Ground Water for Irrigation in Part of the Fort Hall Indian Reservation Idaho

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1576-D

Prepared in cooperation with the U.S. Bureau of Indian Affairs

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By S. W. WEST *and* CHABOT KILBURN

WATER SUPPLY OF INDIAN RESERVATIONS

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By S. W. West and Chabot Kilburn

ABSTRACT

Irrigation of additional land would increase the degree of self-sufficiency of the Indians on the Fort Hall Reservation. Considerable additional land in the Lincoln Creek and Ross Fork districts and on terraces could be irrigated with ground water. These areas are south and east of the Blackfoot and Snake Rivers, respectively, in Tps. 2–6 S., Rs. 33–37 E., Boise base line and meridian.

Most irrigation water for the reservation is diverted from the Snake and Blackfoot Rivers, and only small amounts are obtained from Lincoln Creek and Ross Fork. The water obtained from Lincoln Creek and Ross Fork is not adequate for lands now irrigated in those districts, and potential sites for storage reservoirs in the basins of the two streams reportedly are poor.

Precipitation in southeastern Idaho ranges from about 10 inches on the Snake River Plain to 30 inches or more in some mountainous localities. The estimated average yearly volume of precipitation available for ground-water recharge (volume of precipitation less evapotranspiration and unsalvaged runoff) in the reservation area is estimated to be nearly 140,000 acre-feet.

Ground-water movement is in general parallel to the surface drainage in the Lincoln Creek, Ross Fork, and Foothill districts and moves westward to the Snake River Plain and the Gibson Terrace. The Snake and Blackfoot Rivers are perched above the water table in the vicinity of Blackfoot. Water percolating downward from these rivers joins water from the upland to the south and moves southwestward beneath the Gibson Terrace to springs issuing along the Portneuf River and from the Fort Hall Bottoms. About 1,400 cfs of water is discharged from the springs in the Fort Hall Bottoms and about 185 cfs from springs along the Portneuf River.

Rocks that crop out in the reservation range widely in character and include consolidated sedimentary rocks of Paleozoic and Mesozoic age, silicic volcanic rocks of Tertiary age, the Snake River basalt of Pliocene to Recent age, and younger alluvium and windblown material. Some of the rocks are potentially important sources of water for irrigation.

The potential yield of large-bore wells in the Lincoln Creek and Ross Fork districts probably ranges from a few gallons per minute to a few hundred gallons per minute. A potential yield of large-bore wells in the Gibson Terrace probably is on the order of 500 to 1,000 gpm with drawdowns of a few feet.

The estimated average yearly amount of ground-water recharge from irrigation on Gibson Terrace is 150,000 acre-feet. Estimated yearly recharge from

precipitation on the terrace is about 30,000 acre-feet. The estimated yearly amounts of recharge in the Lincoln Creek, Ross Fork, and Foothills districts north of the Portneuf River are 20,000, 50,000, and 30,000 acre-feet, respectively. Ground water from the Ross Fork and Foothills districts passes beneath the Gibson Terrace toward the Snake and Portneuf Rivers. Thus, the total recharge in the Gibson Terrace from these sources is about 260,000 acre-feet per year. A large but undetermined amount of ground water flows into the area beneath the Gibson Terrace from the northeast between the Snake River and the foothills.

The estimated recoverable ground-water supply in the Lincoln Creek district is about 5,000 acre-feet a year, enough to irrigate 1,200 acres. Pumping of ground water would reduce the base flow of the creek.

The potentially usable supply of ground water in the Ross Fork district is about 12,000 acre-feet, or enough to irrigate 2,000 acres.

The recoverable ground-water supply beneath the Gibson Terrace area is several hundred thousand acre-feet a year, or enough to irrigate many thousand acres. Usable ground water is accessible beneath or near all the nonirrigated arable land on the terrace, and ground-water irrigation of additional land probably is feasible.

INTRODUCTION

PURPOSE AND SCOPE OF INVESTIGATION

The Fort Hall Indian Reservation contains substantial tracts of nonirrigated arable land. Expansion of the irrigated area would increase the prosperity, economic stability, and degree of self-sufficiency of the Indians on the reservation. The U.S. Bureau of Indian Affairs requested the U.S. Geological Survey to make a preliminary study of ground-water possibilities on the reservation, with special emphasis on the availability of ground water in the Lincoln Creek and Ross Fork districts (pl. 1), where additional surface water is not readily available. Adjoining areas, here called the Gibson Terrace, the Foothills, and the Michaud Flats districts, also were studied because of their close hydrologic relationship to the stratigraphic units in the Fort Hall Indian Reservation. The objective of the investigation was to appraise the general ground-water situation, help the Bureau of Indian Affairs plan additional irrigation development in the Fort Hall Reservation, and suggest where more intensive study might be warranted. Fieldwork, including geologic mapping, canvassing of wells, and collection of miscellaneous hydrologic data, was done by S. W. West and G. E. Brandvold, mainly in April 1955. Wells in the Michaud Flats area were canvassed by Chabot Kilburn in April 1959. A preliminary report by S. W. West was released to the open file in April 1956. Subsequently, additional data were obtained and this report was prepared. Well records for the area have been compiled in a separate report (West and Kilburn, 1960).

Useful general information about the geology, water resources, and water-level data in and around the reservation was available in published reports (Mansfield, 1920; Stearns and others, 1936 and 1938;

U.S. Geological Survey Water-Supply Papers on surface-water supply of the United States, part 13, published annually). Local studies of water resources were made by the U.S. Bureau of Indian Affairs in conjunction with irrigation development on the reservation. The U.S. Bureau of Reclamation investigated ground-water levels west of the reservation in the area centering on American Falls, and records from that investigation were available.

ACKNOWLEDGMENTS

Civic officials, well drillers, and well owners furnished well records, well logs, and other useful information and permitted access to wells. The Bureau of Indian Affairs at Fort Hall, Idaho, furnished miscellaneous maps and other useful material.

LOCATION OF THE AREA

The Fort Hall Indian Reservation contains about 800 square miles in Bannock, Bingham, Caribou, and Power Counties, Idaho (fig. 1). The part of the reservation described in this report is south and east of the Blackfoot and Snake Rivers, respectively, in Tps. 2–6 S., Rs. 33–37 E., Boise base line and meridian. The area is divided into five

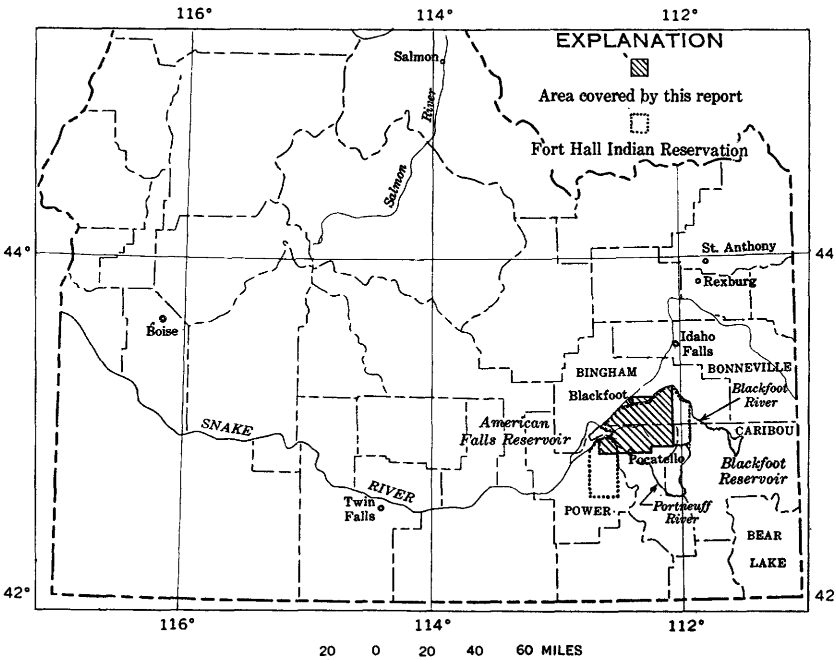

FIGURE 1.—Map of southern Idaho showing Fort Hall Indian Reservation and area covered by this report.

districts to facilitate discussion of the ground-water resources: the Lincoln Creek, the Ross Fork, the Foothills, the Gibson Terrace, and the Michaud Flats (pl. 1).

SURFACE-WATER SUPPLY AND OPERATIONAL PROBLEMS

Lincoln Creek and Ross Fork are small perennial streams for which discharge records are lacking, but the estimated average yearly discharge ranges from 6 to 8 cfs (cubic feet per second) in Lincoln Creek and 5 to 25 cfs in Ross Fork (A. K. Draper, irrigation engineer, Fort Hall Indian Reservation, oral communication, 1955). Much of the runoff is during the nonirrigation season, and facilities for holdover storage are lacking. Sites for reservoirs on the streams reportedly are poor, and the costs of reservoir constuction would be relatively high.

When the discharge averages 8 cfs in Lincoln Creek during an irrigation period of 150 days, 2,400 acre-feet of water is available for run-of-the-stream irrigation from the creek—hardly enough for the 740 acres of land already irrigated in the Lincoln Creek valley. When runoff is less than an average of 8 cfs, the land does not receive sufficient water.

The average runoff in Ross Fork is estimated at 11,000 acre-feet a year (based on an assumed average discharge rate of 15 cfs, the average of the estimated maximum and minimum average yearly flow). On that basis, the yield during an irrigation season of 150 days would be 4,500 acre-feet, or enough for about 1,100 acres of land. Runoff is rapid in late spring and early summer but is small during the nonirrigation season. Currently, all run-of-the-stream water from Ross Fork is utilized, and during late summer the supply is inadequate for the 1,400 acres now irrigated. Irrigation of additional land in the Ross Fork valley would require additional water.

The Buckskin Basin, in the northern part of the Ross Fork drainage basin, contains about 4,000 acres of arable land for which irrigation water has not been obtained. In addition, there are several thousand acres of nonirrigated arable land on the Gibson Terrace and in the adjoining Foothills district. An additional acreage could be irrigated by full use of the available ground- and surface-water supply in the area.

WELL-NUMBERING SYSTEM

The well-numbering system used in Idaho by the U.S. Geological Survey indicates the location of wells within the official rectangular subdivisions of the public lands, with reference to the Boise base line and meridian. The first two parts of a number designate the township and range. The third part gives the section number, followed by two letters and a numeral, which indicate the quarter section, the 40-acre tract, and the serial number of the well within the tract. Quarter sections are lettered a, b, c, and d in counterclockwise order, from the northeast quarter of each section (fig. 2). Within the quarter sections 40-acre tracts are lettered in the same manner. Thus, well 4S–34E–12bb1 is in the NW¼NW¼ sec. 12, T. 4 S., R. 34 E., and is the well first visited in that tract.

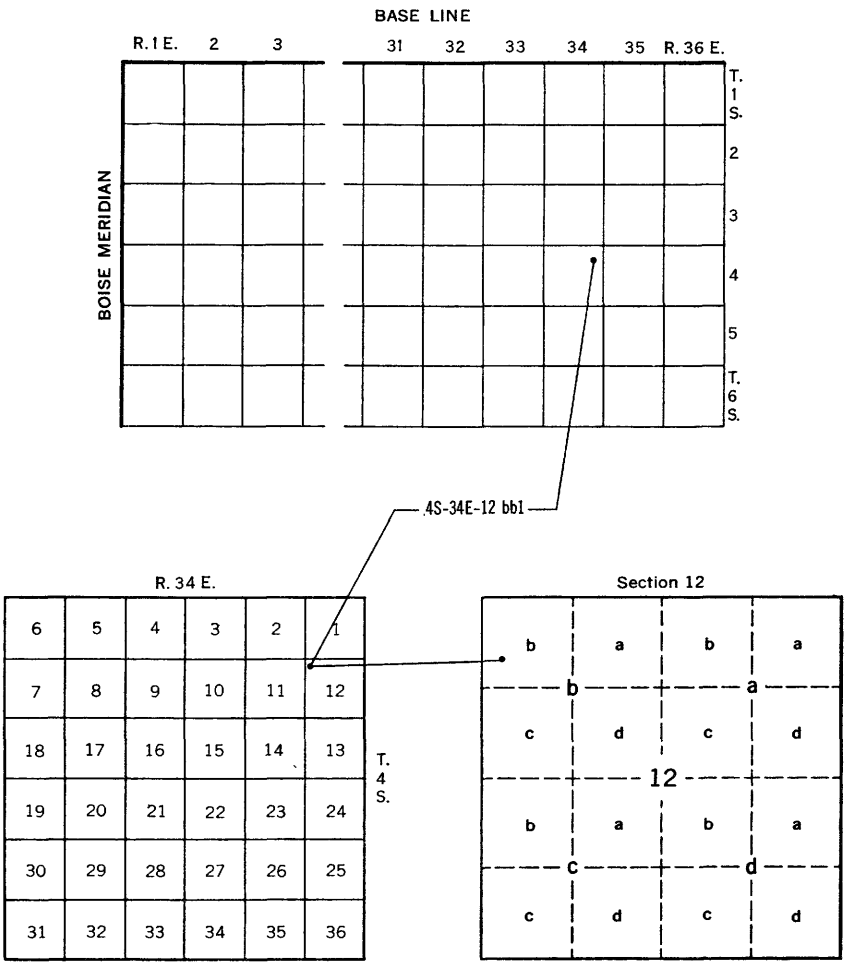

FIGURE 2.—Sketch showing well-numbering system.

PHYSICAL SETTING

SURFACE FEATURES AND DRAINAGE

The Fort Hall Indian Reservation occupies parts of the Bannock, Portneuf, and Pocatello Ranges and the Snake River Plain. The altitude ranges from about 4,400 feet to more than 8,500 feet. In general, the mountains are smooth and rounded, but some of the higher peaks are moderately rugged. Interspersed between the mountains are broad valleys and basins that generally were formed on relatively soft rocks. The intervening harder rocks form ridges that generally have a north- or northwest-trending strike.

Buckskin Basin and the valleys of Ross Fork and Lincoln Creek are characterized by rounded gentle slopes. Locally, Ross Fork and Lincoln Creek have formed small flood plains across which they meander.

Several benches have been formed at the base of the mountains; one of the most prominent is Pocatello Bench that extends northward from Pocatello. The benches were cut by streams flowing for the most part directly off the uplands. The larger streams have well-developed flood plains and divide the benches into narrow segments. The flood plains merge with a broad alluvial plain, 6 to 8 miles wide, known as Gibson Terrace. The terrace extends westward to the Fort Hall Bottoms, which is on the present flood plain of the Snake River. The junction of the terrace and the Fort Hall Bottoms is marked by an erosional scarp whose maximum height is about 75 feet near the mouth of the Portneuf River. The height of the scarp decreases northeast of Ferry Butte, and the terrace merges with the Snake River Plain near Blackfoot. Southwest of the Portneuf River the terrace is known as Michaud Flats.

The Fort Hall Reservation is drained by five principal streams; all are tributary to the Snake River. They are, from north to south, the Blackfoot River; Lincoln Creek, a tributary of the Blackfoot; Ross Fork, a tributary of the Portneuf River; the Portneuf River; and Bannock Creek. Numerous springs issue on the Fort Hall Bottoms and supply the waters of Spring and Clear Creeks. Other springs discharge large amounts of water into the Portneuf River at the northeast end of Michaud Flats.

CLIMATE

The climate of the southeastern Snake River Plain is semiarid, the yearly precipitation averaging about 10 inches. Precipitation is moderately well distributed throughout the year; July and August are the driest months. The mean annual temperature is 45.0°F at Blackfoot and 47.2°F at the Pocatello Airport (table 1); in the mountainous parts of the Fort Hall Reservation the mean annual temperature is somewhat lower.

The prevailing southwest winds commonly are strong and persistent. The average humidity is low, and evaporation from open water surfaces and transpiration by plants are high during the summer. The average length of the growing season for most crops on the Fort Hall Reservation is about 120 days, but the growing season for the hay crops commonly grown in the Lincoln Creek and Ross Fork valleys is as long as 150 days in some years.

TABLE 1.—*Normal monthly and annual precipitation and mean monthly and annual temperature at stations in or near the Fort Hall Indian Reservation* [1]

[From records of the U.S. Weather Bureau]

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Normal annual
Precipitation, in inches													
Blackfoot	1.01	0.83	0.91	0.96	1.32	0.93	0.66	0.64	0.76	0.99	0.83	0.92	10.76
Fort Hall Indian Agency	.76	.72	.81	1.11	1.13	.92	.59	.66	.80	.98	.79	.73	10.00
Pocatello Airport (Phillips Field)	1.21	.93	1.13	1.32	1.21	1.02	.76	.72	.90	1.04	1.06	1.14	12.44
Temperature, in degrees Fahrenheit													Mean annual
Blackfoot	21.2	25.5	34.9	45.4	53.5	61.5	69.1	66.8	51.1	46.4	34.2	23.8	45.0
Fort Hall Indian Agency	21.7	27.4	36.2	45.6	54.5	61.9	70.5	67.4	57.8	48.3	34.7	25.2	45.9
Pocatello Airport (Phillips Field)	22.0	28.5	36.6	46.3	55.3	63.0	72.7	70.1	59.8	49.3	35.9	26.8	47.2

[1] Normals and means are based on the period 1921–50.

VOLUME AND DISPOSITION OF PRECIPITATION

Precipitation in the mountains of southern Idaho is considerably higher than on the Snake River Plain, for it is as much as 30 inches or more per year in some localities. However, lack of good forest stands in the mountains of the Fort Hall Reservation indicates that annual precipitation there is generally less than 20 inches. Precipitation data are not available for higher elevations; so the total volume of precipitation for each district was computed from an isohyetal map of the U.S. Corps of Engineers (written communication, October 1948).

The estimated average yearly volume of precipitation and its disposition in the report area are summarized in table 2. To make the estimate, evapotranspiration on nonirrigated land was assumed to equal all precipitation during the growing season, plus 50 percent of nongrowing season precipitation, not to exceed 3 inches (Blaney and Criddle, 1949). Evapotranspiration is assumed to be 2.2 feet per year on irrigated land in the Lincoln Creek and Ross Fork valleys. Water used for irrigation of the Gibson Terrace is imported surface water and does not enter into the computation. The total annual amount available for ground-water recharge is estimated to be 140,000 acre-feet.

TABLE 2.—*Estimated average yearly volume of precipitation and its disposition in part of the Fort Hall Indian Reservation*

District	Area (acres)	Volume of precipitation (acre-feet)	Evapotranspiration (acre-feet)	Unused runoff (acre-feet)	Ground-water recharge [1] (acre-feet, rounded)
Lincoln Creek	46, 500	60, 000	34, 600	3, 400	22, 000
Ross Fork	90, 600	125, 000	70, 500	6, 500	48, 000
Foothills:					
Area north of the Portneuf River	68, 900	75, 000	45, 000	--------	30, 000
Area south of the Portneuf River	8, 000	8, 000	5, 000	--------	3, 000
Gibson Terrace	71, 900	72, 000	45, 000	--------	27, 000
Michaud Flats	21, 000	19, 000	12, 000	--------	7, 000
Totals (rounded)	300, 000	360, 000	210, 000	10, 000	140, 000

[1] Volume of precipitation minus evapotranspiration and unused runoff.

INFLUENCE OF TOPOGRAPHY ON LOCAL WATER SUPPLY

The altitude and configuration of the land surface influence the amount and nature of precipitation and the runoff characteristics of drainage basins. Several feet of snow accumulates in the winter on the higher mountains in the Fort Hall Reservation. Melting of the snow commonly is slow, and, though the mountain slopes are steep, much of the melt water enters the ground. Some of the water restores soil moisture, some runs off, and the rest percolates to the water table and moves downvalley by underflow. The perennial flow of Lincoln Creek and Ross Fork is sustained by runoff of upland precipitation and ground-water discharge. During periods of heavy rainfall and rapid melting of snow, much water runs off; but during dry periods, upland surface runoff is remarkably small.

Snowfall on the Gibson Terrace ordinarily is light, and the snow rarely accumulates to a thickness of more than 2 or 3 feet. Melting of the snow often is rapid; but owing to the gentle slope of the land surface, runoff is light and much of the water enters the permeable soil, a part of it becoming ground water.

The depth to the water table in areas of high relief characteristically is greater than it is in areas of low relief; however, it commonly is modified by local differences in the permeability of the water-bearing materials and by unequal distribution of ground-water recharge.

STATUS OF DEVELOPMENT ON THE RESERVATION

The reservation is in the most prosperous farming and industrial area of eastern Idaho. From 1940 to 1950 the population increased by 6,986 in Bannock County and 2,227 in Bingham County (table 3). The increase in the Fort Hall Reservation was 778, or 27 percent.

The economy of the reservation is chiefly agricultural, but a small amount of phosphate is mined. Some plain and valley tracts are irrigated, the largest being on the Gibson Terrace. A small acreage of wheat is raised by dryfarming on foothill terraces. Stock grazing is the principal agricultural enterprise on nonirrigated reservation lands. Good stands of native grass on foothill slopes and terraces provide summer forage for many sheep and cattle. Water for the livestock is pumped by windmills from several wells dispersed in the rangeland.

TABLE 3.—*Population of Bannock and Bingham Counties, and the Fort Hall Reservation north of Tyhee, 1940–50*

[From publications of the U.S. Bureau of the Census]

Name	Year		Percent increase
	1940	1950	
Bannock County	34, 759	41, 745	20
Pocatello	18, 133	26, 131	44
Bingham County	21, 044	23, 271	11
Blackfoot	3, 681	5, 180	41
Fort Hall Reservation north of Tyhee	[1] 2, 903	3, 681	27

[1] The population of the Fort Hall Reservation north of Tyhee was computed as the sum of the populations in the Tyhee, Fort Hall, Riverton, and Blackfoot No. 2 (rural) precincts.

Water rights and water use on the reservation are very complex. An analysis of these would be appropriate in a comprehensive study, but it is beyond the scope of this report. Most irrigation water used in the northern part of the reservation is diverted from the Snake and Blackfoot Rivers, but a small amount is obtained from Lincoln Creek and Ross Fork. Water is diverted from the Snake River west of Shelly in sec. 31, T. 1 N., R. 37 E., and is transmitted through the reservation canal to the Blackfoot River, into which it spills in sec. 24, T. 2 S., R. 36 E., upstream from the principal diversions on the reservation (pl. 1). In addition, a small amount of water is diverted to the Blackfoot River from Sand Creek. Blackfoot Reservoir, on the Blackfoot River, which has a designed storage capacity of about 413,000 acre-feet, impounds runoff from the upper basin of the Blackfoot River (fig. 1). An equalizing reservoir and diversion dam on the Blackfoot River at the SE cor. in sec. 12 , T. 3 S., R. 35 E., deliver water to the Fort Hall Main (upper) Canal. Water is diverted to the North (lower) Canal from the Blackfoot River at a lower diversion dam in the SW¼ sec. 11, T. 3 S., R. 35 E. Water is obtained from Lincoln Creek and Ross Fork by simple ditch diversions. There are no storage reservoirs on these creeks.

The Fort Hall Irrigation Unit (U.S. Indian Irrigation Service Map, March 1933) consists of about 47,045 acres on a part of the Snake River Plain herein called the Gibson Terrace. An area of about 33,000 acres on the terrace is irrigated regularly (F. M. Owl, Superintendent, Fort Hall Indian Reservation, oral communication, 1955). A considerable area of nonirrigated sandy land lies west of Fort Hall. About 740 acres is irrigated in the Lincoln Creek valley with creek water, and about 1,400 acres in the Ross Fork valley is irrigated from Ross Fork.

Michaud Flats contains about 30,000 acres of nonirrigated arable land. The Bureau of Indian Affairs is developing 21,000 acres of the flats for irrigation with water from Snake River, which is stored in Palisades Reservoir. As of April 1959, about 2,300 acres of land on Michaud Flats was irrigated with ground water from 16 privately owned wells.

GROUND-WATER GEOLOGY

GEOLOGIC FEATURES THAT AFFECT THE WATER SUPPLY

The occurrence of ground water on the Fork Hall Reservation is closely related to the geology and is as varied as the geologic features. The water-bearing materials range from highly permeable to nearly impermeable.

Consolidated rocks of Paleozoic age that crop out in the Lincoln Creek and Ross Fork districts are chiefly quartzite, limestone, dolomite, and sandstone. Undifferentiated sedimentary rocks of Mesozoic age consist of shale, impure limestone, and sandstone. Layers of silicic volcanic flow rocks, welded tuff, and volcanic ash—all Tertiary in age—overlie the Paleozoic and Mesozoic sedimentary rocks in a large part of the area. Much of the older rock was covered by basalt—part of the Snake River basalt—which is Pliocene to Recent in age, during a late episode of volcanic activity. The basaltic lava flows spread over the eroded, irregular surface of consolidated older rocks and over accumulations of detritus derived from them. Alluvium and windblown materials, ranging widely in thickness, overlie much of the consolidated rocks. The surface distribution of the various rock units is shown on the geologic map (pl. 2). Table 4 summarizes the distribution of geologic formations and their physical and water-bearing characteristics. For further information on the geology the reader is referred to Mansfield (1920), who described the geologic formations in more detail than presented in this report.

The consolidated sedimentary rocks in the Fort Hall area are steeply tilted in many places and are intensely faulted and jointed, and locally they are brecciated. Some of the sedimentary rocks of Paleozoic and Mesozoic age are very permeable owing to closely spaced systems of fractures. Ground water, percolating through fractures in the limestone and dolomite, has enlarged many of the openings by solution, further increasing the permeability of the rocks. The folded shale is compact and much less permeable than other sedimentary rocks. The silicic volcanic rocks and the basalt also are very permeable, owing to closely spaced intersecting fractures. The alluvium and windblown materials range widely in permeability because of variations in their texture and bedding characteristics.

The physical character and structural attitudes of the rocks on the Fort Hall Reservation affect the rate of ground-water recharge, the storage capacity of the rocks, and the direction and velocity of ground-water movement. The intensely fractured consolidated rocks that crop out in the mountains may locally accept ground-water recharge readily and transmit it to foothills and lowlands. In the northern part of the area, permeable silicic volcanic rocks underlying the alluvium and the Snake River basalt are productive aquifers. The Snake River basalt is the principal aquifer in the Snake River Plain and contains water at shallow depth at some localities north of Gibson, but at many places in the upland parts of the reservation the basalt is above the water table. The well-sorted alluvial sand and gravel beneath the Gibson Terrace and Michaud Flats is a highly productive aquifer and probably is the best source of ground water for irrigation in the Fort Hall Reservation. In the valleys of Lincoln Creek and Ross Fork, gravel and other alluvial deposits are less permeable than those beneath the Gibson Terrace, because they contain a larger proportion of poorly sorted fine-grained material. The windblown materials are mainly well-sorted silt and sand which mantle large areas underlain by alluvium and consolidated rocks. They range in thickness from a veneer to several tens of feet. The fine-grained deposits have a high moisture-retention capacity and support a good stand of range vegetation. Thin deposits of coarse windblown sand are widespread on the northern part of the Gibson Terrace, Michaud Flats, on the adjacent foothills, and in the lower part of the valley of the Blackfoot River. This material is highly permeable and has a relatively low moisture-retention capacity. Where canals cross the coarse sand on the Gibson Terrace, the transmission loss of irrigation water is high.

TABLE 4.—*Summary of stratigraphic units in the Fort Hall Indian Reservation*

Era or system	Stratigraphic unit	Thickness (feet)	Physical characteristics and areal distribution	Water-bearing characteristics
Quaternary	Windblown silt or sand		Well-sorted fine-grained sand and silt forming a veneer a few feet to a few tens of feet thick over older units at many places.	Generally thin and above the zone of saturation.
	Alluvium	0–50±	Unconsolidated clay, silt, sand, and gravel; poor to excellent sorting; bedding irregular to lenticular. Present under the flood plains of the Snake, Blackfoot, and Portneuf Rivers and their larger tributaries; locally present along Ross Fork and Lincoln Creeks. Underlies the Fort Hall Bottoms, Michaud Flats, and the Gibson Terrace.	Contains unconfined ground water beneath the flood plains of principal streams; sand and gravel yield moderate to large quantities of ground water in the Gibson Terrace, Fort Hall Bottoms, and Michaud Flats areas. The alluvium has not been adequately explored in the Ross Fork and Lincoln Creek areas.
	Snake River basalt	0–200	Basalt, olivine-bearing light- to dark-gray, dense to vesicular; irregular and columnar jointing is typical; thickness of flow layers variable. Locally includes beds of basaltic cinders. Crops out over an extensive area east of Gibson, at Ferry Butte, and locally northeast of Tyhee. Is intercalated at depth with sediments in the central part of the Ross Fork district and the Buckskin Basin. Underlies or is intercalated with alluvium beneath the Blackfoot River flood plain.	The principal aquifer beneath much of the Snake River flood plain and possibly Michaud Flats; yields unconfined water copiously to wells. Locally in the Foothills and Ross Fork districts it may be above the water table.
Quaternary and Tertiary	Slope wash, older alluvium, alluvial fan deposits, and reworked volcanic ash	Unknown	Unconsolidated clay, sand, gravel, and volcanic ash derived from the erosion of soft Tertiary deposits and rearranged and deposited on lower slopes and in valleys; commonly poorly sorted and poorly bedded. Crops out extensively along the lower slopes of the mountains and in valleys. Largely mantled by windblown silt.	Beds of coarse-grained material below the water table may yield moderate amounts of ground water to wells. Locally contains water under artesian pressure. Water-bearing properties not well known. Will probably yield adequate supplies for livestock.
Tertiary	Silicic volcanic rocks	Unknown	Intrusive and extrusive igneous dikes and flows, welded tuff(?), and beds of ash; chiefly andesite, augite quartz latite, and rhyolite; glassy to coarse grained and porphyritic. Crops out discontinuously in a northeastward-trending belt in the Foothill district and along the northwest side of the mountainous area.	Joints and fault zones in the flows and welded tuff and beds of coarse-grained ash may yield small to moderate quantities of water to wells. Not adequately explored in area.
	Salt Lake formation of Pliocene age	Unknown	White marl, dense yellowish to dove-colored limestone, light-colored conglomerate, composed of light or dark pebbles, that have a white calcareous matrix, and some greenish clay and dark shale; unconformably overlies the rocks of most of the older systems. Interbedded with them are beds of white volcanic ash and greenish or yellow tuff and beds of partly waterworn volcanic debris. Recognized only in areas east of Buckskin Basin and south of Fort Hall Agency.	Water-bearing properties not known but probably will yield adequate water for livestock supplies; otherwise not an important aquifer.

Mesozoic	Sedimentary rocks, undifferentiated	10,250±	Consists of yellow, brick-red, and light-colored sandstone; laminated to thick-bedded, gray to purplish, in part siliceous and cherty limestone, and brick-red to olive-drab shale. Exposed in a northwestward-trending belt in the northeastern part of the reservation. Structure is complex and involves both folding and faulting. More resistant beds may be fractured and brecciated locally.	Joints and fractured zones yield water to numerous springs, and would probably yield small amounts of ground water to wells. The rocks as a whole are impermeable.
Paleozoic	Sedimentary rocks, undifferentiated	Unknown	Consists of gray to drab-colored thin to massive siliceous and cherty limestone and dolomitic limestone, some for the most part shattered and veined; white and reddish to purplish, dense, vitreous and siliceous quartzite, and some phosphatic shale and chert at top of the section. Crops out extensively in mountains east of Fort Hall and Pocatello. Structure is complex and involves both folding and faulting.	Joints and fractured zones yield water to numerous springs, and would probably yield small amounts of ground water to wells. The rocks as a whole are impermeable.

OCCURRENCE OF GROUND WATER

Each of the five principal physical subdivisions (districts) of the Fort Hall Reservation has distinctive geologic features that affect the occurrence of ground water. In the valley part of Lincoln Creek and Ross Fork and in the Gibson Terrace and Michaud Flats districts (pl. 1) shallow unconfined aquifers accept recharge readily and furnish ample water for domestic and stock use. Some of the shallow aquifers are potential sources of water for irrigation. In the Foothills and Lincoln Creek districts, and possibly in other districts, artesian aquifers have been tapped by wells at a few places, but the potential yields of these aquifers and their possible role in irrigation development are not known. Seeps and springs having small to large yields are common in the northern and western parts of the Fort Hall Reservation. Contours drawn on the water table in part of the area are shown on plate 1, and records of wells are given in a companion report by West and Kilburn (1962).

LINCOLN CREEK DISTRICT

The valley of Lincoln Creek was eroded out of ancient sedimentary and volcanic rocks. Coarse detritus from the mountains was deposited in coalescing alluvial fans (part of the slope wash, older alluvium, alluvial fan deposits, and reworked volcanic ash on pl. 2) that form the lower slopes of the valley. Subsequently, alternate erosion and deposition in the lowland formed the flat narrow flood plain which is the modern valley floor. The alluvial fans adjacent to the valley floor were extensively eroded, and at many places they are now covered by windblown silt. The depth, configuration, and specific nature of the consolidated bedrock beneath the valley are not known. Well 3S–36E–14db1, the only one drilled to bedrock in the valley, is 268 feet deep, and the depth to bedrock is 145 feet. The water yield of the bedrock reportedly was small.

Small springs and seeps issue from consolidated rocks of Paleozoic and Mesozoic age, and one group, Yandell Springs, in sec. 31, T. 3 S., R. 37 E., yields several cubic feet per second apparently from cherty and siliceous limestone of Paleozoic age.

The valley alluvium consists of interbedded clay, sand, and gravel, and poorly sorted mixtures of these. Commonly, the alluvium contains appreciable amounts of coarse sand and gravel. It probably would yield at least several tens of gallons of water per minute to properly constructed and effectively developed wells.

The water table is at a depth of less than 50 feet beneath much of the Lincoln Creek flood plain (pl. 3) and is at or near the surface beneath some of the low-lying land. Ground-water seeps are common in the lower parts of the valley. Part of the shallow ground water is tributary to Lincoln Creek and sustains the base flow of the stream. The general direction of ground-water underflow is along the axis of the valley, toward the Blackfoot River valley (pl. 1). Pumping of ground water would reduce the amount discharged to Lincoln Creek and the Blackfoot River valley and the amount of creek water available for irrigation.

Practically nothing is known about artesian water in the Lincoln Creek district. Well 3S–36E–2ad1 at the Lincoln Creek School (185 ft deep) reportedly flowed about 25 gpm (gallons per minute) into a basement pit about 7 feet deep when the well was completed in January 1935.

ROSS FORK DISTRICT

The early geologic history of the Ross Fork basin was similar to that of the Lincoln Creek basin. Erosion by Ross Fork was interrupted during Quaternary time by basaltic lava flows which blocked the mouth of the valley and impounded the creek. Sediments deposited in the lake above the natural dam were predominantly fine grained. The basalt dam eventually was breached by erosion, or the lake was filled with sediments, and stream erosion was renewed. Some of the lake sediments, intermixed with windblown silt, were reworked by Ross Fork during the development of the present-day flood plain. The average thickness of the flood-plain sediments and lakebeds and the character of the underlying materials have not been determined.

Basalt crops out along Ross Fork in the central part of sec. 31, T. 4 S., R. 36 E., and is present beneath part of the area. Well 4S–35E–22ac1, in the Foothills district about 2 miles north of the creek, was drilled in basalt from 88 to 256 feet and in gravel from 256 to 260 feet below the land surface. Well 4S–36E–19cb1, in Buckskin Basin, was drilled in basalt and cinders from a depth of 53 feet to the bottom at 273 feet. Well 5S–36E–5cb1 is 150 feet deep and near the bottom is rock that reportedly resembled basalt. Well 5S–36E–7dd1, which is 96 feet deep, was drilled entirely in fine-grained sediments.

Gravel probably is interposed between the basalt and older bedrock at most places in the Ross Fork district, but the only direct evidence is a driller's report of gravel beneath the basalt in well 4S–35E–22ac1. The average depth of the base of the basalt in the Ross Fork basin has not been determined.

The average depth of wells in the valley flood plain is less than 100 feet. The depth to the water table in much of the Ross Fork valley is less than 50 feet (pl. 3). Two miles north of the confluence of the South Fork and Ross Fork Creeks, however, the depth to water in well 4S–36E–19cb1 is about 230 feet.

The general direction of ground-water movement in the Ross Fork basin is northwestward, in the same direction as the surface drainage (pl. 1). The water-bearing materials beneath the valley floor are relatively low in permeability and their cross-sectional area is small. Saturation of almost the full cross-sectional area and a steep water-table gradient are necessary to transmit the ground water through the valley. Near the confluence of Ross Fork and South Fork the ground water moves through the southern part of the Buckskin Basin, through alluvium and other aquifers in the Foothills district, and thence westward beneath the Gibson Terrace toward the Snake River. The relatively great depth to water in the Buckskin Basin is caused partly by the higher altitude of the land surface and partly by the presence of permeable gravel and basalt. A small saturated cross-sectional area of the aquifers and a gentle water-table gradient are adequate to transmit the available water.

Wells on the flood plain in the upper part of the Ross Fork valley probably would yield several tens of gallons of water per minute, but pumping would reduce ground-water inflow to the surface streams.

Wells in the basalt and gravel aquifers of Buckskin Basin might yield several hundred gallons of water per minute, with pumping lifts of 200 to 300 feet. Pumping probably would not directly affect the flow of Ross Fork.

FOOTHILLS DISTRICT

The depth to the water table beneath much of the Foothills district is more than 200 feet, and in the higher areas the depth probably exceeds 500 feet (pl. 3). Unconfirmed ground water occurs in basalt, gravel, and silicic volcanic rocks; confined (artesian) water occurs under low pressure at some places in the silicic rocks.

Water for stock is obtained from a few wells in the Foothills district, and the available supply is adequate for additional stock wells. In much of the district the pumping lift would average more than 300 feet. Several deep irrigation wells on the Pocatello Bench have tapped artesian aquifers. The average lift in these wells probably is less than 270 feet. The performance of three irrigation wells in the district is summarized in table 5.

The unconfined ground water in the Foothills district migrates to the lowland aquifers, and most of it passes beneath the Gibson Terrace (pl. 1). Water in the artesian aquifers may pass beneath the Blackfoot River and the Gibson Terrace, leaving the area without reappearing at the surface. The amount of water transmitted by artesian aquifers is not known, but it may be substantial.

TABLE 5.—*Performance of wells on Pocatello Bench in the Foothills district*

[Water-bearing material: V, volcanic rock (undifferentiated); Ss, sandstone]

Well	Depth of well (ft)	Water-bearing material	Water level: Depth to water (ft)	Water level: Date of measurement	Yield: Pumping rate (gpm)	Yield: Drawdown (ft)	Yield: Duration of test (hr)	Date of test	Specific capacity (gpm per ft drawdown)
5S-34E-13db1	800	V, Ss(?)	153.4	4-24-59	2,070	50	8	1956	41
35da1	450	V, Ss(?)	164	Fall 1950	1,800	33	--------	1950(?)	55
5S-35E-30ab1	731	V, Ss(?)	237.2	4-24-57	3,060	58	8	1955(?)	53

GIBSON TERRACE DISTRICT

The sedimentary materials underlying the Gibson Terrace rest on an irregular surface of basalt and silicic volcanic rocks, where they were deposited over much of the area by the Snake River during a cycle of channel and flood-plain deposition. After that cycle the Snake River eroded part of the flood plain, formed the Fort Hall Bottoms and the modern river valley, but left a flood-plain remnant which is the Gibson Terrace. Two volcanic cones in the northern part of the terrace, Gibson and Ferry Buttes, protrude through the terrace.

The sediments beneath the Gibson Terrace and the Fort Hall Bottoms range in texture from clay to boulders. Gravel and coarse sand predominate in the upper 100 to 150 feet. Well-sorted sand with stringers and lenses of gravel are common. A few beds are principally clay and silt. Little is known about the sediments at depths greater than 150 feet because few wells on the Gibson Terrace are deeper than 150 feet.

The depth to the water table in the Gibson Terrace district ranges generally from a few feet to about 85 feet, but beneath much of the area it is less than 50 feet (pl. 3). The average measured depth to water in 49 wells was 48 feet. The greatest depth to water is in the eastern part of T. 5 S., R. 34 E., north of Tyhee.

Water for domestic and stock use is obtained from small-diameter wells averaging less than 100 feet in depth. The ground water is plentiful and well failures are rare. Some apparent failures have been corrected by deepening the wells to a more productive water-bearing zone.

The capacity of aquifers beneath the Gibson Terrace is considerably greater than the draft by existing small-diameter wells and small pumps. Larger wells probably would yield at least as much water as wells that tap similar water-bearing materials in nearby areas. For example, the town of Blackfoot, 1 mile north of the Fort Hall Reservation (pl. 1), has 5 public-supply wells. Another large-capacity well at Blackfoot furnishes water to the Idaho State Hospital South. All but one of these wells was drilled through the alluvium into the underlying volcanic rocks from which they obtain their water supplies. Their depths range from 100 to 868 feet, and their average diameter is 16 inches. The yields during pumping tests ranged from 650 to 930 gpm and averaged 735 gpm. Pocatello and adjacent communities, at the southern end of the terrace, also obtain their water supplies from the alluvium underlyling the terrace. The specific capacity of two of the wells owned by the city of Pocatello was very large. One yielded more than 3,000 and another 5,900 gpm per foot of drawdown. The yields and specific capacity of several wells near Blackfoot and Pocatello are summarized in table 6.

TABLE 6.—*Performance of large-capacity wells*

[Water-bearing material: G, gravel; B, basalt; C, cinders; V, volcanic rock (undifferentiated); R, rhyolite]

Well	Depth of well (ft)	Water bearing material	Water level		Yield			Date of test	Specific capacity (gpm per ft drawdown)
			Depth to water (ft)	Date of measurement	Pumping rate (gpm)	Drawdown (ft)	Duration of test (hr)		
In and near Blackfoot and Pocatello									
2S-36E-33da1	38	G	7	1955	1,350	15	1	1954(?)	90
3S-35E- 1dd1	371	B	19.5	9-19-56	300	40	12	1955(?)	7.5
2bb1	623	B, C	45	5-24-54	2,000	15	3	1954	133
2cc1	478	B	25	April 1955	600	2	12	--------	300
2cc3	868	V	30	December 1957.	685	50	8	1957(?)	14
3ac1	182	B, G	49	1-18-49	732	± 9	--------	1957	81
3ac2	179	B, G	49	1-18-49	600	7	--------	--------	86
3da1	100	G(?)	54	4-1-55	650	2	--------	--------	325
10bb1	132	B, C	46	April 1955	930	1	--------	--------	930
6S-34E- 3cc1	255	C	65	4-24-59	1,350	5	4	1957	270
15bd1	301	G	59.6	6-7-58	2,180	18.5	12	1958	118
15cb1	320	S, G	37.6	4-21-53	1,825	19	2.5	1953	96
16cd3	78	G	38	February 1955.	100	4	1	1955	25
23ab1	155	G	88	February 1956.	3,000	<1	6	1956	3,000+
26ba1	350	G	37.5	8-27-52	1,980	.3	11.7	1952	5,900
27db1	137	--------	25.1	8-20-52	500	4	48	--------	125
35ad1	132	G, V(?)	33	12-7-54	2,250	8.2	2	1954	274
35db1	105	G	31.6	8-20-52	2,000	17	--------	1940	118
In the Michaud Flats district									
5S-33E-34ad1	155	S, G	12.8	4-26-59	±1,425	21	24	1955	68
6S-33E- 1cd1	265	C	52	January 1954.	1,800	<1	6	1954	1,800+
1da1	240	V, C	35.0	4-27-59	3,040	<1	1	1954	3,040+
10da1	214	G(?), V	32	--------	1,300	3.5	--------	--------	371
11ac1	309	S, G	41.3	8-28-52	1,800	9	--------	1954(?)	200
11db1	130	G	50.3	4-27-59	1,500	6	--------	1952	250
12cc1	103	G	56.6	4-27-59	877	12	--------	1950	73
12cd1	196	G, R(?)	68	9-13-51	1,500	2	4	--------	750
12da1	113	S, G	65.4	8-18-52	242	4	24	1952	60
13bb1	206	G, R(?)	51	--------	1,800	6	4¼	1950	300
15ad1	203	G	60	--------	1,300	12	--------	--------	108
15dc1	205	--------	85.7	4-25-59	1,190	5	--------	1958	238
19aa1	374	--------	--------	--------	700	<1	--------	--------	700+
21ac1	280	G	75	--------	2,700 to 2,900	12 to 15	--------	--------	225-193
21bb2	227	G	39.1	4-25-59	2,560	14	5	1954	183

Comparison of the water-table gradient and the estimated flow through the aquifers underlying the Gibson Terrace also suggests that these aquifers are very permeable. In a later section of the report it is estimated that local recharge to aquifers underlying the Gibson Terrace is about 260,000 acre-feet per year. This would be equivalent to an underflow of about 230 mgd (million gallons per day) at the outer edge of the terrace, where the water-table gradient averages roughly 20 feet per mile.

Underflow in an aquifer is given by the equation—

$$Q=TIW, \text{ or } T=\frac{Q}{IW}$$

where

Q is the quantity of underflow in gallons per day,
T is the coefficient of transmissibility of the aquifer in gallons per day per foot,
I is the hydraulic gradient in feet per mile,
W is the width of the aquifer in miles.

The margin of the terrace is about 14 miles long, and using this distance as the width of the aquifer in the equation gives a coefficient of transmissibility of about 800,000 gpd per ft (gallons per day per foot). The actual transmissibility probably is considerably larger, because an undetermined amount of underflow from the Snake River Plain to the northeast also provides underflow beneath the Gibson Terrace and discharges to the Snake River in this reach. Assuming a saturated thickness of 100 feet and a transmissibility of about 800,000 gpd per ft, the field coefficient of permeability would be about 8,000 gpd per sq ft.

Hydrographs of two observation wells (fig. 3) show that water-level fluctuations are strongly influenced by irrigation. Well 5S–34E–20cb1 is in an area intensively irrigated with surface water. The water level starts rising almost as soon as water is turned into the canals, the first part of April, and declines when the canals are dry at the end of the irrigation season. Well 4S–34E–5cc1 has the same general trend. but the record indicates the time of rise and decline in the water level lags behind well 5S–34E–20cb1 because it is a few miles away and down the water-table gradient from an irrigated area.

Underflow from the Gibson Terrace is toward the Snake River and its tributaries between Blackfoot and Pocatello (pl. 1), and some of the ground water is discharged into those streams. Depletion of ground water by consumptive use on land brought under ground-water irrigation would decrease ground-water discharge to the surface streams.

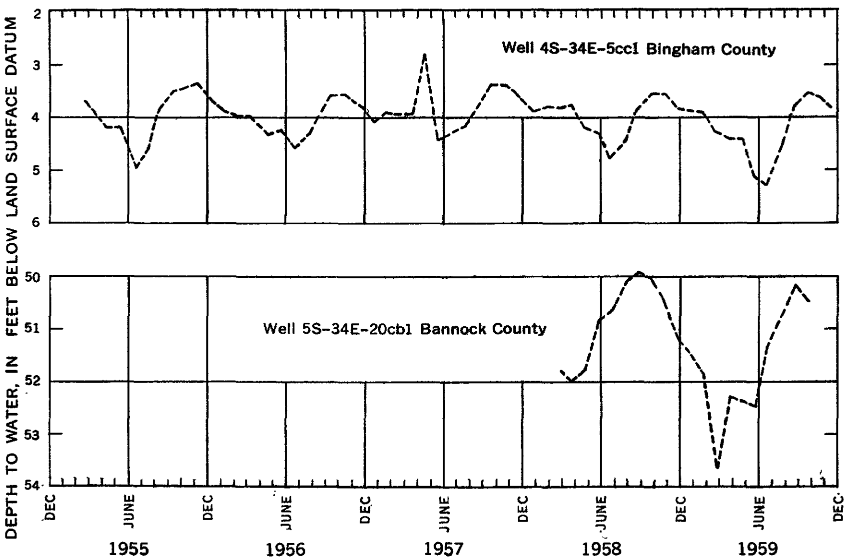

FIGURE 3.—Hydrographs of wells 4S–34E–5cc1 and 5S–34E–20cb1, Bannock and Bingham Counties.

MICHAUD FLATS DISTRICT

Michaud Flats is underlain by interbedded gravel and fine-grained sediments which comprise part of the alluvial fan deposits of the Portneuf River and Bannock Creek. In much of the area these sediments were probably deposited on an irregular surface of basalt and silicic volcanic rocks. Many wells drilled in the northeast quarter of T. 6 S., R. 33 E., pass through the alluvium and reportedly penetrate volcanic rocks at depths of less than 225 feet.

The water in the alluvium and volcanic rocks in much of the area is unconfined, but the water may be confined locally. The depth to water in Michaud Flats generally ranges from a few to about 100 feet, but in much of the area the depth is less than 50 feet below the land surface (pl. 3). Much ground water is discharged from springs into the Portneuf River along the northwest side of the flats. One of the larger springs, Wide Creek, discharges about 60 cfs.

Exploration and development of ground water for irrigation and industrial uses has been more intensive in Michaud Flats than in other parts of the reservation. Many wells mainly in sand and gravel aquifers yield large amounts of water with little drawdown. The volcanic rocks yield large supplies locally. Domestic and stock wells rarely fail to obtain adequate supplies of water from the alluvium. The performance and yield of several large capacity wells are summarized in table 6.

Water-level fluctuations beneath Michaud Flats have been recorded in wells 5S–33E–35cc1 and 6S–33E–20ab1 (fig. 4). The magnitude of the annual fluctuations is small; it is about 2 feet or less. Well 6S–33E–20ab1 may record fluctuations of an artesian aquifer. The water level in this well has declined about 1 foot between 1954 and 1958. The short record available for well 5S–33E–35cc1 shows little net change in water level.

GROUND-WATER RECHARGE

Ground-water recharge in the Fort Hall Reservation is by percolation of irrigation water from canals and irrigated fields, infiltration of precipitation, and underflow from adjacent upgradient areas. Locally, Lincoln Creek, Ross Fork, and the Blackfoot River lose water by seepage. The amount of recharge from irrigation depends on the amount of water supplied to the land in excess of crop needs and the permeability and moisture-retention capacity of the subsurface materials. Consumptive use varies with the types of crops grown, the length of the growing season, the number of daylight hours, the temperature and humidity, and probably with the amount of water applied (Blaney and Criddle, 1949). The final proportional disposition of irrigation water as soil moisture, surface waste, and ground-water recharge in the reservation is not known. On the basis largely of data compiled by Criddle (1947) for water depletion by irrigated crops under conditions similar to those around Fort Hall, the writers estimate that the average yearly consumptive water requirement of irrigated crops in the reservation is about 16 inches (1.3 acre-ft per acre) of applied water and about 3 inches of precipitation. Owing to lack

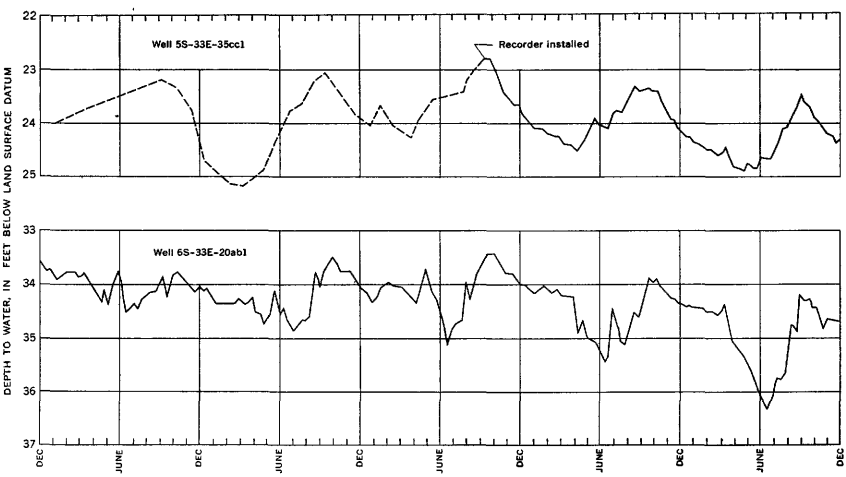

FIGURE 4.—Hydrographs of wells 5S–33E–35cc1 and 6S–33E–20ab1, Power County.

of empirical data for the irrigated land, the estimate of consumptive use was made deliberately liberal, and therefore the ensuing estimate of ground-water recharge is correspondingly conservative. Accordingly, the yearly rate of consumptive use assumed for further computations is 2.0 acre-feet per acre of applied water and 0.2 foot of precipitation.

The average yearly farm-delivery requirement of water for all irrigated land on the reservation reportedly is about 4 acre-feet per acre. The actual delivery rate is less than 4 feet to the Lincoln Creek and Ross Fork valleys but considerably more than 4 feet to parts of the Gibson Terrace. The total diversion to the Gibson Terrace averaged about 220,000 acre-feet per year during recent years. Consumptive use of 2.0 acre-feet per irrigated acre leaves about 150,000 acre-feet for ground-water recharge from irrigation on the Gibson Terrace—220,000 acre-feet − (2 acre-ft per acre × 33,000 acres). Table 7 shows the sources of recharge for some of the districts.

TABLE 7.—*Summary of ground-water recharge, by districts, in area north of the Portneuf River*

District	Amount and source of recharge (acre-feet per year, rounded)	
	Irrigation	Precipitation [1]
Lincoln Creek		20, 000
Ross Fork		50, 000
Foothills		30, 000
Gibson Terrace	150, 000	30, 000
Michaud Flats		10, 000
Total	150, 000	140, 000

[1] From table 2, rounded values used.

The amount of ground-water recharge from irrigation and from precipitation on the Lincoln Creek and Ross Fork districts were not segregated because there is no interbasin transfer of irrigation water; all the water is derived from precipitation within the respective drainage basins. Irrigation with creek water in the two basins has changed radically the preexisting natural proportions of evapotranspiration, surface runoff, and ground-water recharge. The total amount of recharge in each was computed as the volume of precipitation less surface runoff and evapotranspiration.

An estimate of the average yearly volume of precipitation and its disposition in each of the ground-water districts was derived as stated on page D7. (See table 2.) Precipitation that is not disposed of by evapotranspiration or runoff becomes ground-water recharge.

In the Gibson Terrace district, recharge from precipitation, from irrigation loss, and from underflow from other districts is estimated to be about 260,000 acre-feet a year (30,000 acre-ft from precipitation, 150,000 from irrigation, and 80,000 of underflow from the Ross Fork and Foothills districts). In addition, a large but undetermined amount of underflow between the Snake River and the foothills enters the area from the northeast.

In the Michaud Flats district, recharge is from precipitation on the area, underflow from the upland to the south, and underflow from the Portneuf River and Bannock Creek basins. Recharge from precipitation is probably the smallest of these. The volume of recharge from other sources has not been determined, but it may be substantial. Stearns and others (1938, p. 139, 223) estimated that underflow in the Portneuf valley was 50,000 acre-feet a year. The discharge of Bannock Creek is extremely small in comparison with similar basins. Further, the sparse records of inflow from streams tributary to Bannock Creek suggest that the Bannock Creek basin is yielding considerably more water than can be accounted for. Thus, it is possible that ground-water outflow from this basin is substantial. The discharge from 3 springs on the southwest side of the Portneuf River alone amounted to 185 cfs (Stearns and others, 1938, p. 138). It seems likely that total underflow beneath Michaud Flats is several hundred cubic feet per second.

GROUND-WATER MOVEMENT AND DISCHARGE

Ground water moves from places of recharge to places of discharge down the hydraulic gradient at approximately right angles to the contours on the water table or pressure surface. The approximate position of the water table in the spring of 1955 is shown by the water-table map (pl. 1). Water-level contours for Michaud Flats were not drawn because of inadequate information on the altitude of wells.

The direction of ground-water movement in the Ross Fork, Lincoln Creek, and Foothills districts is in general parallel to the surface drainage. The general direction of movement is westward to the Gibson Terrace and Snake River Plain. Both the Snake and Blackfoot Rivers are above the water table in the vicinity of Blackfoot. Water percolating downward from these streams and from irrigated land on the Snake River Plain northeast of the Gibson Terrace moves southwest beneath the terrace to join ground water percolating into the area from the south. The ground water moves southwestward beneath the Gibson Terrace and discharges from springs in the Fort Hall Bottoms. Stearns and others (1938, p. 137) estimated that about 1,400 cfs of water is discharged from the springs in the Fort Hall Bottoms and along the Portneuf River near its mouth. This figure of

1,400 cfs apparently included 230 cfs from springs on the northwest side of the Snake River and American Falls Reservoir and 185 cfs from springs on the southwest side of the Portneuf River. Deducting these amounts from 1,400 leaves about 1,000 cfs discharging from the Fort Hall Bottoms southeast of the Snake River. However, according to Stearns and others (1938, p. 139), the total gain of the Snake River from springs in the reach between Blackfoot and American Falls is about 2,500 cfs. Spring discharge not directly accounted for (2,500 cfs, the total gain, 1,400 estimated from Fort Hall Bottoms) in the reach from Blackfoot to American Falls, therefore probably exceeds 1,000 cfs, of which several hundred cubic feet per second probably discharges from the Fort Hall Bottoms. Thus, the discharge from the Fort Hall Bottoms is at least 1,000 cfs, and it may be as much as 1,500 cfs, or 730,000 to 1,000,000 acre-feet a year. The discharge of these springs is nearly constant, as is indicated in table 8. The annual fluctuation of the springs is in most cases only about 10 percent of their average discharge.

TABLE 8.—*Discharge of springs and spring-fed creeks, in cubic feet per second, in the Fort Hall Bottoms and along the Portneuf River*

Name	Point of measurement			May 1 to Sept. 30, 1955			1925 [2]
	Sec.	T.	R.	Average [1]	Minimum	Maximum	Mean discharge
Fort Hall Bottoms:							
Big Jimmy Creek	NW¼NE¼ sec. 9	5 S.	33 E.	29.0	26	30	37.6
Big Spring Creek	SW¼SE¼ sec. 9	5 S.	33 E.	479.8	465	491	448.0
Clear Creek	SW¼SW¼ sec. 11	5 S	33 E.	128.6	123	140	130.0
Ford Creek	SW¼SW¼ sec. 11	5 S.	33 E.	7.1	6	8	7.4
Kinney Creek	SW¼SE¼ sec. 10	5 S.	33 E.	26.8	25	28	29.3
Adjacent to Portneuf River:							
Wide Creek	NE¼SW¼ sec. 26	5 S.	33 E.	61.4	55	70	60.0
Batise Spring	SW¼NE¼ sec. 7	6 S.	34 E.				[3] 50
Fish Hatchery Spring	SE¼NE¼ sec. 1	6 S.	33 E.				[3] 75

[1] Average of daily measurements from May 1 to Sept. 30, 1955.
[2] Stearns, and others (1938, p. 138).
[3] Sept. 14, 1925.

Springs and seeps are common throughout the mountainous parts of the reservation; however, the discharge of these springs and seeps has not been determined. The largest spring is probably Yandell Springs in the SE¼ sec. 31, T. 3 S., R. 37 E., which discharges several cubic feet per second and supplies a large part of the flow of Lincoln Creek.

Ground water is discharged by phreatophytes locally in the Lincoln Creek valley, along Ross Fork. and in the Fort Hall Bottoms where the water table is near the surface.

Large amounts of ground water are pumped for irrigation, industrial, and municipal use. The total estimated ground-water withdrawals for the above uses, in the area of this report, is about 50,000 acre-feet per year. The areas of major withdrawals are the Blackfoot area, 4,000 acre-feet; Pocatello area, 35,000 acre-feet; Michaud Flats, 8,000 acre-feet; and the Pocatello Bench area, 2,000 acre-feet. The wells are pumped at rates ranging from about 300 to 3,000 gpm. Some additional ground water is pumped for domestic and stock use.

WATER SUPPLY

The total water supply of an area consists of all the surface water and all the ground water, and a complete inventory of the water supply would include both. In the present study, however, data on the availability, diversion, and use of surface water contain discrepancies that cannot be resolved within the scope of this report. Accordingly, a discussion of the surface-water supply, as such, is omitted. Assuming the supply to be a relatively fixed quantity under established water rights, irrigation of additional land on the reservation would depend on more efficient use of the surface water and on utilization of ground water. However, it is apparent that any increased consumptive use of ground water within the area will ultimately decrease the amount of ground water discharged to the Snake River and American Falls Reservoir, and thus will affect the amount of surface water available from that system.

The overall ground-water supply in the report area was estimated on the basis of precipitation and streamflow records and consumptive-use requirements. The estimated recharge from precipitation in the report area is 140,000 acre-feet a year (table 2). The recharge from irrigation (exclusively on the Gibson Terrace) is about 150,000 acre-feet a year (p. D22). The total from these two sources is 290,000 acre-feet a year. An additional large but undetermined amount of ground water moves into the Gibson Terrace from the northeast.

Not all the potential ground-water supply can be intercepted by pumping from wells. The relatively large increment of recharge from surface-water irrigation, however, favors recovery during the irrigation season.

Although the rates of ground-water recharge and underflow are not constant, it seems reasonable to assume that, in the part of the reservation irrigated with surface water, 30 to 40 percent of the yearly ground-water outflow occurs during the irrigation season of 120 to 150 days. Probably not all the seasonal outflow could be intercepted by pumping but perhaps a substantial portion could be. The proportion of the total yield that can be intercepted in any basin depends upon many hydrologic factors and operational practices; however, in general, an estimate of 25 percent is believed to be reasonably conservative for the Fort Hall Reservation. It is recognized that probably much more than the estimated 25 percent of the total ground-water supply could be pumped by drawing heavily from storage during the pumping season. Table 9 summarizes the ground-water supply of the districts and shows the amounts that could be pumped by assuming a recovery of 25 percent. Nearly all the ground water from the Foothills district, the Ross Fork district, and the Gibson Terrace moves through the permeable sand and gravel of the Gibson Terrace to the Snake River. Also, a large amount of underflow from the Snake River Plain to the northeast flows beneath the Gibson Terrace to the Snake River. Also, a large amount of undermated discharge of springs in this reach is about 1,000 to 1,500 cfs, or on the order of 1,000,000 acre-feet per year. Undoubtedly several hundred thousand acre-feet of water could be withdrawn from aquifers underlying the terrace. However, withdrawal of water for irrigation on the terrace would deplete inflow to American Falls Reservoir by an amount equivalent to the increased consumptive use in the area.

TABLE 9.—*Estimated average yearly ground-water supply in part of the Fort Hall Indian Reservation*

[Rounded amounts, in acre-feet]

District	Total supply	Recoverable supply assuming recovery of 25 percent
Lincoln Creek	20, 000	5, 000
Ross Fork	50, 000	12, 000
Foothills:		
Area north of the Portneuf River	30, 000	7, 000
Area south of the Portneuf River	3, 000	700
Gibson Terrace:		
Irrigation return and precipitation	[1] 180, 000	45, 000
Underflow from northeast and southeast	600, 000–800, 000	150, 000–200, 000
Michaud Flats [2]		

[1] Exclusive of underflow from the nortrheast and the Foothills and Ross Fork districts. Includes 150,000 acre-ft from irrigation and 30,000 acre-ft fom precipitation.
[2] Not determined. See discussion p. D23.

SUITABILITY OF THE WATER FOR IRRIGATION

GENERAL CHEMICAL FEATURES

Little is known about the quality of ground water in the Fort Hall Indian Reservation, as systematic water sampling has not been done. However, considerable data are available for adjoining areas. Table 10 lists the available water analyses that have been made by the U.S. Geological Survey, the Idaho Department of Public Health, and private laboratories of ground and surface waters in and adjacent to the Fort Hall Reservation.

Both the ground waters and the surface waters range moderately in concentration of dissolved solids, the range for ground waters being from 242 to 564 ppm (parts per million) and that for surface waters being 248 to 314 ppm. The ground water is predominantly a calcium bicarbonate water containing lesser amounts of magnesium. One analysis, however, indicates a high calcium sulfate water.

CLASSIFICATION OF THE WATER FOR IRRIGATION USE

The chemical suitability of water for irrigation depends chiefly on four factors: the content of dissolved solids (salinity) indicated by specific conductance, the relative proportion of sodium to calcium and magnesium, the bicarbonate concentration as related to the concentration of calcium and magnesium, and the concentration of boron. Among these four principal factors, the amount of dissolved sodium in proportion to the amount of calcium and magnesium largely determines the suitability of water for irrigation.

Two criteria for evaluating the sodium (alkali) hazard of irrigation waters are the percent sodium (Wilcox, 1948) and the sodium-adsorption-ratio (SAR) (U.S. Salinity Laboratory Staff, 1954). Neither one of these is an absolute criterion by itself because the suitability of a water is influenced in some degree both by soil-drainage conditions and by water-management and soil-amendment practices.

The classification and suitability of eight samples of water for irrigation use in the Fort Hall Reservation area (based on the chemical analyses in table 10) are shown in table 11. In the remaining samples of table 10 the amount of sodium and potassium in the sample and the specific conductance of the sample were not determined and, thus, their suitability could not be evaluated.

The samples are rated as good to excellent according to percent sodium (Wilcox, 1948); and they have a medium salinity hazard and a low sodium ("alkali") hazard, according to the specific conductance and the sodium-adsorption-ratio of the water (U.S. Salinity Laboratory Staff, 1954). It is probable that most of the waters, for which analyses are shown in table 10, would be suitable for irrigation.

TABLE 10.—*Chemical analyses, in parts per million, of water in the Fort Hall Indian Reservation area*

Analytical agencies: IDPH, Idaho Department of Public Health; USGS, U.S. Geological Survey; WCC, Westvaco Chemical Co.; SFC, Betz Laboratories, for J. R. Simplot Fertilizer Co.; USN, U.S. Navy Sanitary Engineer Lab., 13th Naval District

Well or spring location	Date of collection	Agency making analysis	Temperature	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium-adsorption-ratio	Specific conductance (micromhos at 25°C)	pH
3S-35E- 3ac1, 2	4- 8-48	IDPH	55	20	0.02	83	26	20	------	290	44	14	0.2	------	0	396	314	12	0.5	------	7.3
3ac2	8-25-51	IDPH	------	26	.01	77	19	17	------	250	36	14	.4	0	0	350	270	12	.4	------	7.3
4S-34E-36cb1	6- 6-54	IDPH	57	------	.01	50	20	------	------	204	40	23	.2	------	------	326	207	------	------	------	7.7
4S-35E-12bd1	8-23-57	USGS	68	39	.20	51	16	11	3.2	211	7.2	19	.1	16	.10	280	193	11	.3	433	8.0
6S-33E-12cd1 }																					
13ba1 }	8-30-51	WCC	------	44	------	------	------	------	------	------	28	27	1.0	------	------	------	144	------	------	------	7.5
13bb1 }																					
12cd1 }																					
13bb1 }	4-15-59	WCC	------	42	0	------	------	------	------	------	40	28	.8	------	0	300	156	------	------	------	7.4
6S-34E- 7cc1 }																					
7cd1	10-31-58	SFC	------	34	------	178	84	------	------	------	136	44	------	------	------	------	262	------	------	------	7.4
7dc2	8-21-57	SFC	------	------	------	920	200	------	------	------	1,080	40	------	------	------	------	1,120	------	------	------	6.0
15aa1	7-17-47	USN	------	24	.05	75	27	[1]36	------	------	38	45	------	------	------	423	298	21	------	------	7.4
15ab1	do	USN	------	16	.05	75	27	[1]18	------	------	28	38	------	------	------	375	298	12	------	------	7.6
15cb1	8- 7-52	IDPH	------	25	.04	75	24	------	------	284	38	41	.1	1.8	.2	424	288	------	------	------	------
23bd1	do	IDPH	------	25	0	86	30	------	------	286	50	70	.0	3.6	.1	564	336	------	------	------	------
23ca1	do	IDPH	------	24	0	75	26	------	------	288	42	49	.1	65	.2	448	296	------	------	------	------
23ca2	do	IDPH	------	24	0	76	25	------	------	288	41	51	.0	1.6	.1	445	292	------	------	------	------
26ba1	do	IDPH	------	11	.05	46	26	------	------	212	46	46	.6	.3	0	356	222	------	------	------	------
27db1	do	IDPH	------	23	.54	77	32	------	------	308	55	57	.0	.2	.2	506	328	------	------	------	8.1
35db3	7-15-45	IDPH	------	------	.09	39	13	------	------	140	22	31	.1			242	151	------	------	------	7.4
35db4	8- 7-52	IDPH	------	22	.04	67	21	------	------	248	32	42	.2	1.2	.3	378	286	------	------	------	7.4
7acS1	7-23-57	USGS	56	44	.01	74	18	44	7.2	217	110	41	1.3	5.2	1.2	452	258	26	1.2	689	7.7
Snake River at Blackfoot Bridge SE¼SW¼ sec. 33, T. 2 S., R. 35 E.	1-16-49	WCC	32	23	.03	46	12	19	3.7	173	43	14	1.1	1.0	------	248	164	20	.6	387	7.7
Wolverine Creek NW¼NE¼ sec. 17, T. 2 S., R. 38 E.	7-23-57	WCC	65	18	0	67	22	7.8	2.2	239	70	8	.3	.6	0	314	258	6	.2	508	8.0

[1] Na and K calculated as sodium (Na).

TABLE 11.—*Classification and suitability of water for irrigation use in the Fort Hall Indian Reservation*

[C_2 indicates medium salinity hazard and S_1 indicates low sodium hazard]

Well No. or location	Classification and suitability	
	Percent sodium	Salinity and sodium hazards
3S-35E- 3ac1	Good	
3S-35E- 3ac2	Excellent	
4S-35E- 12bd1	do	C_2, S_1
6S-34E-15aa1	Good	
6S-34E-15ab1	Good to excellent.	
6S-34E-7acS1	Excellent	C_2, S_1
SE¼SW¼ sec. 33, T. 2 S., R. 35 E.	do	C_2, S_1
NW¼NE¼ sec. 17, T. 2 S., R. 38 E.	do	C_2, S_1

FEASIBILITY OF NEW IRRIGATION WITH GROUND WATER

The feasibility of ground-water irrigation depends, among other things, on (1) the perennial availability of adequate ground water, (2) the accessibility of the ground water in areas of potential use, (3) the yield of individual wells or well fields, (4) the pumping lift, and (5) the number of wells required. Consideration of other factors, such as the quality of arable land, the cost of the water-distribution system, the installation and maintenance costs of wells and pumps, and the unit cost of power for operating the pumps, is beyond the scope of this report. In the following discussion the Foothills district is excluded, because, so far as is known, ground-water irrigation in that district has not been considered by the Bureau of Indian Affairs.

LINCOLN CREEK DISTRICT

According to records of the Bureau of Indian Affairs, there is 1,200 acres or more of nonirrigated arable land in the Lincoln Creek valley. The average farm-delivery demand for that land would be slightly less than 4,800 acre-feet of water a year. Irrigation with sprinklers probably would require somewhat less water. The estimated ground-water outflow in the Lincoln Creek district is 20,000 acre-feet per year. Assuming that 25 percent of this (5,000 acre-ft) could be recovered, there would be enough water to furnish 4.2 acre-feet per acre to the 1,200 acres. A larger amount of water could be obtained by drawing heavily from storage. Pumping of ground water would reduce the base flow of Lincoln Creek to some extent.

Well yields in the valley of Lincoln Creek ordinarily would be small. Large drawdown and relatively high pumping lifts would be necessary to obtain higher yields, and a proportionately large number of wells would be needed to withdraw the required amount of water. The construction, development, and maintenance costs of wells and pumps would be correspondingly large. Further investigation, including test-well installation, would be necessary to develop reasonably firm estimates of available water, practicality of pumping, and effects of pumping on the flow of Lincoln Creek.

ROSS FORK DISTRICT

The Bureau of Indian Affairs would like to obtain sufficient ground water in the Ross Fork district to irrigate 2,000 acres, all of which presumably is in an area that could be served with the usable ground-water supply. Pumping of about 8,000 acre-feet of ground water per year would be necessary for furrow irrigation, but less would be needed for sprinkler irrigation. The estimated outflow of ground water in the Ross Fork district is 50,000 acre-feet per year. Assuming that 25 percent of this amount could be recovered, the supply is adequate for the 2,000 acres. By drawing heavily from storage it is likely that a larger amount could be recovered, probably sufficient for all the irrigable land in the district.

Yields from wells in the Ross Fork District would range widely and would be smaller in the southern part than in the northern part. The number of wells required to withdraw the necessary water cannot be estimated but probably would not be excessive. The pumping lift in the northern part of the district would be greater than in the southern part, but would be less than 250 feet at most places. The costs of well construction, pump installation, and maintenance probably would range from moderate to somewhat high.

The feasibility of irrigating the arable land in the Ross Fork district is sufficiently probable to warrant further study, including drilling of test wells, if development on that scale is desired by the Bureau of Indian Affairs. Alternative means for irrigating with surface water may be more feasible, but the alternatives have not been studied by the writers.

GIBSON TERRACE DISTRICT

The estimated recoverable ground-water supply in the Gibson Terrace district is several hundred thousand acre-feet a year (table 9 and p. D26), enough to irrigate many thousand acres. The number of nonirrigated arable acres on the Gibson Terrace is not known. Planimetric measurements on maps indicate a total land area of 73,000 acres that could be supplied by gravity from the Fort Hall Main Canal. About 33,000 acres already is irrigated, leaving 40,000 nonirrigated acres. A substantial part of that acreage is not arable because it is occupied by stream channels, shifting sand dunes, and gravelly soil. Usable ground water is readily accessible beneath or near all the nonirrigated land on the Gibson Terrace.

Performance of wells near Blackfoot and Pocatello suggest that wells in the Gibson Terrace district likely would have relatively high yields and small drawdowns. And the average pumping lift would be low. The cost of well construction, pump installation, and maintenance would be correspondingly low. Thus, irrigation of additional land on the Gibson Terrace with ground water seems feasible. The factor most likely to limit the feasibility is the quality of the soil on the terrace. The soil was not studied by the writers.

MICHAUD FLATS DISTRICT

Wells in the Michaud Flats district yield several hundred to several thousand gallons per minute with moderate drawdown and low average pumping lifts. The district contains 20,000 to 30,000 acres of arable land, of which an estimated 2,300 acres has been irrigated.

The total amount of ground water available in the district is unknown. However, when the present Michaud Flats Unit of the Fort Hall project is completed, perhaps 30 to 60 percent of the imported water will become ground-water recharge and this will constitute an important additional supply to the area.

PRINCIPAL CONCLUSIONS

The feasibility of new irrigation with ground water on the Fort Hall Reservation cannot be fully appraised at this time owing to the meagerness of hydrologic data. The assumptions and conclusions based on that data necessarily are tentative, and substantial errors are inevitable. The derived estimates of the ground-water potential within the reservation, however, seem to be of a reasonable order of magnitude. They indicate that the overall water supply in the Fort Hall Reservation is sufficiently large for a worthwhile expansion of irrigation. A comprehensive investigation of the water resources is warranted if the scale of potentially feasible development is of interest to the Bureau of Indian Affairs. Some ground-water irrigation could be accomplished in the Lincoln Creek, Ross Fork, and Gibson Terrace districts. Pumping water for the entire arable acreage in the Lincoln Creek and Ross Fork districts might result in a considerable lowering of the water table in those areas.

Ground-water irrigation in the Lincoln Creek and Ross Fork districts would be restricted by the probable low average yield of wells and the relatively high cost of well construction and pump installation. The feasibility of ground-water irrigation in the northern part of the Ross Fork district is diminished by the high pumping lift. The factor most likely to limit ground-water irrigation on the Gibson Terrace is the quality of the soil. The potential of the Michaud Flats district is not appraised.

Any increase in consumptive use of ground water in the area will be accompanied by a corresponding decrease in ground-water discharge, although there would be a timelag between increased use and decreased outflow. As ground-water discharge is an important component of surface flow in the Snake River, increased use of ground water will decrease the amount of surface water available.

ADDITIONAL WATER STUDIES

Data on ground water in the reservation consist of a few records of static water level in wells (chiefly one measurement per well) and of minor miscellaneous information about existing domestic and stock wells. The properties of the aquifers are known only from fragmentary drillers' logs, verbal descriptions of materials penetrated in existing wells, and direct examination of outcrops of aquifers and rocks believed to resemble the acquifers. Additional data would be helpful.

Use of water from the reservation canal and the Blackfoot River possibly could be modified to permit serving additional land for which supplemental ground water might be pumped. The available ground-water supply of the Gibson Terrace district presumably could be used to irrigate many thousand acres.

It is estimated from topographic maps of the Geological Survey that the Fort Hall Reservation contains nearly 20,000 acres of land upslope from the Fort Hall Main Canal and downslope from the 4,800-foot land-surface contour. The 4,800-foot contour crosses the Blackfoot River a few miles upstream from its confluence with Lincoln Creek. The amount of arable land in the tract is not known, but it includes parts of the Lincoln Creek, Ross Fork, Foothills districts, and some irrigated land in the creek valleys. Certain partly irrigated bench land, locally called the Pocatello Bench, also is below the 4,800-foot contour, but it is largely south of the reservation and is not included in the tract. Consideration might be given to the possibility of diverting water from the Blackfoot River at an altitude of 4,800 feet and delivering the water through gravity canals to the arable land in the tract described.

Additional hydrologic studies would be necessary to derive valid estimates of the total quantity of usable water from all sources on the reservation and of the amount of land that could be supplied with irrigation water.

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