm with drawdown of 42 ft.
13b6	Guy Mabee	1959	Dr	42R	6	M	Qg	10R				D				CWCB, reported to yield 20 gpm with drawdown of 20 ft.
13b7	Bill Reiter	1958	Dr	50R	6	M	Qg					D				CWCB, reported to yield 2 gpm.
13b8	Arthur W. Buss	1959	Dr	114R	6	M	Qg					C				CWCB, reported to yield 40 gpm.
13cb	L. Elmore		Dr	33R	6	M	Qg	20R				D				CWCB.
13cb2	T. E. Hill	1958	Dr	110R	6⅝–5	M	Qg				J, E	C				CWCB, Lg.
24bc	Wagner and Steinke.	1956	Dr	70R	6	M	Qg	40R				D				CWCB, Lg, reported to yield 5 gpm for 5 hrs with drawdown of 10 ft.
25cc	Pauline Ashton	1959	Dr	147R	5½	M	Tu, p€(?)	30R			T, E	C				CWCB, Lg, reported to yield 2 gpm with drawdown of 140 ft.
25cc2	C. E. and M. E. Huff.	1959	Du	12R	48	C	Tu									CWCB, reported to flow 45 gpm.
25cc3				25R			Tu	18R				D				CWCB, reported to yield 25 gpm.
26	Donald H. Sanden.	1955	Dr	71R	6–5	M	Qg	40R				D				CWCB, reported to yield 3 gpm for 2 hrs with drawdown of 31 ft.
26acc	N. W. Solenbarger.	1959	Dr	122R	6–5	M	Qg, Tu	18R								CWCB, Lg, reported to yield 20 gpm with drawdown of 10 ft.
26bbd							Qt					N	60	7.7	750	Referred to as soda spring. Estimated flow 3 gpm.
26bc	A. W. Sherred	1959	Dr	122R	5	M	Qg, Tu(?)									CWCB, reported to yield 7 gpm.
26bd	Thomas L. Younkers.	1958	Dr	50R	5½	M	Qg	18R			T, E	D				CWCB, reported to yield 5 gpm with drawdown of 40 ft.
26bdd	John Dillie		Dr	150R	6	M	Qg	21R		8,330		D		8.2	525	Lg, WS.
26bdd2	do	1960	Du	28R	42	CB	Qg	20.5	6–23–60	8,330	J, E	D		7.0	240	
26dba	W. W. Lininger		Dr	312R	6	M	Tu, K					D	57	8.2	1,090	Well has flowed at land surface.
26dbc	do		Dr	90R	6	M	Qg	30R				D	47	8.1	480	

TABLE 8.—*Records of selected wells and springs in Middle Park*—Continued

Well or spring No.	Owner or operator	Year completed	Type	Depth below land surface (feet)	Casing: Diameter (inches)	Casing: Type	Geologic source	Distance to water level below land surface (feet)	Date of measurement	Land-surface altitude at well or spring (feet)	Pump and power	Use	Temperature (°F)	pH	Specific conductance (micromhos)	Remarks
B3-76-26ca	Charles Hartman	1959	Dr	84R	5	M	--	35R	--	--	--	D	--	--	--	CWCB, reported to yield 6 gpm.
26cd	H. G. Pickerel	1959	Dr	100R	5	M	Qg	18R	--	--	--	C	--	--	--	CWCB.
27dc	--	--	--	140R	--	--	--	105R	--	--	--	D	--	--	--	CWCB, reported to yield 10 gpm.
27dd	L. Longo	1958	Dr	35R	--	M	Qg	27R	--	--	J, E	C	--	--	--	CWCB.
27dd2	J. C. Moffett	1959	Dr	110R	5	M	Qg(?)	25R	--	--	--	D	--	--	--	Do.
34abc	National Park Service.	1957	Dr	80R	6	M	Qg	--	--	8,320	T, E	PS	45	7.2	350	
34cd	Clyde Cantrell	--	Dr	172R	40–5	C, M	--	130R	--	--	--	D	--	--	--	CWCB, reported to yield 3 gpm for 3 hrs with drawdown of 42 ft.
34cdc	Ray Wagner	1956	Dr	350R	--	--	Tu	80R	--	--	--	C	60	8.2	390	Lg.
34cdd	Bruce Goodlow	1959	Dr	388R	8⅝–6⅝	M	Qg, Tu	85R	--	--	--	D	--	--	--	CWCB, reported to yield 24 gpm with drawdown of 30 ft.
B4-75-31bcd	National Park Service.	--	Du	24.4	36	M	Qg	16.2	8-17-60	8,680	Cy	N	45	6.3	50	WS.
31cdb	do	1946	Du	17.5	48	M	Qg	11.5	do	8,570	J, E	D	46	7.2	180	Lg.
B4-76-12dbc	do	--	Du	9.4	5	M	Qg	5.7	do	8,790	N	N	--	--	--	
12dbc2	do	--	Dr	27	6	M	Qg	10.7	do	8,790	J, E	D	--	6.2	110	Water contains 3.0 ppm iron.
13dd	--	--	--	20R	--	--	--	6R	--	--	--	C	--	--	--	CWCB, reported to yield 15 gpm.
13dd2	--	--	--	130R	--	--	--	100R	--	--	--	C	--	--	--	CWCB, reported to yield 20 gpm.
24dda	National Park Service.	1962	Dr	91	6	M	Qt, Qg(?)	32.0	11-14-62	8,715	N	TW	41	--	100	Lg, WS, well pumped at 8.3 gpm for 4 hrs with drawdown of 2.4 ft.
25dac	do	--	Dr	42.3	6	M	Qt	17.1	10-4-60	8,680	Cy, H	D	37	6.4	80	
36acd	Ben Burlinger	--	Dr	50R	5	M	Qg	20R	--	--	--	D	--	--	--	CWCB, reported to yield 6 gpm for 2 hrs with drawdown of 5 ft.
36dbb	K. L. Morris	1956	Dr	52R	6	M	Qt	15R	--	--	--	D	--	--	--	CWCB, Lg, reported to yield 3 gpm for 1 hr with drawdown of 10 ft.

B4-78-33bd	John King	------	Dr	72R	------	M	TKmp	4R	------	------	J, E	D	----	----	------	CWCB, Lg, reported to yield 6 gpm.
C1-75- 5aa	John Paulk	1959	Dr	70R	6⅝	M	Qal	25R	------	------	------	D	----	----	------	CWCB, reported to yield 5 gpm with drawdown of 20 ft.
17dac	Blais Wight	1930's	Du	10	36	R	Tlb	3.8	8-12-60	8,840	N	D	49	5.8	80	
20da	Vaughn and Tucker.	1960	Dr	70R	5⅝-5	M	Qal, Tlb	17R	------	------	J, E	C	----	----	------	CWCB.
28bda	St. Regis College	1954	Dr	75R	8	M	Qal, Tlb	18.6	8-11-60	8,720	J, E	D	----	7.4	300	
28cd	Duane Neideres	------	Dr	41R	6	M	Qal	20R	------	------	------	------	----	----	------	CWCB, reported to yield 5 gpm with drawdown of 5 ft.
33a	A. Gruenberg	------	Dr	41R	6	M	Qal	20R	------	------	------	D	----	----	------	CWCB, reported to yield 6 gpm for 2 hrs with drawdown of 5 ft.
33acb	R. R. Mulligan	1957	Dr	39R	------	M	Qal	------	------	------	------	D	----	----	------	CWCB, Lg, reported to yield 5 gpm with drawdown of 25 ft.
33ba	A. Gruenberg	1958	Dr	56R	------	M	Qal	27R	------	------	T, E	D	----	----	------	CWCB, Lg, reported to yield 30 gpm with drawdown of 30 ft.
C1-76-1ac	Neal Smith	1959	Dr	72R	6⅝	M	Qal	6R	------	------	S, E	D	----	----	------	CWCB, Lg, reported to yield 40 gpm.
1bac	George Mackley	------	Dr	------	------	------	Tlb	------	------	8,330	Cy, H	D	45	7.2	490	WS.
25bd	Monte Carroll	1958	Dr	54R	------	------	Qal, Tu(?)	------	------	------	Cy, D	D	----	----	------	CWCB, Lg.
25cd	W. D. Stewart	1958	Dr	25R	6	M	Qal	8R	------	------	J, E	------	----	----	------	CWCB, Lg, reported to yield 10 gpm with drawdown of 15 ft.
C1-78-19dd	M. L. Kirkley	------	Dr	105R	5	M	Tlb	25R	------	------	------	------	----	----	------	CWCB, reported to yield 18 gpm for 2 hrs with drawdown of 75 ft.
C1-79-14dd	D. C. Bromfield	1959	Dr	67R	6⅝	M	Tlb	11R	------	------	------	S	----	----	------	CWCB, Lg, reported to yield 6 gpm with drawdown of 17 ft.
23dc	do	1959	Dr	48R	6	M	Tlb	9.5R	------	------	------	D	----	----	------	CWCB, reported to yield 7 gpm.
C1-81-30cb	U.S. Bureau of Land Management.	1958	Dr	222R	6	M	pЄ	38R	------	7,700	------	S	----	----	------	Lg.
C2-75-10ba	------	------	------	12R	------	------	------	9R	------	------	------	D	----	----	------	CWCB, reported to yield 1 gpm.
C2-76- 3bbc	U.S. Forest Service.	1956	Dr	60R	8	M	Qg	6.0	8-11-60	9,100	J, E	D	39	7.2	200	Lg, WS.
C2-78-36da	Robert Buerger	------	------	------	------	------	------	------	------	9,000	------	D	51	7.2	160	Spring, water derived from surficial material overlying Precambrian bedrock.

TABLE 8.—*Records of selected wells and springs in Middle Park*—Continued

Well or spring No.	Owner or operator	Year completed	Type	Depth below land surface (feet)	Casing: Diameter (inches)	Casing: Type	Geologic source	Distance to water level below land surfac (feet)	Date of measurement	Land surface altitude at well or spring (feet)	Pump and power	Use	Temperature (°F)	pH	Specific conductance (micromhos)	Remarks
C2-79-34bb	Eugene Patrino	1959	Dr	62R	7	M	Qal	29R		8,000		C				CWCB, Lg.
C3-78-18ab	Clayton Hill	1959	Dr	25R			Qal	6R		8,140	J, E	D				Do.
29ab	do	1959	Dr	40R			Qal	26R		8,280	J, E	D				Do.
C4-78-6bd	William Funk	1959	Dr	33R	7	M	Qal	13R		9,350	J, E	D				Do.
22bd	R. G. Young	1959	Dr	40R	7	M	Qal	22R		8,600	J, E	D				Do.
C5-76- 2cc				63R				10R				C				CWCB, reported to yield 20 gpm.
C5-77-18bbcl	City and County of Denver.	1956	Dr	75	7	M	Qal	13.3	9-25-56	8,800	T, G	TW	42	5.9	240	Lg, well pumped at 400 gpm for 137 hrs with drawdown of 10 ft. Water contained 2.1 ppm chloride.
19ba	R. L. Johnson	1960	Dr	50R	7	M	Qal	31R		8,850	J, E	C				CWCB, Lg, reported to yield 25 gpm.
19cd	U.S. Forest Service.	1941	Dr	20R	6	M	Qal			8,900	J, E	D		7.2	180	WS.
22db	William Bonner	1959	Dr	35R	7	M	Qg	14R		9,100	J, E	D				CWCB, Lg, reported to yield 40 gpm with drawdown of 2 ft.
24aa	H. B. Hansen	1958	Dr	80R	6	M	Qg(?)	12R			T, E	C				CWCB, Lg, reported to yield 30 gpm.
24ab	F. E. McHenry	1959	Dr	40R	7	M	Qg	12R		9,275	J, E	D				CWCB, Lg, reported to yield 15 gpm.
30ba				15R				4R				In				CWCB.
C5-78- 1bc	Neal Smith			45R	5	M	Qal					D				CWCB, Lg, reported to yield 30 gpm.
1ca	F. D. Grantham	1959	Dr	35R	7	M	Qal	6R		8,725	J, E	D				CWCB, Lg, reported to yield 50 gpm with drawdown of 3 ft.
12aa	G. E. Dunlap	1960	Dr	110R	7	M	Qg, K	98R		8,975	J, E	D				CWCB.
12ca	R. Bannon and C. Hill.	1957	Dr	46R	4	M	Qal			8,750		D				CWCB, reported to yield 100 gpm.
12dca	R. Z. Roush	1942	DD	27	36-18	M	Qal	16.4	9-25-56	8,770	J, E	D		7.2	300	WS.
12ddc	Public Service Co. of Colorado.		Du				Qal	15.0	9-19-56	8,790		D				

13aa	City and County of Denver.	1960	Dr	35R	7	M	Qal	13R		8,800	J, E	D				CWCB, reported to yield 40 gpm.
13aa2	do	1960	Dr	68R	7	M	Qal	15R		8,800	J, E	D				CWCB, reported to yield 80 gpm.
13aab2	Public Service Co. of Colorado.		Du				Qal	16.3	9-19-56	8,790		D				
35ca	E. L. Marsh	1959	Dr	75R	7	M	Qal	19R		9,050		C				CWCB, Lg, reported to yield 100 gpm with drawdown of 2 ft.
35dd	M. L. Stewart	1960	Dr	59R	35-7	M	Qal	35R		9,150	J, E					CWCB, Lg, reported to yield 35 gpm.
C7-77-18cd	U.S. Forest Service.						Qg			8,980		N	39	7.8	140	Spring, WS.

TABLE 9.—*Drillers' logs of selected wells, Middle Park*

[Formational names have been added to the logs by the author. Depth in feet below land surface]

	Thickness (feet)	*Depth (feet)*
B1-76-6abb		
Topsoil	3	3
Alluvium:		
Silt, sand, gravel, and boulders	23	26
Sand, fine to coarse; contains 1 percent silt and clay	17	43
Tertiary deposits undifferentiated (bedrock): Shale, blue	5	48
B1-76-32ad		
Topsoil	2	2
Jurassic(?) deposits (bedrock): Sandstone, red	12	14
B1-79-2cc		
Terrace(?) deposits:		
Clay	15	15
Sand and gravel	25	40
B1-80-8db		
Topsoil	10	10
Terrace deposits:		
Gravel	20	30
Shale, blue	10	40
Gravel	20	60
B1-80-30aa		
Quaternary and Tertiary deposits, undifferentiated:		
Rock and clay	15	15
Gravel, coarse, and boulders	19	34
Cretaceous deposits undifferentiated (bedrock):		
Shale, black, and gray clay	431	465
Limestone	15	480
Shale and clay; contains some iron pyrite	385	865
Shale, hard; contains some sandstone	86	951
Quartzite	17	968
(No sample)	179	1,147
B2-76-10ba		
Tertiary deposits undifferentiated:		
Clay, gray (driller reports possible tuff); contains large basalt boulders	30	30
Clay with a few basalt boulders, sandy streaks at 70–80 ft	50	80
B2-76-11abc		
Tertiary deposits undifferentiated: Soil, sand, and gravel	30	30
Bedrock:		
Clay	30	60
Sandstone	30	90

TABLE 9.—*Drillers' logs of selected wells, Middle Park*—Continued

B2-76-11ba	*Thickness (feet)*	*Depth (feet)*
Topsoil	1	1
Tertiary deposits, undifferentiated: Sand and gravel	2	3
Cretaceous and Jurassic(?) deposits, undifferentiated (bedrock):		
Clay	15	18
(No sample)	2	20
Shale, gray	6	26
(No sample)	4	30
Sand and shale	7	37
Shale, blue	31	68
Sandstone	4	72
Shale, blue	31	103
Clay and gravel	7	110
Shale, blue	94	204
Sandstone	4	208
Shale, sandy; contains purple and green streaks	47	255
Rock	22	277
Sandstone; contains purple and green streaks	41	318
Clay, red, hard	2	320
B2-76-31bc		
Terrace deposits:		
Clay and gravel	22	22
Gravel, water-bearing	3	25
B2-76-32ddc		
Terrace deposits: Sand and gravel	27	27
Bedrock: Clay, blue	60	87
B2-76-35cc		
Terrace deposits: Clay and gravel	68	68
Cretaceous(?) deposits (bedrock):		
Shale	367	435
Sand, black	3	438
B2-77-2b		
Topsoil, decomposed shale	8	8
Pierre(?) Shale (bedrock): Shale, blue	44	52
B2-77-2ca		
Soil	1	1
Alluvium:		
Clay, sandy, yellow	4	5
Gravel and boulders	12	17
Clay, sandy, yellow	2	19
Cretaceous(?) deposits undifferentiated (bedrock):		
Sandstone, bluish	3	22
Sandstone, gray	26	48
Shale, dark-gray	162	210
Sandstone, shaly	14	224

TABLE 9.—*Drillers' logs of selected wells, Middle Park*—Continued

	Thickness (feet)	*Depth (feet)*
Cretaceous(?) deposits undifferentiated (bedrock)—Continued		
Shale, clayey to silty, dark	20	244
Sandstone, shaly	51	295
Shale	27	322
Sandstone	39	361
Shale	8	369
Sandstone, shaly, and interbedded shale	172	541
Shale	60	609
Sandstone, shaly, and interbedded shale	76	685
Shale	10	695
Sandstone, shaly	123	818
Shale, silty to clayey, dark-gray	267	1,085
Sandstone, light-gray; contains black and green grains	20	1,105
Shale, clayey, dark-gray to black	115	1,220
Shale, dark-gray to black; contains a few thin sandstone layers	415	1,635
Sandstone, fine micaceous	26	1,661
Shale, black; contains traces of calcite	82	1,743
Shale, calcareous, black	35	1,778
Shale, calcareous, black; contains much limestone	3	1,781
Shale, calcareous, black	114	1,895
Shale, very calcareous, dark-brownish gray	30	1,925
Shale, noncalcareous, black	60	1,985
Shale, calcareous, black	21	2,006
Limestone, buff	3	2,009
Shale, silty, black	59	2,068
B2-77-27bc		
Alluvium: Cobble rock	25	25
B2-77-35add		
Terrace deposits: Sand and gravel	112	112
B3-75-5bdb		
Glacial deposits:		
Boulders	25	25
Sand and clay	85	110
Gravel, water-bearing	6	116
B3-75-6a		
Topsoil	1	1
Glacial deposits:		
Gravel and soil	17	18
Sand	46	64
Clay and sand	6	70
Sand	23	93
Gravel	1	94

TABLE 9.—*Drillers' logs of selected wells, Middle Park*—Continued

B3-75-6a2

	Thickness (feet)	Depth (feet)
Glacial deposits:		
Gravel and boulders	30	30
Sand	30	60
Sand and boulders	15	75
Sand	10	85
Gravel, water-bearing	8	93

B3-75-6cc

	Thickness (feet)	Depth (feet)
Glacial deposits:		
Soil, sandy, and glacial boulders	25	25
Sand, coarse	5	30

B3-75-6cc2

	Thickness (feet)	Depth (feet)
Glacial deposits:		
Boulders; driller also reports excessively fine sand and wash gravel	32	32
Clay and rock; contains boulders	19	51
Bedrock(?):		
Clay-shale and a trace of sandstone	47	98
Shale, hard	4	102
Clay and decomposed granite; contains a trace of sandstone	4	106
Sand and sandstone	6	112
Clay and decomposed granite	4.5	116.5
Bentonite clay	14.5	131
Clay, siltstone, and sandstone	2	133
Sandrock and granite	3	136
Soapstone and clay	6	142
Clay and siltstone	15.5	157.5
Clay and sandstone	3.5	161
Clay and siltstone	6.5	167.5
Sandstone and sand	5.5	173
Clay, siltstone, and basalt	3.5	176.5
Sandstone	2	178.5
Soapstone and clay	4	182.5
Soapstone	1	183.5
Soapstone and clay	.5	184
Clay, sandstone, and decomposed granite	9	193
Sand and sandstone	5	198
Clay and sandstone	4	202
Sand and sandstone	3	205
Sandstone, granite, and clay	3	208
Clay and sandstone	8	216
Clay and shale	15	231

B3-75-9b

	Thickness (feet)	Depth (feet)
Glacial deposits: Alternating layers of sand and fine gravel	73	73

TABLE 9.—*Drillers' logs of selected wells, Middle Park*—Continued

B3-76-1aa

	Thickness (feet)	*Depth (feet)*
Glacial deposits:		
Clay	20	20
Sand	155	175
Gravel, water-bearing	7	182

B3-76-12dbd

Glacial deposits:		
Boulders	5	5
Clay	63	68
Clay and gravel	3	71
Gravel, water-bearing	4	75

B3-76-13b

Topsoil	3	3
Glacial deposits:		
Rock and soil	26	29
Gravel	11	40
Sand, fine, packed hard	19	59
(No sample)	1	60

B3-76-13cb2

Glacial deposits:		
Boulders	25	25
Sand	25	50
Clay	10	60
Clay and gravel	50	110

B3-76-24bc

Glacial deposits:		
Clay, sandy, and a few rocks	35	35
Glacial boulders and sandy clay	10	45
Clay with rocky layers; water reported at 60 ft	25	70

B3-76-25cc

Tertiary deposits undifferentiated: Shale and broken formation	35	35
Granite(?) of Precambrian age (bedrock):		
Granite, hard and decomposed	62	97
Granite, hard; contains broken formations	50	147

B3-76-26acc

Glacial deposits:		
Clay and gravel	29	29
Boulders	31	60
Gravel, water-bearing	3	63
Tertiary deposits undifferentiated:		
Clay	12	75
Clay, blue	20	95
(No sample)	27	122

TABLE 9.—*Drillers' logs of selected wells, Middle Park*—Continued

B3-76-26bdd

	Thickness (feet)	Depth (feet)
Glacial deposits:		
Soil, sandy; contains large granite boulders	32	32
Clay, pink	48	80
Clay, blue	68	148
Sand and gravel	2	150

Granite(?) of Precambrian age (bedrock): Granite at 150 ft.

B3-76-34cdc

	Thickness (feet)	Depth (feet)
Tertiary lakebed deposits (bedrock):		
Clay; contains lenses of fine gravel	40	40
Clay (driller reports fractures at 156 ft)	125	165
(No sample)	185	350

B4-75-31cdb

	Thickness (feet)	Depth (feet)
Glacial deposits:		
Till	18	18
Gravel	3	21

B4-76-24dda

[Logged by the U.S. Geol Survey. Term in *italic* indicates a minor principal constituent. Term in SMALL CAPITAL LETTERS indicates a major principal constituent. Two terms in italic in the same interval indicate that the principal constituents are equal. Terms for principal grain sizes within a range of grain sizes are enclosed in parentheses]

	Thickness (feet)	Depth (feet)
Terrace deposits:		
Gravel, very fine (*fine*) to MEDIUM, and very fine to coarse sand	3	3
Gravel, *very fine* to medium, and fine to *coarse* sand	4	7
Gravel, *very fine* to medium, and fine to *very coarse* sand; contains boulder or cobble at 9 ft	8	15
Gravel, *very fine* to fine, and very fine to *very coarse* sand	1	16
Gravel, VERY FINE to fine, and very fine to *coarse* sand	2	18
Gravel, *very fine*, and very fine to *very coarse* sand	2	20
Gravel, *very fine* to fine, and fine to *very coarse* sand	2	22
Gravel, *very fine* to fine, and medium to *very coarse* sand	4	26
Gravel, *very fine* to fine, and fine to *very coarse* sand	4	30
Gravel, *very fine* to fine, and medium to *very coarse* sand	4	34
Gravel, *very fine* to fine, and fine to VERY COARSE sand	9	43
Gravel, *very fine* to fine, and medium to VERY COARSE sand	6	49
Gravel, very fine to fine, and fine to (*medium*, COARSE) very coarse sand	10	59
Gravel, very fine and fine, to (*coarse*) VERY COARSE sand	5	64
Sand, fine to (MEDIUM, *coarse*) very coarse	1	65
Sand, very fine to (*fine*, MEDIUM) coarse	9	74
Sand, fine to (MEDIUM, *coarse*) very coarse	6	80
Gravel, very fine, and very fine (COARSE) to *very coarse* sand	3	83
Glacial(?) deposits:		
Gravel, very fine, and very fine (COARSE) to *very coarse* sand	1	84
Gravel, very fine to medium, very fine to (*coarse*) *very coarse* sand, and SILT OR CLAY OR BOTH	7	91

TABLE 9.—*Drillers' logs of selected wells, Middle Park*—Continued

	Thickness (feet)	*Depth (feet)*
B4-76-36dbb		
Terrace deposits:		
Clay, sandy, a few rocks	20	20
Sand, loose; contains some wash rocks	22	42
Sand, medium to coarse; contains small gravel (driller reports water)	10	52
B4-78-33bd		
Coalmont Formation (bedrock):		
Rock and brown shale	22	22
Shale, blue	28	50
(No sample)	22	72
C1-75-33acb		
Alluvium:		
Gravel and boulders	30	30
Sand, fine	9	39
C1-75-33ba		
Alluvium:		
Boulders, sand, and gravel cemented in clay	27	27
Boulders, sand, and gravel; contains some clay	10	37
Clay, sandy	19	56
C1-76-1ac		
Topsoil	4	4
Alluvium:		
Rock and sand	28	32
Cobble rock, sand, and shale	40	72
C1-76-25bd		
Alluvium: Small boulders	12	12
Tertiary deposits undifferentiated:		
Clay	38	50
Gravel and sand, water-bearing	4	54
C1-76-25cd		
Alluvium: Boulders, gravel, and sand	25	25
C1-79-14dd		
North Park Formation: Cobbles, rock and shale	67	67
C1-81-30cb		
Soil: Sand and decomposed schist, gray to black	18	18
Precambrian (bedrock):		
Schist, moderately hard	37	55
Metamorphic rocks, extremely hard	141	196
Clay, blue	5	201
Clay, blue, extremely hard	4	205
Clay, blue, extremely hard; contains streaks of slate	17	222

TABLE 9.—*Drillers' logs of selected wells, Middle Park*—Continued

	Thickness (feet)	Depth (feet)
C2-76-3bbc		
Topsoil	2	2
Glacial deposits:		
Clay, buff, and small amount of rock	3	5
Clay, gravelly, buff	25	30
Sandstone, tight, rusty	3	33
Clay, sandy, buff; has tough streaks; material jointed	27	60
C2-79-34bb		
Alluvium:		
(No sample)	26	26
Shale and clay; contains small boulders	30	56
Sand and gravel	6	62
C3-78-18ab		
Alluvium:		
Soil and boulders	20	20
Sand and gravel	5	25
C3-78-29ab		
Alluvium:		
Boulders, soil, and clay	34	34
Sand and gravel	6	40
C4-78-6bd		
Alluvium:		
Surface soil and boulders	22	22
Sand and gravel	11	33
C4-78-22bd		
Alluvium:		
Clay and boulders	35	35
Sand and gravel	5	40
C5-77-18bbcl		
Alluvium: Cobbles, sand, and gravel (driller reports hard drilling and many cobbles)	73.5	73.5
C5-77-19ba		
Alluvium:		
Surface soil and boulders	28	28
Sand, gravel, pebbles, and boulders	22	50
C5-77-22db		
Glacial moraine deposits:		
Surface soil and boulders	23	23
Sand and gravel	12	35

TABLE 9.—*Drillers' logs of selected wells, Middle Park*—Continued

	Thickness (feet)	Depth (feet)
C5-77-24aa		
Glacial moraine(?) deposits:		
Clay	12	12
Clay and sand	20	32
Water sand	6	38
Hard rock	2	40
Soft rock	40	80
C5-77-24ab		
Glacial moraine deposits:		
Surface soil and large boulders	12	12
Sand, gravel, and boulders	28	40
C5-78-1bc		
Alluvium: Cobbles and boulders	45	45
C5-78-1ca		
Alluvium:		
Surface soil, gravel, and boulders	24	24
Sand and gravel	11	35
C5-78-13aa2		
Alluvium:		
Surface soil and boulders	12	12
Boulders, sand, and gravel	56	68
C5-78-35ca		
Alluvium:		
(No sample)	30	30
Silt, fine, white	7	37
Clay and shale	20	57
Sand, silty, brown	3	60
Sand and gravel	15	75
C5-78-35dd		
Alluvium:		
(No sample. Old well)	35	35
Boulders, sand, and gravel	24	59