UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HYDROLOGIC EVALUATION OF THE UPPER DUCHESNE RIVER VALLEY, NORTHERN UINTA BASIN AREA, UTAH

Open-File ~~Report~~ 76-771

Prepared in cooperation with the
Utah Department of Natural Resources,
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Salt Lake City, Utah

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Most numbers are given in this report in English units followed by metric units. The conversion factors used are shown to four significant figures. In the text, however, the metric equivalents are shown only to the number of significant figures consistent with the accuracy of the number in English units.

English Units (Multiply)	English Abbreviation	(by)	Metric Units (to obtain)	Metric Abbreviation
Acres		0.4047	Square hectometres	hm^2
Acre-feet	acre-ft	.001233	Cubic hectometres	hm^3
Cubic feet per second	ft^3/s	.02832	Cubic metres per second	m^3/s
Feet	ft	.3048	Metres	m
Gallons per minute	gal/min	.06309	Litres per second	l/s
Inches	in	25.40	Millimetres	mm
		2.540	Centimetres	cm
Miles	mi	1.609	Kilometres	km
Square feet	ft^2	.09290	Square metres	m^2

Chemical concentration and water temperature are given only in metric units. Chemical concentration is given in milligrams per liter (mg/l). For concentration less than 7,000 mg/l, the numerical value is about the same as for concentrations in the English unit, parts per million.

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation: $°F = 1.8(°C) + 32$.

HYDROLOGIC EVALUATION OF THE UPPER DUCHESNE RIVER VALLEY,

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ABSTRACT

The upper Duchesne River valley was studied during 1971-74 as part of an investigation of the northern Uinta Basin area, Utah and Colorado. The purpose of the study was to determine the relation of ground water to surface water, to estimate the quantity of ground water that moves to the Duchesne River, and to assess the probable effect of increased ground-water withdrawal on streamflow.

The primary source of water for the study area is precipitation on the highlands adjacent to and north of the area and on the valley itself. Discharge from the area is mainly by flow in the Duchesne River. Adjacent to and within the valley, ground water and surface water are intimately related, and they can interchange in several ways due to both natural and manmade conditions.

Aquifers in the upper Duchesne River valley range from Paleozoic to Quaternary in age. The consolidated aquifers receive recharge from highland precipitation and streamflow, and probably from interformational transfer of water. The consolidated rocks discharge water through springs and by interformational transfer of water to the valley fill of Quaternary age.

The valley fill, which is composed mainly of outwash and related glacial debris, constitutes the main ground-water reservoir in the valley. The fill is, in general, highly permeable and transmits water rapidly. It is recharged by a small amount of underflow beneath the Duchesne River and its tributaries, by intermittent precipitation directly on the fill, by interformational movement of ground water from the adjacent consolidated rocks, and by seepage of surface water from streams, canals, and irrigated fields. The ground water in the fill is unconfined. The volume of ground water stored in the fill and theoretically available by gravity drainage is a minimum of 40,000 acre-feet (50 cubic hectometres); this volume fluctuates by a maximum of 10 percent annually.

Ground water is discharged from the valley fill by wells and springs, by evapotranspiration, and by seepage into the Duchesne River. The discharge from wells and springs used for domestic, stock, public, and irrigation purposes in 1974 was about 2 cubic feet per second (0.06 cubic metres per second). The discharge by evapotranspiration was about 4 cubic feet per second (0.1 cubic metre per second). Discharge of ground water by seepage to the Duchesne River was about 39 cubic feet per second (1.1 cubic metres per second).

Most ground water, except in parts of the Uinta Formation, and all the surface water sampled in the study area, was fresh.

Because of the high permeability of the valley fill and because unconsumed ground water discharges to the Duchesne River, it can be concluded that lowering ground-water levels by large withdrawals of ground water in the upper Duchesne River valley ultimately would diminish the baseflow of the Duchesne River by about the amount of ground water withdrawn minus the amount salvaged from evapotranspiration.

INTRODUCTION

Purpose and scope of the study

This report is intended to describe the relation of ground water to surface water in the upper Duchesne River valley, to estimate the quantity of ground water that moves to the Duchesne River, and to assess the probable effect of increased ground-water withdrawals on the stream regimen. The report was prepared as a part of a general appraisal of the water resources of the northern Uinta Basin area, Utah and Colorado, which was made by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. Fieldwork for the general appraisal was carried out during the period July 1971-June 1974.

The upper Duchesne River valley is one of two areas that were evaluated in slightly greater detail than the remainder of the northern Uinta Basin area in order to meet specified needs of the Utah State Engineer. The evaluation was based mainly on data accumulated during the study of the northern Uinta Basin area, but data were also used from related concurrent projects. Some of the data used in this report are released separately in one or more of the following reports: Cruff (1975), Fields (1975), Fields and Adams (1975, 1976), Hood (1976), Hood, Mundorff, and Price (1976), and Mundorff (1977). Selected ground-water data are given in table 1.

Location and general features

The northern Uinta Basin area is in northeastern Utah (fig. 1). The

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Figure 1 (caption on next page) near here

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area includes part of the Uinta Mountains and that part of the Uinta Basin which is north of the White, Duchesne, and Strawberry Rivers (Fenneman and Johnson, 1946).

The upper Duchesne River valley discussed here extends from bedrock narrows that confine the river and the West Fork Duchesne River near Stockmore Ranger Station northwest of Hanna approximately 34 mi (55 km) downstream to Duchesne (fig. 2). Where the river leaves the narrows (fig. 3), it flows through a valley about 0.5-1 mi (0.8-1.6 km) wide.

Figures 2 and 3 (captions on next page) near here

Vegetation, both natural and cultivated, is abundant throughout the valley flood plain; but beyond the steep bluffs that border the valley floor, the uplands are covered with a sparse to moderate growth of native juniper (*Juniperus* sp.) and brush. The marked difference is due to the readily available water from a shallow water table and surface sources diverted for irrigation on the permeable flood plain, contrasted with the small amount of precipitation on the poorly permeable rocks of the uplands.

Figure 1.--Location of the northern Uinta Basin area and the upper Duchesne River valley.

Figure 2.--Selected hydrologic data in the upper Duchesne River valley and adjacent area.

Figure 3.--Selected hydrologic data in the Hanna-Tabiona area.

Water use in the upper Duchesne River valley during 1971-74 was mainly for domestic, stock, and irrigation purposes. Domestic supplies were obtained from wells and springs (table 1), and stock supplies were obtained from ground and surface sources. Some water for small public supplies was obtained from springs (Tabiona) and wells (Hanna). At the lower end of the reach, however, the town of Duchesne was expanding a municipal well field (fig. 2) on the valley floor. Small withdrawals of ground water were being made for cooling and fire protection at a pipeline company pumping station at Hanna. Almost all irrigation water used in the upper Duchesne River valley is diverted from the river and its tributaries and from several large springs near the upper end of the reach.

Data-site numbering systems

Well- and spring-numbering system

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well or spring, describes its position in the land net. Under ~~By~~ the land-survey system, the State is divided into four quadrants by the Salt Lake base line and meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section--generally 10 acres (4 hm^2);[1] the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring within the 10-acre (4-hm^2) tract: the letter "S" preceding the serial number denotes a spring. If a well or spring cannot be located within a 10-acre (4-hm^2) tract, one or two location letters are used and the serial number is omitted. Thus (D-4-21)2bad-1 designates the first well constructed or visited in the SE¼NE¼NW¼, sec. 2, T. 4 S. R. 21 E.

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[1] Although the basic land unit, the section, is theoretically 1 mi^2 (2.6 km^2), many sections are irregular. Such sections are subdivided into 10 acre (4-hm^2) tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

Other sites where hydrologic data were collected are numbered in the same manner, but three letters are used after the section number and no serial number is used.

In the Uinta Basin, part of the southeast quadrant has been subdivided by the Uintah base line and meridian as shown in figure 4. Wells and springs in this land parcel are numbered in the same manner described above, but the numbers are preceded by the letter U to show that they are related to the Uintah base line and meridian. Thus well U(C-1-8)10dda-1 is a well in the NE¼SE¼SE¼ sec. 10, T. 1 S., R. 8 W., Uintah meridian, and U(B-1-8)17cbb-S1 is a spring in the NW¼NW¼SW¼ sec. 17, T. 1 N., R. 8 W., Uintah meridian. The numbering system is illustrated in figure 4.

Figure 4 (caption on next page) near here

Figure 4.--Well- and spring-numbering system used in Utah.

Stream-data numbering systems

The Geological Survey uses a nationwide system of numbering sites on streams by referring to the position of the site or station in a downstream order in a given major river basin. The Uinta Basin is in Part 9, the Colorado River basin.

Gaging-station numbers are assigned in a downstream direction along the main stems of the major streams, and all stations on a tributary stream that enters above a main-stem station are numbered before that station. A similar order is followed in listing stations on first rank, second rank, and other ranks of tributaries. The numbering system consists of an 8-digit number for each station, for example 09261000. The first two digits (09) represent the "part" number identifying the hydrologic region used by the Geological Survey for reporting surface hydrologic data. The next six digits represent the position of the location in a downstream order. Thus, almost all data for the Uinta Basin are listed for stations numbered from 09261000, Green River near Jensen, Utah, to 09307000, Green River near Ouray, Utah. (See Hood and others, 1976, table 11.)

For sites on streams where miscellaneous measurements of discharge or chemical quality of water are made, the station is numbered by using its latitude and longitude written together with a two-digit sequence number. Thus, station 402411110455701 is a temporary gage-height recorder site on the Duchesne River at Hanna Bridge in Hanna, where miscellaneous measurements of stream discharge were made and samples of water were obtained for chemical analysis during this investigation. For all sites with this type of number, the corresponding data-site number (site 154 for the example given above) from Hood, Mundorff, and Price (1976) is given.

HYDROLOGIC EVALUATION

The general water-resources system in the upper Duchesne River valley is complex. The primary source of water for the area is precipitation on the highlands adjacent to and north of the area and on the valley itself. Discharge from the area is mainly by flow in the Duchesne River. Adjacent to and within the valley, ground water and surface water are intimately related, and they can interchange in several ways due to both natural and manmade conditions.

Ground water

Geologic setting

The Duchesne River, as it enters the study area, cuts across formations of Paleozoic age, including limestone of Mississippian age and the Weber Quartzite. (See table 1.) Downstream, the river cuts progressively younger beds. The Point, about 1.5 mi (2.4 km) northwest of Hanna, consists of the Glen Canyon (Nugget) Sandstone and overlying beds of the Twin Creek Limestone. The Point is a bedrock spur that extends into the valley. A second bedrock spur extends into the valley about 1 mi (1.6 km) southeast of Hanna, and it consists of the Currant Creek Formation and underlying beds of the Mesaverde Group. Near Tabiona, the canyon walls consist of the basal Duchesne River Formation and the underlying Uinta Formation. Where the river turns eastward, about 5.5 mi (8.9 km) southeast of Tabiona, it moves generally along the contact between the latter two formations. Below Utahn, the river turns generally southward toward Duchesne and cuts across progressively older beds of the Uinta Formation.

Table 1 (p. 15 a) near here

Table 1.-- List of geologic units that crop out in and adjacent to the upper Duchesne River valley (After Hood, 1976, table 1)

Name: a, considered to be a major hydrologic unit because of large areal extent or thickness, large yields to wells or springs, or function as recharge media;

b, considered to be an important hydrologic unit, but restricted in potential development because of constraints related to thickness, distribution, or chemical quality of water

Age	Name
Quaternary	Younger alluvium and gravel surfaces and landslide, talus, and windblown deposits Younger terrace deposits a/Glacial deposits and alluvium of Pleistocene age
Tertiary	Older terrace deposits a/Duchesne River Formation a/Uinta Formation 1/
Cretaceous	a/ Currant Creek Formation b/ Mesaverde Group 2/ Mancos Shale (including b/Frontier Sandstone Member) Dakota Sandstone and Cedar Mountain Formation, undivided
Jurassic	Morrison Formation b/ Curtis Formation(Stump Sandstone of Stokes, 1964) b/ Entrada Sandstone (Preuss Sandstone of Stokes, 1964) Twin Creek Limestone
Triassic(?) and Jurassic(?)	Nugget Sandstone (generally equivalent to a/ Glen Canyon Sandstone to the east) 3/
Triassic	Chinle Formation (including b/ Gartra Member) Mahogany Formation (Ankareh Formation of Stokes, 1964) Thaynes Formation (or Group) Woodside Formation (Woodside Shale of Stokes, 1964)
Permian	Park City Formation (or Group) 4/
Pennsylvanian and Permian	a/ Weber Quartzite (or Formation) 5/
Pennsylvanian	b/ Morgan Formation 6/
Mississippian and Pennsylvanian	Manning Canyon(?) Formation (of Stokes, 1964)
a/ Mississippian 7/	Upper Mississippian rocks, undivided Lower Mississippian rocks, undivided

1/ Aquifer is the uppermost sandy section of the formation, which functions together with the Duchesne River Formation as a common aquifer

2/ Sandstone in the group is the aquifer

3/ For purposes of aquifer discussion, the Nugget and Glen Canyon Sandstones are the same

4/ Identified in some older hydrologic records as the Phosphoria Formation. In some parts of the Uinta Basin, the base of this formation and the underlying Weber Quartzite form a common aquifer

5/ East of the Uinta River, this formation also is called a sandstone. In the study area, some of the formation is a sandstone, but most of it is dense and tightly cemented

6/ Sandstone in the formation is the aquifer

7/ Cavernous limestone in these rocks is the principal aquifer

The consolidated formations, where they lie beneath the Duchesne River, dip generally southward off the flank of the Uinta Mountains (Stokes, 1964). The surface axis of the Uinta Basin intersects the upper Duchesne River Valley at about Tabiona (Hansen, 1969, fig. 57); south and east of Tabiona, the Duchesne River and Uinta Formations dip northeastward to northward. The dip directions cited are generalized; locally, dips are in other directions, particularly in the area from Hanna northwestward. (See Huddle and McCann, 1947.) Faults have displaced the consolidated rocks several hundred feet in places, and many smaller faults cut the rocks near the mouth of the West Fork Duchesne River. Fracturing related to the faulting and to basin subsidence affects most of the formations in the upper Duchesne River valley.

Unconsolidated deposits of Quaternary age have been deposited on the consolidated rocks. In most of the upland areas and in the valleys of tributaries, the unconsolidated deposits are not important sources of ground water, but along the valley of the upper Duchesne River, the unconsolidated deposits constitute a major aquifer. The main river valley during Pleistocene time was deeply carved into the consolidated rocks by glaciation and by glacial meltwater. When the glaciers receded, the valley was partly filled with glacial outwash and related debris. These fluvioglacial deposits subsequently have been partly dissected by renewed downcutting, which has resulted in lowering of the water table and partial drainage of the deposits.

The glacial outwash consists mainly of a mixture of boulders, gravel, and sand with local interbeds of clay. It is overlain by a sandy soil and gravelly clay, which are thin [illegible] generally quite permeable. The thickness of the outwash beneath t[illegible]lood plain and adjacent terraces ranges from a feather edge to a known maximum of 114 ft (34.7 m). (See table 1.)

Table 1a(pages 18 and 19) near here

Location: See well- and spring-numbering system in text; D, well deepened on date giv

Owner: Owner at time well was visited by Geological Survey personnel, or name listed in other records of the Utah State Engineer.

Well depth: Code following depth; 0, depth measured to nearest 1 foot or less; 3, rep other than well driller.

Casing depth: From land surface at well to top of first perforation or other opening. depth.

Well finish: F, gravel-walled with perforated pipe; O, open-ended pipe with no perfoı Mill's knife; W, walled or shored; X, open hole below blank casing.

Major aquifer: Rocks of Quaternary age - 111ALVM, Holocene alluvium; 112OTSH, Pleis Duchesne River Formation; 124UNIT, Uinta Formation. Rocks of Mesozoic age - 211CTCK, Member of the Mancos Shale; 211MVRD, Mesaverde Group or Formation; 221MRSN, Morriso Woodside Formation, or Group. Rocks of Paleozoic age - 310WEBR, Weber Quartzite; 3

Water-bearing material: May consist of one or two symbols; first, if present, is an 5, very coarse grained; 6, clayey; 7, silty; S, soft. Lithology: C, conglomerate; boulders, cobbles, sand, and gravel; S, sand; and V, sandstone.

Depth to consolidated rock: From land surface at well, as given in or inferred from

Altitude: In feet above mean sea level; interpolated from topographic maps.

Water level: From land-surface datum at well: F, flows, but head not measured. Cod nearest 1 foot or less; D, reported by well driller, G, reported by owner or sourc

Use of water: H, household or domestic; I, irrigation; N, industrial; P, public sup shown is the principal one, generally as reported to the Utah State Engineer.

Yield: E, estimated. Where drawdown code indicates well driller, yield also is rep

Drawdown: Code following figure for drawdown - 3, reported by well driller; 5, esti

Chemical analysis available: C, complete, K, specific conductance; M, multiple; P, 76-771

Table 1a.--Records of selected wells and springs in the upper Duchesne River valley and adjacent area

Location	Owner or name	Year constructed	Well depth (ft)	Casing: Depth (ft)	Casing: Diameter (in)	Well finish	Major aquifer	Water bearing material	Depth to consolidated rock (ft)	Altitude	Water level: Feet below land surface	Water level: Date	Use of water	Yield (gal/min)	Drawdown (ft)	Temperature (°C)	Chemical analysis available
1/U(B-1-8)17cbb-S1	Big Spring	-	-	-	-	-	330MSSP	L	-	7,300	-		I	4,210	-	6.5	C
18dda-S1	Larsen Spring	-	-	-	-	-	112OTSH	5R	-	7,115	-		I	e 450	-	6.0	K
19ddd-1	U.S. Forest Service	1966	85 3	75	7	P	do	G	>85	6,980	9 A	6-72	H	12	6 3	11.0	C
27cda-S1	Blind Stream Canyon Spring	-	-	-	-	-	237WDSD	-	-	7,350	-		S	2	-	10.0	C
29cdd-S1	F. M. Giles	-	-	-	-	-	112OTSH	5R	-	6,930	-		H	e 75	-	9.0	P
29dbd-1	Charles Strebel	1950	99 3	99	6	0	do	5R	-	6,980	86 A	5-73	H	30	5 3	-	-
29ddd-1	Floyd Cox	1950	114 3	110	8	P	do	G	-	7,005	90 D	2-50	H	10	10 3	9.5	C
29ddd-2	Elmer Guyer	-	102 6	-	-	-	do	-	>114	6,995	-	-	H	[illegible]	-	12.0	K
2/30ddb-S1	Warm Spring	-	-	-	-	-	310WEBR	-	-	7,030	-	-	I	e 200	-	26.0	C
32acc-1	O. J. Curry	1950	40 3	40	6	0	112OTSH	5R	-	6,910	22 D	1-50	H	30	3 3	-	-
32adc-1	W. F. Rhoades	1952	58 3	58	6	0	do	5R	-	6,920	45 D	12-52	H	30	5 3	-	-
32baa-1	O. J. Curry	1948	63 6	-	-	0	do	5R	-	6,930	4 A	5-73	H	-	-	14.5	K
32daa-1	Ronald Hackett	-	-	-	-	-	do	5R	-	6,885	47 A	5-73	H	-	-	-	K
33bbb-S1	-	-	-	-	-	-	do	5R	-	6,965	-		S	e 50	-	8.5	P
33bca-1	A. F. Rhoades	1952	77 3	-	6	0	do	5R	-	6,940	71 A	5-73	H	30	10 3	9.5	K
33cbc-1	Utah Boys Ranch	1953	55 3	54	6	0	do	5R	-	6,900	41 A	5-73	U	12	- 3	-	-
33cdc-1	J. W. Moon	-	-	-	-	-	do	-	-	6,890	-	-	H	-	-	-	K
U(C-1-7)19dbd-1	Andrew Defa	1949	140 3	36	6	X	211CTCK	C	35	6,675	47 A	5-73	H	10	35 3	10.0	C
30abd-1	Jack Young	1952	80 3	80	6	0	112OTSH	5R	-	6,605	65 D	9-52	H	30	5 3	-	-
30adc-1	B. N. Turnbow	1949	76 3	76	6	0	do	G	-	6,562	60 D	12-49	H	30	-	-	-
30bab-1	D. E. Nye	1949	73 3	-	6	-	do	G	-	6,600	50 D	1-49	H	30	2 3	-	-
32acd-1	E. B. Carter	1947	208 3	60	8	X	124UINT	V	62	6,530	50 D	6-47	H	2	156 3	9.5	C
33aba-1	do	1962	636 6	500	14	X	do	V	-	6,745	F A	5-73	S	-	-	7.5	K
U(C-1-8)3ddc-1	Charles Lee	1971	130 3	110	5	P	221TCRK	-	-	6,940	60 D	11-71	S	12	10 3	-	-
4bbb-1	J. W. Moon	-	-	-	-	-	112OTSH	5R	-	6,880	45 A	5-73	S	-	-	9.0	K
4bbc-1	Robert Park	-	-	-	-	-	do	5R	[illegible]	6,880	-	-	H	-	-	-	K
4bdd-1	Youngtown Inc.	1969	193 3	115	8	P	do	4R	69(?)	6,875	40 D	9-69	H	260	70 3	7.0	M
10caa-S1	O. N. Moon	-	-	-	-	-	do	5R	-	6,755	-		H	e 100	-	9.0	P
10dad-1	C. Fabrizio	1953	70 6	-	8	-	do	-	-	6,763	-	-	H	-	-	10.0	C
10dda-1	Rose Fabrizio	-	16 0	16	48	W	do	R	-	6,740	14 A	3-72	U	-	-	-	-
10dda-2	M. F. Baum	1971	70 3	-	6	0	do	5R	-	6,750	32 D	5-71	H	20	20 3	-	-
11ccd-1	L. S. Defa	1949	45 3	-	6	-	do	5R	-	6,725	28 A	5-73	H	30	5 3	9.0	K
11ccd-2	Weston Thomas	1959	33 3	32	6	0	do	5R	-	6,720	23 A	5-73	H	12	14 3	7.5	K
11cdc-2	Chevron Pipeline Co.	1949	575 3	290	10	P	221MRSN	G	78	6,745	78 D	1-49	H	10	- 3	-	C
11ddc-1	Dorthy Bartoleo	1949	98 3	-	6	-	112OTSH	5R	-	6,755	80 D	9-49	H	30	5 3	-	-
11ddc-2	Ray Lee	1968	97 3	97	6	0	do	5R	>97	6,755	-	-	H	8	- 3	-	K
12cbc-S1	Nick Defa	-	-	-	-	-	211FRNR	V	-	6,920	-		H	e 10	-	11.0	P
12cdb-1	P. M. Reid	1960	78 3	-	6	-	do	V	0	6,870	61 D	10-60	U	12	4 3	-	-
12cdb-1D	do	1966	122 3	122	5	0	do	V		6,870	10 D	11-66	H	20	- 3	13.5	K
13ccc-1	Clifford Roberts	1949	40 3	-	6	-	112OTSH	6R	-	6,640	16 D	2-49	H	30	3 3	-	K
13ccc-2	J. R. Roberts	1963	64 3	64	6	0	do	5R	-	6,650	30 D	6-63	H	20	26 3	10.0	C
13dcc-1	do	1949	184 3	176	6	X	211VRD	V	0	6,720	65 D	3-49	U	30	35 3	-	-
14add-1	K. N. Lee	1949	76 3	-	6	-	112OTSH	5R	-	6,710	62 D	3-49	H	30	1 3	14.0	K
14bac-1	G. W. Burt	1973	38 3	30	6	P	do	5R	-	6,705	26 A	5-73	H	30	7 3	10.0	K
14bda-1	L. S. Defa	1949	30 3	30	6	0	do	5R	-	6,700	4 D	6-49	H	30	12 3	-	K
24bbb-1	J. Humphreys	1966	42 3	42	6	0	do	5R	-	6,442	14 A	5-73	H	20	13 3	-	K
24bbd-1	Jessup Thomas	1949	43 3	-	6	-	do	R	-	6,640	20 D	2-49	H	30	1 3	-	-
24dcc-1	C. J. Moody	1973	200 3	91	6	P	do	5R	-	6,650	71 A	7-73	I	300	190 3	-	-
24ddc-1	do	1959	48 3	48	6	0	do	5R	-	6,590	4 D	7-59	H	9	20 3	9.0	K
24ddd-1	B. S. Thomas	1949	43 3	-	6	-	do	R	-	6,590	28 A	5-73	H	30	2 3	5.5	K
25adb-1	J. C. Sharrow	1973	54 3	54	6	0	do	5R	-	6,600	30 D	6-73	U	15	22 3	-	-
25adb-1D	do	1974	134 3	134	6	0	do	5R	-	6,600	50 D	5-74	H	25	-	-	-
36cad-S1	Town of Tabiona	-	-	-	-	-	124UINT	-	-	7,235	-	-	P	e 50	-	-	M
U(C-2-5)21ccb-1	Hope Esauch	1968	181 3	146	4	P	do	V	49	5,960	49 D	2-68	H	15	1 3	-	-
25cca-1	Howard Prentice	1974	280 3	220	4	F	do	V	44	6,110	165 D	2-74	H	10	- 3	-	-
27aca-1	Shell Oil Co.	1973	740 3	186	6	X	do	V	15	6,050	150 D	2-73	N	55	- 3	-	-
27ccc-1	W. W. Strong	1932	158 6	-	4	0	do	V	36	5,850	F G	5-38	H	1	-	11.0	P
27ccc-2	do	1946	47 3	36	-	P	112OTSH	S	-	5,850	27 D	4-46	H	20	2 3	-	-
28cda-1	W. I. Brown	1946	80 3	45	6	P	124UINT	SV	34	5,935	45 D	4-46	-	5	1 3	-	-
28cda-1D	do	1947	150 3	129	6	P	do	V	34	5,935	16 A	3-72	H	8	34 3	-	C
29bbd-1	Joseph Shanks	1945	56 3	41	6	P	124UINT	V	23	5,955	9 D	10-45	H	10	1 3	-	-
32acd-1	Shell Oil Co.	1973	600 3	350	6	X	do	V	0	6,118	200 D	4-73	N	70	200 3	-	-
34abb-1	Evelyn Birch	1957	148 3	-	-	-	do	V	50	5,852	20 D	3-57	U	12	40 3	-	-
34abb-2	Max Birch	1973	200 3	140	4	P	do	V	60	5,852	10 D	7-73	H	12	125 3	-	-
35bab-1	G. L. Clark	1972	120 3	90	4	P	do	V	42	5,870	15 D	2-72	H	20	75 3	-	-
U(C-2-6)14dbc-1D	C. C. Wright	1948	95 3	70	4	P	112OTSH	R	50	6,070	16 D	8-48	H	20	1 5	17.5	P
14dbc-S1	do	-	-	-	-	-	-	-	-	6,240	-	-	H	-	-	17.5	P
14dbd-1	Leland Wright	1970	43 3	43	6	0	112OTSH	R	-	6,070	30 A	3-72	H	15	8 3	10.0	C
14dbd-S1	C. C. Wright	-	-	-	-	-	123DCRV	V	-	6,090	-		S	e 5	-	18.0	P
18cda-1	Nathan Jones	1945	44 3	28	6	P	112OTSH	S	43	6,225	14 D	12-45	H	15	1 3	-	-

Table 1.[2]--Records of selected wells and springs in the upper Duchesne River valley and adjacent area--Continued

Location	Owner or name	Year constructed	Well depth (ft)	Casing: Depth (ft)	Casing: Diameter (in)	Well finish	Major aquifer	Water bearing material	Depth to consolidated rock (ft)	Altitude	Water level: Feet below land surface	Water level: Date	Use of water	Yield (gal/min)	Drawdown (ft)	Temperature (°C)	Chemical analysis available
U(C-2-6)20abd-1	P. T. Abplanalp	1946	55 3	44	6	P	112OTSH	5R	24	6,190	31 D	2-46	H	20	2 3	-	-
20baa-S1	Elizabeth Brown	-	-	-	-	-	111ALVM	7R	-	6,175	--	-	I	--	-	-	-
20bac-1	do	1946	57 3	46	6	P	112OTSH	S	10	6,195	30 D	3-46	H	15	1 3	-	-
21bba-1	Delbert Broadhead	1945	50 3	38	6	P	do	-	-	6,150	16 D	10-45	H	12	1 3	-	-
22aaa-1	E. N. Wright	1947	58 3	49	6	P	do	S	-	6,105	37 D	4-47	H	15	-	-	-
24aad-1	Mervin Broadhead	1945	79 3	41	6	P	do	-	-	6,030	32 D	7-45	H	5	33 3	-	-
24baa-1	do	1945	32 3	21	6	F	do	R	-	6,025	12 D	7-45	H	12	4 3	-	-
U(C-2-7)10acb-1	Burnell Turnbow	1946	150 3	80	6	P	123DCRV	V	26	6,405	55 A	5-73	U	4	1 3	-	-
10dab-1	David Roberts	1946	61 3	49	6	P	do	V	47	6,365	38 D	1-46	H	20	1 3	9.0	-
11cbd-1	Ray Thomas	1932	80 6	-	-	-	do	V	-	6,370	-	-	H	-	-	-	C
11cdd-1	do	1973	120	60	4	F	do	V	14	6,380	85 D	5-73	H	8	- 3	-	-
13cba-1	J. Christensen	-	10 6	10	72	W	111ALVM	7S	-	6,270	-	-	U	-	-	14.0	P
13cba-2	do	1946	36 3	28	6	P	112OTSH	5R	-	6,265	8 D	3-46	S	20	2 3	-	-
13cba-3	do	1958	37 3	37	6	O	do	5R	-	6,270	10 D	4-58	H	12	6 3	-	-
13cbd-1	do	1944	19 3	15	6	P	do	5R	-	6,260	7 D	11-44	-	7	1 3	-	-
13dbc-1	Certified Packing Co.	1966	100 3	41	6	X	do	5R	41	6,250	15 D	10-66	H	25	12 3	-	-
U(C-3-5)13bbb-2	M. B. White	1948	50 3	40	6	P	do	5R	-	5,712	30 D	2-48	H	20	1 3	-	-
13cac-1	Duchesne City	1970	35 3	35	22	O	do	5R	-	5,660	1 D	6-70	P	-	-	-	C
13cb-S	Murray Spring Area	-	-	-	-	-	112OTSH	[illegible]	-	5,665	-	-	P	-	-	-	-
14ddd-1	Duchesne City	1957	45 3	42	12	O	do	5R	-	5,661	3 D	10-57	P	200	35 3	-	-
14ddd-2	do	1959	49 3	49	12	O	do	5R	-	5,665	10 D	7-59	P	125	25 3	-	-
24acc-1	Vernal Bromley	1947	100 3	46	6	P	do	S	8	5,665	35 D	4-47	H	20	1 3	-	-
24bbb-1	Duchesne City	1962	40 3	38	12	O	do	5R	-	5,651	2 D	9-62	P	120	30 3	-	-
25bcb-1	C. P. Child	1959	14 3	14	6	O	do	5R	-	5,589	5 D	6-59	N	10	5 3	-	-
25bcb-1D	Wright Ranch Co.	1970	29 3	29	6	O	do	5R	-	5,589	11 D	4-70	H	10	12 3	-	-
25bcc-1	C. P. Child	1959	29 3	29	6	O	do	5R	-	5,586	7 D	4-59	-	10	8 3	-	-
25ccc-1	D. E. Bastian	1966	57 3	57	8	O	do	5R	52	5,575	5 D	6-66	H	20	35 3	-	-
25dba-1	Lyn Miller	1972	310 3	245	6	F	124UINT	V	25	5,765	-	-	H	10	- 3	-	-
25dca-1	Brinkerhoff Drilling Co.	1972	300 3	240	6	F	do	V	15	5,746	74 A	3-73	H	8	- 3	-	M
35ad-S	Warm Spring	-	-	-	-	-	do	-	-	5,555	-	-	-	-	-	-	P
36bbd-1	J. W. Rozzelle	1947	50 3	50	6	O	112OTSH	5R	50	5,564	7 D	3-47	U	35	7 3	-	-
36dcc-1	J. A. Clement	-	16 0	-	12	W	do	-	-	5,536	5 A	10-36	U	-	-	-	-

1/ Principal discharge point. During annual maximum, discharge also occurs in channel of adjacent tributary.
2/ Uppermost of several related openings. Total estimated discharge on date given was 5.0 ft³/s (0.14 m³/s).

The unconsolidated deposits are, in general, highly permeable. The hydraulic conductivity, (K),[1/] as calculated from approximations of the transmissivity, (T),[2/] ranges from 5 to 400 ft/d (1.5 to 120 m/d).

Footnotes 1/ and 2/ (next page) near here

(See Hood, 1976, table 6 and pl. 2.) Most of the lower values for K are for wells in the Hanna-Tabiona area (fig. 3), and most of the higher values of K are for wells in the narrower parts of the valley above and below that area. This distribution of K probably is directly related ~~due~~ to the relative velocities of the water that deposited the glacial outwash. In the confined parts of the valley, water velocity was higher and mainly coarse-grained debris--boulders and gravel--was deposited. In the broader parts of the valley between Stockmore and State Road 208, water velocity was lower and finer grained debris was deposited.

The unconsolidated glacial outwash and related deposits are in direct contact with the Duchesne River. They are the most uniformly permeable of the aquifers in the upper Duchesne River valley and the most likely to be developed as a source of additional water. These deposits constitute the ground-water reservoir discussed in the following pages, particularly with reference to the relation between ground and surface waters.

Recharge

The aquifers in the upper Duchesne River valley are recharged by precipitation, by seepage from stream channels, canals, and irrigated fields, and by interformational movement of water.

1/The hydraulic conductivity (K) of a water-bearing material is the volume of water that will move through a unit cross section of the material in unit time under a unit hydraulic gradient. The units for K are cubic feet per day per square foot $[(ft^3/d)/ft^2]$, which reduces to ft/d. The term hydraulic conductivity replaces the term field coefficient of permeability, which was formerly used by the U.S. Geological Survey and which was reported in units of gallons per day per square foot. To convert a value for field coefficient of permeability to the equivalent value of hydraulic conductivity, divide by 7.48; to convert from hydraulic conductivity to coefficient of permeability, multiply by 7.48.

2/ Transmissivity (T) is the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. The units for T are cubic feet per day per foot $[(ft^3/d)/ft]$, which reduces to ft^2/d. The term transmissivity replaces the term coefficient of transmissibility, which was formerly used by the U.S. Geological Survey and which was reported in units of gallons per day per foot. To convert a value for coefficient of transmissibility to the equivalent value of transmissivity, divide by 7.48; to convert from transmissivity to coefficient of transmissibility, multiply by 7.48.

The consolidated aquifers receive most, if not all, of their recharge from precipitation and tributary streamflow on the highlands on either side of the river valley. The amount of recharge depends on the lithology of the individual aquifer and the amount of water available. Thus, limestone of Mississippian age receives relatively large amounts of recharge because it contains sinkholes, which tremendously increase its capacity to transmit water, and because it crops out in the high mountains where precipitation is greatest. (See Huddle and McCann, 1947.) Conversly, the Duchesne River and Uinta Formations mainly are fine grained, thus having little capacity to transmit water, and they crop out mainly in areas where precipitation is the least in the study area. (See Fields and Adams, 1975, fig. 7.)

Some interformational movement of water between consolidated aquifers is inferred, particularly from the limestone of Mississippian age to the Weber Quartzite. The inference is made, first, because the general hydrologic relation of these rocks is the same as that in Dry Fork and Ashley Creek Canyons near Vernal, where Maxwell, Bridges, Barker, and Moore (1971) have demonstrated such interformational movement. Secondly, the inference is made because of the discharge of water at upper Warm Spring, U(B-1-8) 30ddb-S1, and other nearby springs that discharge from a fault zone in the Weber Quartzite. The aggregate discharge from the springs was an estimated 5 ft^3/s (0.14 m^3/s) in November 1971, with a temperature of 26.0°C. The high temperature is probably due to deep circulation of the ground water downdip through the limestone of Mississippian age and then upward into the overlying Weber Quartzite through fractures related to the faulting.

The ground-water reservoir in the unconsolidated glacial outwash and related deposits in the upper Duchesne River valley is recharged by underflow beneath the Duchesne River and its tributaries where they enter the study area, by precipitation directly on the valley floor, by interformational movement of ground water from the adjacent consolidated rocks, and by seepage of surface water from streams, canals, and irrigated fields. Of these sources, underflow is estimated to be smallest, and precipitation probably is a source of recharge only during exceptionally heavy summer thunderstorms or during rapid melting of a thick snow cover. The main sources of recharge are the interformational transfer of water from the consolidated rocks and the seepage of surface water from streams, canals, and irrigated fields. The absolute quantity of recharge derived from interformational transfer of ground water is unknown, but the rate of recharge from the consolidated rocks is relatively constant; in the writer's opinion, it constitutes most of the gain in baseflow of the Duchesne River in the study area. (See section on ground-water inflow to the Duchesne River.) Recharge to the ground-water reservoir from streams, canals, and irrigated fields varies in rate seasonally, and much of the water derived from these surface sources is considered in this report as irrigation return flow that returns rapidly to the Duchesne River.

The estimated volume of underflow into the study area is based on the width of the valley, the estimated saturated thickness of the glacial deposits as inferred from data for the nearest wells (table 1 and Hood and others, 1976, tables 2 and 6) and observations along the narrows of the Duchesne River and the West Fork Duchesne River, the _K_ of the glacial deposits (Hood, 1976, table 6), and the slope of the water table, which is approximated from the land-surface slope along the center of the valley floor in the narrows. Each of the narrows is not more than 1,000 ft (305 m) wide, and the saturated valley fill is estimated to be ~~not more than~~ about 50 ft (15 m) thick, yielding a cross-sectional area of 50,000 ft^2 (4,645 m^2) each. Values for _K_ in the general study area range from 5 to 400 ft/d (1.5 to 122 m/d) and are estimated to average 100 ft/d (30 m/d), or 0.00116 ft/d (0.00035 m/d). The slope is about 40 ft (12 m) in 2,700 ft (823 m), or 0.0148 ft/ft (0.0148 m/m). The estimated underflow from the two forks therefore is:

$$2 \times 50{,}000 \times 0.00116 \times 0.0148 = 2 \text{ ft}^3/\text{s} \ (0.06 \text{ m}^3/\text{s})$$

Underflow beneath the other tributaries to the upper Duchesne River valley study area are estimated to be much less than that from the two forks described and thus are negligible for the purposes of this report.

The volume of recharge to the valley fill from precipitation cannot be estimated from the available data, although it is certain that recharge occurs intermittently. For example, the hydrograph for well U(C-1-8) 10dda-1 (fig. 5) shows little evidence of water-level fluctuation that can be

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Figure 5 (caption on next page) near here

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attributed to the effect of precipitation except July 1973 after an exceptionally heavy storm and in March 1974 when snowmelt may have caused the water-level rise that seems unrelated to river stage. In general, however, it is estimated that direct recharge from precipitation is a minor source of ground water in the unconsolidated deposits in the valley. (See discussion of fluctuations of ground-water levels on page 34.)

The volume of recharge to the valley fill by interformational movement of water from the adjacent consolidated aquifers also cannot be estimated from the available data, but that movement can be demonstrated from several kinds of indirect data. First, wells and springs throughout the area that produce water from consolidated rocks indicate that those rocks discharge water to the valley fill because (1) the consolidated rocks have direct hydraulic connection with the valley fill and (2) the water-surface altitude in the consolidated rocks is higher than the water surface in the adjacent valley fill. For example, well U(C-2-5)27ccc-1 produced a flow of water from the Uinta Formation at a depth of 158 ft (48.2 m). But at well U(C-2-5)27ccc-2, which was drilled to a depth of 47 ft (14.3 m), the water level was 27 ft (8.2 m) below the land surface. Thus, the vertical hydraulic gradient from the underlying Uinta Formation toward the valley fill was at least 27 ft (8.2 m).

Figure 5.--Stage of Duchesne River at Hanna Bridge (data-site 154) and water level in well U(C-1-8)10dda-1, 1973-74.

Ground-water temperatures also demonstrate recharge to the valley fill from adjacent consolidated aquifers, particularly in the vicinity of the rocks of Paleozoic age near the upper end of the study area. The temperature of the shallow ground water derived from surface sources most generally approximates the average annual air temperature in the vicinity. The average annual air temperature at Hanna is 5.9°C (after Fields and Adams, (1976, table 3). The water from well U(B-1-8)19ddd-1, however, has a temperature of 11.0°C, thus indicating that most of the ground water in the fill at the well comes from other than a surface source. This is suggested also by temperatures of 14.5° and 9.0°C for the water from well U(B-1-8)32baa-1 and spring U(B-1-8)29cdd-S1, respectively. In general, ground-water temperatures tend to decrease down the valley, thus indicating a decrease of recharge from consolidated rocks to the valley fill.

Recharge to the valley fill from surface-water sources in the upper Duchesne River valley comes mainly from the Duchesne River as direct infiltration from the river channel, from the unlined canals that head on the river, and from the fields irrigated from those canals. Smaller quantities of recharge are derived from the flow of tributaries, such as Farm Creek, and canals that head on the tributaries or at larger springs such as Big Spring and Warm Spring (southwest of Stockmore Ranger Station). (See table 1 and fig. 3.)

In parts of the upper Duchesne River valley, the channel of the Duchesne River is above the potentiometric surface in the valley fill, and the river is a perennial source of recharge to the fill. Seepage from the river is clearly indicated in figure 5 by comparing the hydrographs for the river and well U(C-1-8)10dda-1. The well is on the left bank about 50 ft (15 m) from the river. Figure 5 shows that during the period April 1973-August 1974, the altitude of the water level in the well was ~~always~~ usually about 4 ft (1.2 m) below the river-water surface. When the stream rises, the pressure head on the channel bottom rises, seepage from the stream increases, and the ground-water level rises. Streamflow recession, conversely, results in a decline of ground-water level. Thus, at the site, the Duchesne River is a constantly losing stream. Although seepage from the river is limited to specific parts of the valley (see section on movement), seepage from canals and fields can be expected throughout the valley where those sources are found.

Occurrence and movement

Ground water in consolidated aquifers in the upper Duchesne River valley is inferred to be unconfined only in the shallowest parts of the individual aquifers in their outcrop areas; deep within the aquifers and downdip, it is confined by overlying beds of lower permeability. Thus, at well U(C-1-7)19dbd-1, which is finished in the Currant Creek Formation near its outcrop, the ground water is unconfined. By contrast, wells U(C-1-7)33aba-1 and U(C-2-5)28cda-1D are finished in parts of the Uinta Formation which contain water under confined conditions.

The potentiometric surface of the consolidated aquifers cannot be contoured for want of control. It can be inferred, however, that the water moves toward the Duchesne River valley and its more deeply incised tributaries because these are the areas of lowest altitude. Movement in most of the consolidated aquifers probably is slow because most of the aquifers are fine grained and thus have low permeability. Movement is relatively rapid in some rocks of Paleozoic age, however, along paths related to structural distortion and, in the limestones, to subsequent solution.

An example of such discharge is Big Spring, which flows from large blocks of scree that overlie limestone of Mississippian age. The spring exhibits variations in rate of discharge, temperature, and specific conductance (table 2) that roughly fit the pattern of precipitation and runoff from snowmelt. (See section on surface water.) The lowest discharge and highest temperature and specific conductance occur from late summer through late winter; the largest discharge and lowest temperature and specific conductance occur about 1 month after peak streamflow.

Table 2 (next page of ms.) near here

The valley fill in the upper Duchesne River valley contains ground water that is mainly unconfined. Locally the fill may contain thin, lenticular bodies of clay that cause transitory artesian effects. Much of the fill is very coarse grained and fairly well sorted; as a result, ground water moves through it rapidly. This is indicated in figure 5, which shows the rapid response of the ground-water level at Hanna to changes in stage of the Duchesne River.

Table 2.--Miscellaneous measurements at Big Spring, U(B-1-8)17cbb-S1

Discharge: e, estimated.
Chemical analysis available: C, complete; K, specific conductance.

Date	Discharge (ft^3/s)	Temperature (°C)	Specific conductance (micromhos at 25°C)	Chemical analysis available
Aug. 25, 1971	e5	6.5	257	C
Aug. 31	9.4	7.0	278	K
Mar. 30, 1972	5.0	6.5	285	K
June 16	e20	4.5	240	K
July 7	12.5	-	-	-
July 20	15.5	5.5	248	K
July 27, 1973	-	7.0	225	K
Sept. 18	e5	6.0	262	C

Figure 3 shows the directions of ground-water movement in the Hanna-Tabiona area. In the subbasin that reaches from Stockmore Ranger Station down to The Point, the net direction of ground water in the valley fill is toward the Duchesne River, although locally a trough in the potentiometric surface is inferred along the east side of the valley near the middle of the reach. The bedrock spur at The Point apparently constricts flow through the valley fill. In the subbasin that reaches from The Point to the unnamed bedrock spur about 1.5 mi (2.4 km) southeast of Hanna, the ground-water level is below the channel of the Duchesne River; ground water moves away from the river throughout the reach, except near the east edge where it moves toward the center of the valley. The unnamed spur apparently does not constrict the ground-water flow. Downstream from the bedrock spur, to an undefined point between the spur and Tabiona, ground water also moves away from the Duchesne River. Downstream from Tabiona to the narrows near State Road 208, the direction of the gradient on the water table changes, and ground water again flows toward the river.

In the narrows below State Road 208, the flow of ground water is restricted. The meager information on water levels in this lower area, downstream to Duchesne, indicates that the general gradient is neither toward nor away from the river, but parallel to the downstream slope of the valley floor. Thus, when the river rises, the valley fill can receive recharge, and when the river recedes, the fill can discharge water to the river.

The quantity of ground water moving through the narrows below State Road 208 was estimated as follows: At gaging station 09277500 (figs. 2 and 3), the valley floor is about 1,400 ft (427 m) wide, and the saturated thickness of valley fill is estimated to be about 40 ft (12 m), giving a cross-sectional area of 56,000 ft^2 (5,200 m^2). The values of $\underline{K}$ estimated for this reach of the upper Duchesne River valley range from 50 to 400 ft/d (15 to 122 m/d); and for purposes of this computation, the average is estimated to be 200 ft/d (61 m/d), or 0.00231 ft/d (0.00070 m/d). The slope is 0.0079 ft/ft (0.0079 m/m). Discharge through the valley fill near the gaging station therefore is estimated to be:

$$56,000 \times 0.00231 \times 0.0079 = 1 \ ft^3/s \ (0.03 \ m^3/s)$$

Storage

Only a rough estimate could be made of the volume of ground water in storage in the upper Duchesne River valley because the amount and distribution of well data were insufficient for calculation of the total volume of the valley fill. The estimate was made by assuming the saturated valley fill to be a tabular mass 0.5 mi (0.8 km) wide, 40 ft (12 m) thick, and 34 mi (55 km) long, which has a specific yield[1/] of 0.10. The minimum volume of ground water in storage in the area therefore is:

$$0.10 \times 0.5 \times 34 \times 40 \times 640 = 40,000 \text{ acre-ft } (50 \ hm^3) \text{ (rounded)}$$

Footnote 1/ (next page of ms) near here

1/ The specific yield (Sy) of an aquifer is the ratio of the volume of water that the saturated rock will yield by gravity to its own volume. The definition implies that gravity drainage is complete, although this rarely occurs in the northern Uinta Basin area. Sy is a dimensionless number related to, but generally larger than, the storage coefficient. Typical values for Sy range from 0.10 to 0.30.

The storage coefficient (S) of an aquifer is the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in head. S is a dimensionless number. Under confined conditions, S is typically small, generally between 0.00001 and 0.001. Under unconfined conditions, S is much larger, typically from 0.05 to 0.30

Fluctuation in ground-water storage in the upper Duchesne River valley during 1971-74 was relatively small and was related mainly to the amount of streamflow. Withdrawals from wells had little effect on the gross volume in storage.

Changes in ground-water storage are indicated by fluctuations of ground-water levels in the unconfined aquifer. The only reliable record of changes in water level in the upper Duchesne River valley is from well (U(C-1-8)10dda-1. (See fig. 5.)
In figure 5, which shows the plots of daily noon measurements in the well and in the adjacent river, only relatively long-term relations are shown, such as the seasonal high levels due to runoff during snowmelt and seasonal low levels due to streamflow recession and finally freezing of water sources in the high mountains north of the site. Changes of shorter duration--1 to 2 weeks--and lesser magnitude--1 ft (0.3 m) or less--indicate the effects of upstream diversion of river water. During these shorter periods, such as mid-July and mid-August 1973, streamflow diminishes and ground-water levels rise because the streamflow is diminished by the diversion and some of the diverted water leaks from local canals and fields upgradient from the well. When the diversions are changed, the reverse effects occur--streamflow increases abruptly, and ground-water levels decline somewhat more slowly. Analysis of details (not shown in fig. 5) of the two records confirms more precisely this short-term inverse relationship. The analysis also shows diurnal natural effects such as the upstream daily freeze-thaw cycle during spring and fall and the effects of evapotranspiration (fig. 6) during the warmest part of the year.

During 1972-74, water levels in well U(C-1-8)10dda-1 changed about 2.5 ft (0.8 m) owing to changes in stage of the Duchesne River and about 1 ft (0.3 m) owing to seepage of irrigation water from canals and fields. The highest level was reached during peak stream discharge in May and June, and the lowest level was in February. From the hydrograph in figure 5, it is inferred that ground-water storage in the vicinity of the well had nearly reached equilibrium by the end of March 1974, because the water-level decline had nearly ceased. On the basis of the 1972-74 water-level records, it is estimated that the long-term fluctuation in ground-water level is a maximum of about 4 ft (1.2 m). This fluctuation represents, at most, 10 percent of the ground water in storage. Although the conditions at well U(C-1-8)10dda-1 specifically represent the ground-water reservoir at Hanna, the conditions may probably also be representative of the reservoir in most of the upper Duchesne River valley.

Discharge

Ground water in the valley fill in the upper Duchesne River valley is discharged from wells and springs, by evapotranspiration, and by seepage into the Duchesne River. Wells and springs that are mainly used for domestic, stock, amd minor irrigation purposes are estimated to discharge about 1,000 acre-ft (1.2 hm^3) per year. Of this, part was returned to the ground as domestic effluent, and the remainder was consumed by evapotranspiration. Other springflow is either consumed by evapotranspiration or flows into the river.

The only area of concentrated ground-water withdrawal was the Duchesne well field (fig. 2). Owing to the growth of the town, annual withdrawals from the well field increased ~~grew~~ from 395 acre-ft (0.49 hm^3) in 1971 to 577 acre-ft (0.71 hm^3) in 1973.

Evapotranspiration of ground water in the upper Duchesne River valley occurs wherever the saturated zone is close to the land surface or within the reach of phreatophytes, native grasses, and grasses and other crops in irrigated fields. Phreatophytes include sparse to dense willow (Salix sp.) and single or clumps of trees including cottonwood (Populus sp.). Some of the area of evapotranspiration has shallow ground-water levels only during the irrigation season, but some phreatophytes are capable of extending their roots to depths exceeding 10 ft (3 m). For example, figure 6 shows the effect of evapotranspiration at well

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Figure 6 (caption on next page) near here

U(C-1-8)10dda-1, which is in a grove of large trees where the depth to water exceeded 10 ft (3 m) during the period shown. The fluctuations shown occurred when the stage of the Duchesne River was relatively steady. The complete record from the observation well shows that evapotranspiration took place from May 1 to about October 5 during the 1973 growing season, when depths to ground water ranged from 11.9 to 13.7 ft (3.6 to 4.2 m).

Figure 6.--Hydrograph of water level in well U(C-1-8)10dda-1, July 5-6, 1972, showing effect on ground-water level of evapotranspiration by a grove of large trees.

Phreatophytes occur in an area of about 6,000 acres (2,400 hm^2) in the upper Duchesne River valley. Water supply available to phreatophytes and other plants ranges from meager where the depth to ground water is more than 10 ft (3 m) and no surface water is available to abundant where ground water is at or near the land surface or where the land is irrigated or is adjacent to a stream. The amounts of water consumed by phreatophytes--whether from ground water, surface water, or direct precipitation--could not be determined during this study. Therefore, an average figure of 0.5 ft (0.15 m) was used for the consumption of ground water by evapotranspiration for the entire 6,000 acres (2,400 hm^2). Thus consumption of ground water by evapotranspiration is estimated to average about 3,000 acre-ft (3.7 hm^3) per year.

Chemical quality

In the Hanna-Tabiona area, almost all the ground water sampled from water wells and springs is fresh[1] and is either of the calcium bicarbonate or the calcium magnesium bicarbonate type. (See Hood and others, 1976, table 10.) Samples from the Frontier Sandstone Member of the Mancos Shale and the Currant Creek Formation showed sulfate and sodium as the dominant anion and cation. No evidence was found downstream, however, that water from the two formations had appreciably altered the chemical quality of ground water in the valley fill. Water in the valley fill is fresh and for the most part is of the calcium magnesium bicarbonate type similar to the water in the Duchesne River.

[1] Freshwater, as used in this report, is defined as water containing less than 1,000 mg/l (milligrams per litre) of dissolved solids; slightly saline water contains between 1,000 and 3,000 mg/l; and moderately saline water contains between 3,000 and 10,000 mg/l.

Downstream from Tabiona, the Uinta Formation adjacent to the Duchesne River valley contains water that is fresh to moderately saline.[1] The dominant ions include magnesium, sulfate, and sodium. In the reach of the river valley between Tabiona and Duchesne, inflow of water from the Uinta Formation to the valley fill has modified the chemical quality of water in the fill at a few places, mainly where wells are finished in the valley fill at the edge of the valley floor. Otherwise, water from the valley fill is similar in chemical character to that from the river.

[1] (Footnote same as above)

Surface water

The Duchesne River has its headwaters in the Uinta Mountains north of the area shown in figure 2. A transmountain diversion is made from the river in the headwater area; otherwise there is little diversion from the stream down to the edge of the study area. Within the area shown in figure 2, two major tributaries join the main stem. The West Fork Duchesne River enters from the west at Stockmore Ranger Station, northwest of Hanna, and Rock Creek enters from the north between Tabiona and Utahn. The following table shows the average annual discharge at gaging stations above, within, and at the lower end of the upper Duchesne River valley described here.

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The Duchesne River has a large number of minor tributaries, but few have any appreciable discharge, and most of that discharge comes during relatively brief periods of snowmelt in March-June and after summer thunderstorms. (See Cruff, 1975, sites 20-23, tables 2 and 4.)

Average annual discharge, 1941-70, at selected gaging stations in the upper Duchesne River drainage basin (from Fields and Adams, 1976, table 12). Locations shown in figures 2 and 3 except as noted.

Station number	Station name	Average annual discharge (ft^3/s)
09274000	Duchesne River near Hanna 1/	77.8
09275500	West Fork Duchesne River near Hanna	47.4
09276000	Wolf Creek above Rhoades Canyon, near Hanna 1/	6.65
09277000	Duchesne River at Hanna	193
09277500	Duchesne River near Tabiona	196
09279100	Rock Creek near Talmage	181
09279500	Duchesne River at Duchesne	351

1/See Fields and Adams (1976, fig. 5).

The Duchesne River and its major tributaries are perennial. Figure 7

Figure 7 (caption on next page) near here

indicates that the period of maximum flow, which is due to snowmelt, is in May or June, and this is followed by a rapid recession to volumes near that of baseflow by about October. From the hydrographs in figure 5, it is evident that the effects of surface water on ground water have ceased by about January 1; thus, it is inferred that return flow to the river from irrigation has almost ceased by that date.

Ground-water inflow to the Duchesne River

The discharge of the Duchesne River from Stockmore Ranger Station to Duchesne increases mainly because of ground-water inflow from the valley fill. Two methods were used to quantify the gain in the river. A seepage study was made in the Hanna-Tabiona area (fig. 3) and, in the reach from the Hanna-Tabiona area to Duchesne, the river gain from ground-water inflow was estimated from records of gaging stations.

The seepage study in the Hanna-Tabiona area was made on October 31, 1973. This date was selected because (1) most irrigation had ceased, (2) killing frost had occurred and therefore ~~(thus~~ evapotranspiration was at a minimum, (3) fluctuations of streamflow were small, and (4) both streamflow and ground-water discharge had reached the lowest values for the period during which field measurements could be made.

Figure 7.--Hydrographs of monthly streamflow at two gaging stations in the upper Duchesne River drainage basin.

The gain in flow of the Duchesne River from ground-water discharge in the Hanna-Tabiona area at the end of October 1973 was estimated to be 34.6 ft^3/s (1.0 m^3/s) as shown in the following table:

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At the time of the seepage study, return flow from the prior irrigation season was not complete, as indicated by the fact that ground-water levels were still declining. (See fig. 5.) For this reason, the gain in flow of the Duchesne River from the discharge of ground water is estimated to be about 30 ft^3/s (0.8 m^3/s). This value compares with the extreme minimum flow observed at gaging station 09277500, Duchesne River near Tabiona, of 27 ft^3/s (0.76 m^3/s) on October 17, 1934 (Hood and others, 1976, table 12), during the extreme drought that affected much of the Western United States.

Measurement site	Discharge (ft^3/s)	Change for calculating net ground-water discharge to the Duchesne River (ft^3/s)
Underflow into valley (estimated) (p. 24)	2	-2
Losses for Rhoades Canal and Big Spring Ditch above reach (estimated) 1/	7	-7
Duchesne River at Stockmore Ranger Station (site 165)	38.0	-
Rhoades Canal near Stockmore Ranger Station (location U(B-1-8)29bda, fig. 3)	9.1	-9.1
Big Spring Ditch near Stockmore Ranger Station (location U(B-1-8)29acb, fig. 3)	3.3	-3.3
Warm Spring (estimated) (p. 22)	5	-5
Duchesne River at The Point (station 09277000)	77.8	+39.8
Duchesne River at Hanna Bridge (site 154)	63.8	-14.0
Little Farm Creek Canal near head (site 158) (estimated) 2/	5	-5
Duchesne River at foot bridge south of Hanna (site 150)	58.5	-5.3
Duchesne River at Tabiona bridge (site 140)	69.9	+11.4
Duchesne River at State Road 208 bridge (site 134)	98.4	+28.5
Duchesne River near Tabiona (station 09277500)	104	+5.6
Water bypassing station in ditch (estimated)	1	+1
Underflow past station (estimated) (p. 32)	1	-1
Net change		+34.6

1/ Based on ditch losses reported by Utah State Engineer (written commun., 1973.

2/ Gage on Parshall flume indicated discharge of 13.5 ft^3/s (0.38 m^3/s), but due to silting of flume, discharge was estimated to be 5 ft^3/s (0.14 m^3/s).

Downstream from the Hanna-Tabiona area to Duchesne, ground-water inflow to the Duchesne River was estimated by comparing the flows at three gaging stations for water years 1964-70. The combined flow at stations 09277500, Duchesne River near Tabiona, and 09279100, Rock Creek near Talmage, were compared with the flow at station 09279500, Duchesne River at Duchesne (fig. 2). (See summary records in Hood and others, 1976, table 12.) The following table shows the computation of average monthly gain of the Duchesne River and the lowermost part of Rock Creek:

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From the foregoing table, the March value of 9 ft^3/s (0.3 m^3/s) was selected as the probable inflow of ground water to the Tabiona-Duchesne reach of the Duchesne River. This value was selected because the minimum wintertime stage of the river is reached in February-March (figs. 5 and 7), and because the various effects of prior-year irrigation do not reach a minimum until after about December. Moreover, discharge of the Duchesne River in this lower reach is partly affected by midwinter thaw during January-February.

The gain from ground-water inflow to the river in the reach between the Hanna-Tabiona area and Duchesne is only about 30 percent of the ground-water inflow to the Hanna-Tabiona reach, which is the same length. The lower rate of ground-water discharge to the downsteam reach is consistent with the lower rates of recharge from precipitation at the lower altitudes and with the lower permeability of the bedrock (Duchesne River and Uinta Formations) that underlie the downstream reach.

	Water years 1964-70					
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Difference in sums of monthly mean discharge at gaging stations (cubic feet per second) 09279500 - (09277500+ 09279100)	-66	-3	18	69	72	53
Years of record	7	7	7	6	6	6
Average monthly gain (cubic feet per second), rounded	-9	-.4	3	12	12	9

Chemical quality

Data for the chemical quality of the water in the upper Duchesne River and its tributaries is given by Hood, Mundorff, and Price (1976, tables 14 and 15) and discussed in detail by Mundorff (1977). In summary, water that enters and flows through the study area during peak flow from snowmelt has a low dissolved-solids concentration--approximately 90-150 mg/l--and is of the calcium bicarbonate type. During low flow, the water has a higher dissolved-solids concentration--in the range of 200 to 400 mg/l--and is of the calcium magnesium bicarbonate type.

SUMMARY AND CONCLUSIONS

In the upper Duchesne River valley, the Duchesne River flows across valley fill that is composed mainly of outwash and related glacial debris. The valley fill is, in general, highly permeable, and it transmits ground water rapidly. The fill is recharged by a small amount of underflow beneath the Duchesne River and its major tributaries, by precipitation directly on the fill, by interformational movement of ground water from the adjacent consolidated rocks, and by seepage from surface sources, including streams, canals, and irrigated fields. Ground water in the valley fill is mainly unconfined. The minimum amount of ground water in storage and theoretically available by gravity drainage is estimated to be 40,000 acre-ft (50 hm^3), and the estimated maximum annual fluctuation in storage is 10 percent.

Ground water is discharged from the valley fill by wells and springs, by evapotranspiration, and by seepage into the Duchesne River.

Although the river and its tributaries are a source of recharge that moves through to the valley fill, the fill also receives recharge from interformational leakage within the study area and precipitation directly on the study area. The discharge by wells and springs used for domestic, stock, public, and minor irrigation purposes in 1974 was about 1,600 acre-ft (2 hm^3), or an annual average of about 2 ft^3/s (0.06 m^3/s). Evapotranspiration consumed an estimated 3,000 acre-ft (3.7 hm^3), or an annual average of about 4 ft^3/s (0.1 m^3/s). By contrast, discharge of ground water into the Duchesne River amounted to an estimated 39 ft^3/s (1.1 m^3/s), or 28,000 acre-ft (34.5 hm^3) per year.

Because of the high permeability of the valley fill and because unconsumed ground water discharges to the Duchesne River, it can be concluded that lowering ground-water levels by large withdrawals of ground water in the upper Duchesne River valley ultimately would diminish the baseflow of the Duchesne River by about the amount of ground water withdrawn minus the amount salvaged from evapotranspiration.

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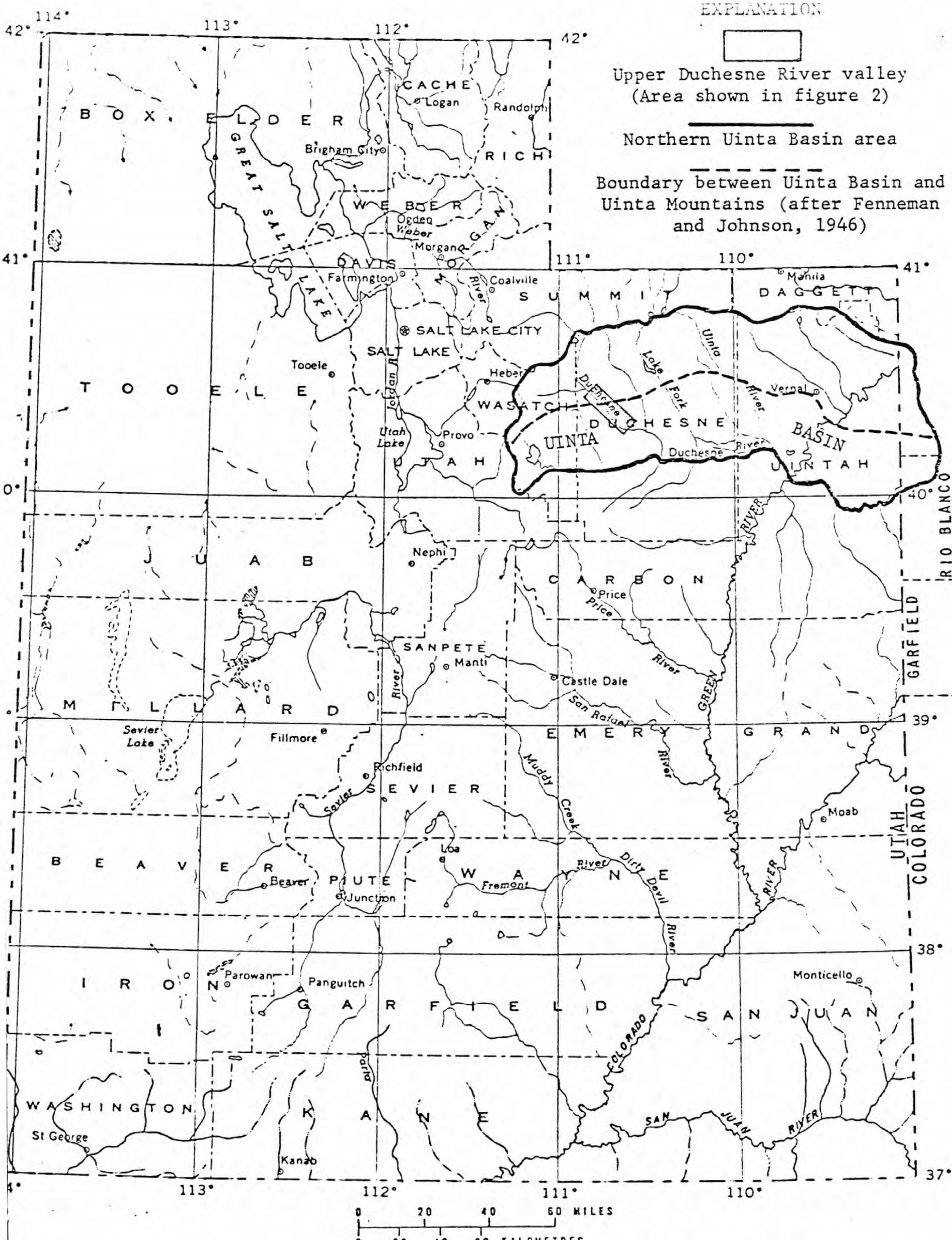

Figure 1.--Location of the northern Uinta Basin area and the upper Duchesne River valley.

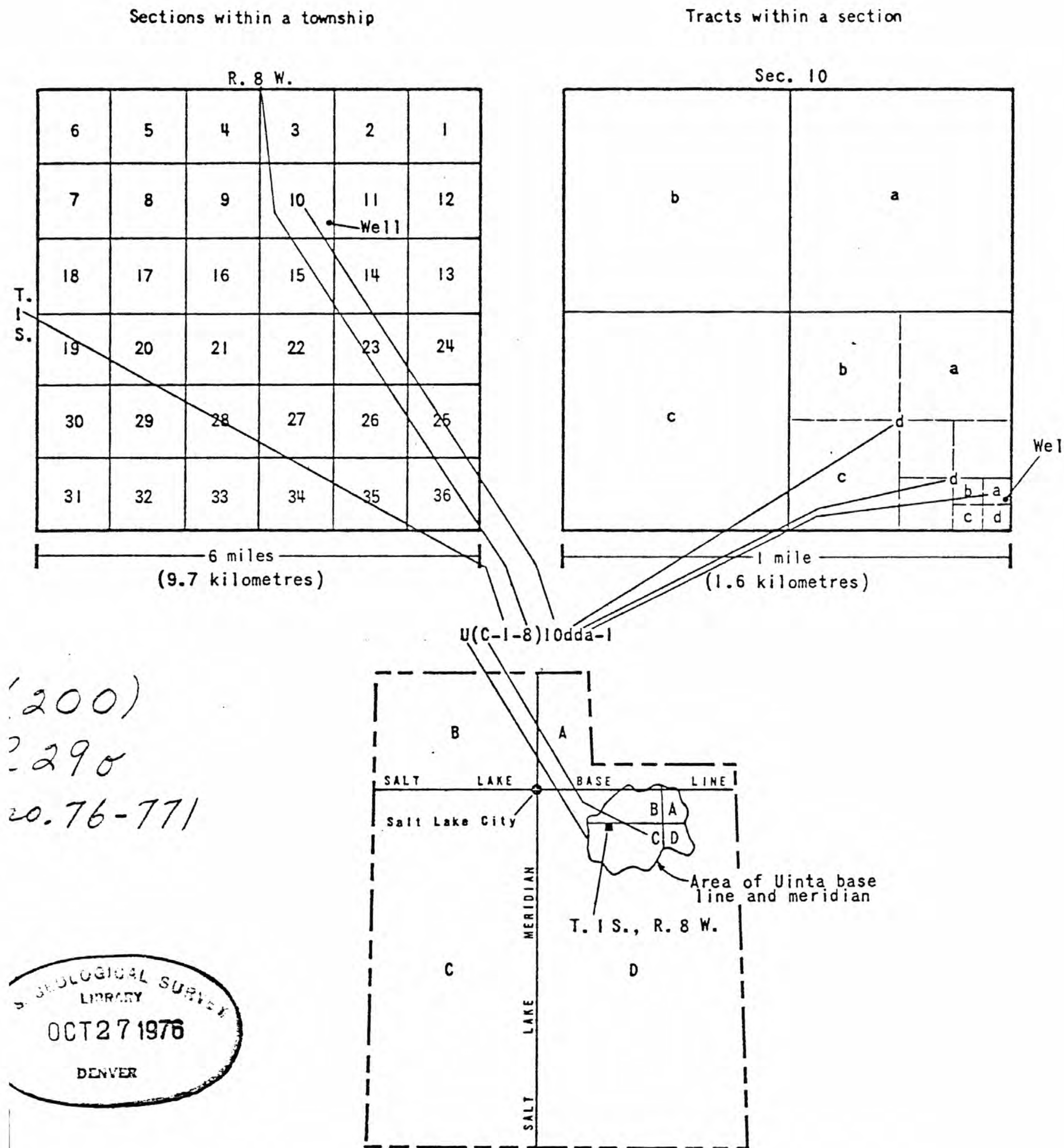

Figure 4.--Well- and spring-numbering system used in Utah.

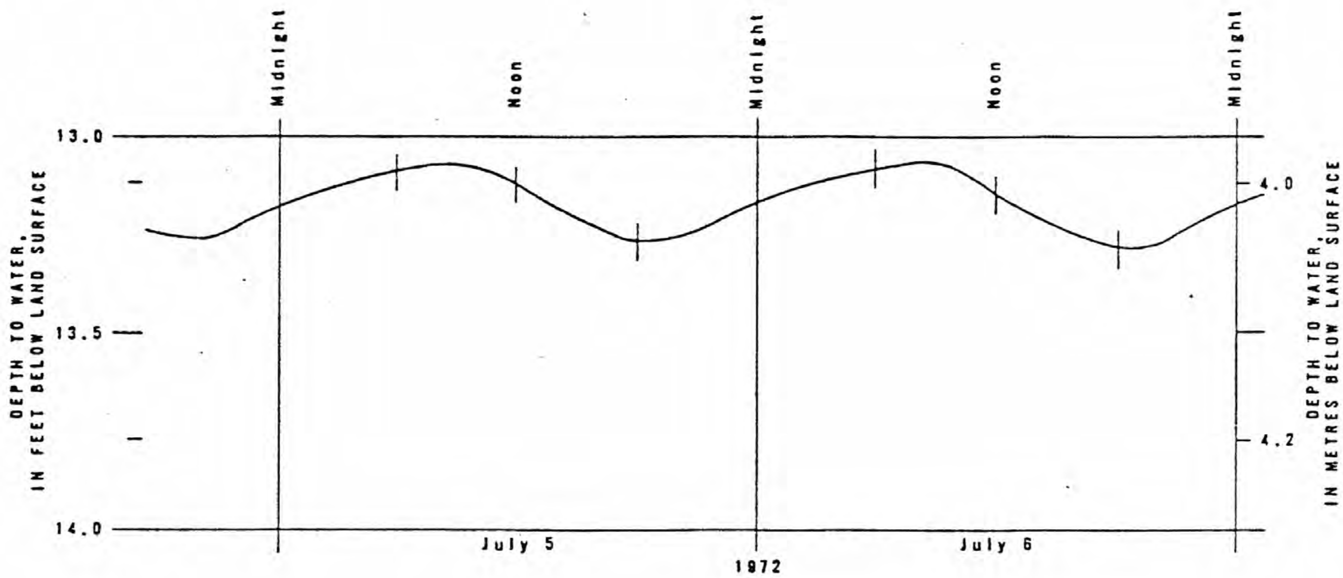

Figure 6.--Water level in well U(C-1-8)10dda-1, July 5-6, 1972, showing effect on ground-water ~~storage~~ level of evapotranspiration by a grove of large trees.

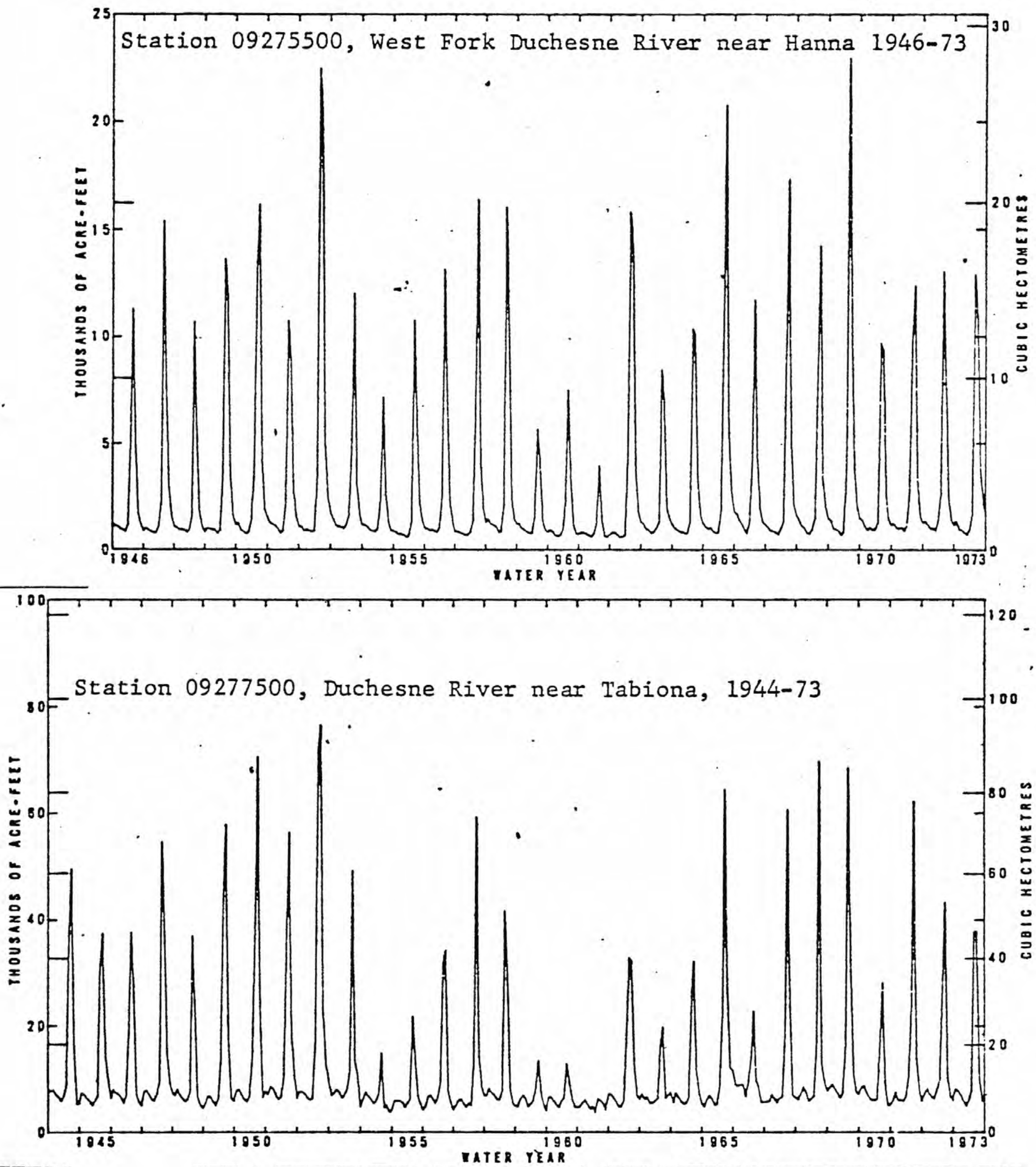

Figure 7.--Monthly streamflow at two gaging stations in the upper Duchesne River drainage basin.