FORT HALL WATER STUDY

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WATER RESOURCES

OF THE

FORT HALL INDIAN RESERVATION

FORT HALL, IDAHO

- FINAL REPORT -

BY

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AND

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JULY, 1979

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INTRODUCTION

PURPOSE AND SCOPE

The purpose of this study is to provide a thorough description of the natural hydrology within the boundaries of the Fort Hall Indian Reservation; provide an inventory of current water use, and a plan for future use to the year 2020. The water inventory and plan was prepared under subcontract by James M. Montgomery, Inc., of Boise, Idaho. It is provided under separate cover.

The geology firm of Robinson & Noble, Inc., was authorized to define the natural flow within the reservation. Preliminary work began in 1973, with a more thorough coverage beginning in June of 1975, when the senior author arrived on site as a resident geologist. Two principal sources of information have been used. These are:

1. Published records and reports, chiefly by the USGS and their cooperators.

2. Direct measurements of streamflows, groundwater levels, and chemical qualities. These were made by Tribal personnel and Robinson and Noble, Inc.

ACKNOWLEDGEMENTS

Numerous Tribal and Bureau officials assisted in this study. The Tribal Council water resource liaisons, Kesley Edmo, "Barney" Creasy, Lional Boyer, and LaNada Boyer, provided continued assistance, as did Bill Langley (Planner) and Dwight Bowen (former Tribal Attorney). Nathan Small, of the Tribal Water Resources Office, ably assisted in all data collection activities. BIA employees Arden Hanson(Technical Services) and August Mueller (Water Rights, Area Office) also provided considerable service throughout the study. Several members of the USGS provided considerable published and unpublished data and information. Many additional people of the Fort Hall Reservation also provided assistance, information, and property access.

WATER RESOURCE SUMMARY

BLACKFOOT RIVER BASIN

The Blackfoot River Basin contains 1,300 square miles, of which 124 (10%) is within the Fort Hall Reservation. The major tributaries to the river that drain reservation lands are Wood Creek, Garden Creek, and Lincoln Creek.

The U.S. Geological Survey (USGS) maintains four recording gage stations on the Blackfoot River, including one on the Blackfoot Reservoir. For this study, a recording gage station was established on Lincoln Creek below Yandell Springs. Additionally, monthly measurement stations were established on Cold Creek, Garden Creek, Wood Creek, Short Creek, Beaver Creek, Deadman Creek, and Deadman Spring. The USGS monitors one stock well near Lincoln Creek. In addition, three wells were monitored for this study.

The average annual stream discharges have been computed for the 1974 to 1978 water years based on the available data (Table 1). The 1976 water year flows are used as the average annual flows for each basin, as precipitation was nearly normal that year. Variations in the annual flow will occur as the yearly precipitation varies. The drought of 1977 placed a large stress on the hydrologic system, as water input was reduced to about 80% of normal. In 1977, most of the tributary streams, as well as the Blackfoot River, averaged between one third and one half of their normal annual flows. During the 1978 water year, rainfall amounts approached normal. The yearly flows, however, continued to lag and in some cases fell lower than the 1977 average. Generally though, the baseflows of the summer of 1978 were higher than the 1977 levels. The streamflow recovery was not immediate, as a large portion of the 1978 snowmelt recharged the dry soil and low water tables. Increased baseflows can be expected if rainfall amounts continue near normal in the future.

Little direct observation of the ground water in this portion of the reservation was possible, due to the scarcity of wells in the area. Wells monitored were in the Lincoln Creek basin and adjacent Snake Plain. In the upland area, the ground water probably exists as rather small, discontinuous pockets in the sedimentary rocks. These pockets account for the scattering of small springs throughout the area. The depth to water table can be expected to

TABLE 1

BLACKFOOT RIVER BASIN- SURFACE WATER HYDROLOGY

	Blackfoot River above Reservoir	Deadman Creek	Deadman Spring	Beaver Creek	Short Creek	Wood Creek	Blackfoot River at Shelley	Garden Creek	Lincoln Creek Gage	Cold Creek	Blackfoot River at Blackfoot
Basin Area - sq. mi.	350	-	-	-	-	16.7	909	11.9	32.3	6.2	1,295
Water Year											
1974 Mean Discharge											
cfs	192	-	-	-	-	-	-	-	7.45	-	382
ac. ft/yr.	139,000	-	-	-	-	-	-	-	5,400	-	276,600
inches	7.4	-	-	-	-	-	-	-	3.1	-	4.0
1975 Mean Discharge											
cfs	197	-	-	-	-	-	-	-	-	-	372
ac. ft/yr.	142,600	-	-	-	-	-	-	-	-	-	269,300
inches	7.6	-	-	-	-	-	-	-	-	-	3.9
1976 Mean Discharge											
cfs	218	0.72	0.26	0.04	0.16	5.87	532	1.06	8.03	1.53	453
ac. ft/yr.	157,800	500	190	30	120	4,250	385,200	770	5,800	1,100	328,000
inches	8.5	-	-	-	-	4.8	7.9	1.2	3.4	3.4	4.7
1977 Mean Discharge											
cfs	71.6	0.25	0.13	0.00	0.03	2.40	392	0.36	7.04	0.90	201
ac. ft/yr.	51,800	180	90	0	20	1,700	284,000	260	5,100	700	145,400
inches	-	-	-	-	-	2.0	5.9	0.4	3.0	2.0	2.1
1978 Mean Discharge											
cfs	-	0.31	0.17	0.02	0.00	1.99	-	0.17	6.56	0.67	-
ac. ft/yr.	-	220	120	10	0	1,400	-	120	4,700	480	-
inches	-	-	-	-	-	1.6	-	0.2	2.8	1.5	-

vary greatly, depending on the elevation and geology. Generally, shallow depths to water can be found in the valley bottoms, with increasing depths in higher areas. Ground water levels showed little response to the 1977 drought.

The water budget developed for this basin area is based on the 1976 water year flows as representing near normal conditions. This budget is illustrated schematically in Figure 1, and tabulated in Table 2.

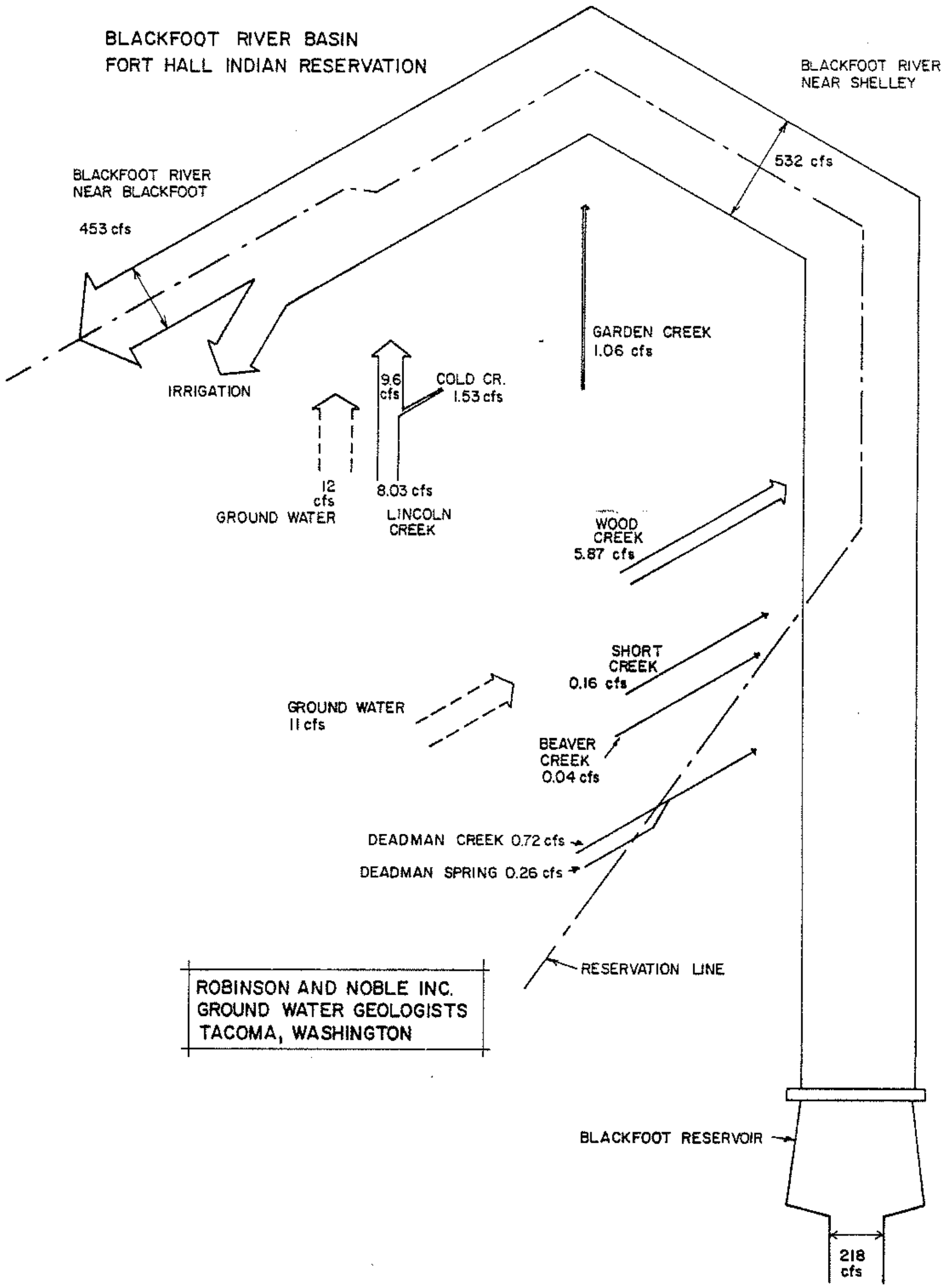
TABLE 2

BLACKFOOT RIVER BASIN - WATER BUDGET

	Inches	CFS	Acre/Feet
Input - precipitation	16.	146.	105,800
Evapotranspiration	11.5	105.	76,100
Total Runoff	4.5	41.	29,800
Surface Water Flow	1.9	17.7	12,800
Upper Tributaries	-	8.1	-
Lincoln Creek	-	9.6	-
Ground Water Flow (124 sq. mi.)	2.6	23.3	16,900
Upper Tributary Area (60 sq. mi.)		11.	-
Lincoln Creek Basin (64 sq. mi.)		12.	-

Water quality was monitored at each stream station and several wells. Overall, the water was found to be fairly hard. Water in the Lincoln Creek basin was found to be very hard, with high levels of sulfate and higher than normal temperatures. Streams draining the Garden and Higham Peak area were found to be high in turbidity.

FIGURE I


BLACKFOOT RIVER BASIN
FORT HALL INDIAN RESERVATION
BLACKFOOT RIVER NEAR SHELLEY
532 cfs
BLACKFOOT RIVER NEAR BLACKFOOT
453 cfs
IRRIGATION
GARDEN CREEK 1.06 cfs
9.6 cfs
COLD CR. 1.53 cfs
12 cfs
GROUND WATER
8.03 cfs
LINCOLN CREEK
WOOD CREEK 5.87 cfs
SHORT CREEK 0.16 cfs
GROUND WATER 11 cfs
BEAVER CREEK 0.04 cfs
DEADMAN CREEK 0.72 cfs
DEADMAN SPRING 0.26 cfs
RESERVATION LINE
ROBINSON AND NOBLE INC.
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TACOMA, WASHINGTON
BLACKFOOT RESERVOIR
218 cfs

ROSS FORK BASIN

The Ross Fork Basin lies at the center of the Fort Hall Indian Reservation. Two main tributaries, the North and South Forks, drain much of the Mount Putnam area and join near Putnam Lodge. The mouth of the basin is herein considered to be the Main Canal crossing. The basin contains a total of 166.5 square miles, of which 160.1 (96%) lies within the reservation.

For this study, a recording gage station was established on the main stem of the Ross Fork in 1973. Monthly measurement stations were also established on the North Fork at Farmer Ditch, the South Fork below Mill Creek, and Mill Creek. Approximately ten wells were monitored in the Buckskin Basin-South Fork area on a monthly basis. Two water level recorders were maintained on two abandoned irrigation wells in Buckskin Basin.

The average annual streamflows for the study period are listed in Table 3. The total flow of Ross Fork at the gage during the 1976 water year was 34.6 cfs. Several cfs are used by irrigation in the minor unit above this gage. Below the gage, measurements indicate between one and two cfs are lost from the creek into the ground water. During the 1977 drought, the annual flow of Ross Fork was 7.58 cfs, less than one quarter of the 1976 flow. Part of this decrease was due to greater irrigation demand. The creek at the gage reached zero discharge during September, 1977. Increased precipitation in 1978 returned the flow to about half of the 1976 flow.

Figure 2 shows the schematic representation of the Ross Fork water budget. Table 4 lists the water budget components. The

TABLE 4

ROSS FORK - WATER BUDGET

	Inches	CFS	Acre/Feet
Input - Precipitation	16.5	202.	146,500
Evapotranspiration	11.5	141.	102,100
Total Runoff	5.	61.3	44,400
Surface Water Flow	2.8	34.6	25,000
Ground Water Flow (166.5 sq. mi.)	2.2	26.7	19,300

ROSS FORK BASIN

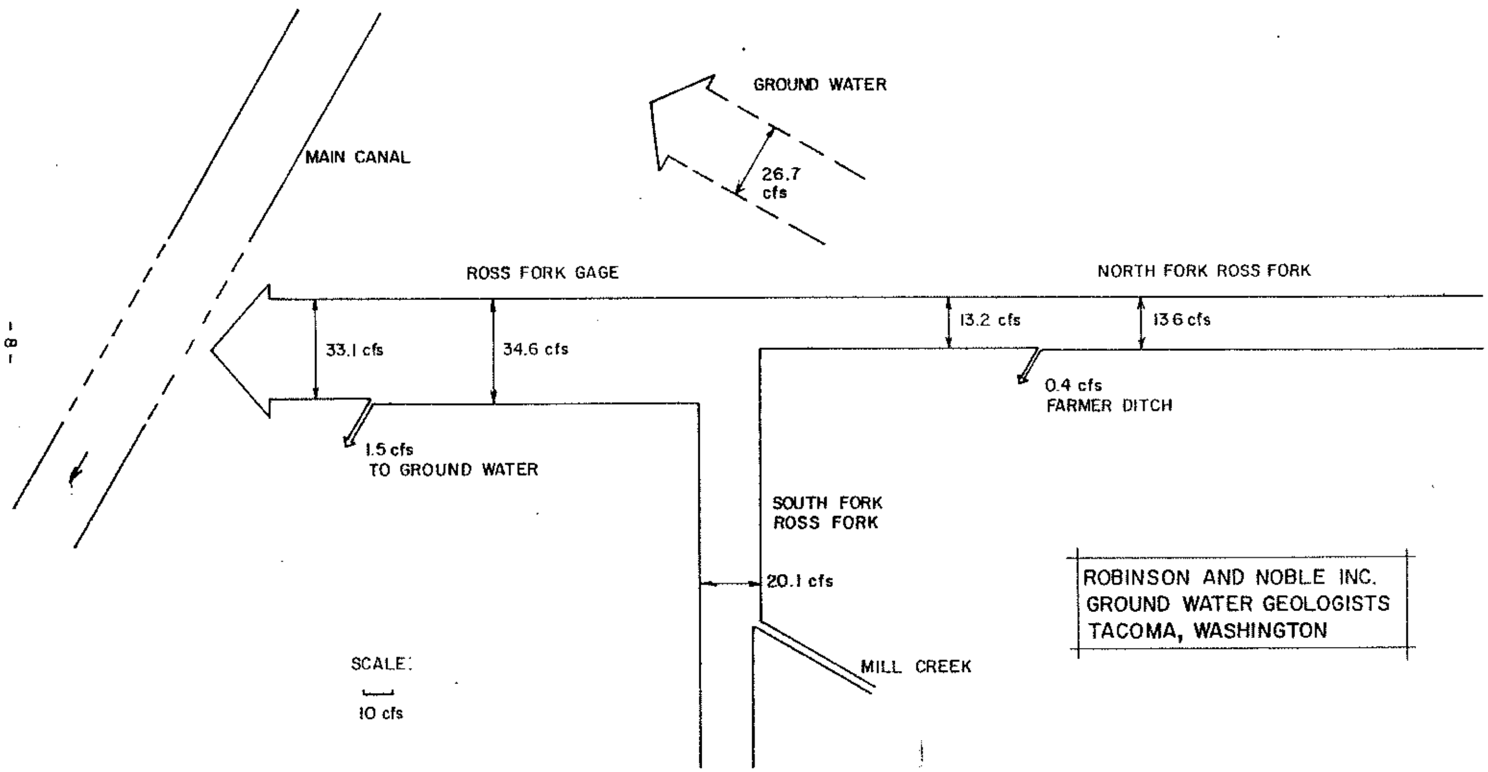


FIGURE 2

ground water generated by precipitation within the Ross Fork basin is calculated at 26.7 cfs. The lower portion of the basin, including Buckskin Basin, is underlain by the Snake River aquifer which transmits a very large quantity of water through this area. The ground water from the Ross Fork basin contibutes to this much larger flow. A great deal more than 26.7 cfs of ground water is actually available from the lower basin.

Water quality in this basin is variable, depending primarily on geologic conditions. Very hard water exists in some areas of the metasedimentary rocks of the North Fork. This water supplies some springs in the vicinity of the Gay Mine. The majority of the water in the South Fork and North Fork areas, however, has normal levels of sulfate and hardness, with high iron concentrations found in the Mount Putnam area. The use of the surface water in the minor unit increases dissolved solids and turbidity in the lower channel. Ground water in the volcanic terrain of the lower basin approximates the quality of the Snake Plain groundwater.

UPPER PORTNEUF RIVER BASIN

The Portneuf River Basin contains 1,250 square miles upstream of the Pocatello gaging station. Below Pocatello, the Portneuf River becomes a part of the Snake Plain hydrologic system. A total of 91.8 square miles of the basin lies within the Fort Hall Indian Reservation, the majority lying upstream of the Portneuf Reservoir. The lower basin is summarized in the Snake Plain section.

A recording stream gage station was established on the upper Portneuf River just upstream of the reservoir. Additional monthly measurement stations were established on Jeff Cabin Creek, Little Toponce Creek and the North Fork Toponce Creek. The average annual discharges for thse streams between 1974 and 1978 are listed in Table 5. The 1976 water year is used for the average flow of the basin. The annual streamflows during the 1977 drought were reduced to between one quarter and one half of normal. The increased precipitation in 1978 returned the flows to normal levels without the lag noted in other basins.

No measurements of ground water levels were made in the upper basin. Studies adjacent to the reservation indicate the water table to be near the valley floor around the Portneuf Reservoir. This is confirmed by the presence of springs along the river. In the upland areas, ground water would be expected to exist in discontinuous pockets, controlled by the rock type and structure. These pockets produce the scattered small springs at higher elevations.

TABLE 5

UPPER PORTNEUF RIVER BASIN SURFACE WATER HYDROLOGY

	Jeff Cabin Creek	Portneuf River Gage	North Fork-Toponce Cr.	Little Toponce Creek	Portneuf River-Pebble
Basin Area - sq. mi.	11.3	89.6	4.78	4.33	260
Water Year					
1974 Mean Discharge					
cfs	-	18.6	-	-	118
ac. ft/yr.		13,500	-	-	85,400
inches	-	2.8	-	-	6.2
1975 Mean Discharge					
cfs	-	-	-	-	113
ac. ft/yr.	-	-	-	-	81,800
inches	-	-	-	-	5.9
1976 Mean Discharge					
cfs	-	22.0	8.43	3.93	127
ac. ft/yr.		15,900	6,100	2,800	91,900
inches	-	3.3	23.9	12.3	6.6
1977 Mean Discharge					
cfs	1.37	8.94	1.75	0.92	-
ac. ft/yr.	1,000	6,500	1,300	700	-
inches	1.6	1.4	5.0	2.9	-
1978 Mean Discharge					
cfs	-	13.9	11.6	4.85	-
ac. ft/yr.	-	10,100	8,400	3,500	-
inches	-	2.1	32.9	15.2	-

The annual water budget for the basin was developed using the 1976 flow data. The components of the budget are listed Table 6, and shown schematically in Figure 3.

TABLE 6

UPPER PORTNEUF RIVER WATER BUDGET

	Inches	CFS	Acre/Feet
Input - Precipitation	18.	132.	95,600
Evapotranspiration	12.	88.	63,700
Total Runoff	6.	44.	31,900
Surface Water Flow	4.7	34.4	24,900
Ground Water Flow (99.6 Sq. Mi.)	1.3	9.6	6,950

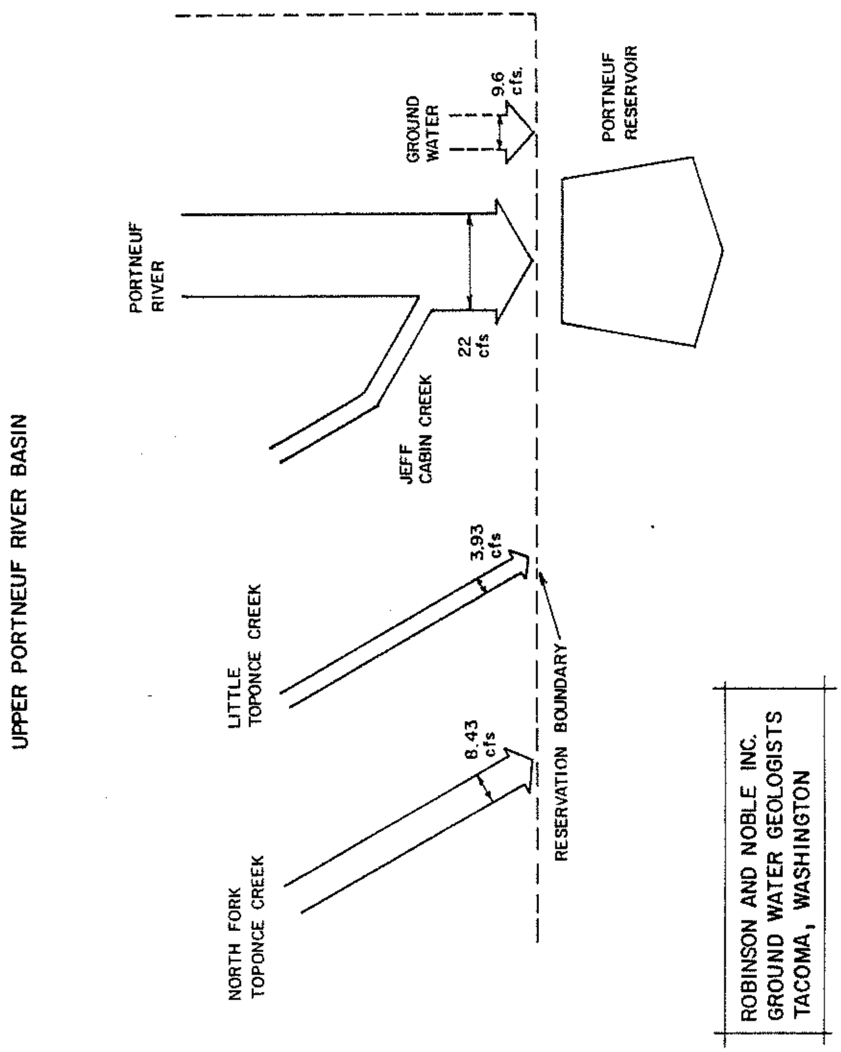
Great variability in water quality was found among the stream water in the basin. Very hard water flows from some springs, such as Qeedup. This water is high in sulfate, hardness, alkalinity, fluoride, and temperature. In contrast, very soft water flows in the Toponce Creeks that is primarily derived from snowmelt. The Portneuf River has an intermediate quality, reflecting the input of these various streams.

BANNOCK CREEK BASIN

The Bannock Creek basin occupies the southwest portion of the reservation. The valley itself is known as Arbon Valley. Bannock Creek flows north, and enters the American Falls Reservoir.

Since 1924, the USGS has maintained a measuring station near the mouth of Bannock Creek for the purpose of summer irrigation measurements. They also maintain two low-flow stations, one on Rattlesnake Creek and one on Bannock Creek below Moonshine Creek.

FIGURE 3


UPPER PORTNEUF RIVER BASIN
NORTH FORK TOPONCE CREEK
8.43 cfs
LITTLE TOPONCE CREEK
3.93 cfs
JEFF CABIN CREEK
PORTNEUF RIVER
22 cfs
GROUND WATER
9.6 cfs.
PORTNEUF RESERVOIR
RESERVATION BOUNDARY
ROBINSON AND NOBLE INC.
GROUND WATER GEOLOGISTS
TACOMA, WASHINGTON

For this study, two recording gage stations were established on Bannock Creek. The upper station lies below the West Fork tributary at the south end of the reservation. The lower station lies near the mouth. In addition, monthly measurement stations were established on West Fork, Moonshine Creek, Rattlesnake Creek at two locations, Midnight Creek, and Michaud Creek. Four wells were monitored along the valley bottom, along with several wells near the junction with the Snake Plain.

The average annual streamflows for the study period are shown in Table 7. The 1976 water year is used as the average flow year for the water budget analysis. The total input of surface water to the creek for that year was 88.5 cfs. This Figure is affected by irrigation both upstream and within the reservation. Streamflow during the 1977 drought year was reduced to about half that of the previous year. Streamflow showed some increase during the 1978 water year, with the notable exceptions of West Fork and Moonshine Creek, which continue to decline.

The water budget for the basin is shown schematically in Figure 4 and listed in Table 8. The calculated ground water flow is

TABLE 8

BANNOCK CREEK BASIN - WATER BUDGET

	Inches	CFS	Acre/Feet
Input - Precipitation	18	548	396,500
Evapotranspiration	12	365	264,300
Total Runoff	6	183	132,200
Surface Water Flow	2.9	88.5	64,100
Ground Water Flow (413 Sq. mi.)	3.1	94.5	68,400

94.5 cfs. Lack of drilling information inhibits further analysis of this flow. Much ground water probably flows through the

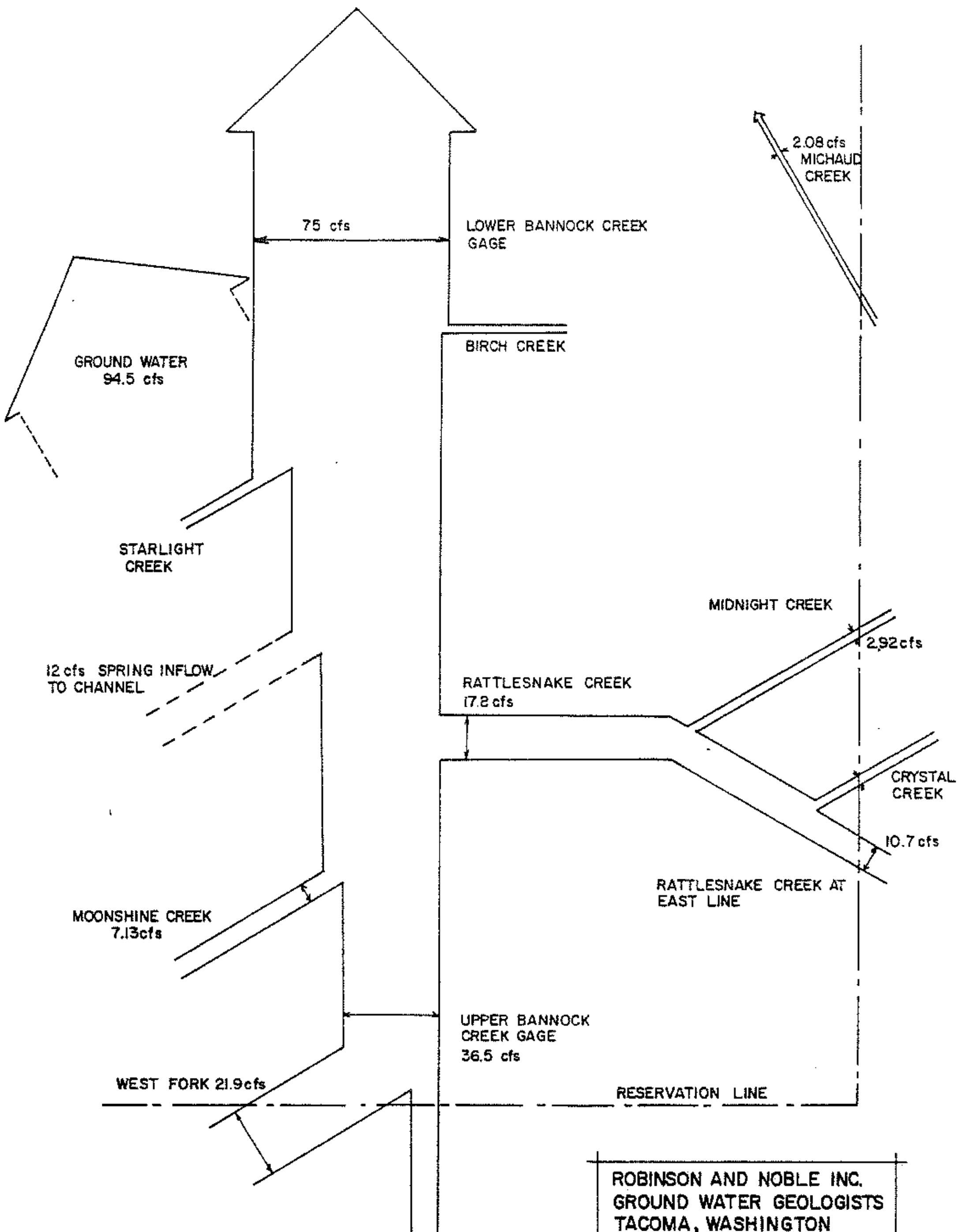
TABLE 7

BANNOCK CREEK BASIN - SURFACE WATER HYDROLOGY

	West Fork	Upper Bannock Cr. Gage	Moonshine Creek	Rattlesnake Cr. East	Midnight Creek	Rattlesnake Creek	Lower Bannock Cr. Gage	Michaud Creek
Basin Area - sq. mi.	14.9	-	44.2	-	-	79.6	413	11.6
Water Year								
1974 Mean Flow								
cfs	15.6	32.3	5.23	-	-	15.8	65	-
ac. ft/yr.	11,300	23,400	3,800	-	-	11,400	47,100	-
inches	14.2	-	1.6	-	-	2.7	2.1	-
1976 Mean Flow								
cfs	21.9	36.5	7.13	10.7	2.92	17.8	75	2.08
ac. ft/yr.	15,900	26,400	5,200	7,700	2,100	12,900	54,300	1,500
inches	20.0	-	2.2	-	-	3.0	2.5	2.4
1977 Mean Flow								
cfs	12.3	18.9	6.35	6.70	0.86	9.49	47	0.81
ac. ft/yr.	8,900	13,700	4,600	4,900	600	6,900	34,000	600
inches	11.2	-	2.0	-	-	1.6	1.5	0.09
1978 Mean Flow								
cfs	9.46	19.5	5.25	9.24	1.74	11.8	49	0.66
ac. ft/yr.	6,800	14,100	3,800	6,700	1,300	8,500	35,500	500
inches	8.6	-	1.6	-	-	2.0	1.6	0.08

FIGURE 4

BANNOCK CREEK BASIN



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limestone and volcanic rock of the Deep Creek Range. Ground water levels did not decrease during the 1977 drought, although levels in 1978 were slightly lower.

Much of the ground water in the basin is relatively low in dissolved minerals in comparison with other upland areas in the reservation. Only near the junction with the Snake Plain is higher mineralized water found, possibly due to geothermal activity. Surface water quality, however, is impacted both off and on the reservation by agricultural land use practices. Both Bannock and Rattlesnake Creeks have higher than normal levels of hardness, chloride, nutrients and turbidity.

SNAKE RIVER PLAIN

The Snake River Plain is a broad lava-filled structural depression that includes 178 square miles in the northwestern portion of the reservation. Three areas of the reservation; Gibson Terrace, Michaud Flats, and the Fort Hall Bottoms, comprise the Snake Plain area. The foothill areas that drain directly to the Plain include an additional 91 square miles. The combined Snake Plain and foothills area amounts to 33% of the reservation.

The Snake Plain is crossed by the four major streams that drain reservation lands. These are the Blackfoot River, Ross Fork, the Portneuf River, and Bannock Creek. Within the Fort Hall Bottoms, a large ground water discharge produces a multitude of springs that join the Snake and Portneuf Rivers. All water draining from reservation lands ultimately enters the Snake River, which forms a portion of the reservation's northwest border.

The USGS maintains three recording gaging stations on the Snake River in the Fort Hall vicinity. Additional gages are operated on the lower reaches of the Blackfoot and Portneuf Rivers. Until 1978, the USGS also monitored eight springs on the Fort Hall Bottoms during the irrigation seasons.

For this study, nine monthly measurement stations were established on the Bottoms Springs, providing some overlap with the USGS measurements. Additional stations were operated on the lower Portneuf River.

The USGS has monitored four wells on this portion of the Snake Plain since 1955. For this study, water level recorders were operated on three additional wells. Also about 40 wells were monitored on a monthly basis.

The spring discharge from the Bottoms dominates the surface water flow in this portion of the reservation. Table 9 lists the mean flows of the major springs. The averages are based on all available discharge information. Most springs were found to maintain mean annual flows within ten per cent of these averages.

TABLE 9

Mean Flow of Major Springs on the Fort Hall Bottoms

	cfs
Hatchery Springs	103
Diggie Creek	263
Jeff Cabin Creek	21.1
Spring Creek	466
Big Jimmy Creek	30.5
Clear Creek	134
Kinney Creek	28.1
Wide Creek	57.4
Jimmy Drinks - East	103
Jimmy Drinks - West	35.4
Ross Fork	58.4

A water budget was developed that quantifies the spring discharge from the Fort Hall Bottoms. This budget is listed in Table 10, and illustrated schematically in Figure 5. The discharges used represent the average flow conditions. This budget analysis identified a total of 2,100 cfs that enters the Portneuf and Snake Rivers in the Fort Hall Bottoms from both on and off reservation sources. Of this, 1,820 cfs was identified as flowing from reservation lands.

The ground water that discharges as spring flow in the Bottoms first travels beneath Gibson Terrace in the gravel and basalt

TABLE 10. Fort Hall Bottoms Water Budget

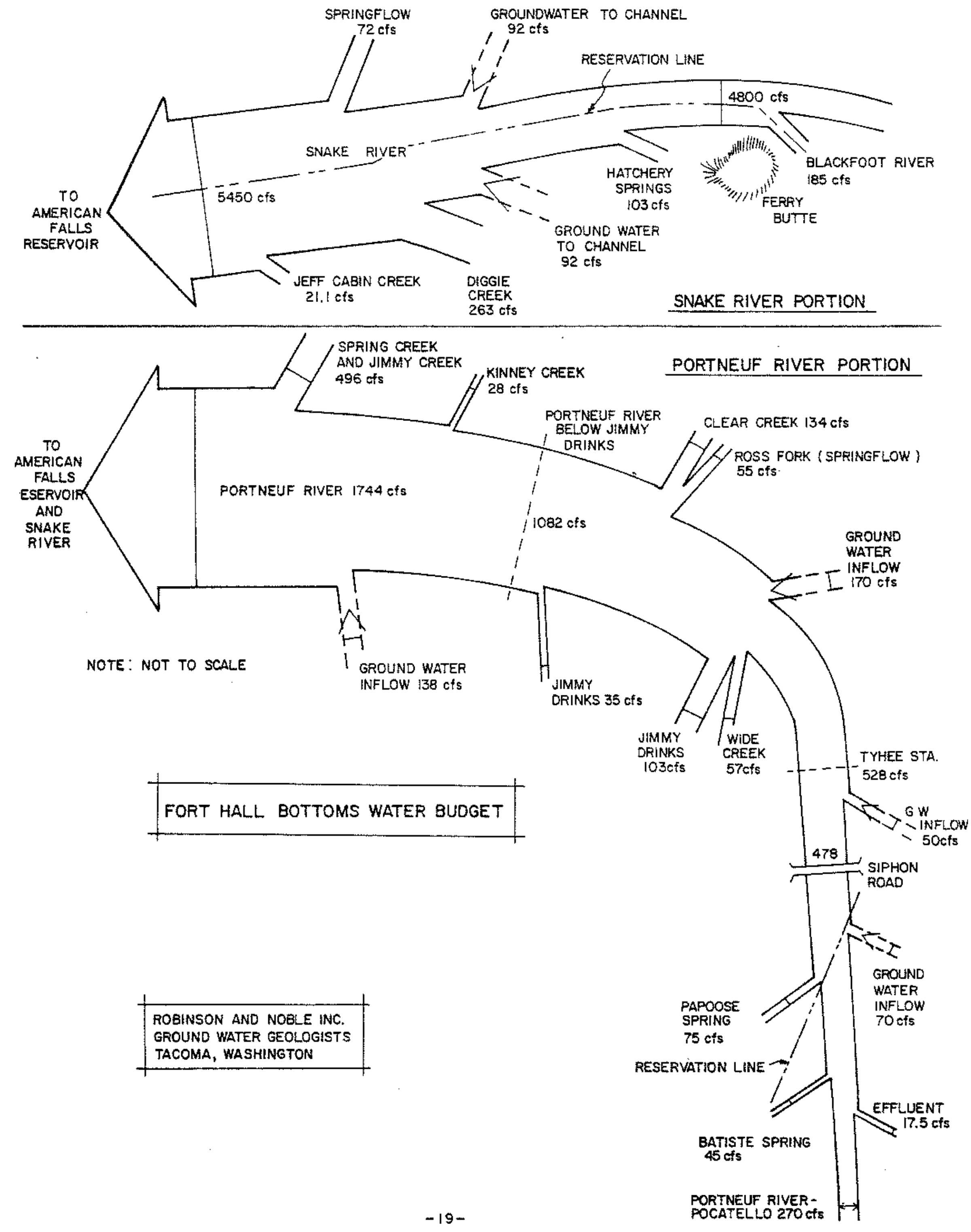
Snake River Reach

Hatchery Springs	103 cfs
Diggie Creek	263 cfs
Jeff Cabin Creek	21 cfs
Unmeasured Inflow from Reservation	92 cfs
Total Reservation Flow	479 cfs

Portneuf River Reach

Flow of Portneuf River at Pocatello		270 cfs
Industrial Effluents	18	cfs
Batiste Spring	45	cfs
Papoose Spring	75	cfs
Unmeasured Inflow-Pocatello to Siphon Rd.	70	cfs
Flow at Siphon Rd.		478 cfs
Unmeasured Inflow-Siphon Rd. to Tyhee Station	50	cfs
Flow at Tyhee Station (USGS)		528 cfs
Wide Creek	57	cfs
Jimmy Drinks Springs	138	cfs
Ross Fork (springflow portion)	55	cfs
Clear Creek	134	cfs
Unmeasured Inflow-Tyhee Station to below Jimmy Drinks	170	cfs
Flow at Station below Jimmy Drinks		1,082 cfs
Kinney Creek	28	cfs
Spring Creek including Jimmy Creek	496	cfs
Unmeasured Inflow-Jimmy Drinks to Mouth	138	cfs
Flow at Portneuf River Mouth		1,744 cfs
Total Identified Gain to Rivers		2,100 cfs.
Gain from Reservation Lands		1,820 cfs.

FIGURE 5


SPRINGFLOW 72 cfs
GROUNDWATER TO CHANNEL 92 cfs
RESERVATION LINE
4800 cfs
SNAKE RIVER
5450 cfs
HATCHERY SPRINGS 103 cfs
BLACKFOOT RIVER 185 cfs
FERRY BUTTE
TO AMERICAN FALLS RESERVOIR
GROUND WATER TO CHANNEL 92 cfs
JEFF CABIN CREEK 21.1 cfs
DIGGIE CREEK 263 cfs
SNAKE RIVER PORTION
SPRING CREEK AND JIMMY CREEK 496 cfs
KINNEY CREEK 28 cfs
PORTNEUF RIVER PORTION
PORTNEUF RIVER BELOW JIMMY DRINKS
CLEAR CREEK 134 cfs
ROSS FORK (SPRINGFLOW) 55 cfs
TO AMERICAN FALLS ESERVOIR AND SNAKE RIVER
PORTNEUF RIVER 1744 cfs
1082 cfs
GROUND WATER INFLOW 170 cfs
NOTE: NOT TO SCALE
GROUND WATER INFLOW 138 cfs
JIMMY DRINKS 35 cfs
JIMMY DRINKS 103cfs
WIDE CREEK 57cfs
TYHEE STA. 528 cfs
FORT HALL BOTTOMS WATER BUDGET
G W INFLOW 50cfs
478
SIPHON ROAD
GROUND WATER INFLOW 70 cfs
PAPOOSE SPRING 75 cfs
ROBINSON AND NOBLE INC.
GROUND WATER GEOLOGISTS
TACOMA, WASHINGTON
RESERVATION LINE
EFFLUENT 17.5 cfs
BATISTE SPRING 45 cfs
PORTNEUF RIVER-POCATELLO 270 cfs

aquifer. The ground water flows in a general southwest direction, entering the reservation as it crosses beneath the Blackfoot River. A large portion of the flow enters upstream of Blackfoot, and passes beneath the Gibson Butte area. This water continues in the southwest direction, crosses beneath the Portneuf River and flows west across Michaud Flats. A relatively small portion of the ground water is not discharged as springflow, and leaves the reservation along the western end of Michaud.

The water table of the main aquifer fluctuates between 4,440 and 4,460 feet near Blackfoot. It ranges between 4,410 and 4,420 feet in the Fort Hall Townsite area, and between 4,440 and 4,415 south of Ross Fork. Under the main portion of Michaud Flats, the water table is maintained near 4,400 feet. It decreases to the west, and ranges between 4,340 and 4,370 at the western end of Michaud.

Based on the water budgets developed for this report, it has been determined that at least 1,410 cfs enters the reservation as ground water flow in the Snake Plain aquifer. To this is added 560 cfs within the reservation. This is derived from ground water contributed by tributary basins, irrigation recharge, and precipitation recharge. Of this, 114 cfs is contributed by reservation lands. Thus, the total ground water flow is at least 1,970 cfs within the reservation. This flow may exceed 2,000 cfs. Of this total, 1,820 cfs discharges in the Fort Hall Bottoms and about 150 cfs is withdrawn for irrigation. The remainder leaves the reservation as ground water at the downstream end.

The water quality of the Snake Plain aquifer was found to be fairly uniform over time and location. However, three instances of water quality degradation exist and are described in this report. These are: 1. Heavy metal contamination of the aquifer in the Michaud area resulting from waste disposal ponds at the two phosphate processing plants; 2. Agricultural chemical build-up in perched water layers near Fort Hall, and 3. The presence of organic chemicals such as PCB in the Bottoms Springs water. Surface waters are usually more susceptible to contamination than ground waters. Both the Portneuf and Upper Snake Rivers are classified by the EPA as too polluted to meet the federal water quality goals for at least five years. Problems include bacteria, turbidity, phosphate, dissolved oxygen, heavy metals and pesticides.

METHODOLOGY

SURFACE WATER

All streamflow measurements were made with a small Price current meter. This was either used in wading for smaller streams or suspended by cable from a bridge or boat for the larger rivers. For the five continuous water level recorders maintained on the streams, the discharge measurements were used to provide the rating curves for the station analyses. Two types of hydrographs were prepared for this report. The first simply shows the individual measurements obtained during the study, and illustrates the range and pattern of the discharge throughout the year. The second shows the mean annual discharges for the period of record, by water years. These were constructed when a sufficient amount of data was available, usually from USGS records. All streamflow measurement stations are located on Plate 1.

(where is plate 1?)

GROUND WATER

Well measurements were made by the wetted tape method, which allowed an accuracy of .01 ft. The measurements were adjusted to depth below land surface by subtracting any casing stickup. Elevations of the wells were taken from the USGS 7½ minute series topographic maps of the reservation. In areas of high relief, these elevations may be subject to some error.

The water level data is plotted to illustrate the depth to water over time. A well that was pumping during the measurement is indicated by a hachured block beneath the plotted point.

All wells for which information was available are compiled in Appendix A. Available well logs are compiled in Appendix B. The individual water level measurements made in this study that were not reduced to hydrograph form are listed in Appendix C. All monitored wells are located on Plate 1.

WATER QUALITY

During this study, numerous tests of water quality were made on both surface and ground water. Analyses were made with a

Hach DR/El-2 Spectrophotometer. An effort was also made to collect all existing data pertaining to reservation waters. All of the analyses made for this study are listed in Appendix D. For the purpose of this report, the analyses at each station were averaged together to provide a rough mean. In this report, the ground water of the Snake Plain, as exhibited by the Bottoms Springs, is considered as average quality. Reference to high or low values are made with respect to this quality.

The parameters measured in this study were not chosen to establish whether the water met current drinking water standards. Rather, they were chosen to illustrate the general chemical character of the water with respect to dissolved minerals and nutrients. It was felt that this would assist in delineation of separate ground water bodies and flow paths, while indicating areas with impacted or unusual quality. The stations sampled for water quality are located on Plate 1.

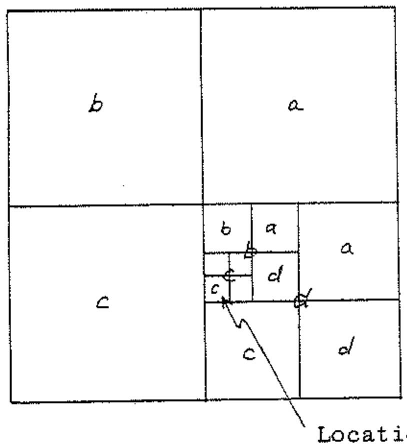
UNITS OF MEASUREMENT AND LOCATION CODE

In this report we have used standard U.S. measurements which are in common current use by most water resources people. Units of length are miles, feet, and inches. Units of area are square miles, acres, and square feet. Units of volume are cubic feet and U.S. gallons; also acre-feet which is 1 foot of water over 1 acre. Rate-of-flow measurements, according to commonly used practice, usually are expressed in gallons per minute (gpm) for ground water pumping, and cubic feet per second (cfs) for surface water flow. Larger flow quantities are sometimes expressed as acre-feet per day or per year (AF/day, AF/yr.). A few useful conversions are:

1 cfs	=	450 gpm	=	2 AF/day
1 AF/day	=	0.5 cfs	=	226 gpm
1 AF/yr.	=	0.6 gpm		
100 AF/yr.	=	62 gpm	=	0.14 cfs

Precipitation is reported in inches and temperature in degrees Fahrenheit (^{o}F).

Locations, unless generalized, are reported by a code developed by the U.S. Geological Survey. The locations are referenced to the township and range grid and the 36 separately numbered square miles (sections) within a given township-range. To subdivide each section, each successive quarter is designated "a, b, c, and d" as shown below:



Location of example given below

As an example, the Episcopal Church at Fort Hall is in the SW$\frac{1}{4}$ of SW$\frac{1}{4}$ of NW$\frac{1}{4}$ of SE$\frac{1}{4}$ of Section 36 in Township 4S, Range 34E of Boise Meridian. According to the code used here, the location is more briefly described as 4S/34E-36dbcc. This description narrows the area to 2$\frac{1}{2}$ acres.

GEOLOGIC TIME SCALE

A generalized geologic time scale is listed in Table 11 to provide a reference for the discussions of the reservation geology.

TABLE 11

GEOLOGIC TIME SCALE

PERIOD	EPOCH	DATES IN MILLION OF YEARS BEFORE PRESENT
Quaternary	Recent Pleistocene	0 - 10,000 yrs. 10,000 - 1 mil. yrs.
Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	1 - 11 11 - 25 25 - 40 40 - 60 60 - 70
Cretaceous		70 - 135
Jurassic		135 - 180
Triassic		180 - 225
Permian		225 - 270
Carboniferous Pennsylvanian Mississippian		 270 - 310 310 - 350
Devonian		350 - 400
Silurian		400 - 440
Ordovician		440 - 500
Cambrian		500 - 600
Pre-Cambrian		600+

CLIMATE AND PRECIPITATION

Precipitation is monitored at four locations within the Fort Hall Indian Reservation. The National Oceanic and Atmospheric Administration (NOAA) maintains a weather station at the Pocatello Municipal Airport on Michaud Flats. Prior to 1938, this station was located within the City of Pocatello. The yearly precipitation totals are available from 1900 and are shown in Figure 6. The average annual precipitation for the 1900-1977 period is 12.23 inches. However, the city site would be expected to receive slightly more precipitation than the airport site. The 1938 to 1977 average, while the station has been located on Michaud, is 11.2 inches. Figure 7 shows the monthly precipitation at the Pocatello Airport station for the 1971-1978 period. It shows that the precipitation is fairly well distributed throughout the year, with July and August usually the dry months.

A second station is located south of the City of Blackfoot within the reservation. It is currently operated by the KBLI radio station. This gage has been monitored since 1897, with a few breaks in the record. The record is shown in Figure 8. The mean annual precipitation is 10.86 inches.

The BIA operates a rain gage located at the agency's offices at Fort Hall. This has been operated since 1915, and indicates an average of 10.35 inches of precipitation a year. This record is shown in Figure 9. It should be noted that the precipitation received here is usually less than that received in Blackfoot. The Bureau also installed a rain gage near the Gay Mine in 1963. The average annual precipitation, based on this 15 year record, is 15.56 inches. The record is shown in Figure 10.

All of the records show similar trends in the annual precipitation amounts. More recently, the decade of the 1950's definitely received below average amounts of precipitation. The yearly total amounts began to increase during the early 1960's, and generally peaked around 1970. These higher amounts exceeded 140% of the average precipitation. Since 1971, the yearly amounts have been declining, as shown by all stations. Table 12 lists the annual amounts of precipitation received at the four

FIGURE 6.
ANNUAL PRECIPITATION - POCATELLO WEATHER STATION, 1900-1977

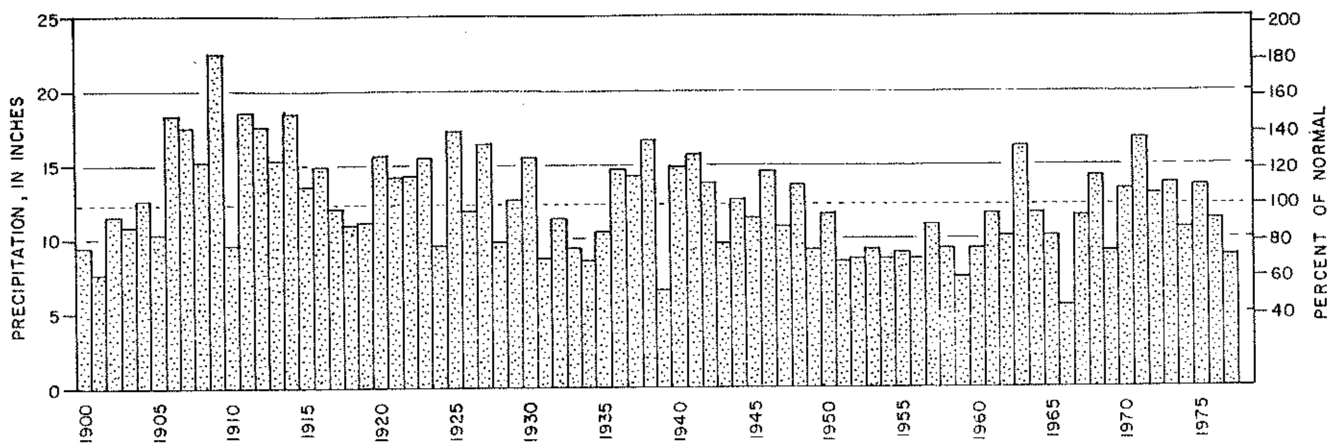


FIGURE 7.
MONTHLY PRECIPITATION - POCATELLO WEATHER STATION, 1971-1978

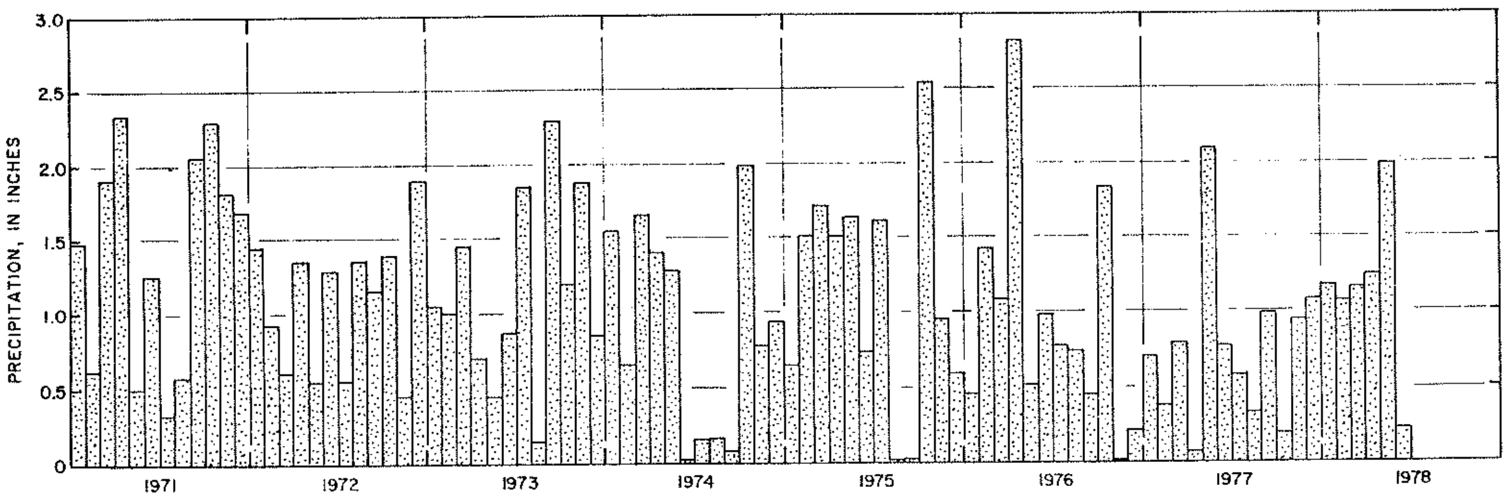


FIGURE 8.
ANNUAL PRECIPITATION – BLACKFOOT STATION, 1897–1976

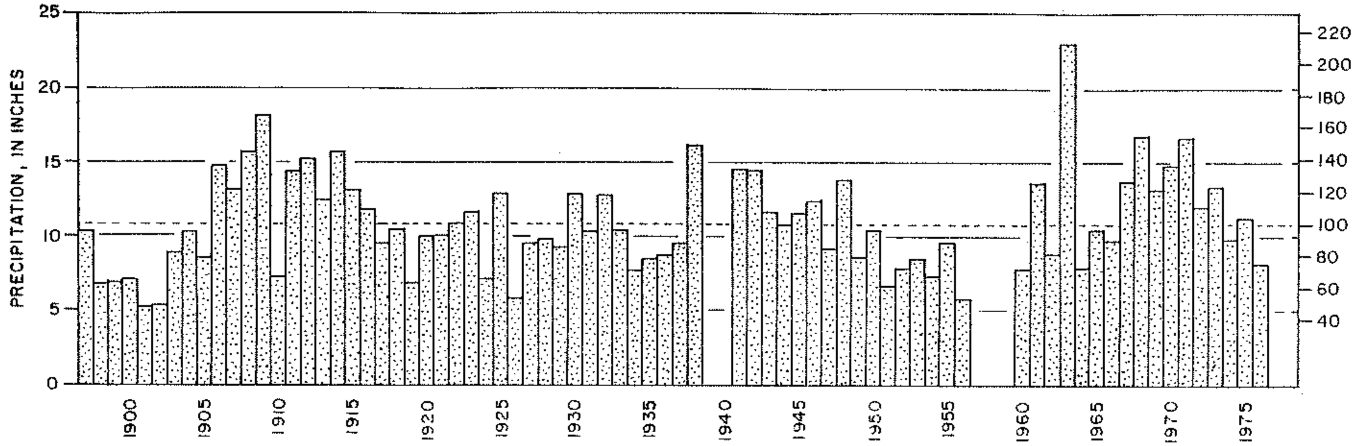


FIGURE 9.
ANNUAL PRECIPITATION – FORT HALL STATION, 1915–1976

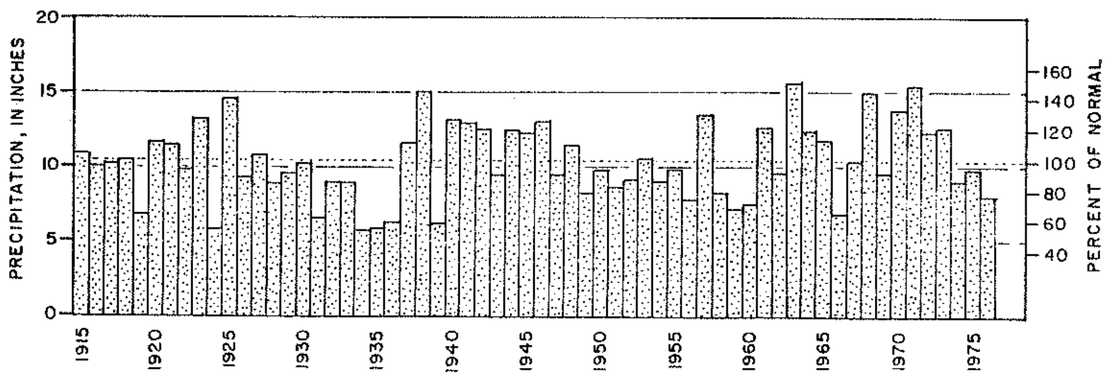


FIGURE 10.
ANNUAL PRECIPITATION
GAY MINE STATION,
1963–1977

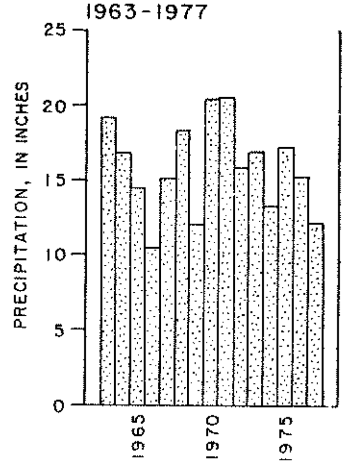


TABLE 12

ANNUAL PRECIPITATION AND PERCENT OF NORMAL FOR THE FORT HALL WEATHER STATIONS

Year	Pocatello		Fort Hall		Blackfoot		Gay Mine	
	Inches	Percent	Inches	Percent	Inches	Percent	Inches	Percent
1972	12.95	116	12.25	118	11.95	110	15.8	102
1973	13.66	122	12.58	122	13.27	122	16.9	109
1974	10.62	95	8.98	87	9.86	91	13.2	85
1975	13.49	120	9.9	96	11.22	103	17.2	111
1976	11.26	101	8.1	78	8.09	74	15.2	98
1977	8.87	79	-	-	-	-	12.15	78
Record Mean	11.2		10.35		10.86		15.56	

stations for the duration of this study. In 1973, during which preliminary hydrologic measurements for this study began, the reservation received about 120% of the normal precipitation. The 1974 year was slightly below normal, with about 90% of the normal amount received. In 1975, during which the intensive hydrologic monitoring was begun, the precipitation received was slightly above normal at most stations. During 1976, the reservation received less precipitation than average, although the Pocatello station was near normal. The drought during the 1977 year resulted from only 80% of the normal precipitation being received. This information indicates that the hydrologic data collected during the water years of 1975 and 1976 provide a good base for the average flow conditions of the reservation. The 1977 water year data indicates the hydrologic response to only 80% of the normal precipitation input.

Since the hydrologic system responds to the changes in the amount of precipitation input it receives, the general decline in precipitation during the 1970's sets a pattern that will influence the surface and ground water outputs. This pattern is noted in numerous hydrographs presented in this report.

The engineering firm of Morrison-Maierle, Inc., prepared an isopach map of the reservation area that shows the lines of equal mean annual precipitation. The map was compiled using all existing precipitation data from both within and surrounding the reservation. This map was used to determine the mean annual precipitation received by each drainage basin within the reservation. Table 13 lists these average precipitation amounts for the respective basins.

An analysis of the rainfall-runoff relationship for this area was made by Mundorff and others (1964). Figure 11 illustrates the relationship between the total annual precipitation over the basin and the total water yield from the basin. This water yield includes both surface and ground water flow. The difference between the total water yield and the annual precipitation represents the evapotranspiration that occurs. Table 13 also includes this distribution of the precipitation for each basin, based on the Mundorff analysis. These figures are used in the water budget analysis of each basin.

TABLE 13

AVERAGE ANNUAL PRECIPITATION - FORT HALL DRAINAGE BASINS

Drainage Basins	Mean Annual Precipitation (in inches)	Evapo-transpiration (in inches)	Total Water Yield (in inches)
Blackfoot River Basin	16	11.5	4.5
Ross Fork Basin	16.5	11.5	5.0
Upper Portneuf River Basin	18	12	6.0
Bannock Creek Basin	18	12	6.0
Foothills	11	10	1.0
Snake River Plain	10.8	9.8	1.0

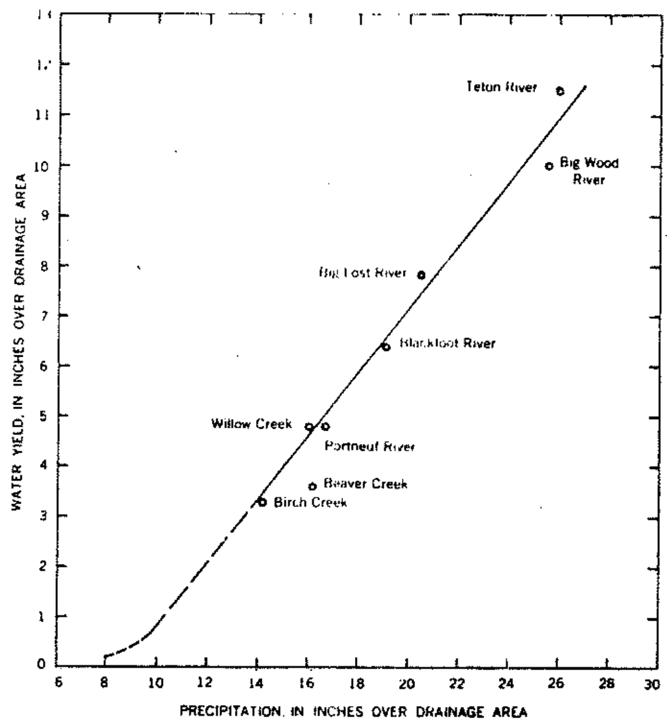


Figure 11.- Relation of water yield to average annual precipitation

which flows generally northward toward the Blackfoot River. The tributary, Cold Creek, originates in several springs near Higham Peak on the east side of the basin.

GEOLOGY

The only geologic study of this area of the reservation was done in 1913 by Mansfield (1920). The following description is a summary of his findings.

The bedrock of the upper Basin and Range area of the Blackfoot basin is composed primarily of Triassic and Jurassic marine sedimentary rocks that have been folded and faulted into the present mountain ranges. These rocks include sandstones, shales, and limestones.

Within the reservation, rocks of this type occur in a ridge running in a northwest-southeast line that includes Garden Peak, Higham Peak, and Lincoln Peak. This ridge separates the Lincoln Creek basin from the other Blackfoot River tributaries. These rocks underlie the upper parts of Deadman, Wood, and Garden Creek basins. At lower elevations east of this ridge are Tertiary volcanic rocks which include rhyolites, andesites, and tuffs. These younger rocks overlie the older sedimentary rocks in the valley area. The Blackfoot River canyon itself, and the lower parts of the tributary basins within the reservation, are cut into Quaternary basalt flows, which filled the ancestral Blackfoot River valley during the formation of the Snake River Plain.

The upland area of Lincoln Creek basin is composed of a wide variety of bedrock types. The eastern part of the basin, including the upper part of the Cold Creek basin, is underlain by the Jurassic and Triassic marine sedimentary rocks. Most of the small springs, including Cold Creek, originate from these formations. The central part of the basin, including Yandell Mountain, is underlain primarily by a Pennsylvanian limestone. Yandell Springs originate from this rock. Also in this area are outcroppings of the Permian phosphate shales. The southwestern part of the basin is underlain by older limestones of Mississippian, Ordovician, and Cambrian age. The western edge of the basin is formed by a line of hills composed of Tertiary rhyolites. This ridge includes Stevens Peak and runs to the west of Chicken Flats and Sage Hen Basin. The lower part of the basin is covered with alluvium and volcanic sand, which obscures the contact between the older sedimentary rocks of the upper basin and the younger volcanic basalts and rhyolites.

The geology of the lower part of the Blackfoot Basin, where the river flows across the Snake River Plain, is relatively simple. Volcanic rocks, either Tertiary rhyolites in the Stevens Peak area, or Quaternary basalts further downstream, underlie the river channel. This rock is covered by varying thicknesses of sand and gravel alluvium. The geology of this area is covered more fully in the Snake Plain section of the report.

The log of one domestic well near the mouth of Lincoln Creek indicates lava to be within 66 feet of the surface, although some wells of greater depth in the area show no lava.

Much of the bedrock in the upper Blackfoot basin is covered with a layer of unconsolidated rock fragments originating from the weathered bedrock itself; or deposits of loess, a wind-blown silt. Alluvium is usually deposited in low-lying areas as fans or stream deposits. The loess usually covers the entire surface, thinning at higher elevations and near steep slopes, and ranging in thickness up to tens of feet.

HYDROLOGY

DATA SOURCES

On the Blackfoot River, the USGS maintains several recording gage stations that are currently in operation. Upstream of the reservation, they maintain a station on the Blackfoot River above the Blackfoot Reservoir (130630) and a station on the reservoir itself (130650). Along the reservation boundary, they operate two stations on the river. The first is near Shelley (130660) and has been operated intermittently since 1909. The second is near Blackfoot (130685) which has been operated since 1913. They maintain no recording stations on any of the tributaries within the reservation.

The BIA Irrigation Office has taken periodic measurements of the tributaries within the reservation since 1967; however, these are usually only taken once a year during low flow and on an intermittent basis.

For the purpose of this study, the tributary streams were monitored to determine the annual runoff from reservation lands. A recording gage station was established on Lincoln Creek below Yandell Springs in 1973. In addition, monthly measurement stations were established in 1975 on Cold Creek, Garden Creek, Wood Creek, Short Creek, Beaver Creek, Deadman Creek and Deadman Spring. The stations upstream of Garden Creek were not measured during the winter months due to access problems. Consequently, the mean annual flows for these streams only reflect the latter spring runoff and summer baseflow segment of the yearly cycle.

There is little information available on ground water in this area of the reservation. The USGS monitors one well near the Lincoln Creek basin and the edge of the Snake River Plain. It is located in 2S/36E-36cdd, and has been monitored since 1955. For this study, three additional wells were monitored monthly. Two are located in the Lincoln Creek valley and one on the Snake River Plain.

Upstream of the Lincoln Creek basin, no wells are known to exist. There are a few stock wells in the upper elevations of Lincoln Creek for which limited data is available. These have generally been abandoned.

SURFACE WATER

Deadman Creek - Deadman Spring

Deadman Creek is a small perennial tributary of the Blackfoot River. It is the uppermost tributary of the Blackfoot that drains reservation lands, and flows off the reservation before joining the river. The hydrograph showing the individual measurements is shown in Figure 12. The mean annual discharges measured for the 1976 and 1977 water years were 0.72 cfs and 0.25 cfs respectively. Measurements for the 1978 year average 0.31 cfs. Lack of access during the winter months prohibited measurement of the peak flows; consequently the mean flows are probably low. During the study, flows ranged between 0.1 and 1.3 cfs, with the lowest flows occurring during the 1977 drought year. During years of normal precipitation, the baseflow should remain near 0.3 cfs.

Deadman Spring's source is just inside the reservation line. It contributes about 0.2 cfs to the flow of Deadman Spring, which it joins after leaving the reservation. The flow continued through 1977, although at a reduced rate of about 0.1 cfs. The hydrograph is shown in Figure 13.

FIGURE 12.
BLACKFOOT RIVER BASIN - DEADMAN CREEK

Location: 4 S/ 38 E 13 aa
Elevation: 5825 feet

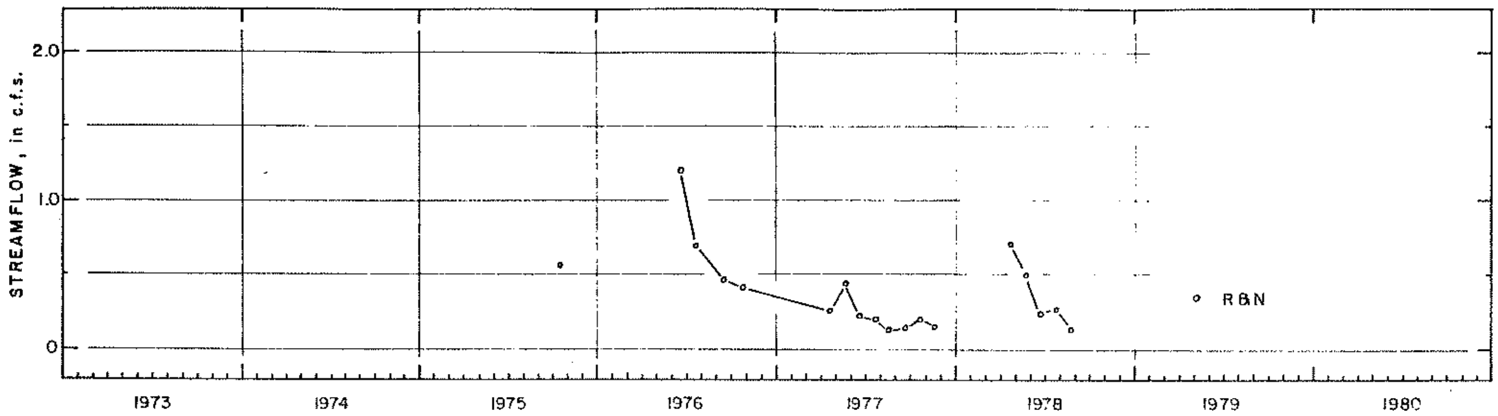
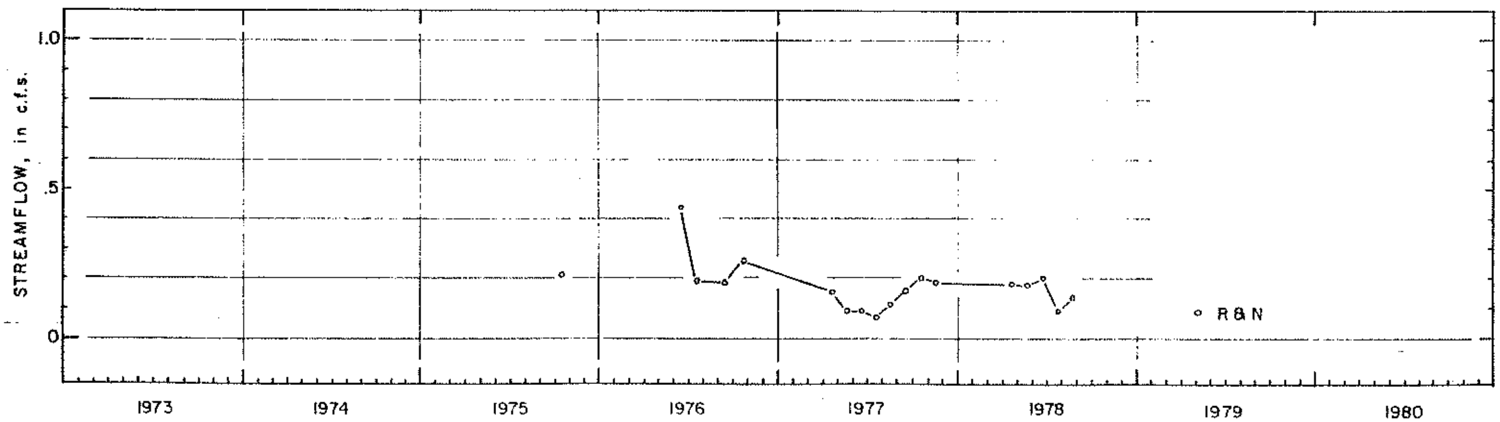


FIGURE 13.
BLACKFOOT RIVER BASIN - DEADMAN SPRING

Location: 4 S/ 38 E 13 ac
Elevation: 5825 feet



Beaver Creek

Beaver Creek is a small ephemeral stream that leaves the reservation and swings to re-enter just before joining the Blackfoot River. During the study period, Beaver Creek only flowed after the 1976 and 1978 spring runoff, at less than 0.2 cfs (Figure 14). The stream quickly dried up after the runoff. No flow was noted during 1977.

Short Creek

Short Creek, like Beaver Creek, is a small creek that flows primarily during spring runoff. It did maintain a flow of about 0.14 cfs during 1976, but dried up during 1977 due to the lack of runoff. No flow was noted during 1978. (See Figure 15).

Wood Creek

Wood Creek drains an area of 16.7 square miles, entirely within the reservation, and flows in a northeasterly direction to join the Blackfoot River. The streamflow originates with several scattered springs to the southeast of Higham Peak.

Flow measurements made during the 1976 water year indicate a mean discharge of 5.87 cfs (Figure 16). Measurements were made only during the summer and fall due to access limitations. During the 1977 water year, the mean flow was 2.4 cfs, with the lowest flow recorded in October, 1977 of 1.5 cfs. Flow measurements made in 1978 indicate some improvement in baseflow, although still below previous mean flows. The average for that water year was 1.99 cfs.

Garden Creek

Garden Creek drains a basin of 11.9 square miles, all of which lies within the reservation. The stream flows generally northwest toward the Blackfoot River. The streamflow originates from springs near the base of Garden Peak. No water is used for irrigation within the basin; however, the stream empties into the Littlw Indian Ditch when it enters the Snake Plain.

The surface runoff of this basin was found to be low in comparison with the size of the basin. During the 1976 water year, the stream averaged only 1.06 cfs, or 0.09 cfs/sq. mile. This compates with 0.35 cfs/sq. mile for Wood Creek. During the 1977 water year, the creek nearly dried up, averaging 0.36 cfs (Figure 17). The baseflow showed some recovery during 1978, although no large spring

FIGURE 14.
BLACKFOOT RIVER BASIN - BEAVER CREEK
Location: 3 S / 38 E 25 da
Elevation: 5750 feet

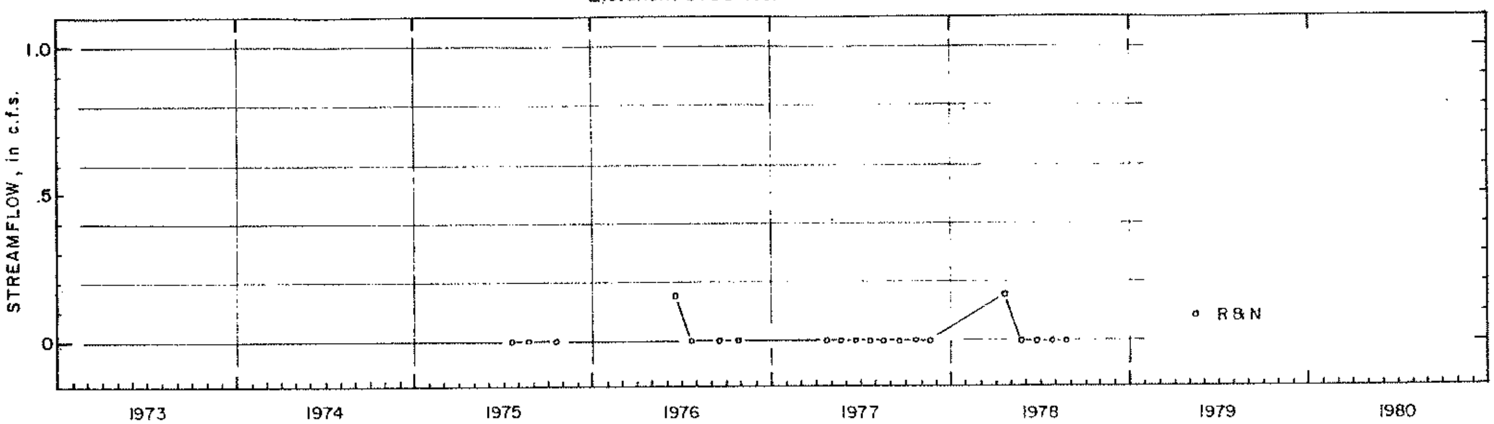


FIGURE 15.
BLACKFOOT RIVER BASIN - SHORT CREEK
Location: 3 S / 38 E 23 ac
Elevation: 5620 feet

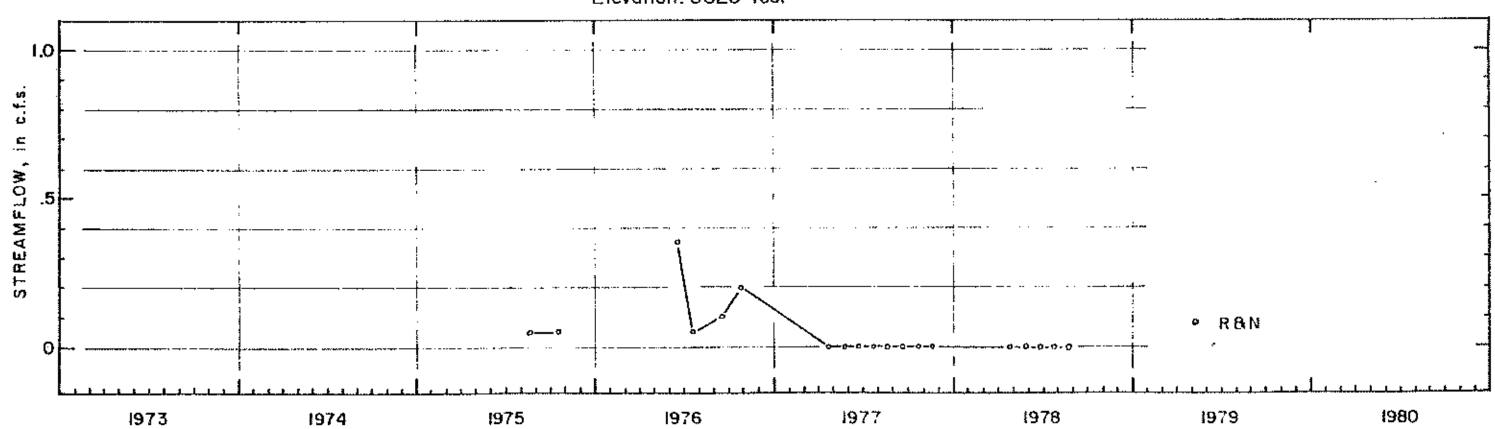


FIGURE 16.
BLACKFOOT RIVER BASIN - WOOD CREEK (U.S.G.S. 130658)
Location: 3 S / 38 E 16 aba
Elevation: 5320 feet
Drainage area: 16.7 sq. mi.

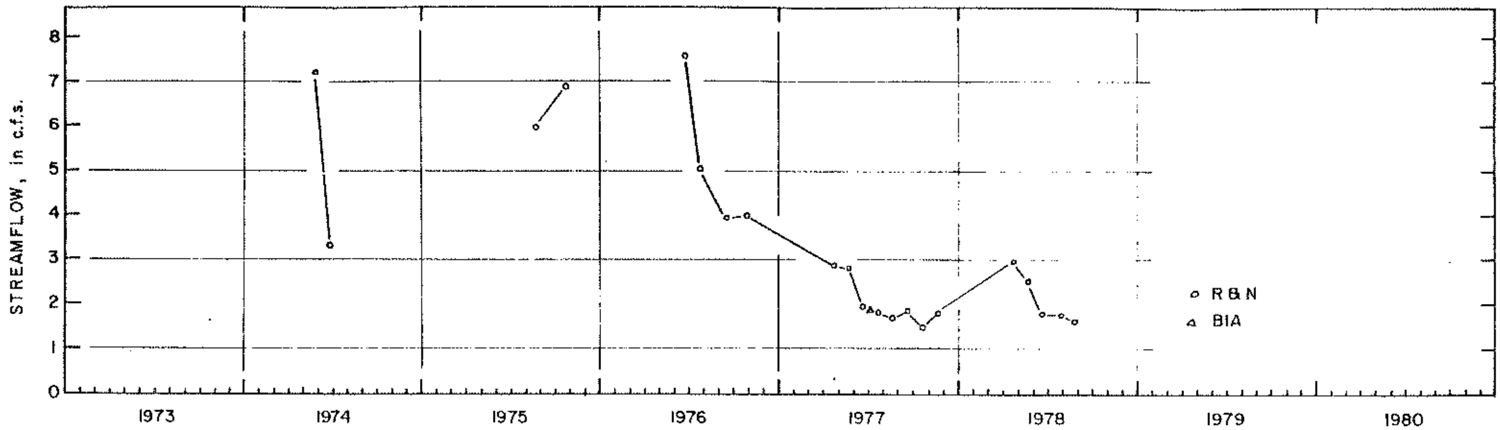
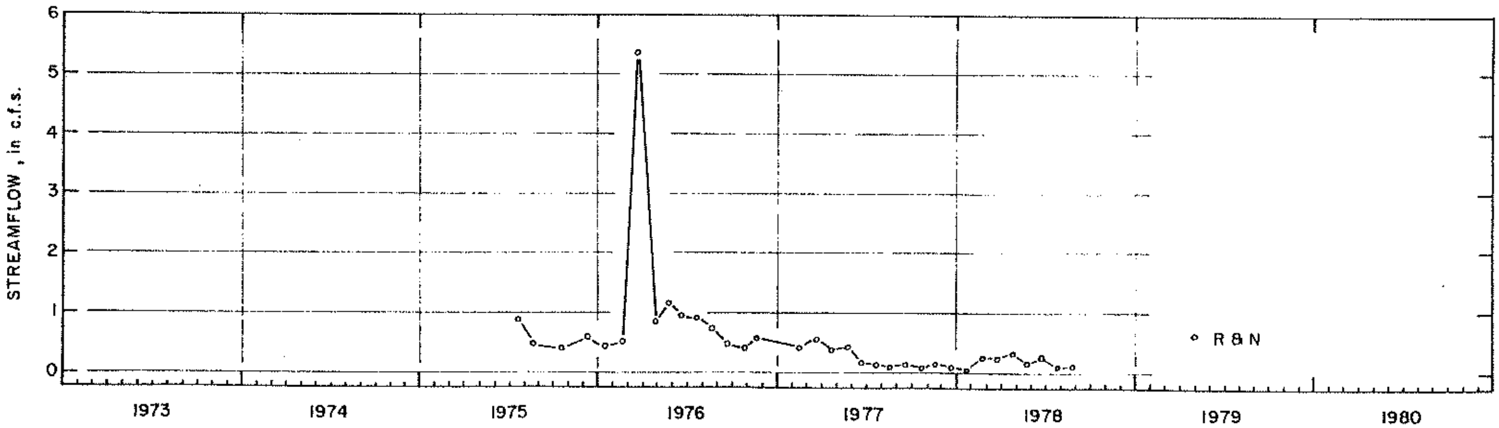


FIGURE 17.
BLACKFOOT RIVER BASIN - GARDEN CREEK
Location: 2 S / 37 E 17 dda
Elevation: 4640 feet
Drainage area: 11.9 sq. mi.



runoff was evident. Average flow for the 1978 water year was 0.17 cfs. The low surface yield of this basin may indicate significant loss to ground water.

Lincoln Creek

Lincoln Creek is the largest tributary to the Blackfoot River draining reservation lands. The entire basin includes 64.2 square miles. The upper reach of Lincoln Creek originates with several small springs in the Box Spring area. This baseflow is very small, and usually dries up before reaching the Yandell Springs area. Yandell Springs are located near the center of the basin, at the northern base of Yandell Mountain. This group of springs provides the majority of the baseflow for the remaining stretch of Lincoln Creek. Several irrigation ditches divert water from the creek for use on the valley bottom lands. The remaining flow at the valley mouth usually infiltrates into the sand on the Snake Plain before reaching the Blackfoot River.

The recording gage is located downstream of Yandell Springs. It receives runoff from 32.3 square miles of basin. One irrigation ditch withdraws water above the recorder. The hydrograph, showing mean monthly flows, is shown in Figure 18. The baseflow of Lincoln Creek remains remarkably constant throughout the year. The mean baseflows for the water years 1974, 1976, and 1977 were 7.45, 8.03 and 7.04 cfs respectively. The measurements made in 1978 indicate a mean flow of 6.56 cfs. The decline in 1977 and 1978 can be attributed to the drought, and indicates that the aquifer supplying Yandell Springs is less responsive to seasonal recharge variations than other aquifers.

Cold Creek

Cold Creek is the only perennial tributary of Lincoln Creek. It originates with several small springs on the western slopes of Higham Peak and flows westerly, draining a valley of 6.2 square miles. During the 1976 water year, the flow averaged 1.53 cfs, with the late summer baseflow near 1.2 cfs (Figure 19). This decreased during 1977 to an average flow of 0.90 cfs, with the lowest flows near 0.50 cfs. Measurements made in 1978 indicate some improvement in baseflow although no extended spring runoff occurred as in 1976. Mean flow for the 1978 water year was 0.67 cfs; a decrease from 1977 due to the low flows prior to the 1978 runoff.

FIGURE 18.
BLACKFOOT RIVER BASIN
LINCOLN CREEK at GAGE

Location: 3S/36E-25daa
Elevation: 4780 feet

Drainage area: 32.3 sq. mi.

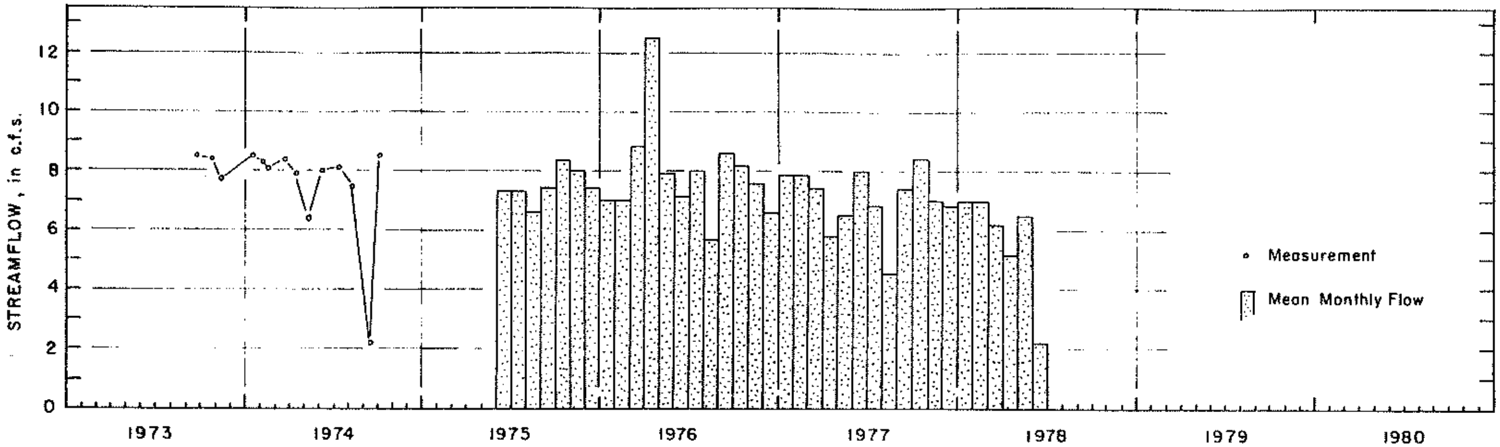
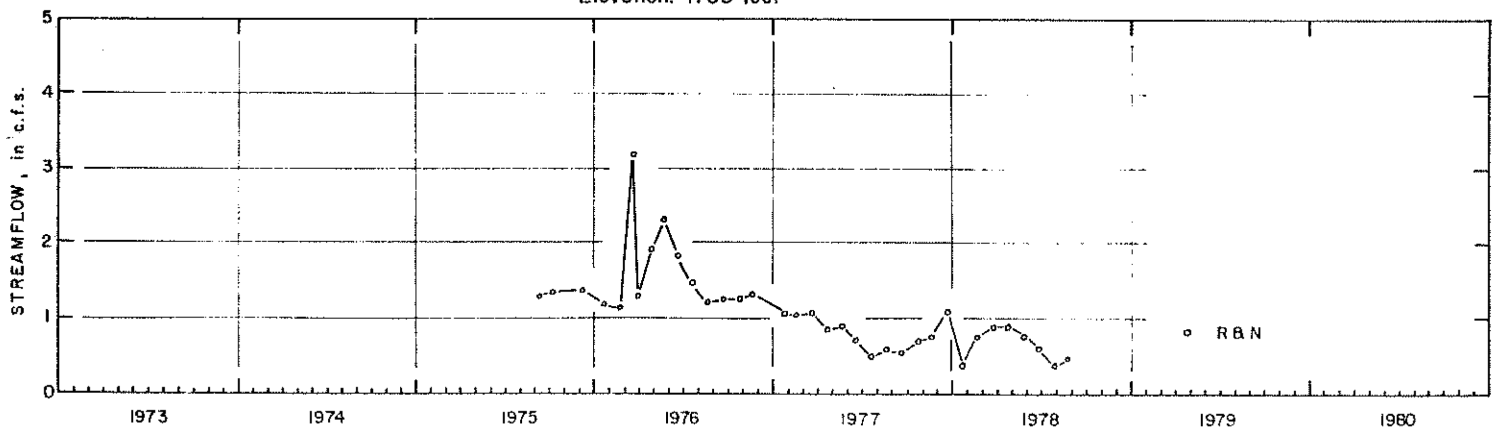


FIGURE 19
BLACKFOOT RIVER BASIN - COLD CREEK

Location: 3 S/36 E 24 ada
Elevation: 4760 feet

Drainage area: 6.2 sq. mi.



The creek is used primarily for stock supplies along its course, and empties into the main irrigation diversion in the Lincoln Creek valley.

Blackfoot River

The upstream USGS gage on the Blackfoot River has been operated since 1967 and is located several miles upstream of the Blackfoot Reservoir. The mean annual flows at this station are shown in Figure 20. The river at this point contains the highest discharges per drainage area within the basin. This is due to the relatively high amounts of precipitation that fall on the mountain ranges in this area. During the water years of 1974 to 1976 the river here accounted for the equivalent of between 7.4 and 8.4 inches of water over the upstream basin.

The second USGS gage is located on the river near Shelley, downstream of the Blackfoot Reservoir. It lies between the Wood Creek and Garden Creek basins. The station has been operated intermittently since 1909, but has only been re-established in 1975. For the 1976 water year, the discharge per basin area was less than at the upstream station. This decrease is due to evaporation losses from the reservoir, less precipitation recharge in the lower elevations of the basin, and possibly regulation of the reservoir.

The downstream gage, near Blackfoot, is located near Ferry Butte. It records a lower average discharge than the Shelley gage, and a much lower discharge per drainage area. This is due to the withdrawal of water for the Fort Hall Irrigation System and possible losses to ground water in the Snake Plain stretch of the river. Before entering the Snake Plain, the Blackfoot River is a gaining stream, where the elevation of the ground water table is above the stream elevation, and tributaries drain this ground water into the stream. When the Blackfoot flows over the Snake Plain, it is above the water table. Consequently, the stream water can leak out of the channel into the ground. The average yearly discharges near Blackfoot are shown in Figure 21.

During the drought of 1977, the discharge of the upper Blackfoot River above the reservoir was only about 33 per cent of the 1976 flow. The station near Shelley recorded almost 74 per cent of the 1976 flow. This increase was due to stored water released from the Blackfoot Reservoir. The gage at Blackfoot recorded approximately 44 per cent of the 1976 flow. It should be noted that the 1976 average flow was one of the highest recorded on the river.

FIGURE 20.

BLACKFOOT RIVER BASIN - BLACKFOOT RIVER above reservoir (U.S.G.S. NO. 130630)

Location: 7S/42E 14ad   Drainage area: 350 sq. mi.   Elevation: 6260 feet

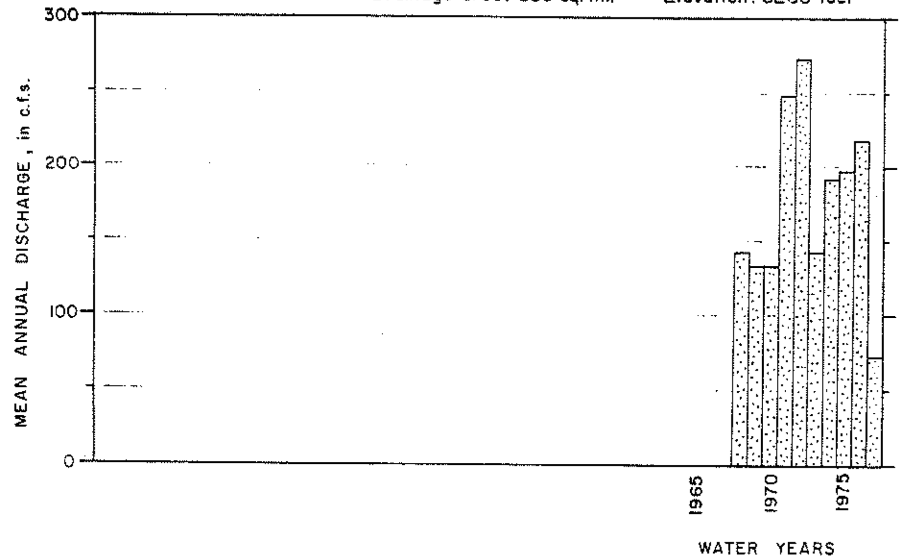
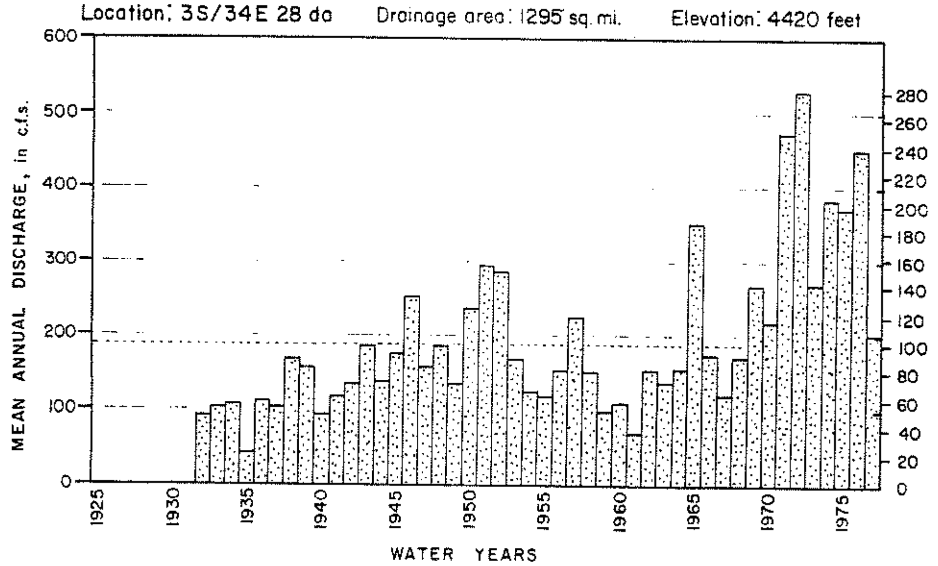


FIGURE 21.

BLACKFOOT RIVER BASIN - BLACKFOOT RIVER near Blackfoot (U.S.G.S. NO. 130685)

Location: 3S/34E 28 da   Drainage area: 1295 sq. mi.   Elevation: 4420 feet



GROUND WATER

In the Blackfoot River basin, upstream of Garden Creek, no wells are known to exist within the reservation. The only available information on the ground water resource is derived from the surface hydrology and bedrock geology. Within the higher elevations of the basin, relatively small, discontinuous pockets of ground water exist in the marine sedimentary rocks. These aquifers, due to structural controls, discharge in springs that provide the baseflow to the perennial streams such as Garden, Wood and Deadman Creeks. The downstream portions of these basins are generally composed of volcanic rock, which in some areas may have good permeability. As no well information exists, knowledge of the water table conditions is limited. The creeks may lose water in these volcanic areas, re-supplying the ground water.

In the Garden Creek basin, the stream flows over the Nugget Sandstone for almost its entire length. Stream water loss into this sandstone may account for the low annual flow at the mouth. The ground water in these areas probably discharges directly into the Blackfoot River; or in the case of the Garden Creek basin, into the Snake Plain aquifer.

Four wells were monitored downstream of Garden Creek during this study. A stock well, located at 2S/36E-36cdd has been monitored by the USGS since 1955. This well penetrates into the Nugget Sandstone. The record on the well (Figure 22) shows no significant water level changes since 1955. It exhibits a slight seasonal variation of between one half and one foot, with the low cycle occurring during the spring. The total variation has been within three feet throughout its history. The elevation of the water table here is usually near 4,560 feet. This is probably continuous with the water table beneath the Blackfoot River in this area.

An irrigation well, located upstream near the Blackfoot River at 2S/37E-19aa, exhibits a large seasonal variation (Figure 23). No drilling information is known about the well, although it is probably fairly deep, penetrating the Snake Plain aquifer. The seasonal cycle, not including the pumping drawdowns, varies up to 20 feet, with lows during the springs. The increase during the summer months is consistent with the Snake Plain wells in the vicinity, and is due to recharge by surface irrigation and stream water. A second well on the Snake Plain, located at 3S/36E-2dba, also exhibits a significant seasonal variation (Figure 24),

FIGURE 22.

WELL: 2 S/36 E 36 cdd | Depth: 105 feet | Open hole: 97-105 feet | Land surface: 4636 feet | Measuring point: 2.0' above ground

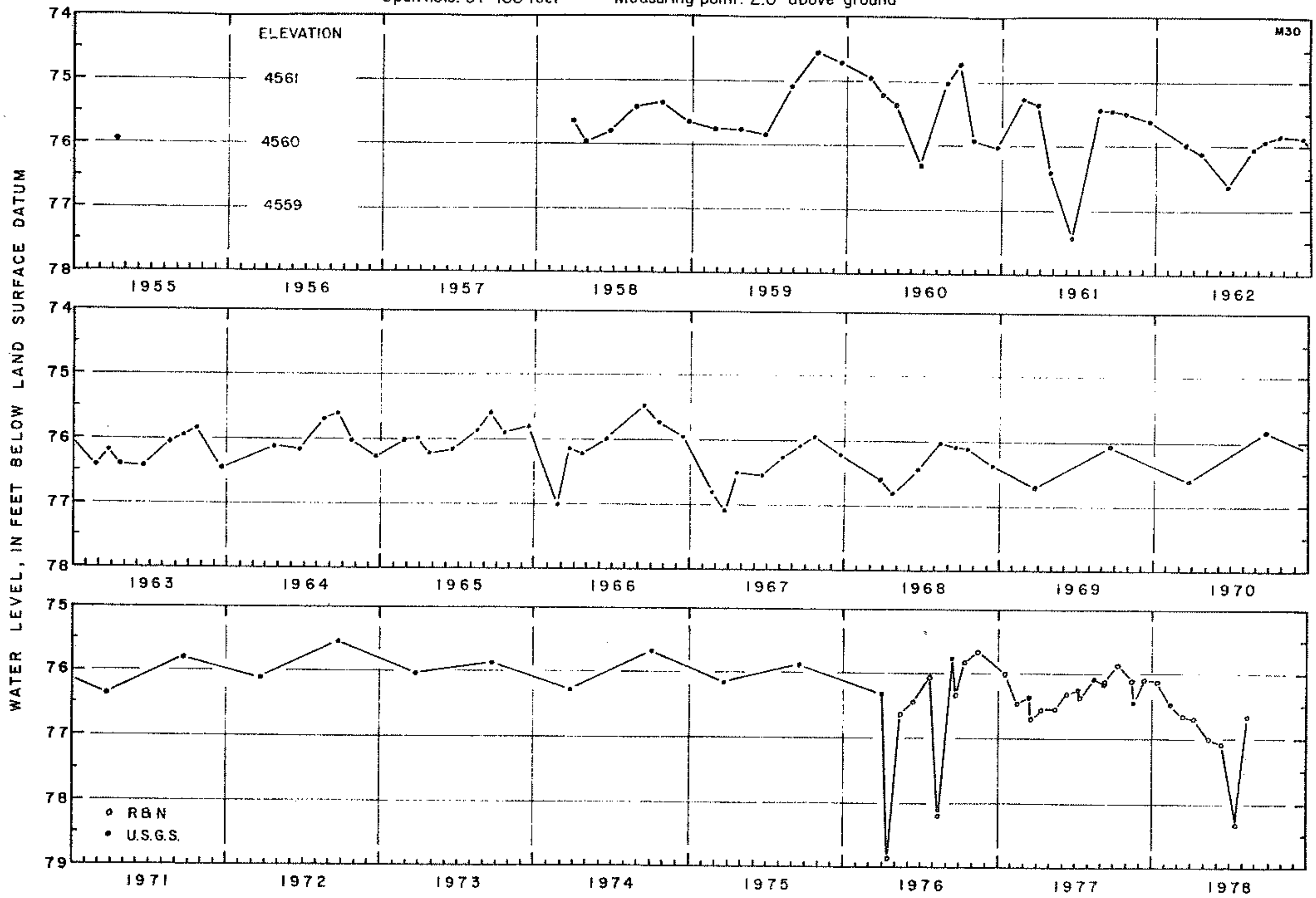


FIGURE 23.

WELL: 2 S/37 E 19aa   Depth: unknown   Land surface: 4575 feet
Measuring point: .7' above ground

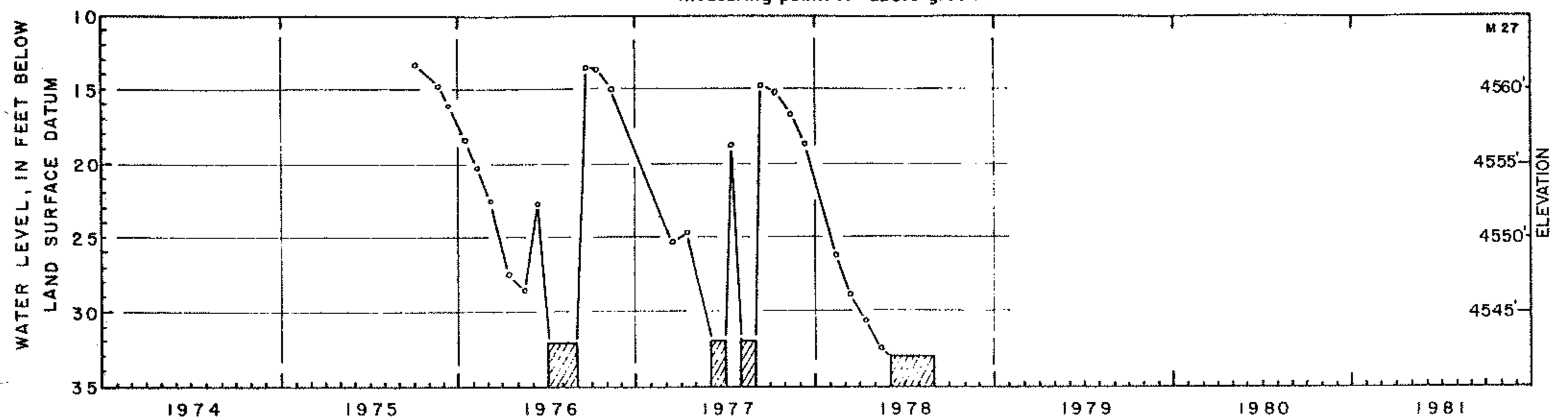
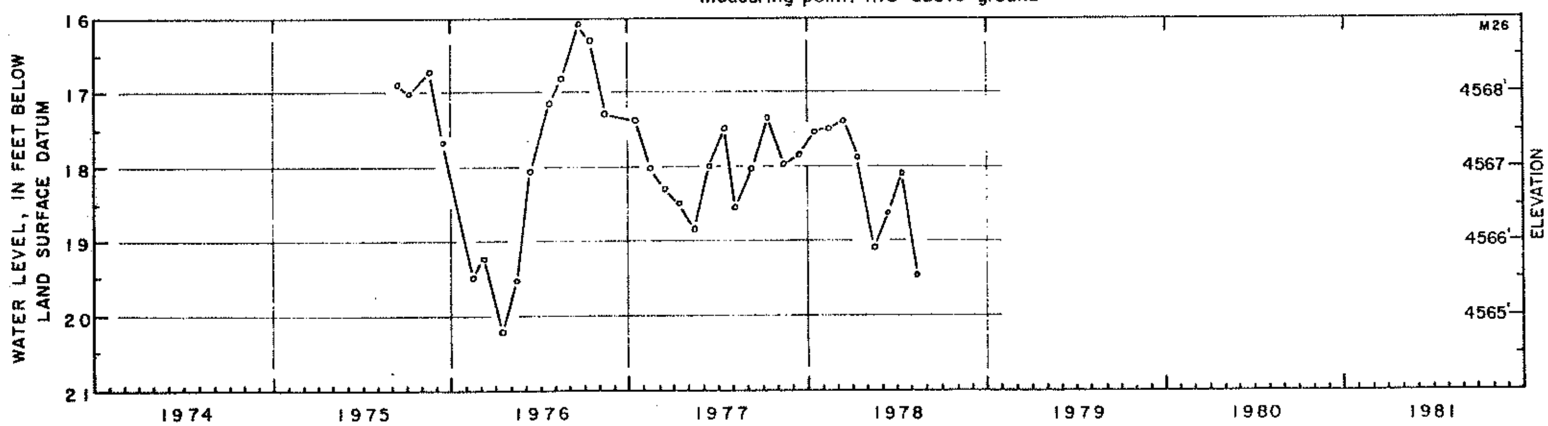


FIGURE 24.

WELL: 3 S/36E 2 dba   Depth: unknown   Land surface: 4585 feet
Measuring point: 1.16' above ground



although only about four feet. It is reported to be fairly shallow, and probably penetrates the alluvial sediments at the Lincoln Creek - Snake Plain junction.

The fourth well monitored, 3S/36E-25adc, lies in the Lincoln Creek valley at the Creasy Ranch. It is reported to be about 100 feet deep. Since 1975, the static level shows a slight increase, with slightly higher levels occurring during the summer months (Figure 25). The water table here is near the 4,747 foot elevation, considerably higher than the Snake Plain water table.

Due to the lack of sufficient water table elevation data, the flow direction of the ground water is difficult to define, particularly upstream of Garden Creek. However, it is probable that the ground water in the individual basins generally follows the surface water drainages. In the Lincoln Creek valley, the ground water seems to follow the course of the creek, in a northerly direction. The results from our monitoring agree favorably with the conditions depicted by West and Kilburn (1963, Plate 1) for the valley. The water table is at a fairly shallow depth in the valley bottom, usually less than twenty feet to water. In some lower areas of the valley, the water table is at the surface. This provides some inflow to Lincoln Creek in the downstream area.

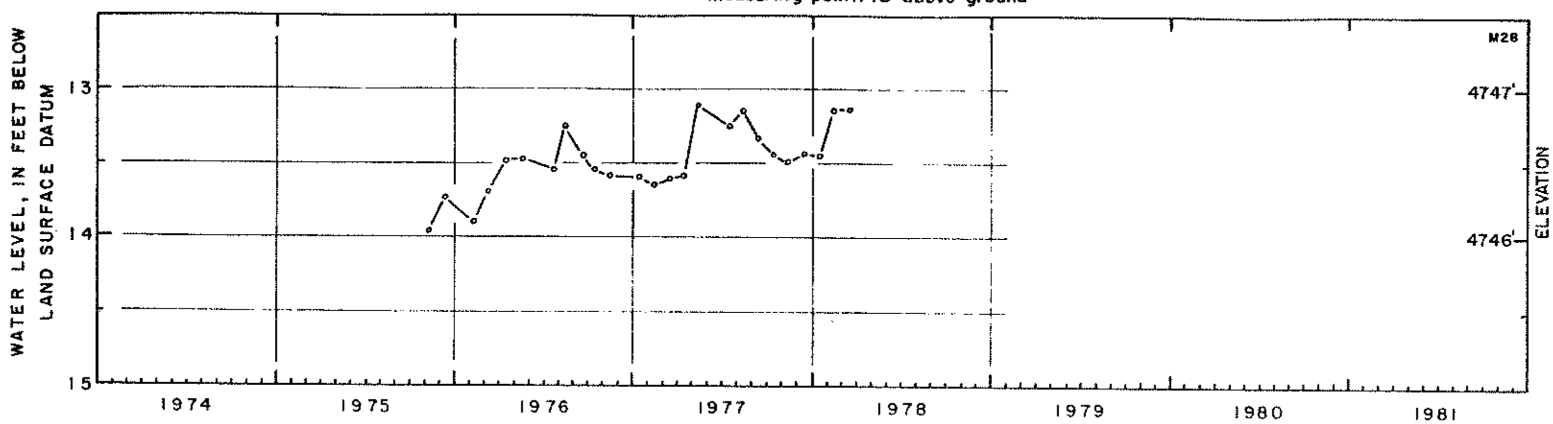
In the higher elevations of the Lincoln Creek basin, the depth to water will depend on the elevation and geologic setting. In the stock wells in the uplands, water levels range between 50 and 310 feet, with most levels near 200 feet. Elevations of the water table range between 4,675 and 5,260 feet.

WATER BUDGET

Reservation lands within the Blackfoot River basin account for 124 square miles. This area receives approximately 16 inches of precipitation annually, ranging from near 10 inches on the Snake Plain to over 20 inches near the Lincoln Peak area. Based on the analysis by Mundorff and others (1964), this would yield an equivalent of 4.5 inches of runoff, or 41.1 cfs (29,760 acre feet/year). Flow measurements for the tributary creeks to the Blackfoot River from this area during the 1976 water year accounts for 17.7 cfs, or almost half of the total runoff. This indicates that an

FIGURE 25.

WELL: 3S/36E 25 adc   Depth: unknown   Land surface: 4760 feet
Measuring point: .3' above ground



additional 23.3 cfs (16,869 acre feet/year) leaves the basin as ground water flow, either to the Blackfoot River or the Snake Plain aquifer.

In the upper Lincoln Creek basin, upstream of the recording gage, the basin receives an average of 17 inches of precipitation, yielding about 5.3 inches of runoff, or 12.6 cfs. The surface flow of the basin accounts for approximately 8.0 cfs yearly, leaving approximately 4.5 cfs (3,250 acre feet/year) as valley underflow. This underflow would increase to approximately 12 cfs near the mouth of Lincoln Creek, due to subsurface runoff from the downstream half of the basin.

West and Kilburn (1963) estimate the recharge to the Lincoln Creek basin to be 20,000 acre feet/year (27.5 cfs), slightly higher than the 15,600 acre feet derived from this analysis. They conclude that 25 per cent, or 5,000 acre feet could be utilized for irrigation. However, this would probably require a relatively large number of wells, with large drawdowns. This activity could result in a reduced flow in Lincoln Creek.

WATER QUALITY

SURFACE WATER QUALITY

Table 14 lists the averaged chemical quality of the streams sampled in the upper Blackfoot River area. Each stream is discussed below. The individual chemical analyses are listed in Appendix D.

Deadman Creek - Deadman Spring

Deadman Creek water quality is fairly representative of the Blackfoot drainage from the reservation. Generally, it is slightly less mineralized than the Bottoms Springs water, and maintains a fairly uniform quality throughout the year. One notable characteristic is a higher than normal turbidity level.

The spring originates near the reservation line, and is less mineralized than the creek water. It also maintains unform quality over time.

Beaver Creek - Short Creek

These two creeks are both ephemeral tributaries to the Blackfoot

TABLE 14
BLACKFOOT RIVER BASIN
AVERAGED SURFACE WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Deadman Creek 4S/38E - 13 aa	9	57	459	8.07	189	206	28	20	0.30	0.3	0.05	0.04	0.46	9	10
Deadman Spring 4S/38E - 13 ad	1	61	355	7.59	131	136	21	24	0.14	0.6	0.01	0.03	0.38	5	6
Beaver Creek 3S/38E - 25 db	3	59	230	7.60	105	95	15	4	0.41	0.3	0.00	0.03	0.28	8	1
Short Creek 3S/38E - 23 ac	5	54	283	7.77	121	126	22	2	0.28	0.3	0.00	0.05	0.35	9	5
Wood Creek 3S/38E - 16 aba	10	53	477	8.26	191	214	28	17	0.32	0.3	0.04	0.05	0.43	9	12
Garden Creek 2S/37E - 17 dda	89	47	509	8.22	217	235	24	21	0.41	0.3	0.06	0.06	0.47	9	22
Blackfoot River (Rich Lane) 3S/36E - 3 acb	5	40	448	8.24	202	215	15	26	0.14	0.6	0.08	0.04	0.51	11	2
Blackfoot River (Blackfoot) 3S/35E - 9 add	18	47	410	8.20	160	180	15	28	0.13	0.4	-	0.10	-	-	1

River, primarily flowing during the snowmelt season. The chemistry of both streams is similar. They are significantly less mineralized than the perennial tributaries in the area, particularly with respect to hardness and sulfate. Short Creek, which usually maintains its flow later into the summer, exhibited a fairly uniform quality over time.

Wood Creek

Wood Creek has a very uniform chemical character, similar to Deadman Creek. This similarity is probably due to the fact that both streams drain the same bedrock strata, possibly the same aquifer. The parameters measured varied little throughout the year although some dilution probably occurs during spring runoff. No increase was noted during the lower flows associated with the 1977 drought. Turbidity levels were noted to be higher than normal.

Garden Creek

Garden Creek water was found to be slightly more mineralized than the other tributaries to the upper Blackfoot River, and fairly similar to the Bottoms Springs water. The quality remained uniform throughout the year; the only change occurred druing the spring snowmelt period then most parameters are diluted. Garden Creek was found to contain some of the highest turbidity levels found on non-flooding streams on the reservation.

Lincoln Creek

Average chemical analyses of the Lincoln Creek basin surface waters are shown in Table 15.

Box Spring is located in 4S/38E-6 and was sampled as it approached the Gay Mine area. It appears to be impounded there. Flow was estimated at only a few tenths of a cfs. The water was of good quality, being only slightly more mineralized than the Bottoms water.

Lincoln Creek - Dry Hollow Road - Above Yandell Springs, Lincoln Creek is formed by the flow of several small springs west of Box Spring. The flow was visually estimated at only a few tenths of a cfs, and was sampled at the Dry Hollow Road crossing at 4S/37E-3. The water here is very mineralized, with high levels of chloride, sulfate, and hardness.

Lincoln Springs 1 and 2 - These two small springs enter Lincoln Creek from the east side of the valley east of Yandell Springs. Both are very small and are used primarily for stock water. Both are similar in chemistry to Box Spring.

TABLE 15

LINCOLN CREEK BASIN

AVERAGED SURFACE WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Box Spring 4S/37E - 12 bba	2	48	-	8.08	230	270	42	16	0.09	0.3	0.05	0.02	0.39	-	1
Lincoln Creek (Dry Hallow Rd.) 4S/37E - 3 abc	2	52	1130	8.24	218	425	139	122	0.06	0.3	0.11	0.04	0.50	-	2
Lincoln Spring #1 3S/37E - 29 dca	2	52	580	7.35	230	250	30	20	0.07	0.7	-	0.05	-	-	1
Lincoln Spring #2 3S/37E - 34 bc	0	53	550	7.43	230	235	30	19	-	-	-	-	-	-	1
Yandell Springs 3S/37E - 31 db	0	74	810	7.52	220	340	28	151	0.09	0.4	-	0.04	-	-	2
Lincoln Creek 3S/36E - 25 daa	85	68	791	7.91	200	342	25	157	0.21	0.3	0.05	0.04	0.88	8	24
Cold Creek 3S/36E - 24 adab	37	45	557	8.21	210	242	36	22	0.38	0.4	0.03	0.04	0.46	10	24
Lincoln Creek (mouth) 3S/36E - 2 caa	7	43	1027	7.99	255	407	32	227	0.16	0.3	0.19	0.06	0.98	9	3

Yandell Springs - This group is located in 3S/37E-31db, at the base of Yandell Mountain. The flow comprises almost the entire baseflow of Lincoln Creek. The spring flow is composed of at least four separate springs, each of which has a unique chemical character. The temperatures range from 68°F to 88°F, with the degree of mineralization increasing with temperature. The three distinguishing characteristics are the high sulfate, fluoride, and hardness levels. Samples tested by the State of Idaho showed very low levels of trace metals.

Lincoln Creek - The water quality of Lincoln Creek was monitored at the automatic recording gage, downstream of Yandell Springs. The water here is contributed entirely by Yandell Springs, except during the spring snowmelt period. The concentration of minerals showed some variation over the year, with higher values occurring during the summer months. It is not known whether this is due to annual variations in the spring water itself, or to increased evaporation and irrigation during the summer.

Cold Creek is the major tributary of Lincoln Creek and was monitored above the Lincoln Creek Road at the stream measuring site. The water is of good quality with much lower mineral concentrations than Lincoln Creek. The quality more closely resembles the Bottoms Springs water. The levels of dissolved minerals remained fairly constant throughout the year, with some dilution occurring during spring runoff. This stream also exhibits a higher than normal turbidity throughout the year.

Lincoln Creek - Mouth - Near the mouth of Lincoln Creek the water exhibits higher concentrations of dissolved minerals than at Yandell Springs. Insufficient testing was done to delineate any seasonal variations or effects due to irrigation. No large inflows of spring water enter the creek below Cold Creek, so increased concentrations may be due to evaporation of the warm stream water. The increases are predominately in sulfate and hardness concentrations.

Blackfoot River - This river has been monitored by the USGS at Blackfoot since 1951 and above the Blackfoot Reservoir since 1959. It was also monitored in 1974 by the U.S. Environmental Protection Agency (EPA) as part of an irrigation water quality program. Consequently, little chemical sampling was done on the river itself as a part of this study.

To summarize the findings of Laird (1964), the river water is of the calcium bicarbonate type, with the magnesium concentration increasing below the reservoir in the downstream direction. Overall, the river maintains a fairly uniform quality below the reservoir. The findings of this study compare favorably with the existing data.

GROUND WATER QUALITY

Several analyses of ground water were taken from wells in the Lincoln Creek valley and indicate that the ground water chemistry is fairly similar to that of Lincoln Creek (Table 16). Three wells in the upper portion of the valley (3S/36E-13ca, 14ab, and 25adc) have similar quality to that of Yandell Springs, having high levels of hardness and sulfate. The well depths are reported to be around 100 feet, and withdraw water from the unconsolidated sediments that fill the valley.

The wells near the mouth of Lincoln Creek (3S/36E-2cs, 2dba, and 2adc) are reported to be shallower, and discharge water similar in quality to the lower Lincoln Creek. This water is very high in hardness, sulfate fluoride, ammonia and iron. Some of the levels found exceed current drinking water standards. The high levels appear for the most part to be naturally occurring. It is recommended that the Tribe investigate the feasibility of providing better quality water sources for the domestic users in this area.

SUMMARY

The ground water that discharges as spring flow in the Blackfoot Basin area of the reservation appears to be of three types, based on degree of mineralization. The first type, only moderately hard with very low sulfate levels, is evident in Beaver and Short Creeks. These are ephemeral streams very dependent on snowmelt which runs off before accumulating a large amount of dissolved material. The second type is classified as hard, and is exemplified by the majority of perennial streams in this area such as Wood and Cold Creeks. These streams drain the Triassic and Jurassic aged

TABLE 16

LINCOLN CREEK BASIN

AVERAGED GROUND WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity μ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Well 2S/37E - 19 aab	0	54	620	7.74	235	235	15	21	0.14	1.1	0.02	0.03	0.42	-	1
Well 3S/36E - 2 adc	2	64	840	7.50	220	270	30	100	0.22	0.7	-	0.05	-	-	1
Well 3S/36E - 2 ca	18	42	1080	7.57	288	472	50	202	0.16	0.2	0.60	0.66	0.88	-	2
Well 3S/36E - 2 dba	18	50	1325	7.50	274	600	38	331	0.28	0.3	0.12	1.07	1.09	-	5
Well 3S/36E - 13 ca	1	41	710	7.65	200	280	55	61	0.17	0.8	-	0.11	-	-	1
Well 3S/36E - 14 ab	6	55	840	7.65	200	360	30	156	0.17	0.5	-	0.55	-	-	1
Well 3S/36E - 25 adc	0	52	812	7.65	228	392	31	169	0.16	0.6	0.00	0.02	0.72	-	3

sedimentary rocks that form the Garden Peak - Higham Peak - Lincoln Peak ridge. This water contains approximately 200 to 250 mg/l hardness and 20 mg/l sulfate.

The third type is classified as very hard, and is evident in Yandell Springs and the upper Lincoln Creek area. This water seems to be associated with the Pennsylvanian aged Wells Formation. In the Yandell Springs, the water is warm, up to 88°F. The hardness ranges between 350 and 500 mg/l, and the sulfate between 120 and 320 mg/l. This aquifer, associated with the Phosphoria Formation, may be responsible for many of the very mineralized springs in the Gay Mine area.

The Garden Peak - Higham Peak area was found to have significantly higher than normal turbidity levels in the creeks draining the area. These are Cold, Garden, Wood, and Deadman Creeks. It is not known whether this is due to over-grazing, beaver activity in the streams, or geologic conditions, although all are probably a factor to some degree. One contributing factor found in Garden Creek was a small landslide, apparently caused by irrigation of the adjacent benchland. The slide blocked the stream, resulting in a turbidity increase from 27 to 600 FTU's.

Studies by the State of Idaho have identified factors that currently degrade the quality of the Blackfoot River main stem. Upstream of the Blackfoot Reservoir, turbidity is the main problem, resulting from non-point sources. This is currently contributed primarily by agricultural activities in the basin, but could be increased if phosphate mining operations are increased in this area. Below the Blackfoot Reservoir, nutrients and occasionally bacteria, along with turbidity, maintain problem levels.

ROSS FORK BASIN

BASIN DESCRIPTION

The Ross Fork basin lies at the center of the Fort Hall Indian Reservation. It is composed of two main tributaries, the North Fork and the South Fork. The North Fork begins at several springs located northeast of Mt. Putnam. It flows west, through the Narrows, and joins with the South Fork in 4S/36E-31, just north of Putnam Lodge.

The South Fork begins at the southern reservation boundary at the base of Moonlight Mountain, which lies off the reservation. Its flow is augmented by several perennial tributaries, including Sawmill Creek, Thirty Day Creek and Mill Creek. The South Fork flows northward, with Mt. Putnam to the east and the Pocatello Range to the west, until it joins the North Fork.

The combined flow continues in a westerly direction, crossing the southern edge of Buckskin Basin, and enters the Snake River Plain where it crosses the Main Canal. It then continues its westerly course across Gibson Terrace and enters the Fort Hall Bottoms where it combines with Clear Creek before entering the Portneuf River.

GEOLOGY

The geology of the North Fork basin is similar to the other basins in the eastern part of the reservation. The Ordovician and Cambrian quartzites, dolomites, and limestones dominate the Mt. Putnam area in the southern portion of the basin. These rocks form the ridge extending north from Mt. Putnam that joins a ridge of Tertiary volcanic rock dividing Lincoln Creek basin from Buckskin Basin. The northeast part of the North Fork basin is underlain by the Triassic and Carboniferous limestones and shales that include the phosphate ore.

The South Fork Ross Fork valley lies between the Pocatello Range to the west and the Portneuf Range (Mt. Putnam) to the east. The Pocatello Range, including Moonlight Mountain, is underlain by Precambrian quartzites and limestones, similar to the rocks of Mt. Putnam. This rock type is exposed northward to the Pocatello Creek Valley on the west side of the range, and extending just into the reservation on the east. North of that line, most rocks are younger Tertiary and Quaternary volcanic rocks of the Starlight Formation. Some older sedimentary rocks are also present in this area.

Large alluvial fans have developed from the flanks of the mountain ranges in this valley. Drilling of the deep irrigation wells have shown the alluvium extends to at least 800 feet below the valley bottom. A geologic cross section of the South Fork valley and Buckskin Basin is shown in Figure 26. It shows a basalt lava flow that extends partially up the valley. This flow is apparently an extension of the Pleistocene basalt associated with the Buckskin Basin and Snake Plain. Older volcanic rhyolite and ash was found below this basalt, as shown on the cross section. This rhyolite was found to be very discontinuous, either due to faulting or erosion. Ross Fork basin below the confluence of the two forks is underlain by Quaternary basalt associated with the Snake Plain volcanics. These basalts crop out along the creek at the north end of the Pocatello Range. The thickness of the basalt in this area is not known. The area to the north of the creek is Buckskin Basin, which is bounded on the north by the Tertiary volcanics near Stevens Peak, and on the northwest by Gibson Butte, a large basaltic caldera. Buckskin Basin itself is underlain by the basalt to an unknown depth, although it appears to thin out as it overlaps the older sedimentary rocks to the east. The basalt is overlain by approximately 50 to 80 feet of unconsolidated material.

HYDROLOGY

DATA SOURCES

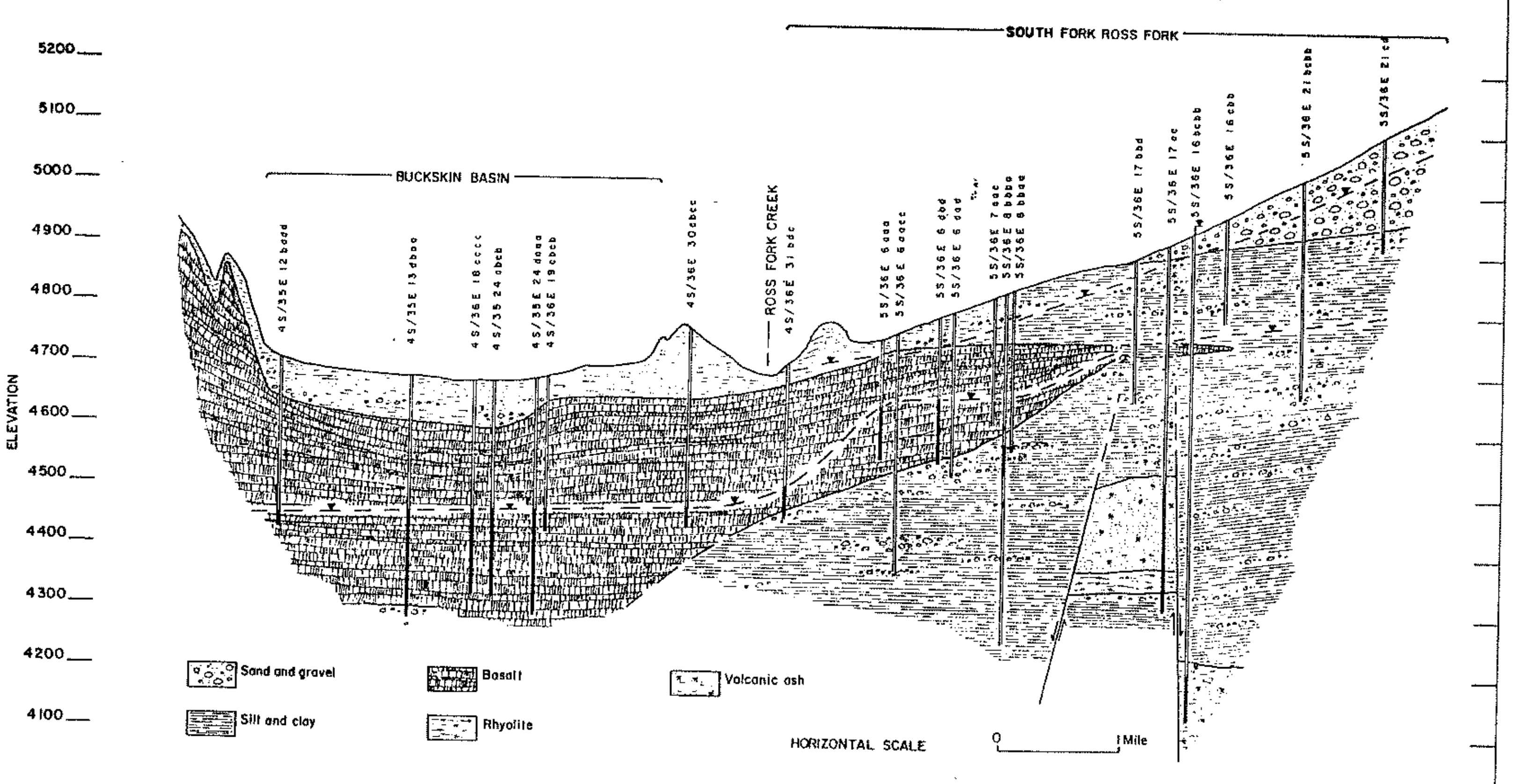
The USGS maintains one miscellaneous station on Ross Fork (130759.6), just above its confluence with Clear Creek. This station is measured only during the irrigation season as part of the inflow studies for American Falls Reservoir. Measurements have been taken since 1924.

The BIA Irrigation Office periodically measures Ross Fork upstream of the Fort Hall Main Canal Crossing.

For this inventory, a recording gage was established in 1973 on

FIGURE 26

BUCKSKIN BASIN - SOUTH FORK ROSS FORK CROSS SECTION



ROBINSON AND NOBLE INC.
GROUND WATER GEOLOGISTS
TACOMA, WASHINGTON

OCTOBER 1978

FOR: SHOSHONE BANNOCK TRIBES
BY: DON BALMER

Ross Fork above the Main Canal crossing at 4S/35E-35ca. In addition, monthly measurement stations were established at the USGS station near the mouth; below the Main Canal crossing, on the North Fork above the Minor Unit Irrigation System, and on the South Fork. An additional station was later established on Mill Creek, a tributary to the South Fork.

No wells have been monitored on a continuous basis by the USGS in the Ross Fork area. A canvass of water levels was made by the USGS in 1955 for the study by West and Kilburn (1963). This included about ten wells in the South Fork - Buckskin Basin area. No wells are known to exist in the North Fork basin, other than those drilled as part of the Gay Mine operation.

For this study, approximately ten wells were monitored in the Buckskin Basin-South Fork basin area on a monthly basis. Also two water level recorders were maintained on wells in Buckskin Basin. Additional ground water investigation of the upper Ross Fork area was conducted in 1977-1978 for the drought relief project. This is discussed by Dow and Balmer (1978).

SURFACE WATER

North Fork - Ross Fork

The North Fork originates with the flow of Big Spring and Contact Spring, located to the northeast of Mt. Putnam. It drains the north and east slopes of Mt. Putnam, along with the southern portion of the Gay Mine area and the Lone Pine Canyon area. The stream has eroded through the bedrock north of Mt. Putnam to form the Narrows, and joins with the South Fork of Ross Fork prior to entering the Buckskin Basin area.

Several irrigation ditches remove water from the creek for the Ross Fork Minor Unit. The uppermost is Farmer Ditch, which removes water just west of the Narrows. Flow measurements were made just upstream of this ditch (Figure 27), with additional measurements below the ditch (Figure 28).

Measurements made during the 1976 water year indicate a mean flow of 13.6 cfs. Summer baseflows during this period were maintained between five and ten cfs. The lack of runoff and recharge during 1977 reduced this baseflow to near 1.0 cfs. The mean flow for that water year was only 4.45 cfs. The return to near normal precipitation in 1978 resulted in increased baseflow and spring

FIGURE 27.
ROSS FORK BASIN - NORTH FORK ROSS FORK

Location: 5 S / 36 E 10a
Elevation: 4980 feet

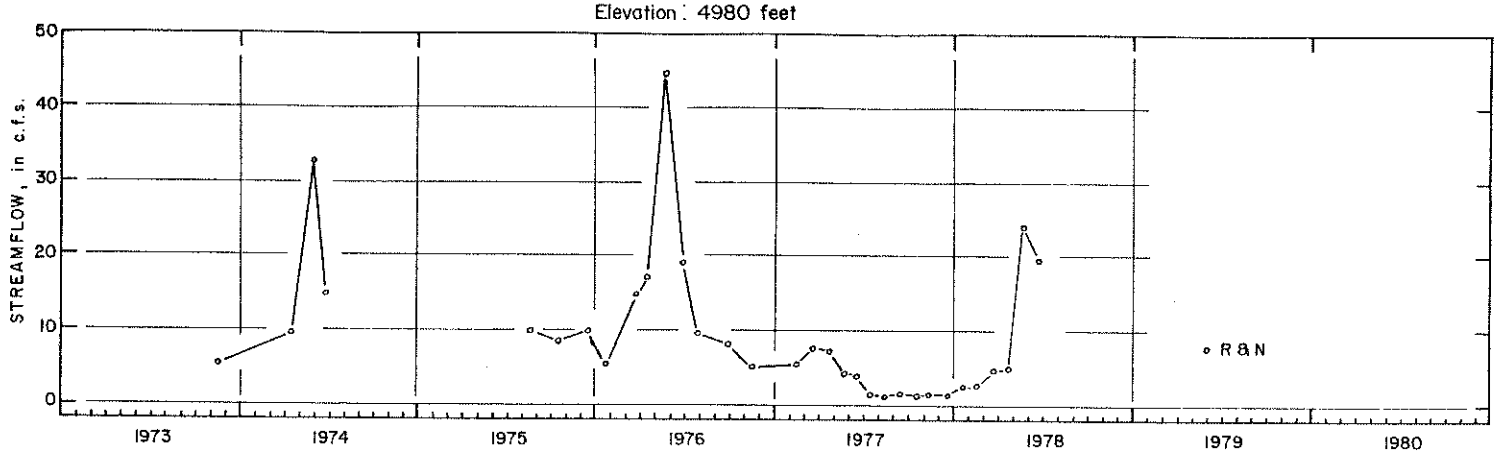
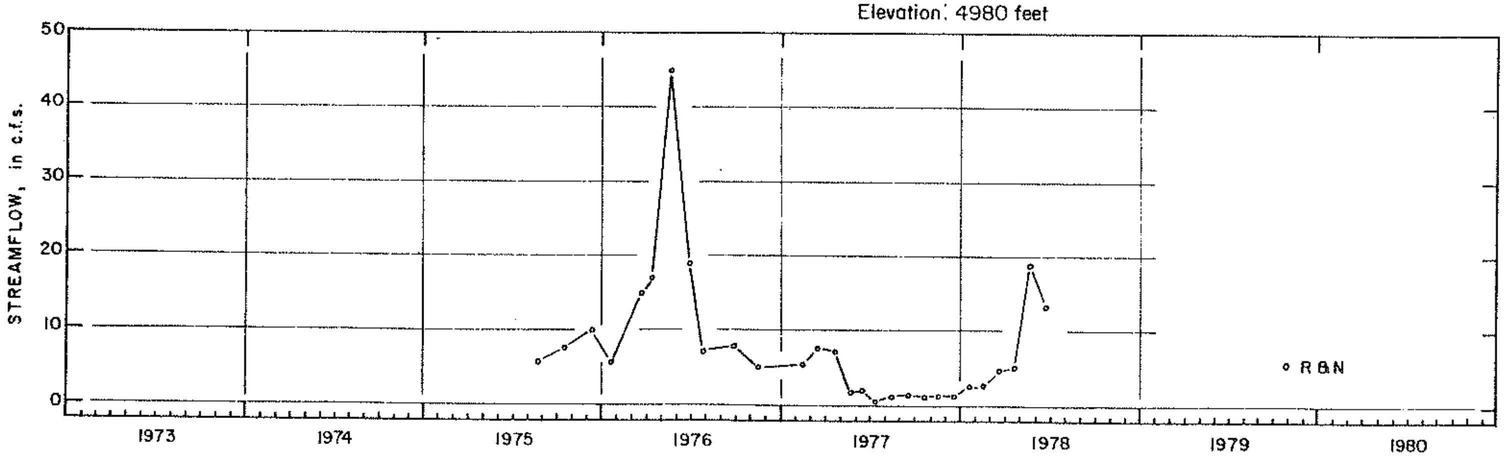


FIGURE 28.
ROSS FORK BASIN - NORTH FORK ROSS FORK below Farmer Ditch

Location: 5 S/36E 10a
Elevation: 4980 feet



runoff. However, the annual flow for that year was only 6.31 cfs, due to the drought effects in early 1978. Measurements indicate between 0.5 and 1.3 cfs annually is diverted to Farmer Ditch.

South Fork - Ross Fork

The South Fork originates near Moonlight Mountain and receives tributary flow within the reservation from Sawmill Creek, Thirty Day Creek, Barclay Creek and Mill Creek. The flow measurements were made on the South Fork below these tributaries and above the Evening Ditch turnout. During the irrigation season Mill Creek is diverted into Smoke Ditch rather than the South Fork. Consequently, periodic measurements were made on Mill Creek during 1977.

The mean flow for the 1976 water year for the South Fork was 20.1 cfs, with summer baseflows near 10 cfs (Figure 29). This summer flow does not include Mill Creek. Very little runoff occurred during the spring of 1977, and the baseflow dropped to 0.3 cfs, averaging 4.88 cfs for the water year. The mean baseflow for Mill Creek while diverted to Smoke Ditch was 1.92 cfs during 1977 (Figure 30). Significant runoff did occur during 1978, with flows comparable to those of the 1976 water year. The annual flow for the 1978 water year averaged 16.3 cfs.

Ross Fork

The North and South Forks of Ross Fork join about a half mile northwest of Putnam Lodge. In this area the streams also receive irrigation return flow from the Ross Fork Minor Unit. Below this junction, the stream enters the volcanic terrain of Buckskin Basin. The recording gage was established in 4S/35E-35ca, in the narrow valley cut into the basalt by the creek. Ross Fork continues through the volcanic hills and flows onto the Snake River Plain approximately 3.5 miles downstream from the gage.

The mean annual flow of Ross Fork at the gage for the 1974 and 1976 water years was 23.6 and 34.6 cfs respectively. The hydrograph, indicating mean monthly flows, is shown in Figure 31. The summer baseflow in this area is usually reduced to 2 cfs by upstream irrigation. During 1977, no spring flood occurred, with the mean flow recorded at 7.58 cfs. The stream reached zero discharge by September, 1977. Extremely low flows lasted until

FIGURE 29.
ROSS FORK BASIN - SOUTH FORK ROSS FORK

Location: 5 S/36 E 28 bdc
Elevation: 5140 feet

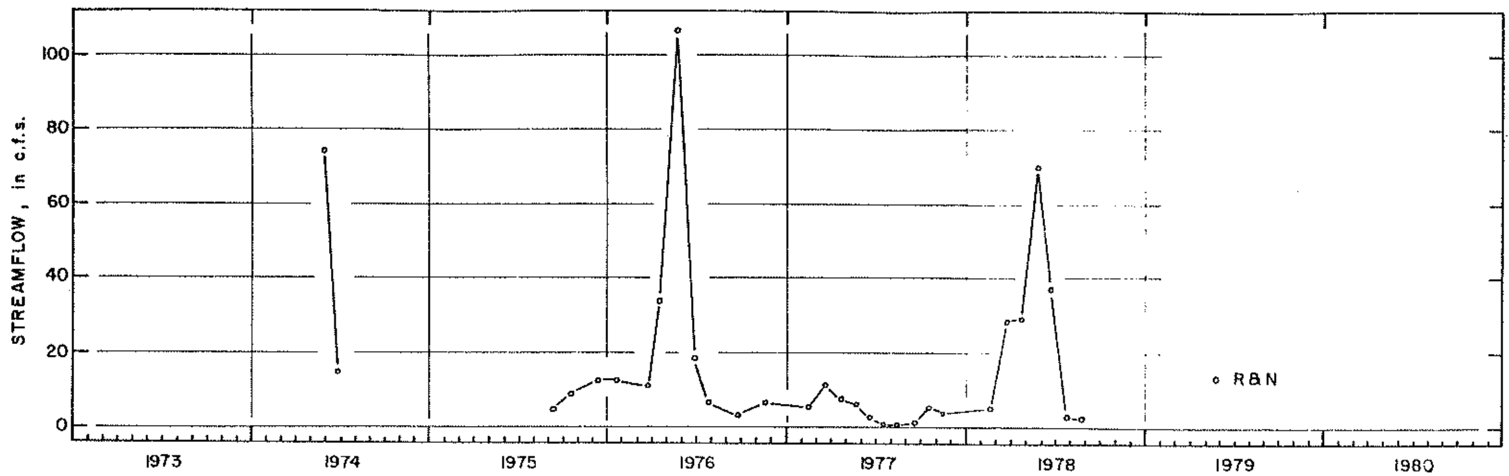


FIGURE 30.
ROSS FORK BASIN - MILL CREEK

Location: 5 S/36 E 34 bca
Elevation: 5310 feet

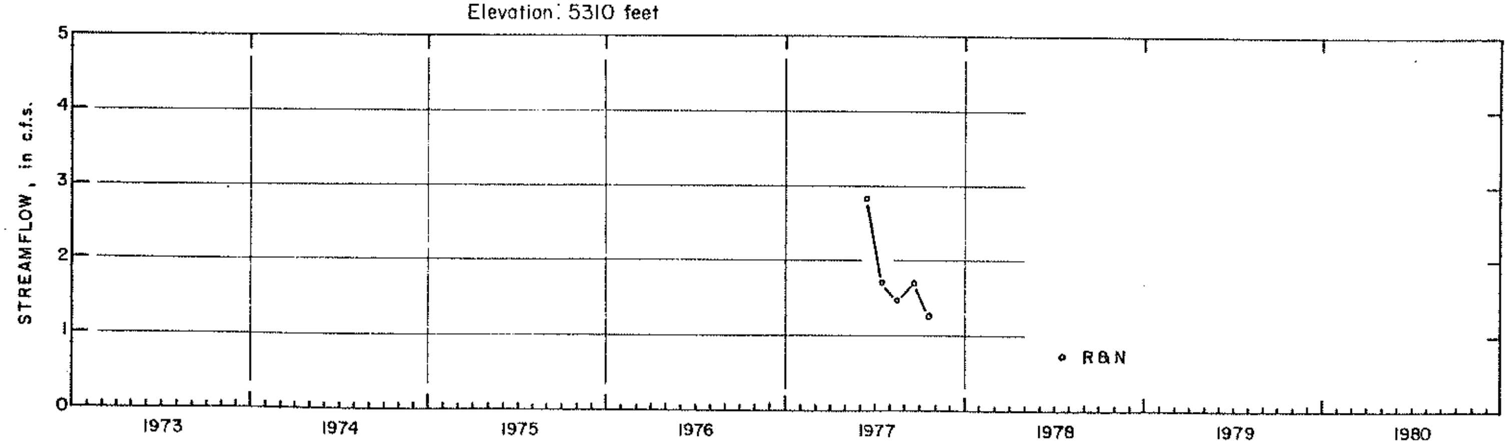
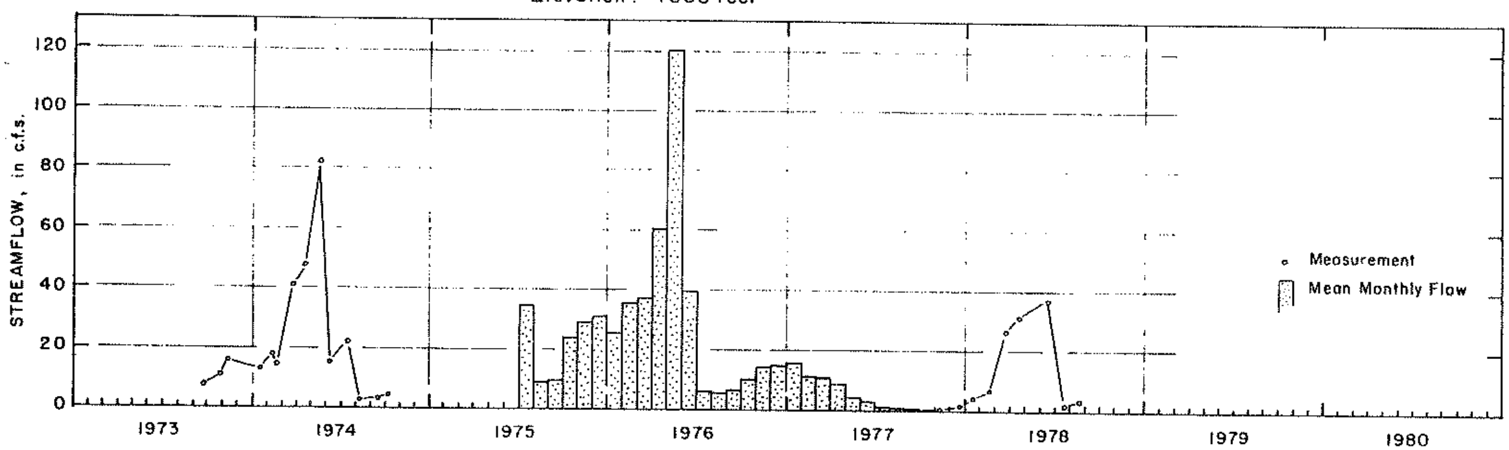


FIGURE 31.

ROSS FORK BASIN
ROSS FORK at GAGE

Location: 4S/35E-35ca
Elevation: 4605 feet

Drainage area: 154 sq. mi.



January, 1978. The spring runoff flows during 1978 were lower than in previous years due to much of the snowmelt recharging the dry soil. However, the baseflow showed some increase over the previous year. The average flow for the 1978 water year was 16.9 cfs.

No flow measurements were made on the Minor Unit irrigation system in Ross Fork. Common practice is to use all of the water provided by the North and South Forks, particularly in late summer. Some return flow does enter the stream at the lower end of the system, and combines with a small amount of spring flow in that area to provide some flow downstream of the Minor Unit during late summer.

In the Buckskin Basin area, the stream receives no ground water inflow as the water table drops below the channel elevation. The stream would be expected to lose water in this reach, particularly while flowing over the exposed basalt bedrock. Due to the irrigation activity in the minor unit, some of which occurs throughout the year, no conclusion can be made regarding any stream loss above the recording gage. In the stretch below the gage to the Main Canal, however, measurements indicate a loss of between one and two cfs. This water is recharged into the basalt aquifer.

As Ross Fork crosses the Main Canal, the stream enters the Snake River Plain. Downstream of this point, the stream flow becomes a function of both the Fort Hall Irrigation System and the ground water inflow in the Fort Hall Bottoms area. For this reason the Ross Fork basin is considered to end at the Main Canal crossing. The Gibson Terrace stretch is discussed in the Snake River Plain hydrology section.

GROUND WATER

The Ross Fork basin contains three distinct sub-basins, each having different geologic characteristics. The North Fork, which drains the mountainous area north and east of Mt. Putnam, contains a variety of bedrock types, including quartzites, limestones, and shales. The South Fork drains a broad valley separating the metasedimentary rocks of the Mt. Putnam area from the more recent volcanic hills to the west. The third area is the volcanic terrain of Buckskin Basin and the hills to the south that dominate the downstream portion of the Ross Fork basin.

In the North Fork, bedrock is usually close to the surface. The terrain is generally of high relief, with little development of broad valleys representative of the South Fork. The bedrock types and structural relationships are the main controls of the ground water flow. Very few wells exist in the basin. A few were drilled in conjunction with the phosphate mining operations, but have little available drilling information. Only a few domestic wells near the South Fork basin have available information. Much of the annual precipitation recharge in the basin drains toward the Danielson Basin and Twitchel Meadows. Here the water surfaces as springflow to provide the baseflow of the North Fork. It is believed that most of the ground water in the alluvium is forced to the surface, due to the bedrock controls in the Narrows and Lone Pine Canyon. Ground water that enters the bedrock may flow northwest directly into the Buckskin Basin volcanics. The bedrock east of the Buckskin Basin is predominately limestone which could conduct appreciable quantities of water.

In the valley downstream of the Lone Pine Canyon, the ground water is confined under sufficient pressure to cause wells to flow. These wells are drilled into the valley alluvium, which exceeds 500 feet in depth. A well drilled at 4S/36E-33caa, under the drought relief program, flows 21 gpm. The specific capacity, however, was found to be only 1 gpm/foot of drawdown. The Truchot domestic well is also reported to have flowed during drilling. This water probably flows from the hills to the north and south of the creek, where precipitation enters the alluvial fan deposits and flows toward the valley.

The South Fork valley contains a thick sequence of sediments which exceed 800 feet in places. The volcanic tuffs, rhyolites, and basalts forming the terrain to the west and north interfinger with these valley fill sediments at various depths, as shown in Figure 26. The bedrock forming the Mt. Putnam area to the east is predominately quartzite, which is generally considered to yield only small amounts of ground water. To the west of the valley are hills composed of rhyolite, basalt, and limestone, which may contain larger quantities.

Two aquifers have been identified in the valley, both having a northerly water flow. The upper aquifer's water table is that depicted by West and Kilburn (1963, Plate 1). It is generally at a shallow depth and interconnects with the surface drainage, providing spring flow to the creeks. This aquifer is tapped by the older, shallow wells in the basin. In the lower part of the basin, the water appears perched on the subsurface basalt flow that extends into the valley.

The second aquifer lies deeper, with a water table approximately 150 feet beneath the valley bottom. The water flows through the lower basalt and underlying sand and gravel zones, and drains into the main basalt aquifer beneath Buckskin Basin. This aquifer is tapped by the deeper domestic wells in the basin. It provides no flow for the surface drainages in the area, and is recharged by the infiltrating snowmelt water and leakage from the upper aquifer.

Two wells in the valley that tap the upper aquifer were monitored monthly. Their hydrographs are shown in Figures 32 and 33. Both exhibit decreasing water levels during 1977, probably in response to the drought conditions. However, the total variations were within two feet in both wells. Figure 34 illustrates the hydrograph of a domestic well in 5S/36E-17bbdd, which taps the lower aquifer. It also exhibits no large seasonal variations. The general decline is due to decreased recharge in 1977. Wells drilled into this lower aquifer during the drought relief program of 1977 were found capable of yielding approximately 200 gpm. Specific capacities were found to be near 3 gpm/foot of drawdown (Dow and Balmer, 1978). This was insuffcient for irrigation supplies, however should assure sufficient domestic and stock water supplies in the future.

The volcanic terrain of the lower basin contains no perennial surface drainage, except for the Ross Fork channel. Most of the precipitation not evaporated enters directly into the ground water system. The main aquifer in the lower basin occurs in the basalt, with the water table lying approximately 220 feet beneath the surface of Buckskin Basin. It is this aquifer that is tapped for irrigation water in the Buckskin area. The water table here is contiguous with the Snake Plain aquifer water table to the north and west. The ground water was found to flow generally west, toward Fort Hall.

It is apparent that relatively little of this water is contributed from the North or South Fork valleys. The only possible source of this water appears to be from the Snake Plain aquifer to the northeast of the basin. Previous studies have assumed that the Snake Plain aquifer east of Blackfoot ends near the Blackfoot

FIGURE 32.

WELL: 4 S/36 E 32 cccb　Depth: 210 feet　Land surface: 4765 feet

Perforations: 100'-112' & 117'-155'　Measuring point: .2' above ground

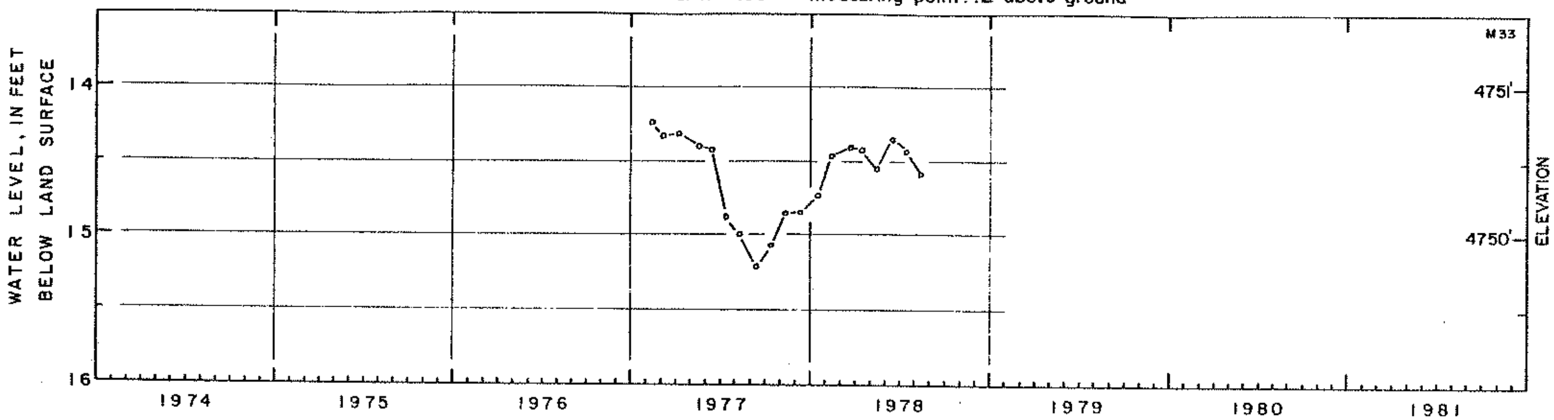


FIGURE 33.

WELL: 5 S/36 E 8 bcbb　Depth: unknown　Land surface: 4840 feet

Measuring point: 1.0' above ground

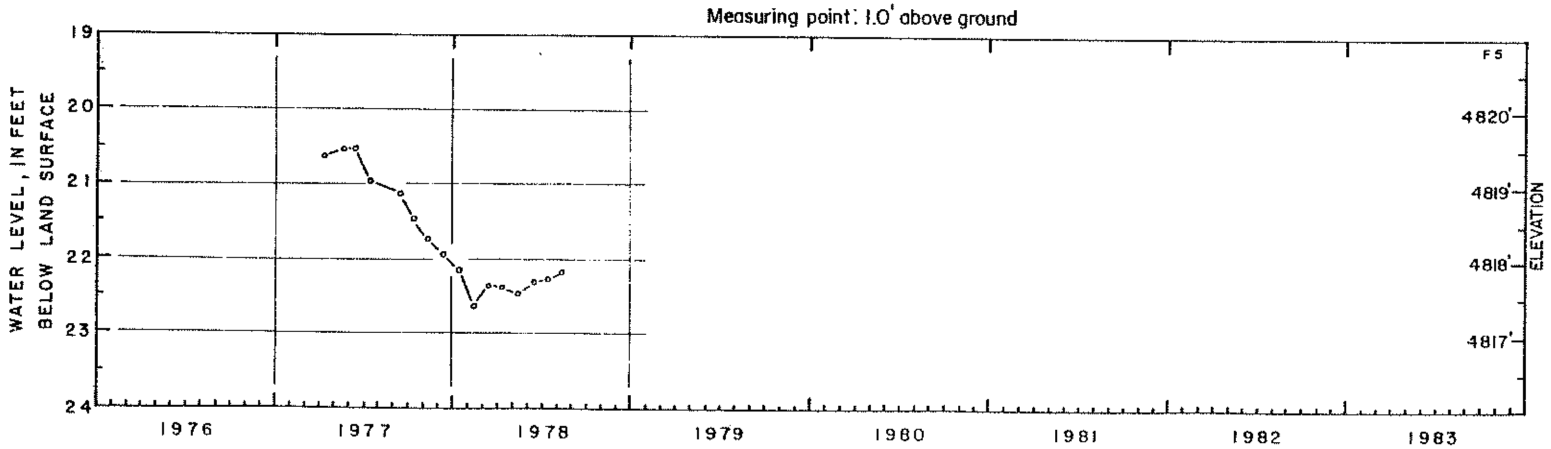
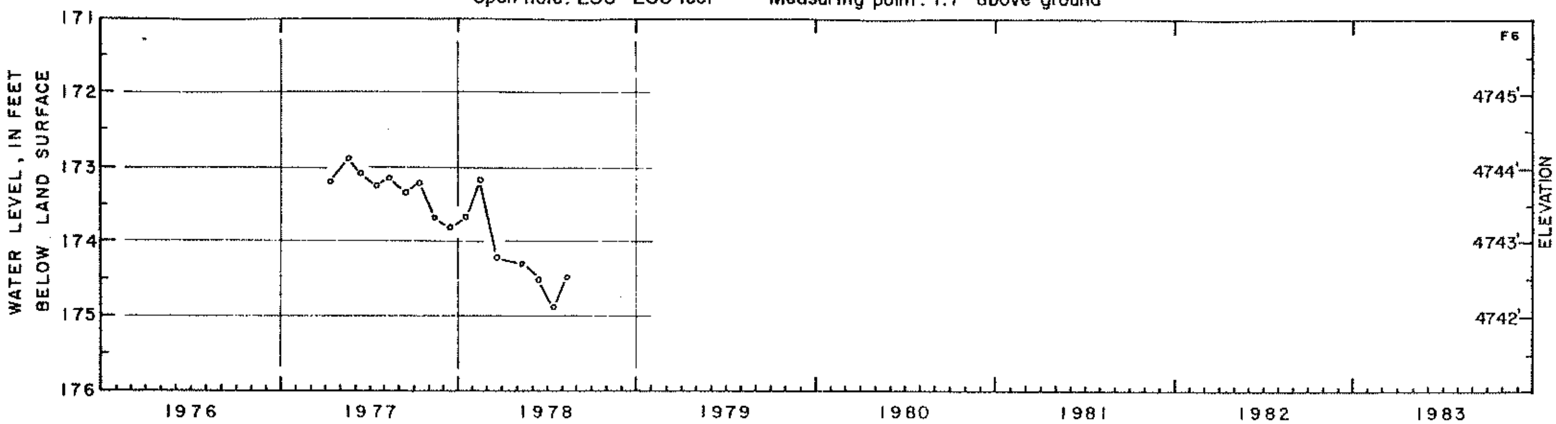


FIGURE 34.
WELL: 5 S/36 E 17 bbdd

Depth: 260 feet
Open hole: 250 - 260 feet

Land surface: 4917 feet
Measuring point: 1.7' above ground



River. It appears, instead, to extend south beneath the volcanic uplands of lower Lincoln Creek and Ross Fork Creek basins. The ground water is believed to flow beneath the Blackfoot River west of Lincoln Creek, travelling in a southwest direction. It would pass beneath the Chicken Flats and Stephen Peak areas to enter the Buckskin Basin area. The rock in the area northeast of Buckskin Basin is predominately Tertiary rhyolite which is older than the Snake River basalt and usually less permeable. The Buckskin Basin, and Gibson Butte to the north, is underlain by the more recent basalt flows. This area may have been the source of the flows beneath the Gibson Terrace.

Several wells provided reasonably good records in the lower basin area. Two automatic water level recorders were operated on abandoned wells in Buckskin Basin. Two additional wells there were monitored monthly. Three wells downstream of the basin were also monitored monthly.

The wells in Buckskin Basin generally did not exhibit the typical seasonal variations found in other Snake Plain wells to the northwest. This may be due to the basin being relatively isolated from surface water irrigation systems. The record of well 4S/36E-20bcbd, near the southeastern edge of the basin, exhibits a slight seasonal cycle of less than one foot (Figure 35). It also exhibits a steady decline of approximately one foot per year since 1973. This decline is similar to conditions found on the Gibson Terrace, although of a somewhat greater magnitude, and is due to the general decline in precipitation amounts since 1971. The well was abandoned as inadequate for irrigation supplies. It does penetrate the basalt, which at this area lies above the water table, and withdraws water from the older underlying sedimentary rock. Thus the decline probably represents reduced recharge from the Ross Fork basin to the east.

The abandoned well at 4S/36E-30bbdc is believed to no longer represent the main aquifer. The static level remained remarkably constant (Figure 36), at approximately 30 feet above the regional water table. This level may represent a perched water system or signify some sealing of the lower aquifer.

The stock well located at 4S/35E-12bddd (Figure 37) exhibits a static level comparable with the Snake aquifer. However, it also exhibits a somewhat erratic pattern. During the latter part of

FIGURE 35.
WELL: 4 S/36 E 20 bcbd   Depth: 400'   Land surface: 4785 feet
Open hole: 120'-400'   Measuring point: 4785 feet

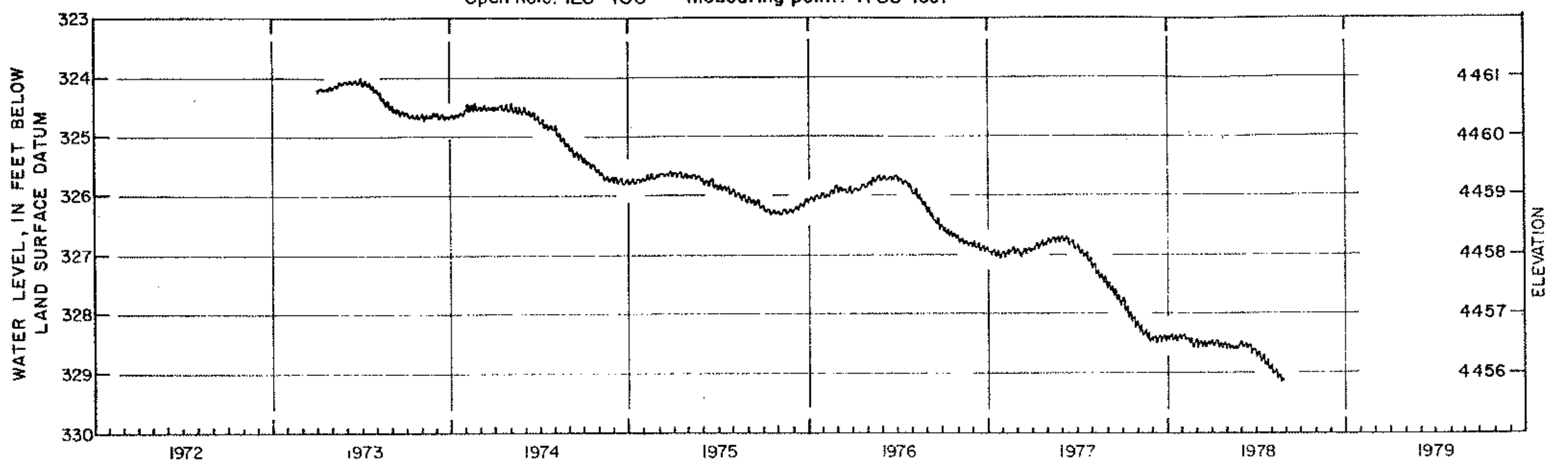


FIGURE 36.
WELL: 4 S/36 E 30 bbdc   Depth: unknown   Land surface: 4722 feet
Measuring point: 4722 feet

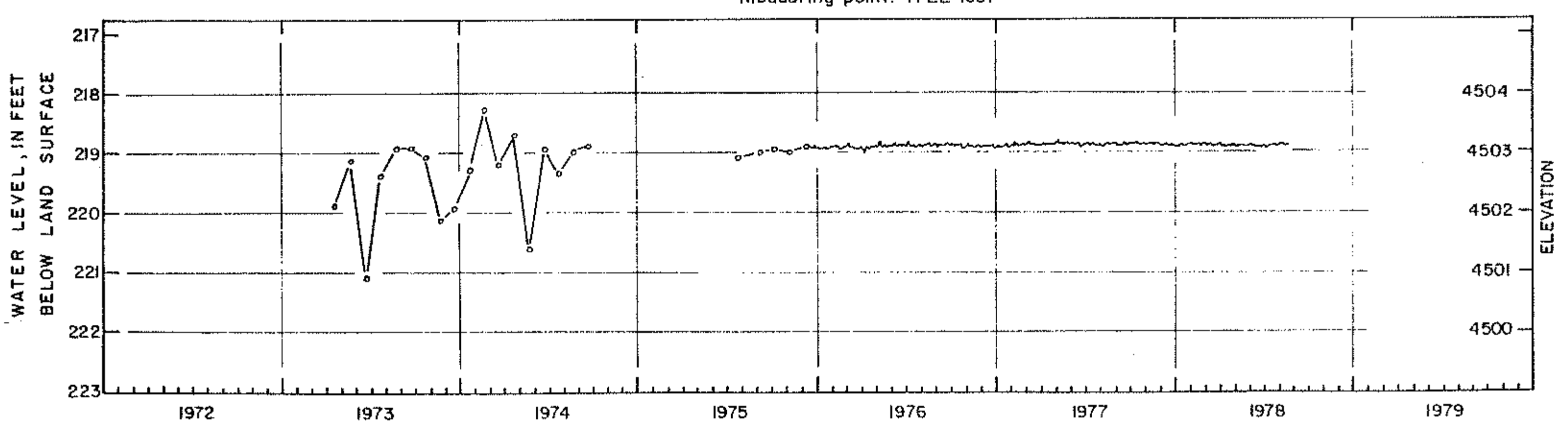
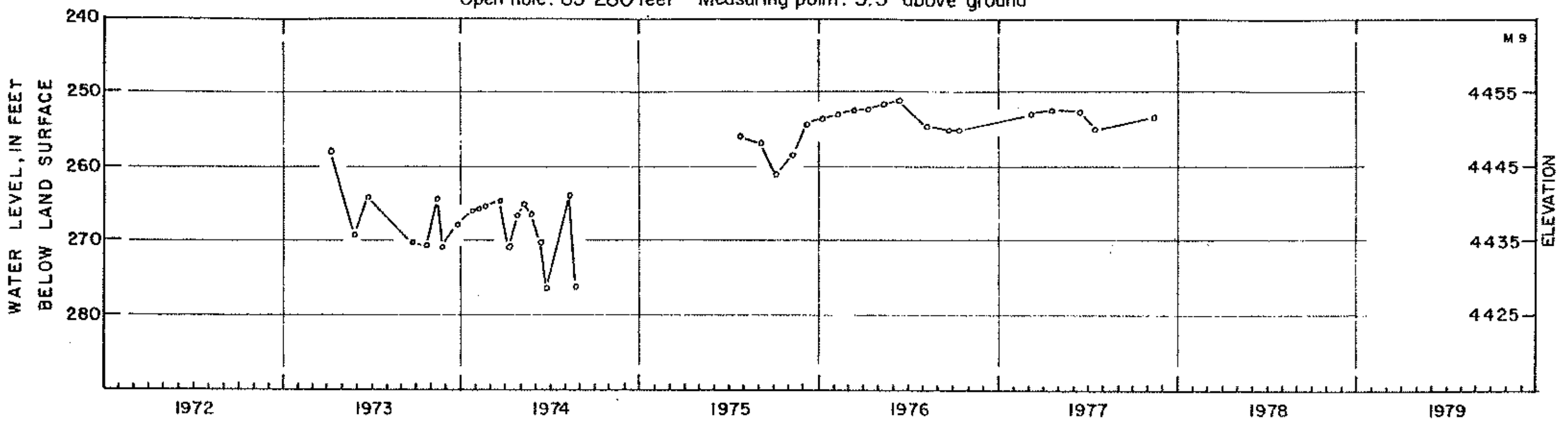


FIGURE 37.

WELL: 4 S / 35 E 12 bddd — Depth: 280 — Open hole: 65-280 feet — Land surface: 4705 feet — Measuring point: 3.5' above ground



1977, no readings could be obtained. This may indicate a drying up of the well, which was originally drilled to 280 feet, or an obstruction in the well.

The remaining well monitored, 4S/35E-24cacd, was the only production well suited for observation. Unfortunately, the other production wells lacked good access. The access to this well also became obstructed in 1976. The record (Figure 38) provides little information on seasonal variation or general trends, although an increasing water table is indicated prior to 1976. It was found that drawdowns during pumping were only about 20 feet.

Downstream of Buckskin Basin, two wells near the Ross Fork channel were monitored (4S/35E-33db and 4S/35E-34cab). Both are 250 feet deep and have static levels somewhat higher than the main aquifer to the north. This is believed due to recharge from the hills to the south and from stream flow loss in Ross Fork. Also, the Snake Plain aquifer may pinch out in this area as it abuts against the headlands. A third well, just north of the basin divide in 4S/35E-28acaa (Figure 39) is believed drilled into the basalt and exhibits a marked seasonal variation, totaling about six feet, which matches Snake Plain aquifer wells on the adjacent Gibson Terrace.

WATER BUDGET

The entire Ross Fork basin, ending at the Fort Hall Main Canal, contains 167 square miles. The mean annual precipitation for the entire basin is considered to be 16.5 inches, which provides for approximately five inches of total water yield, or 61.3 cfs (44,400 acre ft/year). The surface water yield for the basin is 34.6 cfs at the gage. Of the remaining 26.7 cfs designated as ground water, the majority, or approximately 20 cfs, would be generated by precipitation on the North and South Fork basins. The remaining 6.7 cfs would be contributed from the lower basin. It is estimated that approximately 11,200 acre feet of ground water (15.5 cfs) is withdrawn in the Buckskin Basin area for irrigation. This would be a significant portion of the Ross Fork ground water flow; however, its withdrawal has little effect on the ground water table. This is the main indication that a large amount of ground water is imported into the basin, via the Snake Plain aquifer.

FIGURE 38.
WELL: 4 S / 35 E 24 cacd   Depth: unknown   Land surface: 4652 feet
Measuring point: 4652'

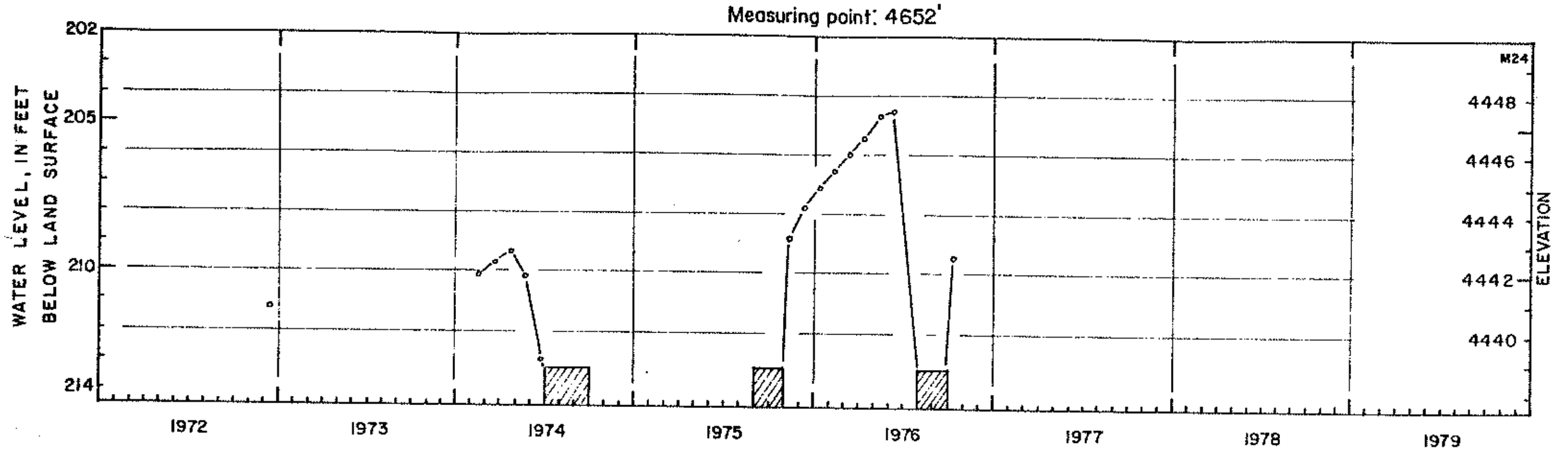
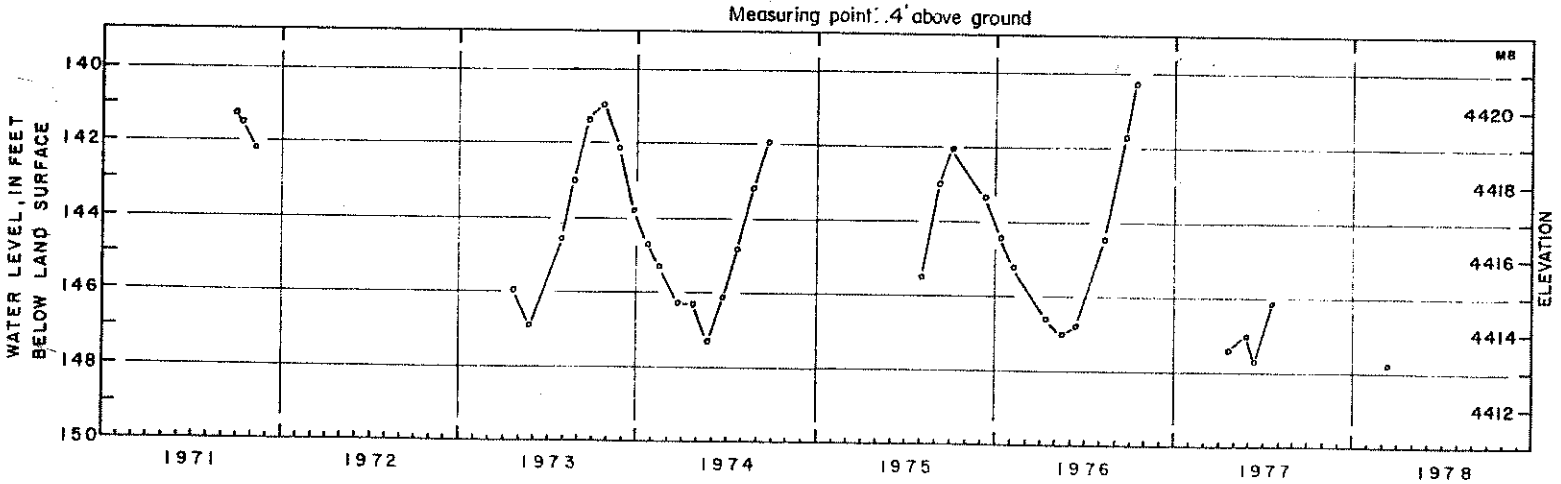


FIGURE 39.
WELL: 4 S / 35 E 28 acaa   Depth: unknown   Land surface: 4561 feet
Measuring point: .4' above ground



WATER QUALITY

SURFACE WATER QUALITY

Table 17 lists the averaged chemical qualities of the Ross Fork surface waters discussed below.

Contact Spring

Contact Spring is located at the head of the North Fork of Ross Fork in 5S/37E-15addc. It is a perennial spring and was named by the author due to the change in soil color near the spring. No flow measurements were made at the spring, but it was visually estimated at less than 1 cfs. The 1977 flow was significantly lower than the 1975 flow, presumably due to the drought of that year.

The water is significantly less mineralized than most reservation water, particularly with respect to sulfate and chloride. The water is moderately hard, due in part to its flow through the limestone and dolomite rock in the area.

Big Spring

Big Spring is located in 5S/37E-16addb, and provides the majority of the baseflow to the North Fork of Ross Fork. No flow measurements were made at this spring. It flows year-round, usually several cubic feet per second, although its flow was decreased in 1977.

The quality of the water is almost identical with that of Contact Spring, indicating they may drain the same ground water reservoir. The water quality remained fairly constant over the two years in which samples were taken.

North Fork-Ross Fork

The water quality of the North Fork of Ross Fork was sampled at the head of Farmer Ditch, at the flow measuring station. The analyses here show an increasing mineralization of the water as it travels downstream. Almost all of the parameters measured showed increases. The probable cause of this increase is inflow of higher mineralized spring water into the stream, along with some impact from the existing land uses in the upper basin.

TABLE 17

UPPER ROSS FORK BASIN

AVERAGED SURFACE WATER QUALITY

Location	Turbidity FTU	Temperature ^{o}F	Conductivity μ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfaie mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Contact Spring 5S/37E - 15 addc	1.5	44	230	7.94	128	128	9	1	0.08	0.4	-	0.04	0.21	-	2
Big Spring 5S/37E - 16 addb	0	46	237	7.80	121	125	8	2	0.10	0.4	0.01	0.02	0.28	-	4
North Fork-Ross Fork 5S/36E - 10 ac	10	47	404	7.95	147	172	33	11	0.25	0.3	0.03	0.08	0.39	10	20
Gay Mine Spring 4S/37E - 27	0	48	1510	7.50	262	498	195	147	0.16	0.6	0.14	0.05	0.52	-	2
Lone Pine Creek 4S/36E - 27	4	51	1175	8.13	283	462	153	54	0.31	0.5	0.14	0.05	0.52	-	3
Thirty Day Creek 5S/36E - 33 ddd	7	49	77	8.18	45	50	5	5	0.11	0.2	0.07	0.09	0.48	-	1
Mill Creek 5S/36E - 34 bca	3	57	213	7.87	108	108	6	0	0.15	0.3	0.03	0.08	0.40	8	6
South Fork-Ross Fork 5S/36E - 28 accb	8	48	347	7.78	127	150	31	10	0.20	0.4	0.05	0.15	0.40	10	20
Putnam Creek 5S/36E - 23 dccd	3	46	93	7.51	50	50	8	4	0.13	0.2	0.03	-	0.41	-	1
Ross Fork 4S/35E - 35 cab	22	49	541	8.09	202	217	42	18	0.27	0.3	0.06	0.07	0.44	10	22

These impacts include dry farming, phosphate mining, and cattle grazing.

There is generally an inverse relationship between the dissolved minerals and discharge, with dilution of the minerals occurring during the spring flood season. Mineral concentrations were cut approximately in half during the higher discharges. The only parameters to increase during flooding were turbidity and phosphate.

Gay Mine Spring

This spring is located in the vicinity of the Gay Mine and is used for the mine water supply. The water is very hard, with high levels of chloride and sulfate. The quality is similar to other springs that flow from the Wells formation in this area.

Lone Pine Creek

This creek originates from very small springs that combine and flow down the Lone Pine Canyon. This water, like the Gay Mine Spring, is very hard, with high chloride and sulfate levels.

Thirty Day Creek

Thirty Day Creek originates on the west flank of South Putnam Mountain and flows into the South Fork of Ross Fork. No flow measurements were made on this creek. One sample was taken of the base flow during the 1977 drought. It showed the quality to be very good, with a very low concentration of dissolved minerals. The water is classified as soft. This low mineralization is probably due to a combination of high snowmelt runoff, a short travel time in the basin, and the presence of quartzite bedrock, which is very resistant to weathering.

Mill Creek

Mill Creek originates between North and South Putnam Mountains and flows west into the South Fork of Ross Fork. During the summer this creek provides water for the Smoke Irrigation Ditch. The water quality was sampled at the head of Smoke Ditch, at the flow measuring station.

The quality of this water, while more mineralized than Thirty

Day Creek, is still very good, and is similar to Big Spring on the North Fork. This is probably due to the presence of similar bedrock in both areas. The baseflow quality measurements taken in 1977 show a very constant level of dissolved minerals over the summer.

South Fork-Ross Fork

The South Fork samples were taken at the discharge measuring site, upstream of the Rose Farm. These analyses showed a higher level of minerals than the tributaries, although the levels were still slightly less than the North Fork. One exception was the concentration of iron. It was noted that the levels of iron in the streams originating on Mt. Putnam are usually higher than elsewhere on the reservation. The levels of dissolved minerals were fairly uniform over the study period, with some dilution occurring during the spring runoff.

Putnam Creek

Putnam Creek originates on the northwest slope of Mt. Putnam and crosses Farmer Ditch on its path to Ross Fork. It was named by the author and sampled once in 5S/36E-23d. The creek becomes ephemeral in its lower reaches as it flows across the alluvial fans of Mt. Putnam. The quality is very good, with very low concentrations of most constituents tested, as was the case with Thirty Day Creek.

Ross Fork

Water quality samples were taken at the gaging station on Ross Fork, downstream from Buckskin Basin. This is below the Ross Fork Minor Irrigation Unit, and receives some irrigation return flow. The water here contains higher concentrations of dissolved minerals than either the North or South Forks. These increases are probably due to the irrigation system and dry farm impacts. While turbidity is generally higher, there is no apparent increases in nutrient levels due to this activity. Dilution of all constituents except turbidity occurs during the spring runoff.

An EPA survey done in 1974 showed similar levels of dissolved material, along with very low pesticide levels.

GROUND WATER QUALITY

The ground water sampled from wells in the South Fork valley has variable quality, depending on location (Table 18). The upper valley ground water is similar to the South Ross Fork chemistry, having a low sulfate level and relatively low hardness. A domestic well in the North Fork valley (4S/36E-32adb) discharges very hard water, high in sulfate and flouride. This is characteristic of other ground water around the Gay Mine area. Ground water sampled from the basalt of Buckskin Basin indicates a quality somewhere between these other two extremes. It is somewhat similar to the average ground water quality beneath Gibson Terrace,although higher in hardness and chloride and lower in fluoride. This type of water also occurs in the Putnam Lodge well, which withdraws water from the basalt flow that partially extends up the Ross Fork valley.

SUMMARY

The majority of the springs in the North Fork basin, such as Big Spring, are of good quality, with low hardness, sulfate, and chloride levels. This type of water provides the majority of the baseflow to Ross Fork in this area. Other springs to the north of the creek, with smaller discharges, were found to have very high levels of dissolved minerals. Springs such as these probably contribute to the increasing mineralization of the North Fork as it flows downstream. The impacts on the stream water quality presently appear to be dry farming, phosphate mining, and range activities, although the magnitude of these impacts appears to be minimal.

The South Fork is somewhat similar in chemistry. Tributary spring flows are generally of very low mineralized water, most of which is derived from snowmelt from Mt. Putnam. The water increases in mineralization in the downstream direction, probably due to land use impacts and inflow of harder spring water. The water of both the North and South Forks is used in this area in the Minor Unit Irrigation System. All streamflow is usually diverted into the ditches, especially during the late summer. The return flow to the creek is augmented by additional springflow, however the resulting streamflow is

TABLE 18

ROSS FORK BASIN

AVERAGED GROUND WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity μ-mhos per cm	pH	Total Alkalinity mg/1 $CaCO_3$	Total Hardness mg/1 $CaCO_3$	Chloride mg/1 Cl	Sulfate mg/1 SO_4	Ortho Phosphate mg/1 PO_4	Nitrate mg/1 N	Ammonia mg/1 N	Iron mg/1 Fe	Fluoride mg/1 F	Dissolved Oxygen mg/1	Number of Samples
Well 4S/35E - 24 cacd	0	52	715	7.69	237	270	51	28	0.14	0.8	0.00	0.03	0.37	-	3
Well 4S/36E - 32 adbb	4	53	968	7.52	192	418	16	243	0.18	0.4	0.00	0.16	1.07	-	3
Well 5S/36E - 5 cbdc	1	54	460	8.00	160	165	22	6	0.23	0.4	-	0.04	0.34	-	1
Well 5S/36E - 6 aaab	2	46	750	7.65	295	285	48	23	0.15	0.7	0.04	0.03	0.51	-	1
Well 5S/36E - 17 acac	-	58	395	8.18	185	180	15	1	0.60	0.4	0.02	0.20	-	-	1

higher in dissolved solids than the upstream tributaries. The agricultural activities also contribute to a higher turbidity in the stream below the Minor Unit.

UPPER PORTNEUF RIVER BASIN

BASIN DESCRIPTION

The Portneuf River originates from several springs in the Lincoln Peak area, and flows south between the Chesterfield Range to the east and the Portneuf Range (Mt. Putnam) to the west. It is impounded in the Portneuf Reservoir as it leaves the reservation. It receives tributary inflow from Jeff Cabin Creek within the reservation, and from the Toponce basin, the northernmost part of which lies to the west of Jeff Cabin Creek.

Jeff Cabin Creek flows southeast in a basin between Mt. Putnam and the Portneuf River. It enters the Portneuf River above the Reservoir. Jeff Cabin basin contains 11.3 square miles and lies entirely within the reservation.

Both Little Toponce Creek and North Fork Toponce Creek drain an area to the east of South Mt. Putnam and southwest of Jeff Cabin Creek. They flow generally southeast and leave the reservation. They combine after leaving, along with other tributaries, and enter the Portneuf River downstream of the Portneuf Reservoir. The area of the Toponce basin within the reservation is 10.6 square miles.

The Portneuf River continues south to Lava Hot Springs, where it turns and begins a northwesterly course through McCammon, Inkom, and Pocatello. It re-enters the reservation downstream of Pocatello in the Portneuf Bottoms, and then becomes impounded in the American Falls Reservoir.

The entire Portneuf River basin above the USGS gage at Pocatello includes 1,250 square miles. A total of 91.8 square miles, including the Toponce basin and 0.26 square miles of the Pocatello Creek basin, lies within the reservation. This amounts to seven percent of the Portneuf River basin. In this report, the Portneuf River basin is considered to end near the USGS Pocatello gage. The downstream segment of the river in the Portneuf Bottoms is included as a part of the Snake Plain.

GEOLOGY

The upper basin of the Portneuf River contains a wide variety of rock types. The hills from Lincoln Peak south to the Baker Canyon area are composed of Triassic marine shales and limestones. The Mt. Putnam area, including the Toponce and Jeff Cabin Creek basins, is underlain by older Ordovician and Cambrian quartzites, dolomites, and limestones. At lower elevations in various parts of the basin, Carboniferous limestones, including the phosphate shales, occur.

The lower relief areas in the basin are covered with alluvial fan deposits and river alluvium of unknown thickness. The only geologic mapping of the basin was done in 1913 by Mansfield (1920).

HYDROLOGY

DATA SOURCES

No government agencies currently monitor streamflow in the upper Portneuf River Basin within the reservation. The USGS did maintain a gaging station on the Portneuf River just upstream of the Portneuf Reservoir from 1912 to 1914. However, no measurements have been taken by them since that time.

For this study, a recording gage station was established in 1973 in 6S/38E-3d near the old USGS station. Also, monthly measurements were taken on Little Toponce Creek and the two branches of the North Fork of Toponce Creek where they leave the reservation. In addition, periodic measurements were made on Jeff Cabin Creek. These stations were generaly inaccessible during the winter and early spring.

No wells were monitored in the upper basin area. Only one shallow domestic well is known to exist and is located at the Faulkner Ranch.

SURFACE WATER

Portneuf River - above Reservoir

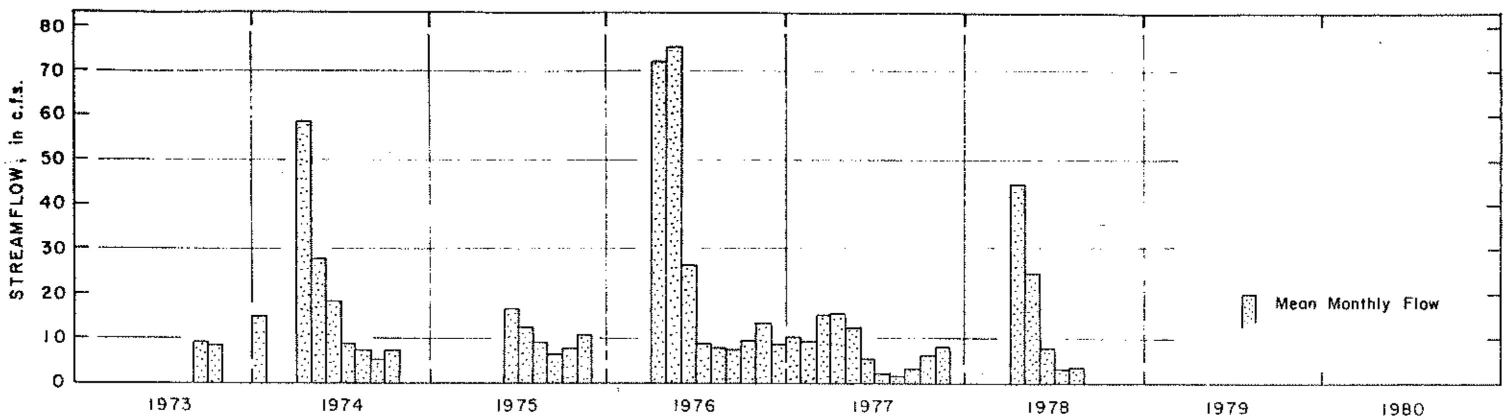
Figure 40 shows the mean monthly flow during 1912-1914 and

FIGURE 40.

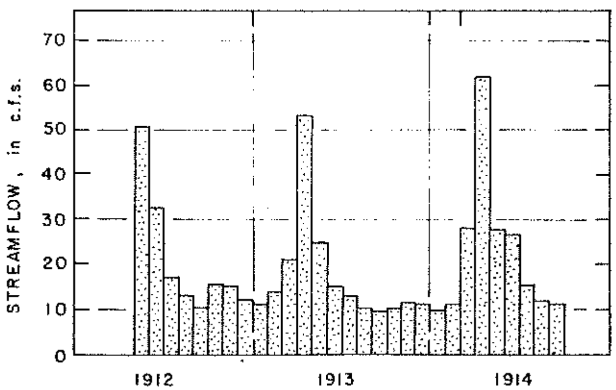
PORTNEUF RIVER BASIN
PORTNEUF RIVER above Reservoir

Location: 6S/38E-3d
Elevation: 5400 feet

Drainage area: 78.3 sq. mi.



USGS STATION 130700
MEAN MONTHLY DISCHARGE 1912-1914



1973-1978. The mean annual discharges for the 1913 and 1914 water years were 17.7 and 19.4 cfs respectively. Above normal precipitation was received during that time. Comparable values of 18.6 and 22.0 cfs were found during the 1974 and 1976 water years. The 1975 water year lacked sufficient data for a representative flow. The lowest baseflows for the 1974 and 1976 years were about 7 cfs. During the 1977 water year, due to reduced recharge, the low flows approached 2 cfs, with an annual mean flow of 8.94 cfs. Flow measurements made during the 1978 water year indicated a return to near normal baseflows in late 1977 and normal runoff flows during the spring of 1978. The mean annual flow for the 1978 water year was 13.9 cfs.

Jeff Cabin Creek

Jeff Cabin Creek is the main tributary to the Portneuf River before it leaves the reservation. It flows generally southeast, joining the Portneuf just south of Faulkner Ranch. Its channel in many places is composed of a succession of beaver ponds. Hence, evaporation would be expected to significantly reduce the flow during summer months. As its flow is included in the Portneuf River station, only a few measurements were made to determine baseflows (Figure 41). Measurements were made about three miles upstream of the mouth, because there are indications that the stream may lose flow as it approaches the Portneuf River floodplain.

The September, 1976, measurement of 1.68 cfs is probably a fairly representative indication of normal summer baseflows. This was reduced during the 1977 drought to about 1.2 cfs. The 1974 measurement of 6.4 cfs represents a flow influenced by spring runoff.

North Fork Toponce Creek

The North Fork of Toponce Creek originates on the eastern slope of South Mt. Putnam. It flows generally southeast and leaves the reservation about 3.5 miles from its source. Before leaving, the channel divides on an alluvial fan, forming two separate channels that rejoin about 0.5 miles south of the reservation. The combined flow measurements of these two channels are shown in Figure 42. The streams were inaccessible during the winter; hence some portion of the spring runoff data is

FIGURE 41.
PORTNEUF RIVER BASIN - JEFF CABIN CREEK
Location: 5 S / 38E 32 dba
Elevation: 5640 feet

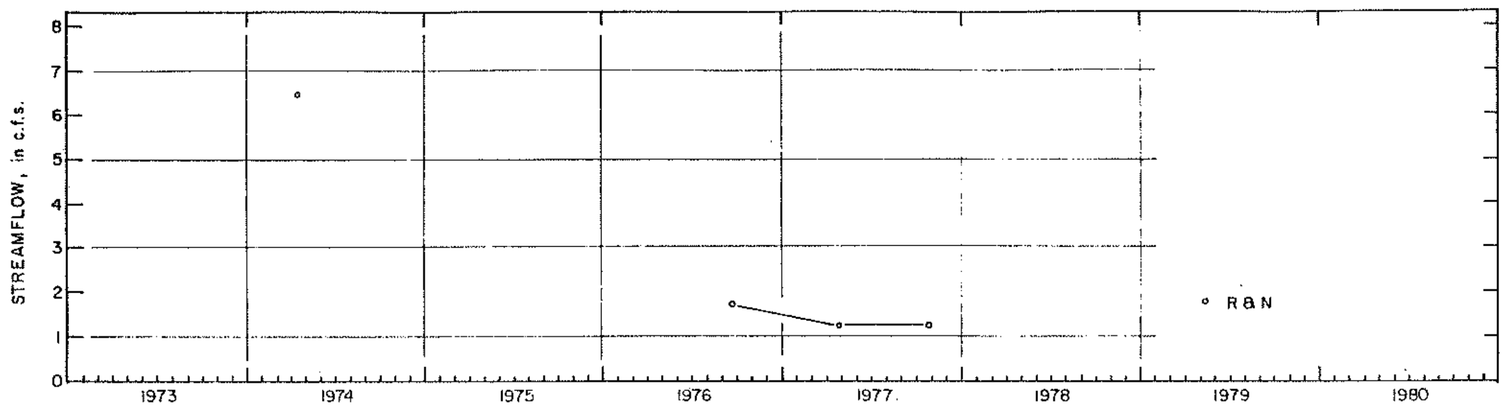
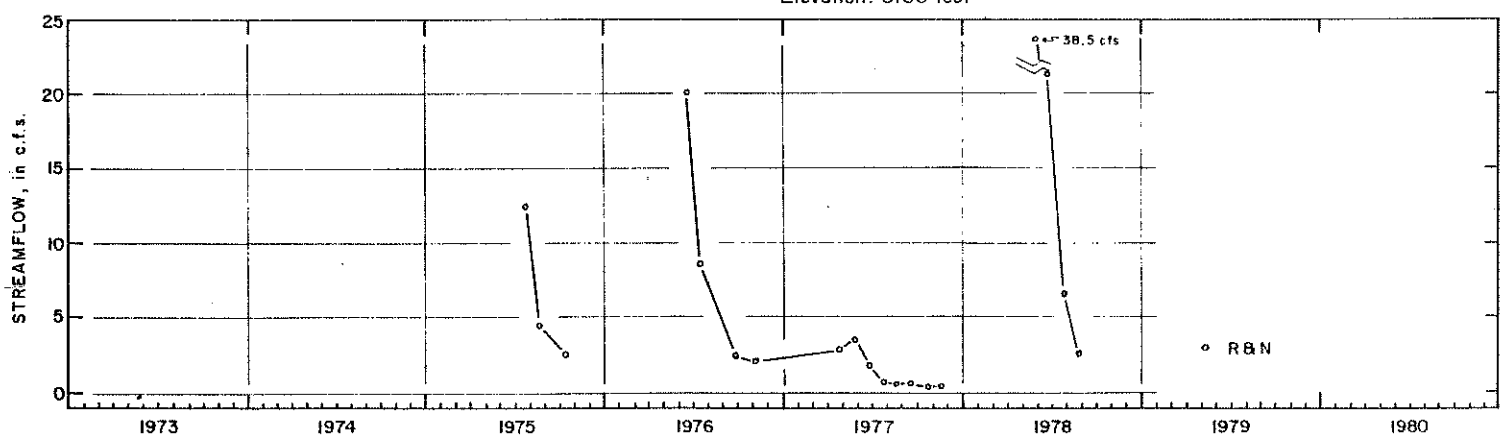


FIGURE 42.
PORTNEUF RIVER BASIN - NORTH FORK TOPONCE CREEK
Location: 6 S / 37 E 12 dc
Elevation: 6160 feet
Drainage area: 4.78 sq. mi.



absent. The flow measurements were made at the reservation border.

The mean flow for the 1976 water year is 8.43 cfs; however, this is based on only four measurements. Minimum baseflows during 1975 and 1976 were near 2.0 cfs. During the 1977 water year, the mean flow was only 1.75 cfs, with minimum baseflows reduced to 0.4 cfs by October, 1977. By this time, the western channel had dried completely. Spring runoff flows returned to normal in 1978. Spring runoff was usually in excess of 20 cfs by June, with actual flood flows probably much higher. The average for the 1978 water year was 11.6 cfs.

The surface water yield for this basin is very high relative to the other basins of the reservation. The 1976 flows averaged 1.76 cfs per square mile of basin. This compares to 0.25 cfs per square mile for the upper Portneuf River basin. This high yield can be attributed to the high amount of snowmelt runoff from the south Mt. Putnam area.

Little Toponce Creek

The Little Toponce Creek flows parallel to the North Fork Toponce Creek, between it and Jeff Cabin Creek. The stream begins in a valley opposite of Bear Canyon of Ross Fork, and flows 3.5 miles before leaving the reservation. It joins with the North Fork about 1.5 miles downstream of the reservation. Like the North Fork, the stream was inaccessible during the winter. The measuring station was established at a road crossing about 0.3 miles upstream of the reservation border.

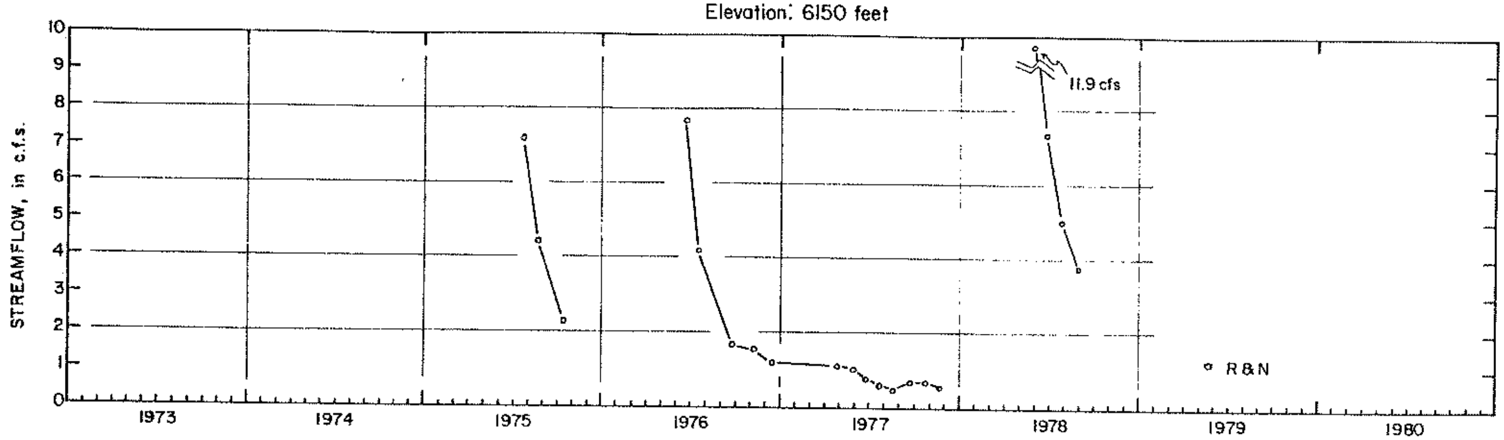
The mean flow for the 1976 water year was 3.93 cfs, with minimum baseflows in late 1976 of about 1.5 cfs. The mean flow fell to 0.92 cfs during the 1977 water year, with the lowest flow measured at 0.45 cfs in August, 1977. The spring runoff discharge measured in 1978 showed a return to normal conditions. The earliest runoff flows measured were between 7 and 10 cfs, with flood flows probably higher. The average flow for the 1978 water year was 4.85 cfs. (Figure 43).

Although the basin area is approximately the same as the North Fork's, flows for the Little Toponce were about half as much. The discharge per area for the Little Toponce for 1976 was 0.91 cfs per square mile, compared with 1.76 cfs per square mile

FIGURE 43.
PORTNEUF RIVER BASIN - LITTLE TOPONCE CREEK

Location: 6 S/38 E 7cac
Elevation: 6150 feet

Drainage area: 4.33 sq. mi.



for the North Fork. This may be due to the Little Toponce basin being at a lower elevation than the North Fork, hence receiving less snowfall. Maximum elevation in the Little Toponce Basin is near 7,900 feet, while the maximum for the North Fork is over 8,900 feet.

Portneuf River - Off Reservation

As the Portneuf River continues downstream of the reservation, it receives additional flow through tributaries and ground water inflow to the channel. Major tributaries to the Portneuf include Toponce Creek, Marsh Creek, Rapid Creek, and Mink Creek. The river receives ground water inflow until it reaches the McCammon area. Between McCammon and Inkom, the ground water table falls beneath the level of the Portneuf. Norvitch and Larson (1970) have presented preliminary calculations that indicate that 87 cfs is lost from the river between McCammon and Pocatello. Presumably, this water flows through the aquifer beneath Pocatello. It is known that this aquifer has a very high transmissivity; the city has several high-yield municipal supply wells in operation. The Portneuf River loss may be the major source of this ground water flow. The lower Portneuf River hydrology is discussed in the Snake Plain section.

GROUND WATER

In the upper Portneuf basin, upstream of the Portneuf Reservoir, little information is available on the ground water flow. Two studies of the Portneuf basin have dealt with the water resources in the surrounding area. The first was by Stearns and others (1938) and the second was by Norvitch and Larson (1970). Both studies produced ground water contour maps that are essentially similar. Stearns shows the water table elevation near the Portneuf Dam to be near 5,350 feet. Norvitch and Larson showed the same elevation, and also show the water table around the reservoir to be at 5,400 feet. This is near the ground surface elevation, indicating the depth to water in the valley bottom to be only several feet. The static level in the Faulkner well is reported to be 16.5 feet.

Both studies show the ground water in this area to be flowing south, along the Portneuf River. As the river flows south, it gains in flow as the ground water discharges into the river.

The presence of springs in the valley bottom within the reservation confirms the high water table and ground water discharge to the river. The ground water in the valley bottom is contributed primarily by precipitation falling on the adjacent uplands which flows down through the alluvial material on the hillslopes to the sediments filling the valley.

Other than the well drilled at the Faulkner Ranch, no wells exist in the upper valley within the reservation. Consequently, there is little information regarding valley fill thickness and sediment type. The unconsolidated material probably contains most of the ground water in the upper basin. The various bedrock types composing the uplands do contain some ground water. Little would be expected in the quartzites near Mt. Putnam; however, the limestones and shales could contain appreciable amounts. The flow of the ground water in these rock units would be primarily controlled by the structure and stratigraphic relationship of the rock units. Work at the Gay Mine has indicated that pockets of ground water are usually small and discontinuous. These bodies of water usually discharge as spring flow as the water table rises to intersect the land surface. This creates the many upland springs in the basin.

WATER BUDGET

The upper basin of the Portneuf River receives a mean annual total of approximately 18 inches of precipitation. According to the analysis by Mundorff and others (1964), this would yield approximately six inches of total runoff. The total basin area above the measuring stations discussed herein is 99.6 square miles. Of this, 90.0 square miles lies within the reservation. The total runoff from this area amounts to about 31,872 acre feet, or 44.0 cfs. Surface water measurements indicate the average runoff from both the Portneuf and Toponce basins is about 34.4 cfs. This would indicate that approximately 9.6 cfs, or 6,950 acre feet per year, leaves the reservation as ground water flowing south beneath the Portneuf River.

WATER QUALITY

SURFACE WATER QUALITY

The averaged chemical analyses for the surface water stations discussed below are listed in Table 19. The individual analyses are listed in Appendix D.

Qeedup Springs

Qeedup Springs is located in 4S/38E-32d, and flows across Alkali Flats into the Portneuf River. It is formed by three or four small springs and produces a fairly good flow, visually estimated to be between one and two cfs. This spring has several similarities with Yandell Spring. As the samples taken on October 14, 1975, indicate, there is a significant difference in quality between the individual springs; however, the combined quality is fairly constant over the year. The spring water is highly mineralized, especially with respect to alkalinity, hardness, sulfate, and fluoride. While none of these constituents are high enough to present a health hazard to those drinking the water, it is nevertheless undersirable. The third similarity with Yandell is its apparent source from the Wells Formation, a Pennsylvanian-aged limestone, and a higher than normal temperature.

Baker Canyon Creek

Baker Canyon Creek is the name given to a small spring that flows eastward down the south side of the Bakers Canyon Road, toward Qeedup Spring. The creek flows intermittently, and was dry during the summer of 1977. The two quality samples taken on the creek show a significant variation. These samples were taken at different locations along the creek, so it is not known if the variation occurred in the spring itself or as the water flowed downstream. Both samples were of fairly good quality, only slightly more mineralized than the Bottoms Springs water.

Warm Spring

Warm Spring is a small perennial spring that originates in 5S/38E-34ccb, next to the Portneuf Valley Road north of Faulkner's Ranch. The spring flows east to the Portneuf River. The water here is of fairly good quality; alkalinity and hardness being the only higher-than-normal constituents.

Rass Creek

Rass Creek is a small perennial tributary of the Portneuf River

TABLE 19

UPPER PORTNEUF RIVER BASIN

AVERAGED SURFACE WATER QUALITY

Location	Turbidity FTU	Temperature ^oF	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Dissolved Oxygen mg/l	Number of Samples
Qeedup Spring 4S/38E - 32 dda	0	65	1221	6.91	482	607	24	181	0.15	0.4	.00	.03	0.91	-	7
Baker Canyon Creek 4S/38E - 30 cb	2	57	652	8.04	182	268	56	58	0.10	0.2	.00	.04	0.43	-	2
Warm Spring 5S/38E - 34 ccb	0	62	605	8.00	275	300	12	37	0.20	0.3	.00	.02	0.22	-	1
Rass Creek 5S/38E - 27 ccdb	2	35	440	8.39	170	200	10	33	0.14	0.3	.03	.02	0.29	-	1
Jeff Cabin Creek 5S/38E - 32 dba	4	54	325	7.88	167	167	11	1	0.18	0.3	.03	.12	0.33	9	5
Portneuf River 6S/38E - 3 da	6	52	656	8.10	269	306	25	48	0.29	0.3	.07	.04	0.53	10	13
Toponce I 6S/37E - 13 abba	4	53	41	7.55	23	24	5	0	0.07	0.3	.06	.14	0.29	9	9
Toponce II 6S/37E - 13 aaba	6	51	37	7.21	21	20	5	0	0.09	0.3	.08	.30	0.29	8	11
Toponce III 6S/38 E - 7 cacc	11	55	61	7.29	31	31	6	0	0.12	0.3	.10	.51	0.28	8	11

and was sampled at 5S/38E-27ccdb at the road crossing. The flow was visually estimated at 0.5 cfs. The water is of fairly good quality, having relatively low levels of the minerals tested.

Jeff Cabin Creek

Jeff Cabin Creek is one of the main tributaries of the Upper Portneuf River. The water is apparently derived from Ordovician and Cambrian quartzites and limestones. The quality of the water is very good, with low levels of minerals and nutrients. The quality appears fairly stable throughout the year.

Portneuf River

The upper Portneuf River water quality was monitored at the recording gage station above the Portneuf Reservoir. The flow here is composed of springs of varying chemical quality, as described above. Generally, the water is somewhat more mineralized than is found on the Bottoms area, due to the input of springs such as Qeedup. However, none of the minerals that were tested for reached the undesirable level. The low-flow conditions during 1977 did not seem to affect the quality measurably, except possibly with lower dissolved oxygen levels.

North Fork - Toponce Creek

The North Fork of Toponce Creek diverges before leaving the reservation, probably due to beaver activity. These two branches were sampled at the reservation boundary as stations Toponce I and II. As expected, the quality is fairly similar. What is notable are the very low levels of dissolved minerals in these streams. This water is probably the least mineralized found on the reservation. The quality showed little variation throughout the year. A notable exception to the low mineralization is the high iron concentration, which approaches or exceeds the drinking water standard. This was found to be characteristic of some of the streams draining the Mt. Putnam area.

Little Toponce Creek

Little Toponce Creek exhibited slightly higher chemical concentrations than the North Fork, but again very low in comparison with the rest of the reservation. Again, the notable exception was iron, which commonly exceeded the drinking water standard of 0.3 mg/l. As with the North Fork, little seasonal variation in quality was noted.

BANNOCK CREEK BASIN

BASIN DESCRIPTION

The Bannock Creek basin occupies the southwestern portion of the reservation. Bannock Creek drains the valley between the Deep Creek Mountains on the west and the Bannock Range to the east. It rises in Oneida County about 15 miles south of the reservation boundary, and flows north, entering the reservation just north of Pauline. The creek continues north through the reservation, crosses the Michaud Flats area of the Snake River Plain at the northern end of the two mountain ranges and enters the American Falls Reservoir. The total basin area above the I-15W bridge is 413 square miles. The area within the reservation is calculated to be 154 square miles,or 39 percent of the total basin.

Bannock Creek receives the flow of several perennial tributaries within the reservation. The three most important, in downstream order, are West Fork, Moonshine Creek, and Rattlesnake Creek. West Fork originates in a group of springs at the base of West Fork Canyon in the Deep Creek Mountains. It flows easterly, and enters the reservation before joining Bannock Creek. The West Fork basin, as measured from the point where it enters the reservation, includes 14.9 square miles, of which only 0.8 square miles, or five percent, lies within the reservation.

Moonshine Creek also originates in the east flank of the Deep Creek Mountains, north of Bannock Peak. Three tributaries, Keogh Creek, Sawmill Creek, and Squaw Creek, contribute to its flow from the uplands. Much of the baseflow is apparently contributed by springs near the Arbon Valley floor, prior to the stream entering Bannock Creek. The basin contains 44.2 square miles, of which 33.3 square miles, or 75 percent, lie within the reservation.

The third main tributary, Rattlesnake Creek, enters the creek below Moonshine, draining the Bannock Mountains to the east of Arbon Valley. Rattlesnake Creek begins north of Bradley Mountain, and flows northwesterly, intercepting the tributary flows of Clifton Creek, Crystal Creek, and Midnight Creek. Both Midnight and Crystal Creeks enter the reservation before joining Rattlesnake Creek. The creek then turns west and flows into Bannock Creek. The entire basin contains 79.6 square miles, with only the lower 7.7 square miles, or 11 percent, within the reservation.

Two other smaller tributaries enter Bannock Creek; Starlight Creek from the west, and Birch Creek from the east. The Starlight basin contains 15.3 square miles, of which 14.8, or 96 percent,lies within the reservation.

Below these tributary inflows, Bannock Creek crosses, and can be diverted into the Michaud irrigation system. Upstream from this system, several small irrigation ditches divert water from Bannock and Rattlesnake Creeks. These ditches form the Bannock Creek Minor Unit.

Michaud Creek lies to the east of Bannock Creek, and drains the foothills area. It occupies a basin of 11.6 square miles, of which 5.4 square miles, or 47 percent, lies within the reservation. The creek flows north and empties into the Michaud Canal System. Prior to development of the area, it apparently emptied into Bannock Creek.

GEOLOGY

The geology of this area of the reservation was studied by Mansfield (1920) and more recently by Trimble and Carr (1976). Their work is summarized here.

The Bannock Range east of Bannock Creek is composed primarily of Precambrian and Cambrian quartzites similar to those forming Mt. Putnam. However, these rocks are not exposed at the surface within the reservation. They continue north to the Michaud Creek basin just east of the reservation line.

A ridge of foothills that runs parallel to the Bannock Range and divides the Rattlesnake basin from Bannock Creek is composed of younger dolomites and limestones southwest of Rattlesnake Creek and quartzites north of Rattlesnake Creek. These rock units range in age from Mississippian to Cambrian. They appear on the surface as far north as Flatiron Hill, north of Rattlesnake Creek.

North of this area, and extending around the north end of the Bannock Range, occur younger volcanic rocks of Tertiary and Quaternary ages. These volcanic rocks form the headlands behind the phosphate processing plants, and are named the Starlight Formation. The Deep Creek Range on the west side of Bannock Creek is underlain primarily by limestones of the Permian and Pennsylvanian ages named the Oquirrh Formation. This rock appears primarily south of the reservation and extends north only up to the Bannock Peak - Moonshine Peak area. A branch also extends further north along the western edge of the reservation, and forms the western end of the Moonshine Creek basin. The mountainous area forming White Quartz Peak, Bannock Peak, and extending northeast to Moonshine Creek is underlain by older limestones and dolomites.

North of the Squaw Creek - Moonshine Creek area, the hills are all underlain by more recent Tertiary volcanic rhyolites and tuffs of the Starlight Formation. These volcanics extend north to the Wheatgrass Bench area.

All of the mountainous areas of the basin have developed alluvial fans that cover the rocks of the lower elevations. These deposits are composed of Quaternary sands and gravels. As in the eastern part of the reservation, wind-blown silt (loess) covers much of the bedrock, thinning out at higher elevations.

HYDROLOGY

DATA SOURCES

In the Bannock Creek Basin, stream measurements are currently made by the USGS at four miscellaneous and partial-record stations. Two low flow stations are maintained to supply base flow measurements each year. These are located on Bannock Creek below Moonshine Creek (130760) and on Rattlesnake Creek (130761) above the irrigation ditches, and have been used since 1973. Prior to that, they were monitored monthly between 1955 and 1959. One crest stage station is operated on a dry gully to record the maximum spring flood each year. A miscellaneous station (130762) is located near Interstate 15W near the mouth and is monitored only during the irrigation season. This station has been monitored since 1924 as part of the American Falls Reservoir studies.

The BIA Irrigation Office also collects low flow information for Bannock Creek and the major tributaries. This has been taken intermittently since 1967.

For this study, two recording gage stations were established on Bannock Creek in 1973. The upper station is located inside the southern reservation boundary, below the confluence with West Fork. The lower station is located at a road crossing just south of USGS station 130762 and Interstate 15W. In addition, monthly measurement stations were established on all major tributaries. These include West Fork, Moonshine Creek, Rattlesnake Creek at two locations, Crystal Creek, Midnight Creek and Michaud Creek.

No wells in the Bannock Creek Basin are monitored by any agencies upstream of the Snake River Plain. Four wells were monitored in the valley bottom during this study. At higher elevations in the basin only a few abandoned stock wells are known to exist.

SURFACE WATER

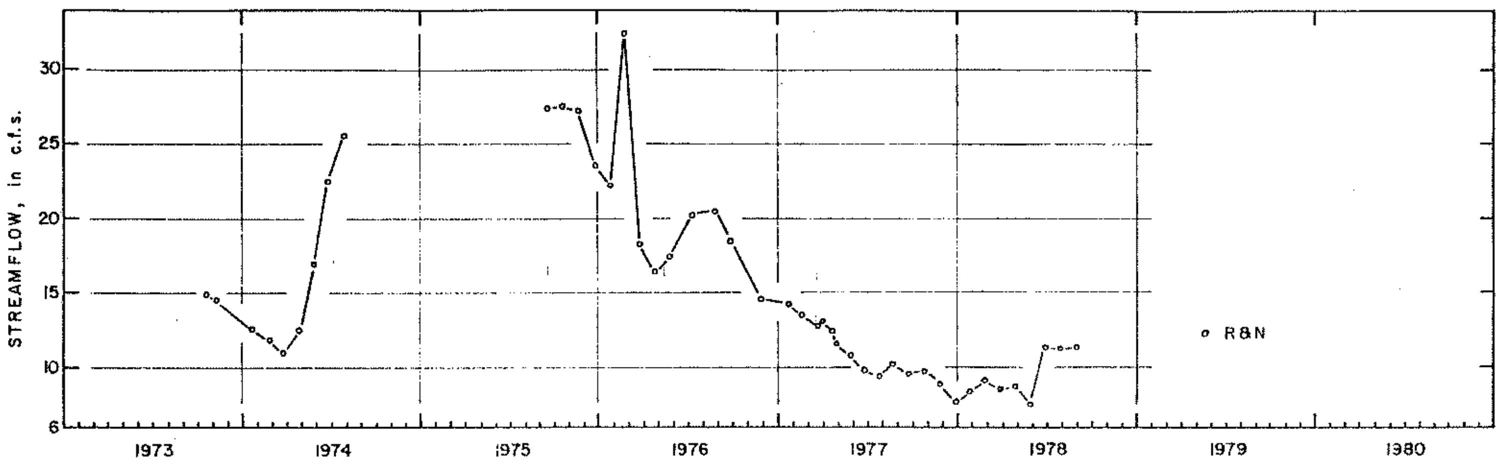
West Fork

The West Fork of Bannock Creek originates in a group of springs near the mouth of West Fork Canyon, approximately one mile south of the reservation border. Most of the springs lie in the southern half of 10S/33E-5. West Fork flows generally eastward, then swings northeast to cross into the reservation and joins Bannock Creek in 9S/33E-34. Flow measurements were made at the reservation line.

The flow measurements taken during this study illustrate an unusual spring flow history. The mean annual flows for the 1974, 1976 and 1977 water years were 15.6, 21.9, and 12.3 cfs respectively. Measurements made during the 1978 water year indicate a mean flow of 9.46 cfs. The plot of the individual measurements (Figure 44) illustrates the anomalous character. During the 1974 and 1976 water years, the springs seemed to exhibit a pattern whereby flow increased during the summer, peaked in the fall, and decreased during the winter. The discharge ranged between 11 and 28 cfs during this cycle. However, in the fall of 1976 the spring flow did not return to its previous year's high level, even though the dry months of the 1977

FIGURE 44.

BANNOCK CREEK BASIN - WEST FORK at reservation line   Location: 9S/33E 34 cdc   Elevation: 4960 feet   Drainage area: 14.9 sq.mi.



drought had not begun. Since the fall of 1976 the spring flow has steadily declined from near 20 cfs to near 8 cfs during the summer of 1978.

It is obvious that the West Fork basin alone cannot supply the flow of the springs. With approximately ten square miles of basin upstream of the springs, an equivalent of 30 inches of water over the basin is discharged as springflow. This would amount to more than the annual precipitation.

It appears that a much larger area of the Deep Creek Mountain Range drains toward the West Fork Canyon. As the range is composed primarily of limestone, the water that falls on a large area of the range is probably channeled along joints and solution cavities into the West Fork basin. As no wells exist in the higher elevations, the extent of this recharge area cannot be defined.

Two possibilities seem to exist to explain the anomalous flow behavior. The first is that the higher flows during 1974 and 1976 were due to higher amounts of precipitation in the area, with a more normal flow of near 15 cfs. However, the precipitation for the 1975 and 1976 water years was only 0.49 and 1.07 inches above normal respectively at the Pocatello Airport station, with 1974 below normal. It is doubtful that this magnitude of increase in precipitation could double the flow of the West Fork springs.

The second, more likely, possibility is that the limestone aquifer may have other discharge areas, even in other basins. The limestone bedrock extends north into the Moonshine Basin and west into the Rock Creek basin. It is possible that the aquifer may increase discharge in other basins to the exclusion of West Fork. This could be done by the opening and closing of the joints and solution cavities either by the chemical action of the water itself or movements of the rock. It has been noted that the baseflow of Moonshine Creek has steadily increased between 1967 and 1977, although not at the magnitude that West Fork has decreased. It may be that the East Fork of Rock Creek is the other main outlet of the aquifer. This spring lies on the west slope of the Deep Creek Mountains adjacent to the West Fork springs and at approximately the same elevation, near 5200 feet. Flow measurements made during the 1950's by the USGS show the East

Fork Springs to be similar in magnitude with West Fork. No recent measurements have been made, however. It may be that these two springs share varying amounts of the aquifer discharge. Only continued monitoring of the springs will provide an answer to the hydrogeologic controls on the aquifer.

Upper Bannock Creek

The Upper Bannock Creek gaging station records both the flow of Bannock Creek and the West Fork tributary, after they enter the reservation. The flow hydrograph is shown in Figure 45. The mean annual flow for the 1974, 1976, and 1977 water years was 32.3, 36.5, and 18.9 cfs respectively. Mean flow for the 1975 water year was probably in excess of 30 cfs. Baseflow measurements taken by the USGS between 1973 and 1976 at their station below Moonshine Creek support these figures. These are considerably higher than those recorded during the 1950's at their station. Part of this increase is due to above average amounts of precipitation during the last ten years, compared with below average amounts during the 1950's. However, most of the increase is apparently due to increased flow from West Fork, particularly during the 1974 to 1976 water years.

Baseflows during 1974 and 1975 were above 30 cfs at the gage. They decreased to approximately 25 cfs in 1976 and 12 cfs in 1977. This decrease was mainly due to the decrease in flow in West Fork, and partially due to the drought in 1977. The mean annual flow during the 1978 water year was 19.5, with low flows near 13 cfs. This is a result of decreasing flow in West Fork with increasing flows in Bannock Creek. Figure 46 shows the calculated flow hydrograph of Bannock Creek upstream of West Fork. It indicates that mean annual flows are near ten cfs, with summer low flows near five cfs entering the reservation.

Moonshine Creek

Moonshine Creek drains the eastern slopes of the Deep Creek Mountains north of West Fork and Bannock Peak. Three tributaries, Keogh Creek, Sawmill Creek, and Squaw Creek contribute to the flow of Moonshine Creek. The creek flows generally eastward and empties into Bannock Creek about 1.5 miles south of Rattlesnake Creek in 8S/33E-34cb.

FIGURE 45.
BANNOCK CREEK BASIN
UPPER BANNOCK CREEK at GAGE

Location: 9S/33E-34ac
Elevation: 4930 feet

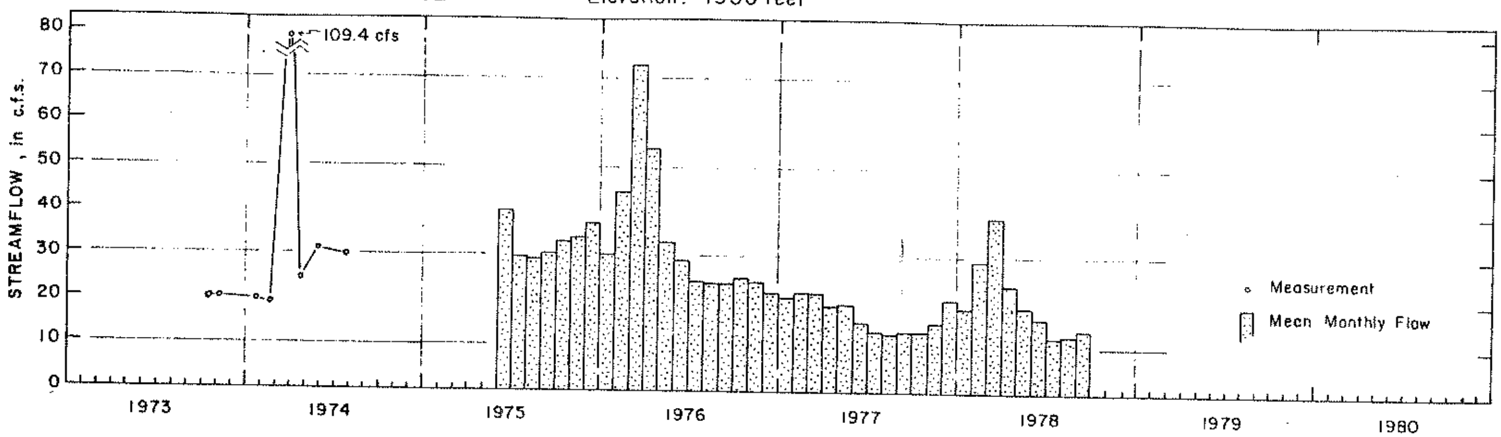
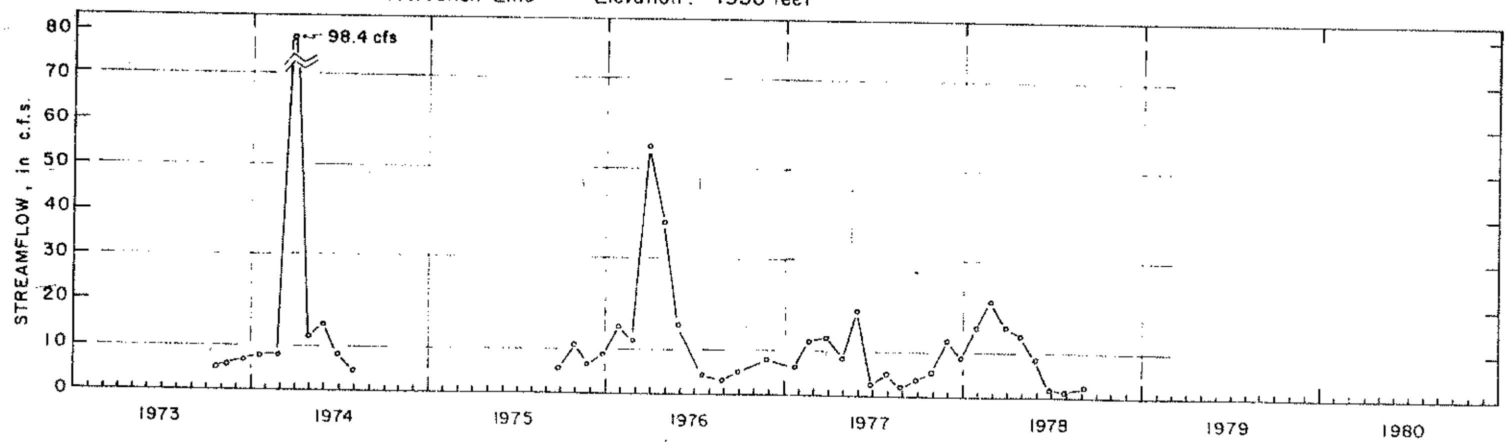


FIGURE 46.
BANNOCK CREEK BASIN
BANNOCK CREEK at South Reservation Line

Location: 10S/33E-3aaa
Elevation: 4950 feet



The discharge measurements (Figure 47) indicate that flow has increased significantly between 1967 and 1977. Measurements by the BIA Irrigation Office show baseflows of between two and three cfs in 1967 and 1968, and between three and five in 1972. Measurements taken during this study shown an increase from 5.23 cfs during the 1974 water year to 7.13 cfs in 1976. During the drought of 1977 the flows averaged 6.35 cfs. The baseflows were maintained above five cfs throughout the year.

The hydrograph (Figure 47) does not have the usual pattern of peak flows during the spring with steadily declining baseflows throughout the summer. Rather, the flow is fairly irregular. During the spring of 1976 a large flood occurred in the basin which completely filled the channel whose depth exceeds six feet. The flood flow probably exceeded 150 cfs.

Much of the baseflow contributed to Moonshine Creek apparently originates as springflow that enters the creek near the mouth. A discharge measurement taken on September 9, 1975, below the mouth of Squaw Creek, the lowermost tributary, indicated a discharge of 1.46 cfs. The discharge at the mouth at this time was near 5.0 cfs.

At present, it is not known if the increase in streamflow is related to the decreasing flow of West Fork to the south or other factors. Both basins share the limestone bedrock that predominates in the Deep Creek Range, although the water of Moonshine Creek is significantly harder than that of West Fork.

<u>Bannock Creek - below Moonshine Creek</u>

The USGS maintained a recording gage on Bannock Creek at 8S/33E-28da between 1955 and 1959. The mean monthly discharges are shown in Figure 48. Summer baseflows during this period usually ran near ten cfs. This is far below the baseflows recorded during the present study. Continued measurement at this site by the USGS between 1973 and 1976 indicate low flows ranging between 27 and 42 cfs. This agrees with our baseflow measurements made on the contributing tributaries to this location.

These lower flows may have been due to the lower amounts of precipitation received then. Each year during the 1950's, below average precipitation was received at the Pocatello Airport

FIGURE 47.
BANNOCK CREEK BASIN - MOONSHINE CREEK at mouth

Location: 8S/33E 34ccb
Elevation: 4750 feet
Drainage area: 44.2 sq. mi.

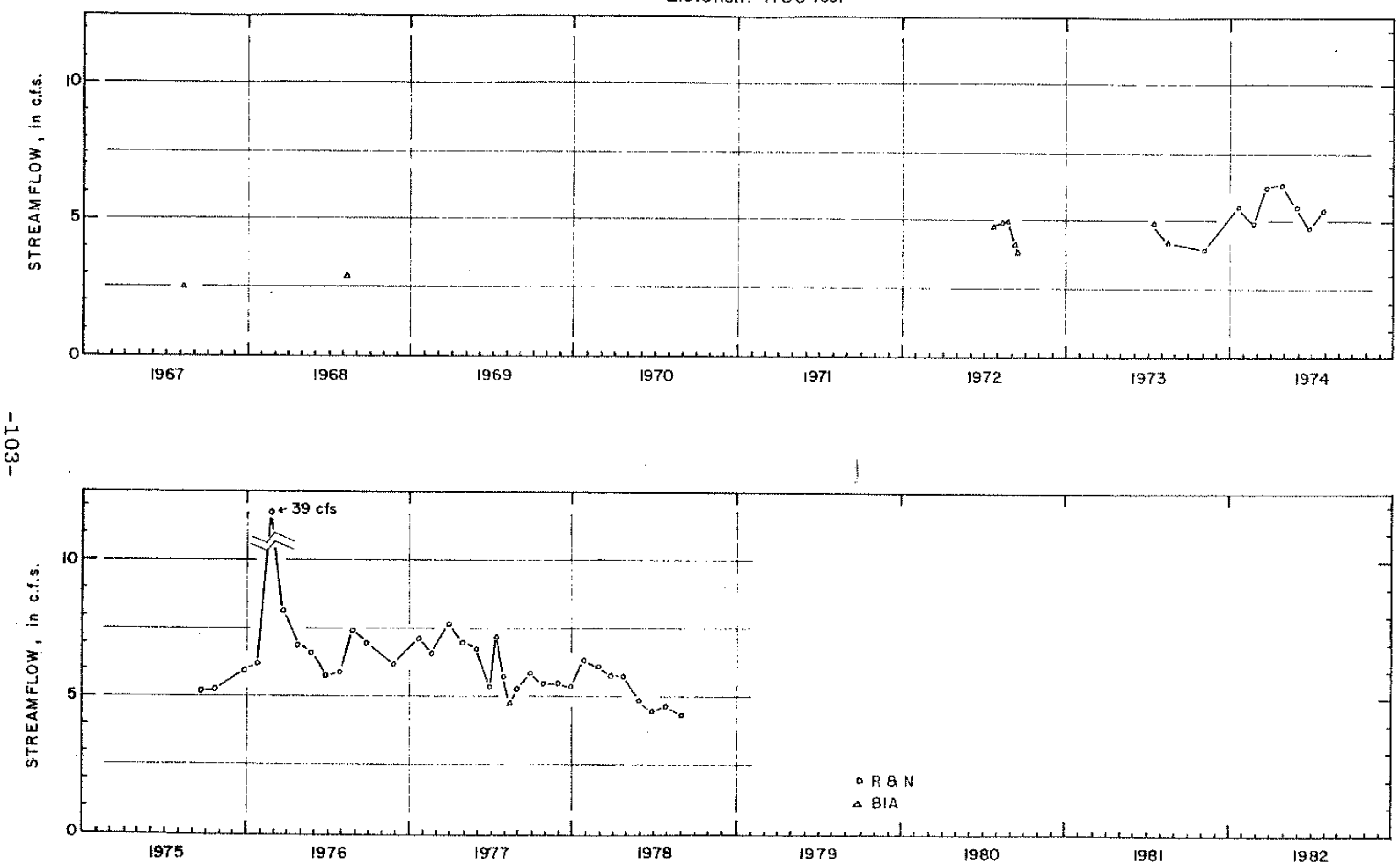
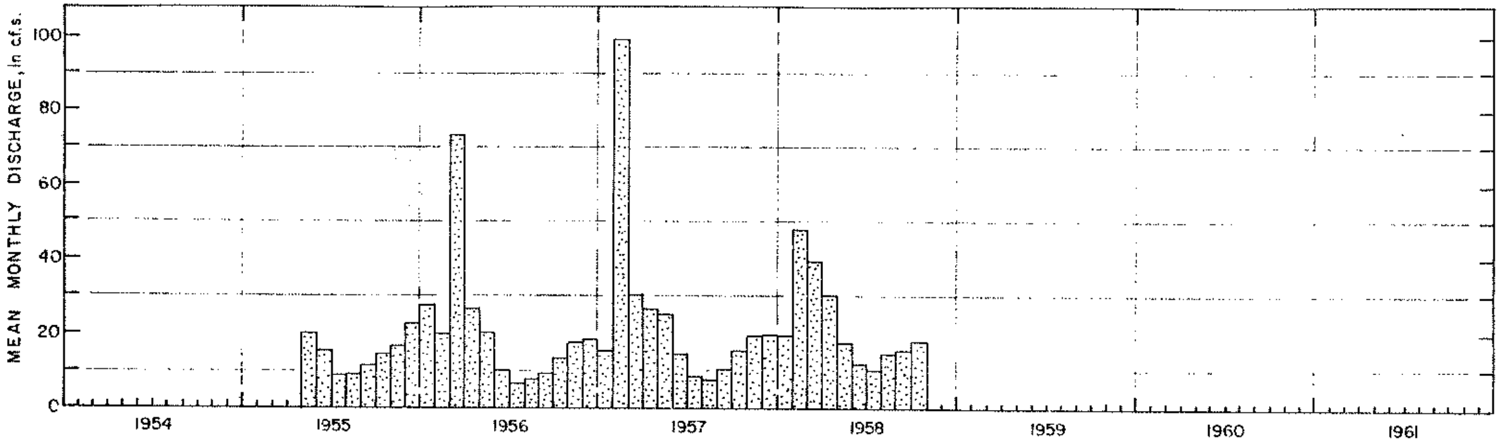


FIGURE 48.

BANNOCK CREEK BASIN - BANNOCK CREEK below Moonshine Creek
(U.S.G.S. NO. 130760)

Location: 8 S / 33 E 28 da
Elevation: 5670 feet

Drainage area: 230 sq. mi.



station. Also, a large portion of the baseflow at this location is provided by West Fork and Moonshine Creek. Both of these streams exhibit unusual flow characteristics. It may be possible that both were low during the late 1950's.

The mean annual flows during the water years of 1956 to 1958 were 21.2, 23.3, and 21.6 respectively. These are below current low flow measurements at that location.

Rattlesnake Creek

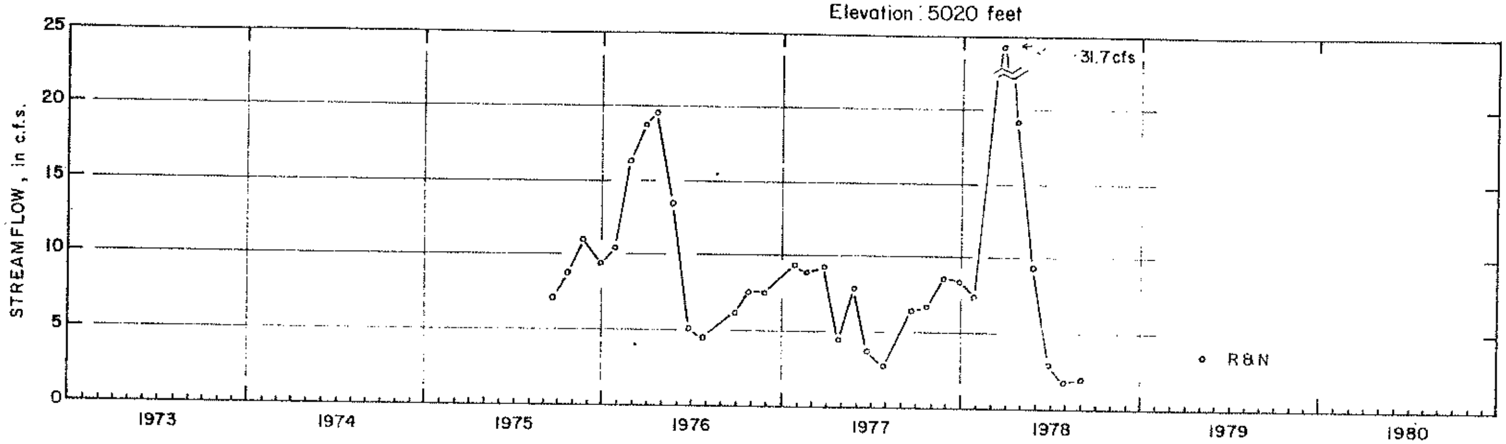
Rattlesnake Creek is the largest tributary draining the Bannock Range within Bannock Creek basin. The creek is approximately 16 miles long, originating north of Bradley Mountain and flowing generally northwest. It intercepts numerous perennial and ephemeral tributaries, the most important of which are Clifton Creek, Crystal Creek, and Midnight Creek. The lower four miles of Rattlesnake Creek flow through the reservation, joining Bannock Creek in 8S/33E-28ad.

Two flow measuring stations were established on Rattlesnake Creek. The upstream station is at the reservation border. The downstream station is near the mouth of the stream, downstream of the Arbon Valley Road bridge. Midnight and Crystal Creeks enter Rattlesnake Creek between these two stations. Two small irrigation ditches withdraw water from Rattlesnake Creek about one mile downstream of the Midnight Creek junction. Also, some irrigation water is withdrawn upstream of the reservation.

Rattlesnake Creek - Reservation Line - The mean annual flow for the 1976 water year at this station was 10.7 cfs. Spring flood flows were measured up to 20 cfs with higher flows noted (Figure 49). The flow dropped later in the year to near five cfs. Little snowmelt runoff was evident in 1977; however, the baseflow was not greatly reduced during that water year. The mean annual flow for the 1977 water year was 6.70 cfs with some flows as low as 2.8 cfs. The baseflow quickly recovered in the fall of 1977 to near nine cfs. The spring floods during 1978 were significant, with a flow of 31.7 cfs recorded on March 30, 1978. The mean flow for the 1978 water year was 9.24 cfs.

FIGURE 49.
BANNOCK CREEK BASIN - RATTLESNAKE CREEK at reservation line

Location: 8 S/33 E 36 ada
Elevation: 5020 feet



Crystal Creek - Crystal Creek is the first tributary to enter Rattlesnake Creek after it enters the reservation. It flows generally parallel to Midnight Creek, draining the area between Midnight and Rattlesnake Creeks. The stream originates off the reservation and primarily drains off reservation lands. Only the lower half mile of channel is within the reservation. Flow measurements were made at its junction with Rattlesnake Creek.

Two measurements of summer baseflow were made in 1976, which averaged 0.56 cfs. The creek dried up during 1977 and remained dry through the year. The flow measurements are shown in Figure 50. Some water is taken from the creek upstream of the reservation for irrigation use.

Midnight Creek - Midnight Creek is the main perennial tributary to Rattlesnake Creek within the reservation. It flows generally south from its source at Dead Cow Spring, which lies off the reservation. The stream is approximately 7.5 miles long, the lower 1.5 miles of which lie within the reservation. Flow measurements were made at the reservation border.

The mean annual flow for the 1976 water year was 2.92 cfs. A large amount of runoff occurred in the spring of 1976, with recorded flows up to ten cfs and higher flows observed (Figure 51). Baseflows usually remained around 1.5 cfs. During 1977, little snowmelt runoff was recorded, with baseflows dropping to 0.30 cfs in September, 1977. The mean flow for the 1977 water year was 0.86 cfs. The baseflow continued around 0.50 cfs until the runoff in 1978, which exceeded 5.0 cfs. The mean flow for the 1978 water year was 1.74 cfs. Some water is removed for irrigation uses upstream of the reservation.

Rattlesnake Creek - USGS Station - During the 1956 to 1958 water years, the USGS measured Rattlesnake Creek below Midnight Creek. They recorded mean flows of 7.6, 9.8, and 10.0 cfs for these years respectively. All three of these years received below normal precipitation, 1956 receiving less than 1977. The flow measurements are shown in Figure 52. The baseflows during these years

FIGURE 50.
BANNOCK CREEK BASIN - CRYSTAL CREEK at mouth

Location: 8 S/33 E 25 dca
Elevation: 5000 feet

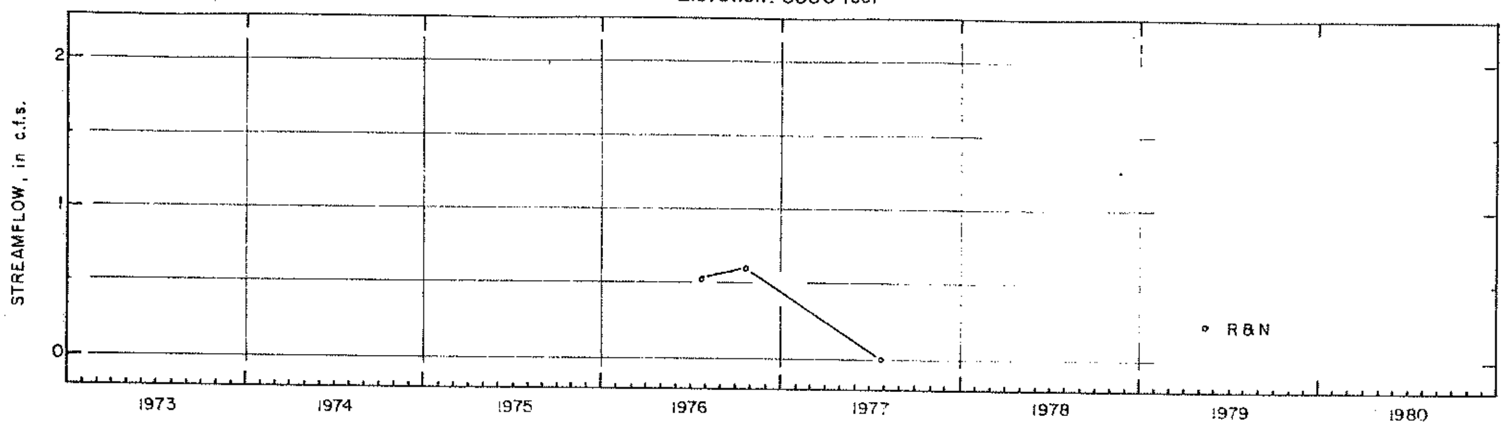


FIGURE 51.
BANNOCK CREEK BASIN - MIDNIGHT CREEK at reservation line

Location: 8 S/33E 24 aaa
Elevation: 5200 feet

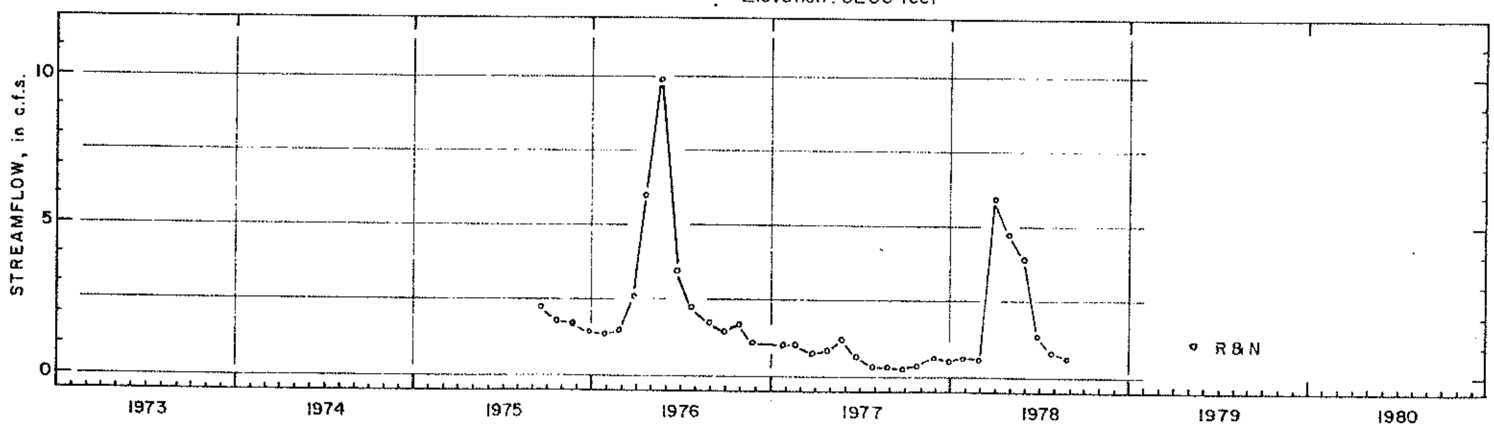
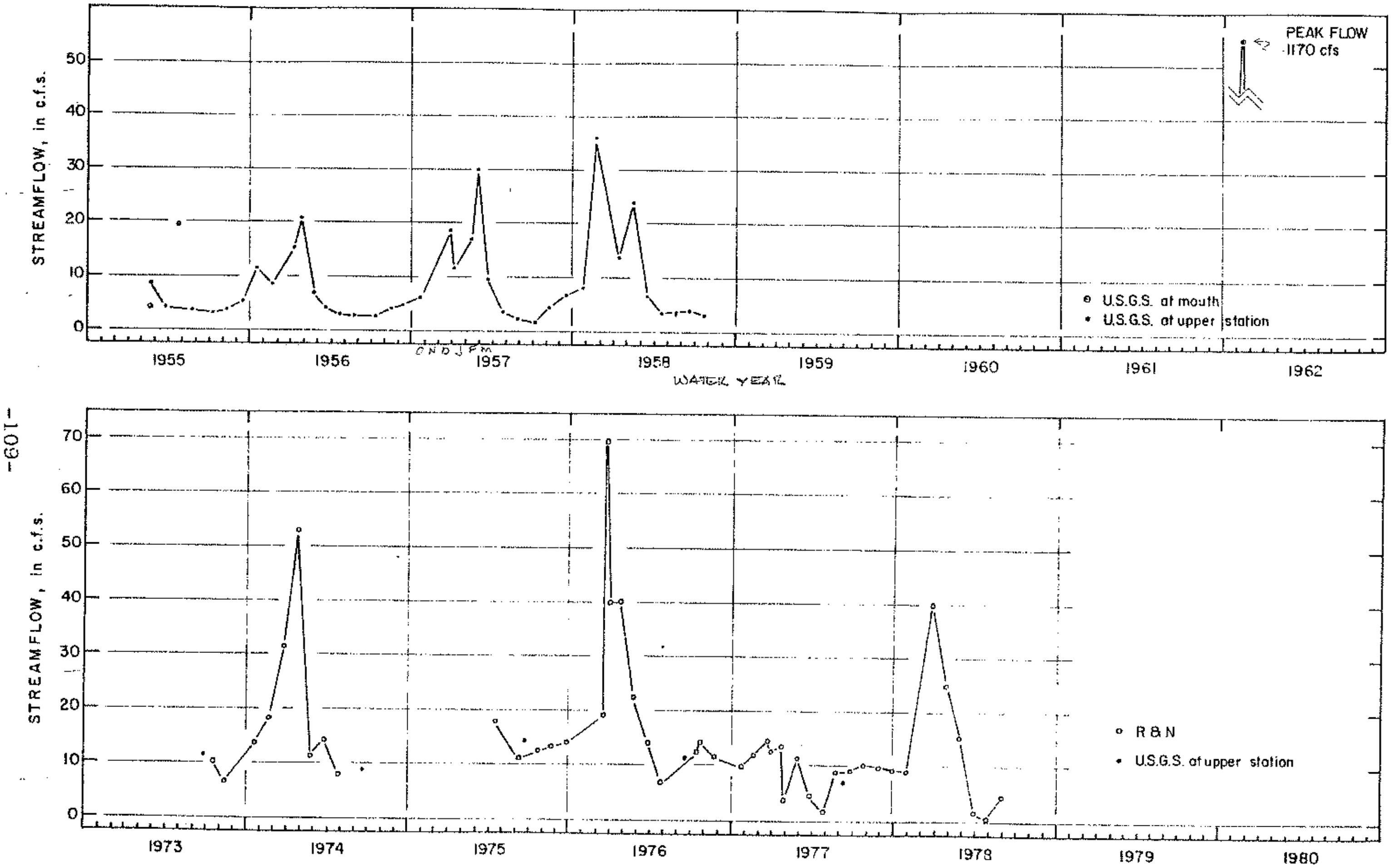


FIGURE 52.
BANNOCK CREEK BASIN - RATTLESNAKE CREEK at mouth (U.S.G.S. 130761)

Location: 8S/33E 28 ada
Elevation: 4710 feet

Drainage area: 79.6 sq. mi.



usually ranged between two and four cfs.

Rattlesnake Creek - at mouth - At the station established for this study near the stream mouth, the mean flow for the 1976 water year was 17.8 cfs. The spring flood flows were recorded up to 70 cfs, with higher flows observed (Figure 52). The subsequent baseflows were usually above 10 cfs. During the 1977 water year, the baseflow remained fairly constant near 9 cfs, although lower flows were noted, probably due to upstream irrigation. The mean flow that year was 9.49 cfs. Significant runoff did occur again in 1978, with flows up to 40 cfs recorded, and a mean annual flow of 11.8 cfs.

The measurements taken in the Rattlesnake Basin indicate some ground water inflow to Rattlesnake Creek within the reservation. Increases in flow during the non-irrigation season occurred on the order of one to three cfs between the border stations and the mouth of the stream.

Starlight Creek

Starlight Creek is a small perennial tributary to Bannock Creek. It drains the Deep Creek Range north of Moonshine Creek and joins Bannock Creek north of Rattlesnake Creek at 8S/33E-21ba. The flow originates in several scattered springs in the volcanic terrain that composes the basin. Periodic measurements by the BIA Irrigation Office for the last ten years indicate a late summer baseflow of about 0.3 cfs. No other flow measurements were made for this study.

Birch Creek

Birch Creek is a small perennial tributary to Bannock Creek, similar in size to Starlight Creek. Birch Creek drains the Bannock Range and flows west to enter Bannock Creek north of Rattlesnake Creek at 8S/33E-5aaa. The sources of the flow are several small springs near the reservation border.

Flow measurements made in the fall of 1972 and 1977 indicate baseflows between 0.2 and 0.4 cfs. The stream did not appear to be significantly affected by the drought in 1977.

Lower Bannock Creek

The lower Bannock Creek gaging station was established below the Michaud Irrigation System. The canal system imports Portneuf River water into the area, and can withdraw Bannock Creek water as needed where it crosses Bannock Creek. The system also has seven irrigation wells that contribute to the surface water system. The return flow water from the system drains into Bannock Creek.

Summer measurements at the gage site have been made by the USGS since 1924 (Figure 53). Since they are only taken during the irrigation season, the measurements are not fully representative of the mean annual flow. However, the measured means have remained fairly constant between 1925 and 1963, averaging around ten cfs. The Michaud Irrigation System began importing Portneuf River water in 1964. Since that time, the flow of the lower stretch of the creek has increased greatly, due to the addition of the irrigation return flow. The flow hydrograph of the Lower Bannock station (Figure 54) shows the impact of the irrigation system regulation. Only during the winter months is the flow representative of the natural basin flow.

The combination of the tributary mean annual flows indicates the approximate mean flow of the basin for the 1974, 1976, 1977, and 1978 water years to be 53.3, 63.4, 34.7, and 36.6 cfs respectively. The lower Bannock gage records for the 1975-76 non-irrigation season indicate that about 12 cfs is contributed to Bannock Creek within the reservation between the upstream measuring stations and the lower gage. This is springflow that enters the creek along the valley bottom. Thus the computed mean annual yield of the basin without the influence of the Michaud Irrigation system would be 65, 75, 47, and 49 cfs for the 1974, 1976, 1977, and 1978 water years respectively. These figures are used in the water budget analysis as more representative of the natural flow of the basin at this point.

Michaud Creek

Michaud Creek originates with several small springs upstream of the reservation border and flows generally northward, into the reservation. It flows out onto Michaud Flats and empties into the Michaud Irrigation Canal. The stream is approximately eight miles long, with over six miles within the reservation.

FIGURE 53.
BANNOCK CREEK BASIN
LOWER BANNOCK CREEK at GAGE (USGS 130761.5)
Location: 6S/33E-20cc
Elevation: 4395 feet
Drainage area: 413 sq.mi.

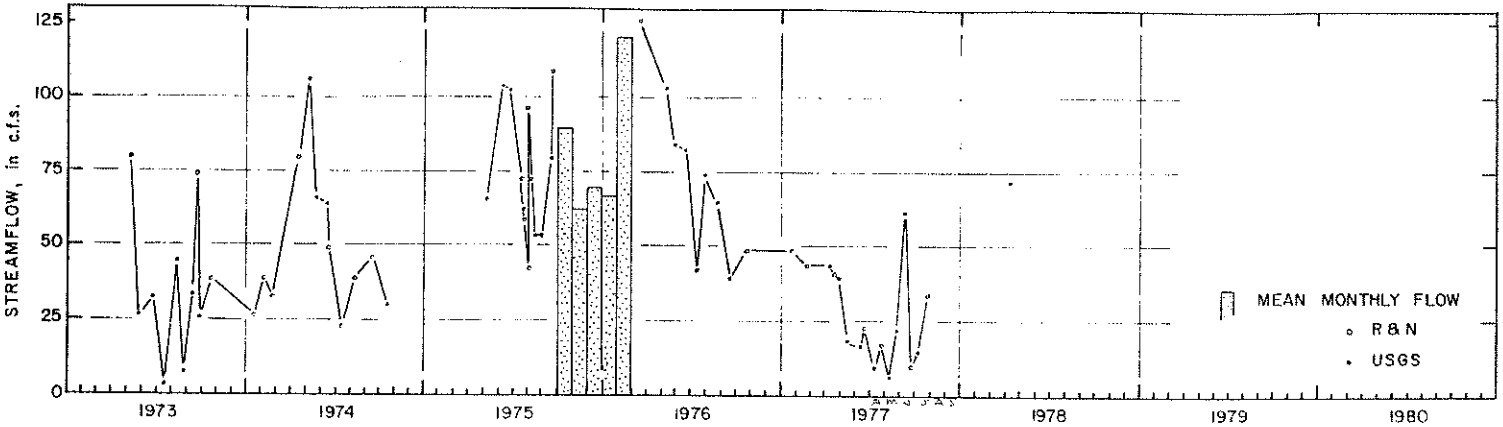
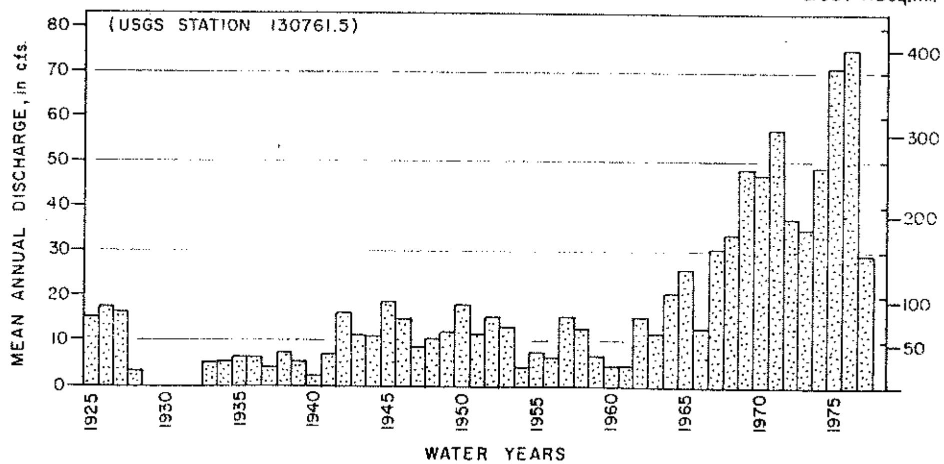


FIGURE 54.
BANNOCK CREEK BASIN
LOWER BANNOCK CREEK at GAGE
Location: 6S/33E-29bb
Elevation: 4395 feet
Drainage area: 413sq.mi.



During the 1976 water year, the mean flow was measured at 2.08 cfs. Snowmelt runoff during 1976 provided a large amount of flood flow, measured at up to five cfs with higher observed flows (Figure 55). The subsequent baseflow remained near one cfs into 1977. As little snowmelt occurred in 1977, the baseflows decreased to 0.4 cfs in July of that year. The mean flow for the 1977 water year was 0.81 cfs. Baseflows for 1978 did not show significant increases, although the flow did increase to near one cfs. The mean annual flow for the 1978 water year was 0.66 cfs, in part due to reduced flows that lasted until the spring of 1978.

GROUND WATER

Little previous investigation has been done regarding the ground water resources in the Bannock Creek basin. At most, previous studies of the Snake Plain attempted to estimate the ground water contribution from the basin to the Snake aquifer. Detailed study of the basin is hampered due to the scarcity of wells and drilling information. Except for a few scattered stock wells in the basin uplands, only a few domestic wells exist near the Bannock Creek valley bottom.

Due to the scarcity of well logs, the subsurface geology is not well understood, particularly where the basin joins the Snake Plain. It is not known if the Snake Plain basalt exists near the valley mouth. Wells further north on Michaud Flats reach 500 feet without encountering basalt. The Owl Canal wells to the west of the creek reach to 735 feet. They encounter approximately 400 feet of alternating sand, gravel and clay deposits above sandstone. This sandstone may be the volcanic ash of the Starlight Formation. These Tertiary volcanic flows probably inter-finger with the sedimentary valley fill deposits of Arbon Valley. The thicknesses of these valley fill deposits are not known.

Two abandoned domestic wells in the valley bottom were monitored throughout the study. No drilling information was available for either well, however both are probably drilled only into the valley fill sediments. The upstream well, located in 7S/33E-20dcbc, exhibited a pronounced seasonal variation (Figure 56). The water level rise during the summer is most probably due to recharge from surface irrigation and snow melt infiltration. The variation usually amounts to eight feet. Between 1973 and 1977, a slight increase in water level appears evident, probably in response to

FIGURE 55.
BANNOCK CREEK BASIN - MICHAUD CREEK   Location: 6S/33E 26adc
Elevation: 4680 feet

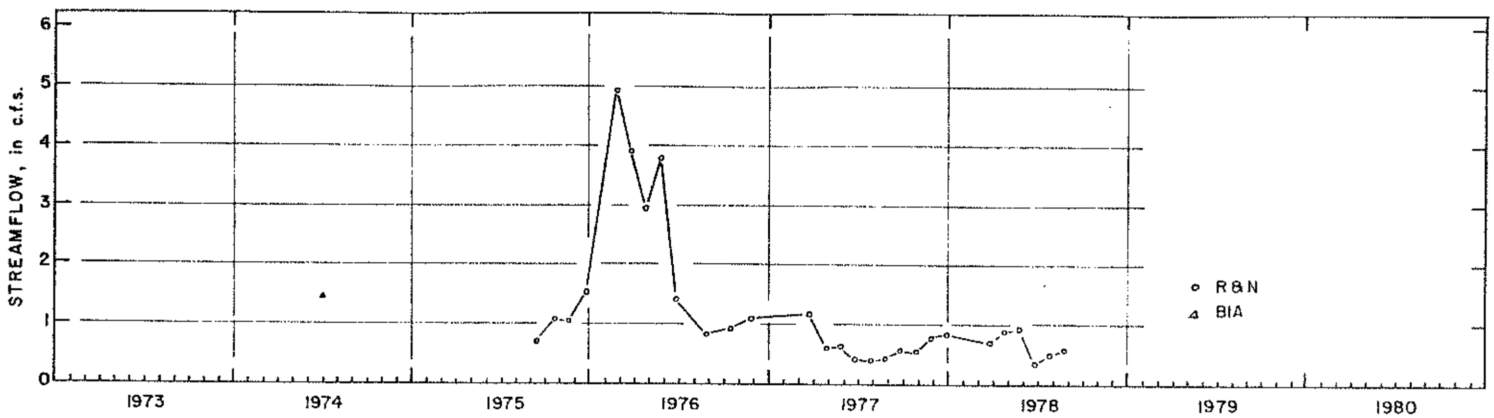
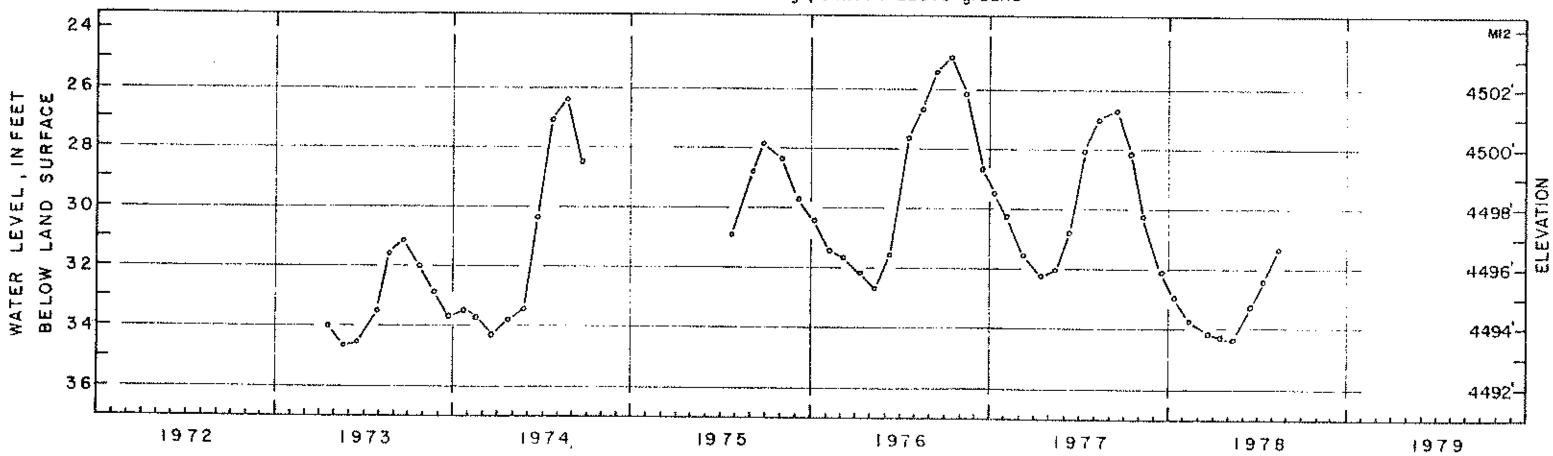


FIGURE 56.
WELL: 7S/33E 20 dcbc   Depth: unknown   Land surface: 4528 feet
Measuring point: .4' above ground



higher than normal precipitation amounts during this time. The water levels were not lower during the 1977 drought, although the spring 1978 levels did show a decrease of about two feet.

The downstream well, located at 7S/33E-8dbba, exhibits no seasonal variations (Figure 57). It does, however, show an increase of four feet between 1973 and 1977. Water levels were highest during the 1977 drought. The water levels did begin to drop in 1978, probably as a delayed response to the drought. The static level here is approximately 35 feet below the level of Bannock Creek. Further upstream, south of Rattlesnake Creek, some domestic wells near the creek have static levels of less than 15 feet.

The bedrock geology of the upper Bannock basin does indicate that there is a good potential for modest ground water development. The bedrock of the basin, particularly within the Deep Creek Mountain Range to the west, is composed predominately of limestones and, further north,volcanic rock and ash deposits. These formations are generally capable of transmitting moderate supplies of water. Larger quantities, however, would not generally be available in the upper basin, unless fracture zones were encountered.

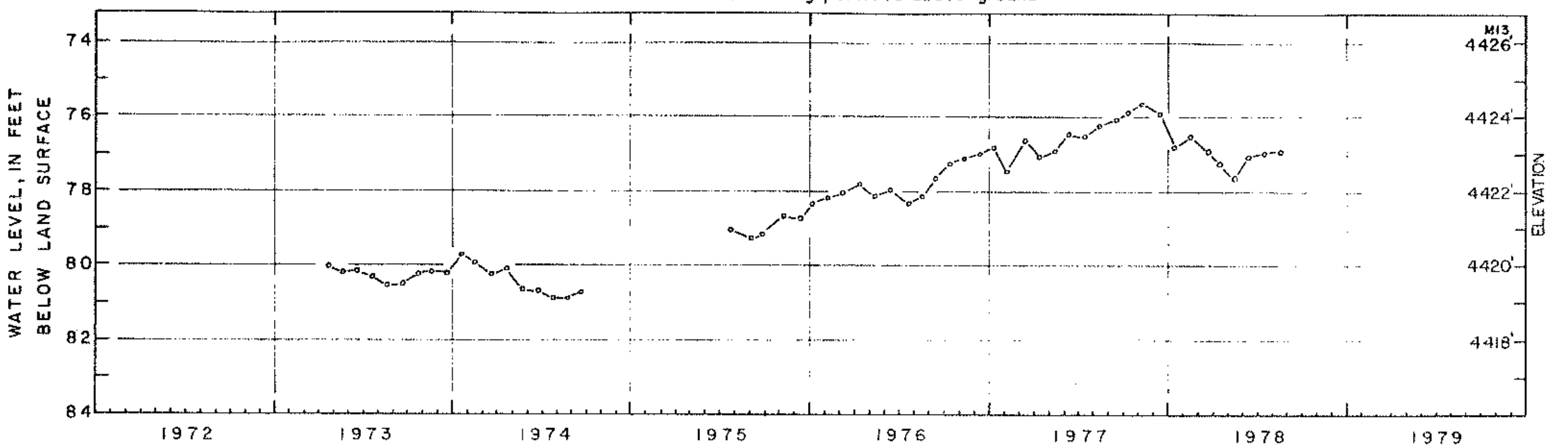
A potential area of development lies near the mouth of Arbon Valley, south of the Bannock Creek Pump Station. However, more exploration is needed in this area to test the potential. If there truly is 80-100 cfs of ground water underflow in the basin, as determined below in the water budget, much of this may be recoverable in this area. The Owl Canal wells operated by the BIA may tap a portion of this underflow.

WATER BUDGET

The mean annual precipitation that falls on the Bannock Creek basin is approximately 18 inches, ranging from ten near the Snake Plain to approximately 25 inches at the upstream end. Using the analysis prepared by Mundorff and others (1964), the basin should yield the equivalent of 6.0 inches of water over the entire basin, or 183 cfs (132,160 acre/feet per year).

The determination of the surface water yield of Bannock Creek is complicated by the operation of three irrigation systems. One lies upstream of the reservation in Rattlesnake and Bannock Creek

FIGURE 57.
WELL: 7 S/33 E 8 dbba   Depth: unknown   Land surface: 4500 feet
Measuring point: .3' above ground



valleys. The second is the Bannock Creek minor unit, consisting of over seven ditches on Rattlesnake and Bannock Creeks. The third is the Michaud Irrigation System, which transports Portneuf River water into the area which drains into the creek. Thus, the flow measurement stations near the mouth of Bannock Creek no longer reflect the actual Arbon Valley drainage.

Measurements during the 1976 water year of Bannock Creek and tributaries indicate surface water flow in the basin to be near 75 cfs. With the addition of 13.5 cfs (Davis and Richins, 1978) for consumptive crop uses, a total surface flow of 88.5 cfs occurred. This leaves 94.5 cfs (68,416 feet/year) per year of ground water flow.

The Michaud Creek basin, not included in the Bannock Creek water budget, receives about 13 inches of precipitation annually. The total yield of the basin is calculated to be 2.14 cfs (1547 acre/feet). The 1976 annual flow was 2.08 cfs, indicating little ground water is generated within the basin. The actual ground water flow in the volcanic terrain, however, is probably a continuation of the Portneuf River and Bannock Creek ground water systems.

A factor that complicates the water budget analysis is the possible difference between the surface drainage basin and the ground water basin. Evidence indicates that the limestone "West Fork" aquifer is significantly larger than the West Fork basin. The actual extent is not known,however. If the ground water basin extends significantly beyond the topographic boundary, additional water could be supplied to the Bannock Creek ground water flow. If, on the other hand, bedrock in the Bannock basin drains away from the basin, for example to Rock Creek, then underflow values would be less than expected.

WATER QUALITY

SURFACE WATER QUALITY

The averaged chemical analyses for the stations described below are listed in Table 20. The individual analyses are listed in Appendix D.

<u>Bannock Creek - South Reservation Line</u>

The water of Bannock Creek, where it enters the reservation in

TABLE 20

BANNOCK CREEK BASIN

AVERAGED SURFACE WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity μ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Bannock Creek - S. Res. Line 10S/33E - 3 aaaa	79	45	970	8.11	250	325	127	27	0.29	0.5	0.14	0.08	0.49	11	19
West Fork 9S/33E - 34 cdcd	3	53	421	8.08	208	208	15	1	0.12	0.4	0.03	0.03	0.30	10	23
Upper Bannock Creek 9S/33E - 34 acdc	143	50	573	8.06	216	238	50	12	0.22	0.4	0.06	0.05	0.34	10	27
Rock Spring #1 9S/33E - 34 aca	2	58	610	8.25	205	235	45	19	0.14	0.6	-	0.03	-	-	1
Rock Spring #2 9S/33E - 34 abd	0	59	600	7.60	200	220	40	19	0.12	0.6	-	0.02	-	-	1
Moonshine Creek 8S/33E - 34 ccb	55	61	602	8.12	232	248	43	13	0.23	0.3	0.03	0.04	0.44	9	22
Rattlesnake Creek E. Line 8S/33E - 36 ada	150	47	739	8.12	236	286	75	21	0.55	0.7	0.06	0.07	0.46	10	22
Crystal Creek 8S/33E - 25 dcab	17	44	438	8.29	219	214	15	3	0.24	0.4	0.05	0.03	0.30	9	8
Midnight Creek 8S/33E - 24 aaaa	5	47	379	8.17	175	177	15	5	0.13	0.4	0.02	0.04	0.29	10	23
Rattlesnake Creek 8S/33E - 28 ada	253	48	610	8.27	217	246	54	15	0.41	0.5	0.06	0.05	0.42	10	26
Officer Spring 8S/33E - 28 acba	0	59	530	7.98	240	250	28	13	0.21	0.3	0.02	0.03	0.30	-	1

TABLE 20 (Cont'd.)

BANNOCK CREEK BASIN

AVERAGED SURFACE WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/1 $CaCO_3$	Total Hardness mg/1 $CaCO_3$	Chloride mg/1 Cl	Sulfate mg/1 SO_4	Ortho Phosphate mg/1 PO_4	Nitrate mg/1 N	Ammonia mg/1 N	Iron mg/1 Fe	Fluoride mg/1 F	Disolved Oxygen mg/1	Number of Samples
Starlight Creek 8S/33E - 21 badb	226	43	398	8.06	168	182	27	7	0.50	0.2	-	0.05	-	-	3
Warm Spring 8S/33E - 10 adac	1	88	260	8.13	110	120	12	12	0.06	0.3	0.00	0.12	0.43	-	1
Birch Creek 8S/33E - 4 babb	8	42	270	8.28	100	120	20	9	0.35	0.3	0.03	0.02	0.28	-	1
Bannock Creek - Eagle Tail Rock 7S/33E - 32 dbba	15	49	605	8.10	260	270	42	13	0.18	-	-	-	-	-	1
Lower Bannock Creek 6S/33E - 20 cccd	49	50	672	8.18	241	267	58	27	0.49	0.7	0.12	0.04	0.50	10	23
Michaud Creek 6S/33E - 26 adc	164	44	409	7.91	137	164	38	17	0.36	0.3	0.04	0.06	0.45	10	18
Michaud Gully 6S/33E - 26 adb	13025	38	178	7.60	110	120	10	0	0.60	0.1	-	0.13	-	-	2
Michaud Creek - at mouth 6S/33E - 22 abba	18	38	442	7.98	145	182	44	22	0.48	0.6	-	0.09	-	-	2

9S/33E-34dd, is fairly high in dissolved solids. This is especially true with the hardness, chloride, and ammonia levels. There is also an apparent seasonal fluctuation in which the higher values occur during the late winter and early spring months. Nutrient levels are not unusually high, with the exception of ammonia. It averages 0.14 mg/l, but is still well within the recommended level for drinking water. Turbidity is also higher than normal, even during base flow conditions, and probably reflects the agricultural practices and presence of livestock in and around the creek.

West Fork

The springs of West Fork discharge water of a fairly constant chemical quality. The water is low in chloride, sulfate, fluoride, and nutrients. It is less mineralized than the Bottoms Springs water. The only fluctuation to occur in quality was the result of snowmelt runoff from the surrounding dry farm area. Little change in dissolved solids resulted,but a large increase in turbidity occurred. The seasonal variation in spring discharge had little effect on its chemical quality.

Upper Bannock Creek

The quality of Bannock Creek at the upper recording station is a result of West Fork's diluting effect on the quality of Bannock Creek. As West Fork's flow varies greatly throughout the year, its influence on Bannock Creek varies proportionately. The baseflow turbidity is lower below West Fork. However, snowmelt floods result in very high levels, due to the large amount of farming in the basin.

Rock Springs 1 and 2

These two small springs originate in 9S/33E-34a near the Arbon Valley Road and flow west to Bannock Creek. They are used as stock water sources. These springs drain the Fish Haven Dolomite. The water is fairly similar in chemical quality to Bannock Creek in this area.

Moonshine Creek

The source of much of the baseflow in Moonshine Creek is spring flow that enters near the mouth of the creek. The water probably discharges from the variety of limestone and dolomite beds in the area. The chemical quality is fairly constant throughout the year, with the exception of spring runoff. The stream near the mouth maintains a relatively high temperature throughout the year, due to the proximity of the spring source. The quality is similar to Rock Springs and slightly more mineralized than the Bottoms Springs water.

Rattlesnake Creek - East Boundary

Rattlesnake Creek, where it enters the reservation, is similar in some respects to Bannock Creek as it enters. There are higher than normal levels of turbidity, chloride, hardness, and phosphate. The quality exhibits a fairly erratic nature, probably due to the impacts of human activities in the upper basin. These include irrigation, livestock, and dry farming. The creek has higher than normal turbidity throughout the year, with levels above 2,000 FTU's during spring flooding.

Crystal Creek

Crystal Creek provides water of lower than normal dissolved solids content which acts to somewhat dilute Rattlesnake Creek chemical levels after it enters the reservation. The flow is small and completely dried up during the summer of 1977. The quality was fairly uniform throughout the year while the stream flowed.

Midnight Creek

Midnight Creek contains some of the better quality water in the Bannock Creek Basin. It acts to further dilute the dissolved solids content of Rattlesnake Creek. The water contains fairly low levels of dissolved minerals and nutrients, and maintains these levels through the year with little variation. Both temperature and turbidity also remain low throughout the year. Turbidity remains low even during spring runoff.

Rattlesnake Creek

Rattlesnake Creek at Arbon Valley Road, just above its juncture with Bannock Creek, still exhibits variations due to off-reservation impacts, although the magnitude has been dampened by the inflows of Crystal and Midnight Creeks. Nutrient levels do not appear to present any problem. although phosphate levels are higher than normal. Turbidity levels also remain high throughout the year, with levels exceeding 3,000 FTU's occurring during spring runoff. Most of this is probably derived from off the reservation.

The U.S. Geological Survey began monitoring Rattlesnake Creek with one low-flow sample taken each year since 1975. This analysis is limited to temperature and conductivity.

Officer Spring

Officer Spring is located in 8S/33E-Section 28a, on the west side of the valley just below the confluence of Rattlesnake and Bannock Creeks. Its quality is fairly representative of most springs in Arbon Valley and similar to the Bottoms Springs quality. The water is probably derived from the Garden City limestone. The flow was estimated to be only a few tenths of a cfs in 1977.

Starlight Creek

Starlight Creek was monitored three times during 1976. The February sample represents the maximum spring flood flow, with resultant low levels of most dissolved minerals. Only turbidity and phosphate were higher than normal during the high flow. The other two samples represent the baseflow chemistry, which is of fairly good quality. The baseflow in late summer is very low, visually estimated at only a few tenths of a cfs.

Warm Spring

Warm Spring is a small spring located in 8S/33E-10adac, in a draw on the east side of Arbon Valley. The spring has a very low flow, and is apparently derived from a rhyolite tuff of the Starlight Formation. The one sample taken in March, 1977, indicated a very low level of dissolved solids but had a temperature of 88°F. Usually it has been found that a directly proportional relationship exists between temperature and dissolved solids, as was noted in Yandell Spring. However, in this case, the sulfate and hardness were very low. This is probably due to the water flowing through volcanic rock types in this area compared with the limestones in the case of Yandell Springs.

Birch Creek

Birch Creek is a small stream that was sampled once in 1977 at 8S/33E-4babb. Its chemistry is very similar to Warm Spring to the south, being fairly low in dissolved solids. However, the springs feeding Birch Creek flow from Pre-Cambrian quartzites rather than Tertiary volcanic rock.

Bannock Creek - Eagle Tail Rock

One sample was taken at 7S/33E-32dbba and represents Bannock Creek before it is influenced by the Michaud Irrigation System. The water here was found to be slightly more mineralized than at the Upper Bannock Creek station, probably due to the inflow of Rattlesnake Creek and the effects of the Bannock Minor Unit Irrigation System.

Lower Bannock Creek

The lower stretch of Bannock Creek was sampled at the recording gage station in 6S/33E-20cc. During the summer the stream at this point has been mixed with the irrigation water of the Michaud System which includes Portneuf River water and ground water. Due to this, the levels of most constituents were fairly erratic through the year. The average nutrient levels were not unusually high, although higher values of phosphate and ammonia were sometimes found during the irrigation season.

Bannock Creek in this area is also monitored by the USGS, the Bureau of Reclamation, and the EPA.

Michaud Creek

Michaud Creek was sampled at the monitoring station in 6S/33E-26adc. Water quality here is fairly good, with lower than normal levels of dissolved minerals. Turbidity, however, is unusually high throughout the year, reaching a maximum during the spring runoff. This appears to be due to the high amount of livestock activity in and around the creek.

Michaud Gully

This gully runs parallel to Michaud Creek along part of its length and flows only during snowmelt runoff. The water contains very high levels of turbidity which enter Michaud Creek. The levels of dissolved minerals are low, reflecting its snowmelt character.

Michaud Creek - Mouth

This station is located in 6S/33E-22abba, and was sampled twice to identify any downstream changes in chemistry. However, no significant changes were noticed.

GROUND WATER QUALITY

The ground water sampled from two wells in the upper Bannock Creek Valley indicate a chemistry generally less mineralized than West Fork, the largest spring in that area (Table 21). The wells are reported to be shallow, probably withdrawing water from the valley fill deposits. It is interesting to note that the predominant rock type of the Deep Creek Mountains that forms the West Fork aquifer, the Oquirrh Formation, is similar in age and character to the Wells Formation, which is associated with the very hard water in the vicinity of the Gay Mine. In the Bannock Creek area, however, the water discharging from the formation is significantly less mineralized, with negligible sulfate.

In the lower section of the Bannock Creek Valley and adjacent area of the Snake Plain, several of the irrigation wells on the Owl Canal discharge water that is significantly more mineralized than either the upstream Bannock Creek ground water or the adjacent Snake Plain water. The water is withdrawn from depths of 200 to 300 feet and is high in hardness and chloride. The water may be derived from the Tertiary volcanic rocks that form the headlands of the Arbon Valley ranges. Some geothermal activity has been noted in the area north of Rattlesnake Creek and south of the Snake Plain and may be partially responsible for the high levels in this area.

SUMMARY

The spring flows that discharge into the streams of the Arbon Valley are relatively low in dissolved minerals when compared with other upland areas of the reservation. They also maintain

TABLE 21

BANNOCK CREEK BASIN

AVERAGED GROUND WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity μ-mhos per cm	pH	Total Alkalinity mg/1 $CaCO_3$	Total Hardness mg/1 $CaCO_3$	Chloride mg/1 Cl	Sulfate mg/1 SO_4	Ortho Phosphate mg/1 PO_4	Nitrate mg/1 N	Ammonia mg/1 N	Iron mg/1 Fe	Fluoride mg/1 F	Dissolved Oxygen mg/1	Number of Samples
Well 6S/32E - 29 ddaa	-	56	420	7.75	150	170	25	31	0.32	-	-	0.04	-	-	1
Well 6S/32E - 33 bbbb	0	56	455	7.86	155	178	26	27	0.14	0.4	0.00	0.03	0.72	-	2
Well 6S/33E - 30 ccbb	0	50	900	7.50	275	360	82	28	0.28	0.8	0.07	0.03	0.43	-	1
Well 7S/32E - 1 aaac	-	50	825	7.45	250	350	90	31	0.15	-	-	0.06	-	-	1
Well 7S/32E - 2 bdac	-	52	705	7.55	240	330	70	20	0.34	-	-	0.04	-	-	1
Well 7S/32E - 3 dbdd	-	54	510	7.62	230	250	50	15	-	-	-	0.04	-	-	1
Well 7S/33E - 6 cdab	-	51	710	7.42	260	310	60	22	0.22	-	-	0.03	-	-	1
Well 9S/33E - 15 cabb	-	62	480	-	-	-	-	-	-	-	-	-	-	-	1
Well 9S/33E - 34 aba	29	59	265	8.83	75	80	42	0	0.04	0.2	0.04	0.92	0.29	-	2

a fairly uniform quality throughout the year. However, stresses on the quality of the surface waters are present both on and off the reservation, primarily due to agricultural activities. Both Bannock and Rattlesnake Creeks contain higher than normal levels of hardness, chloride, nutrients, and turbidity when they enter the reservation. The concentrations are fairly erratic throughout the year, and become somewhat diluted within the reservation due to the inflow of less mineralized spring water and less intense agricultural activities. Within the watershed, turbidity is considered by the State of Idaho as the primary impact on Bannock Creek water quality. Bannock Creek in its lower reach also receives irrigation return flows from the Michaud canal system.

SNAKE RIVER PLAIN

BASIN DESCRIPTION

The Snake River Plain is the dominant geologic and hydrologic feature in southern Idaho. It is a broad plain, 30 to 75 miles wide, which extends in an arc from the Idaho-Wyoming border into Oregon. The plain is bordered on the north and east by the Rocky Mountain Province and on the south by the Basin and Range Province. The plain itself is the eastern extension of the Columbia Plateau Province. The boundary between the Snake Plain and the Basin and Range Provinces runs through the Fort Hall Reservation, generally separating the lowlands from the hilly uplands. The area of the Snake Plain which is on the reservation is approximately 178 square miles. The foot hill areas that drain directly to the plain and are not included in any of the separate basin descriptions include an additional 91 square miles. Thus the total plain and foothills area comprises 33 percent of the reservation.

The Snake Plain area on the reservation is comprised of three primary units. These are Gibson Terrace, Michaud Flats, and the Fort Hall Bottoms. Gibson Terrace is here considered to extend south of the Blackfoot River, including the area north of the Little Indian Canal, to the Portneuf River, and west of the Main Canal. The elevation of much of the terrace within the reservation ranges between 4,420 and 4,450 feet, increasing to near 4,500 feet near Blackfoot. The elevation of the section northeast of the Lincoln Creek basin ranges between 4,550 and 4,600 feet.

The Gibson Terrace is bordered on the west by the Fort Hall Bottoms. The Bottoms extends southwest from Ferry Butte and is bordered generally by the Snake River and lower Portneuf River. The elevation ranges from 4,320 feet near the junction of the Portneuf and Snake Rivers, to 4,400 feet near Ferry Butte. The American Falls Reservoir regularly innundates the lower Bottoms area to a maximum elevation of 4,354 feet. The area referred to in this report as the Portneuf Bottoms is that part of the Fort Hall Bottoms that borders the Portneuf River, separating Gibson Terrace from Michaud Flats.

Michaud Flats is geologically similar to Gibson Terrace and extends west from the Portneuf River to the western reservation boundary. It lies between the Fort Hall Bottoms and American Falls Reservoir to the north and the foothills of the Bannock Creek basin to the south. The elevation ranges from 4,390 feet near the western end to 4,450 feet near the Portneuf River.

All of the main streams draining reservation lands flow across the Snake Plain along their lower reaches. These are the Blackfoot River, Lincoln Creek, Ross Fork Creek, Portneuf River, Bannock Creek, and the Snake River. The Snake River is considered as a separate hydrologic unit, or drainage basin, due to the large ground water supply associated with it. The Snake Plain aquifer discharges into the Fort Hall Bottoms, producing a multitude of springs, among them Spring Creek, Clear Creek, Jimmy Creek, Diggie Creek, Wide Creek, and Jimmy Drinks Springs. This ground water also affects the flows of the streams crossing the Plain. Consequently, for this report, the drainage basins of the upland creeks are considered to end at the point where they enter the Snake Plain. The lower reaches of the stream, along with the Bottoms Springs are considered as part of the Snake Plain system.

GEOLOGY

The Snake Plain area of the reservation, including Gibson Terrace, Buckskin Basin, Michaud Flats, and the Fort Hall Bottoms, is underlain by volcanic rock at varying depths. This rock is primarily basalt but in places is rhyolitic. The basalt has a fairly level surface under much of the plain within the reservation, sloping slightly to the west and south. Two geologic cross sections, Figures 58 and 59, were constructed from well log information on Gibson Terrace. The elevation of the top of the basalt east of Ferry Butte is approximately 4,350 feet, nearing 4,400 near Blackfoot. Near Fort Hall, the level falls off to near 4,200 feet. The upper level of the basalt below the Fort Hall Bottoms is unknown, as no wells exist there, although it would appear to be near the 4,200-foot elevation. The elevation of the top of the basalt continues to about 4,200 feet under the Michaud Flats area, falling off to below 4,100 feet near the western end. A geologic cross section through Michaud Flats is shown in Figure 60.

FIGURE 58.

NORTHERN GIBSON TERRACE CROSS SECTION

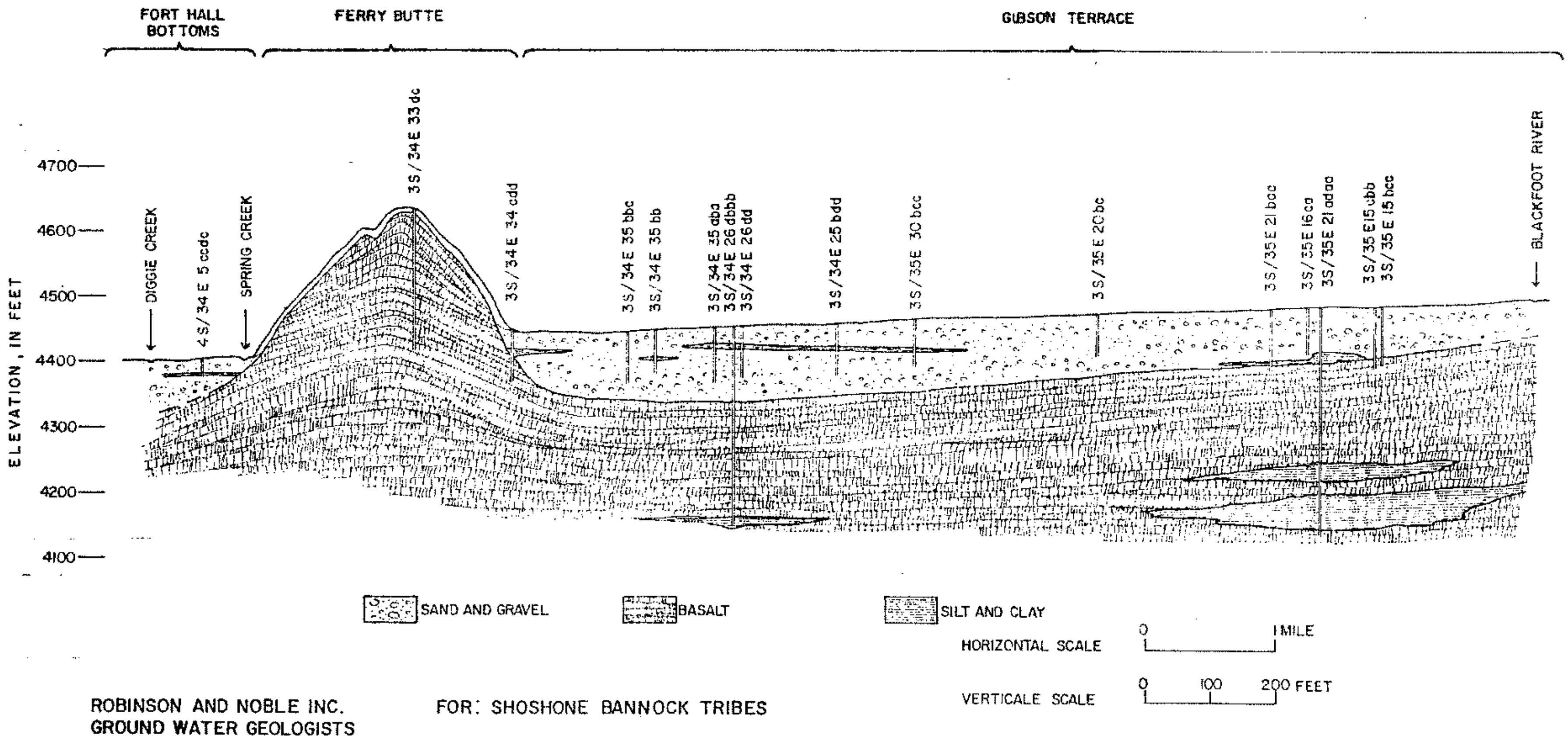


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FIGURE 59.

GIBSON TERRACE - BUCKSKIN BASIN CROSS SECTION

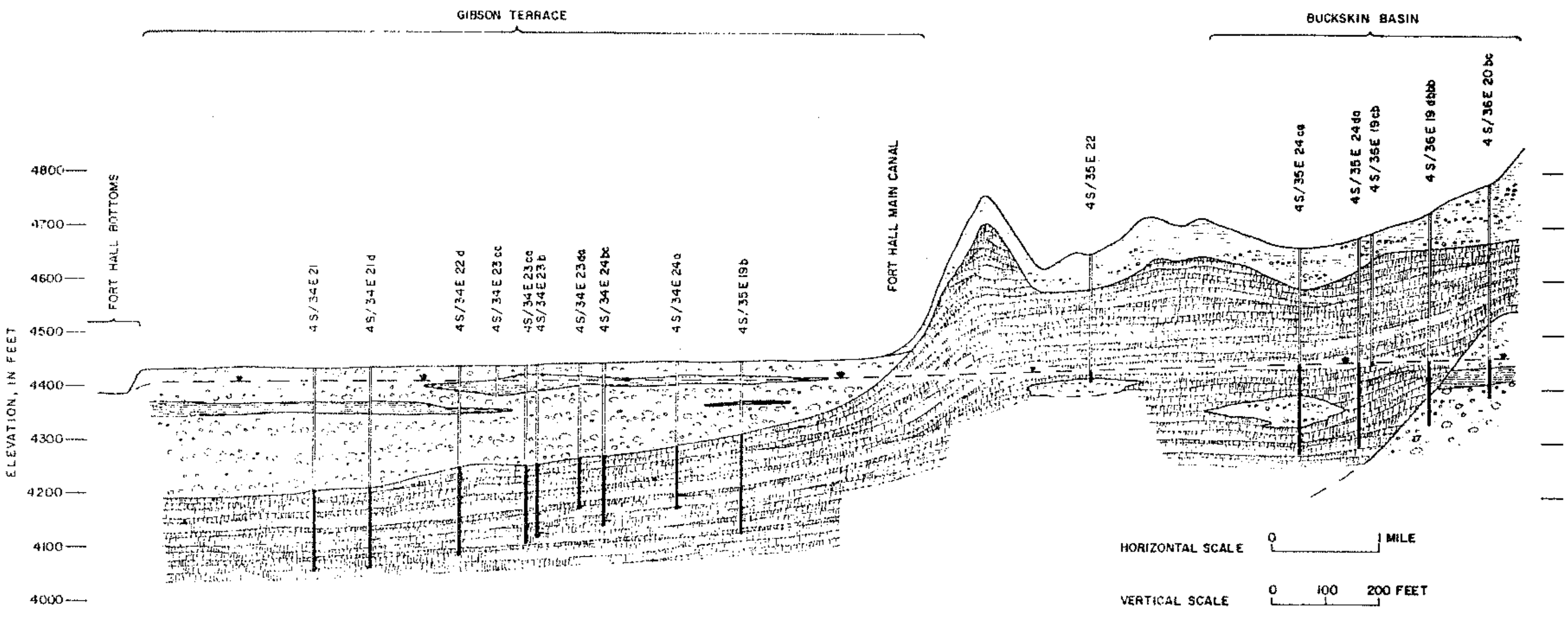

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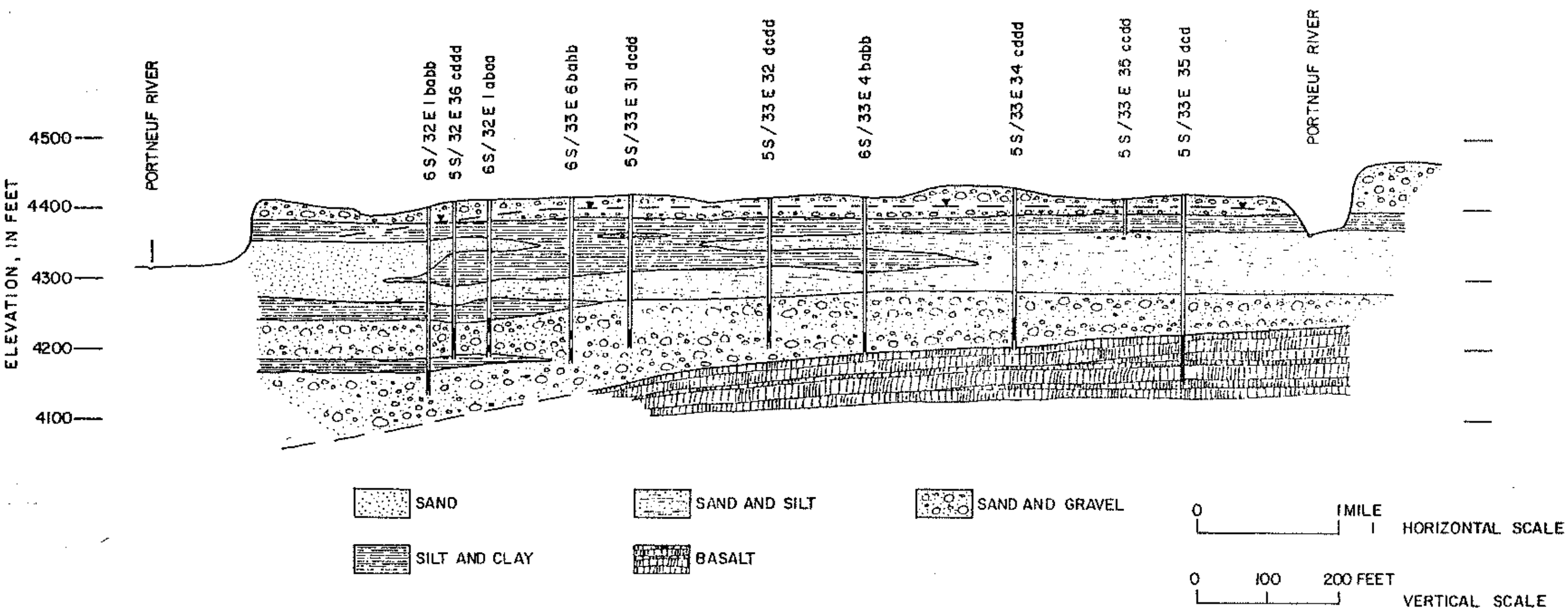
FIGURE 60.

MICHAUD FLATS
ALONG SYPHON ROAD



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The basalt also forms several upland areas, including Ferry Butte, Gibson Butte, and Buckskin Basin. The basalts overlap the rhyolite volcanics that form the headland areas of the mountain ranges. The basalt in the upland areas generally rises up to 4,700 feet, although Gibson Butte reaches 5,200 feet.

Within the reservation, the thickness of the basalt beneath the Snake Plain is not known. Few of the deep wells are known to fully penetrate the lava. At most, the irrigation wells on the plain have penetrated 300 feet of basalt to obtain sufficient water. This basalt forms the most productive aquifer on the reservation. The water is primarily found in cinder zones separating individual basalt flows. Only near the eastern end of Buckskin Basin have wells penetrated to the bottom of the basalt, where it seems to be pinching out against the older rock.

The basalt underlying Gibson Terrace and Michaud Flats is covered by a varying thickness of unconsolidated sediments that also forms an important aquifer. These sediments have been divided into three formations: the Raft, the American Falls, and the Michaud Gravel.

The Raft Formation was deposited on top of the basalt flows after volcanic activity ceased for a time. It is described by Trimble and Carr (1976) as primarily silts and sands with some gravel zones near the bottom. They place the top of the formation near 4,320 feet (Carr and Trimble, 1963).

Based on the well logs of Michaud Flats, the Raft Formation in that area is generally composed of coarser material in the lower part and comprises a major aquifer. It is this zone from which most irrigation wells on Michaud Flats take water. The formation contains at least two lake clay deposits, both of which pinch out in the eastern part of Michaud. The most productive gravel zone exists between 4,270 feet and the top of the basalt, below 4,200 feet. Between 4,320 and 4,270 feet the formation is composed mainly of sands and silts. Few wells tap this zone.

The Raft Formation in this area was deposited by north flowing tributaries of the Snake River. The Snake at this time is believed to have flowed closer to the northern edge of the Snake Plain.

In the Gibson Terrace area, the Raft Formation is composed almost entirely of sand and gravel. Few irrigation wells tap this gravel; most pass through it into the basalt. The gravel, however, is the main domestic water source. These gravels may have been partially contributed by the Snake River as it was forced to the southern edge of the Plain by basalt flows.

The Raft Formation is overlain by the American Falls Formation in both the Gibson and Michaud areas. This formation was caused by the damming of the Snake River by the Cedar Butte basalt flows that occurred approximately eleven miles southwest of the present American Falls townsite.

The American Falls Formation was described by Ridenour (1969). According to his analysis, the basalt flows obstructed the Snake River twice. The first diverted the Snake River and caused deposition of sands and silts up to an elevation of approximately 4,360 feet. This deposition comprises the lower member of the formation. Then a second flow of the Cedar Butte Basalt completely dammed the Snake River, forming the ancestral American Falls Lake. The silts and clays deposited in this lake form the upper member of the formation. This formation extends up to an approximate elevation of 4,400 feet. In the Michaud and Gibson areas, well logs indicate a thickness of approximately 30 feet of this clay layer. The clay seems fairly continuous in the Michaud and Gibson areas, thinning slightly to the northeast. The cross section east of Ferry Butte (Figure 58) shows the clay bed to be less than ten feet thick and discontinuous, possibly indicating the upstream extent of the lake. Near the hills along the edge of the plain, some well logs indicate considerable sand and gravel within the clay layer, possibly due to alluvial fan or delta deposits advancing into the lake.

On the northwest side of American Falls Reservoir, the Raft Formation is overlain by the Big Hole Basalt (Carr and Trimble, 1963) which occurs near the surface. This basalt flow occurred prior to the American Falls Lake, and probably formed the northern boundary of the lake.

Above the lake beds exists another gravel deposit. In the Michaud area, this has been identified as the Michaud Gravel (Trimble, 1976) which was deposited directly on top of the lake clays by the Bonneville flood. This flood resulted from the overflowing of Lake Bonneville, the larger ancestor of

Great Salt Lake. The flood came down the Portneuf River valley and into ancestral American Falls Lake, destroying the basalt dam and emptying the lake. The gravel deposited by the flood extends north almost to Ross Fork and west beyond the reservation. In most places on Michaud Flats, the gravel is between 20 and 50 feet thick. The gravel becomes coarser in the easterly direction, with some boulders in the Pocatello area reaching eight feet in diameter.

On the Gibson Terrace, the American Falls Lake Beds are covered by a 20 to 60-foot layer of sand and gravel. This gravel to the north of Ross Fork may not be part of the Michaud Gravel, but rather may have been deposited by the Snake River at about the same time.

The Fort Hall Bottoms area is probably geologically similar to Gibson Terrace and Michaud Flats. It has been created by erosion of the Snake River and tributary streams to its present level.

In the upland areas of the Snake Plain to the east of Gibson Terrace, the volcanic hills are overlain by varying thicknesses of unconsolidated sediments. Ross Fork was impounded for a time by the basalt flows to the east of the Main Canal to form a lake in the Buckskin Basin area. This lake accumulated approximately 80 feet of silt and sand deposits. The lake was destroyed either by filling with sediment or the erosion by Ross Fork through the basalt flows (West & Kilburn, 1963). Higher hills in the area, including Gibson and Ferry Buttes, are covered with wind-blown silt (loess) of varying thicknesses.

HYDROLOGY

DATA SOURCES

The USGS maintains recording gaging stations at three locations on the Snake River in the vicinity of the Fort Hall Reservation. These are above the Blackfoot River near Shelley (130600), just downstream of the Blackfoot River near Blackfoot (130695), and downstream of the American Falls Reservoir at Neeley (130770). The Snake River between the upper and lower stations receives all of the runoff from the reservation.

The major tributaries within the reservation are all monitored by the USGS in their lower reaches as they cross the Snake Plain. These are the Blackfoot River (130685), Ross Fork (130759.6), Portneuf River, and Bannock Creek (130762); the upstream areas of which are described in their respective chapters. Currently, the USGS monitors the Portneuf at Topaz, Pebble, and Pocatello. After the Portneuf enters the reservation, it is monitored at two locations. The first (130759.09) is at the Siphon Road Bridge (5S/33E-36dcc) where periodic measurements have been made since 1973. The second (130759.1) is located downstream in 5S/33E-36a, where summer measurements have been made since 1924 as part of the American Falls Reservoir inflow studies.

Several springs have been monitored during summer months since 1924 as part of the American Falls Reservoir inflow studies. These include Spring Creek at the Cable Bridge (130759.85), Jimmy Creek (1390759.9), Kinney Creek (130759.9) Clear Creek (130759.3), Ford Creek (130759.4) and Wide Creek (130759.2). Also Spring Creek has been monitored near its source at Ferry Butte (130759.8) periodically since 1974.

For this study, monthly measurement stations were maintained at several USGS stations to provide year-round measurements. These were at Spring Creek (Cable Bridge), Jimmy Creek, Clear Creek (including Ford Creek), and Wide Creek. In addition, stations were established on the Fish Hatchery Springs near Ferry Butte, Diggie Creek (including Mud Slough), and the Jimmy Drinks East and West Branches.

On the Portneuf River, a station was established near the Siphon Road Bridge at the Michaud Pumping Station; a second below the inflow of the Jimmy Drinks Springs and Clear Creek (5S/33E-28aab); and a third near the river mouth at 6S/32E-9a.

The USGS monitors four wells on the Snake River Plain within the reservation. One is located on the Fort Hall Bottoms at the base of Ferry Butte (4S/34E-5ccd), one on Gibson Terrace (5S/34E-20cbb), and two on Michaud Flats (5S/33E-35ccd and 6S/32E-27add). These wells have been monitored since 1955. The two on Michaud Flat currently have automatic recorders, while the other two are measured monthly or semi-annually. All four wells only partially penetrate the gravel aquifer above the basalt.

For this study, four water level recorders were maintained on wells on the Snake Plain. One monitored a perched water table northwest of Fort Hall in 4S/34E-28cdcc. The other three monitored the main aquifer. Two wells penetrated the basalt aquifer on Gibson Terrace (3S/35E-21a and 4S/35E-17a) while one penetrated the gravel aquifer on Michaud Flats (6S/32E-26ba). In addition, 23 wells were monitored on a monthly basis on Gibson Terrace, with additional wells checked periodically. On Michaud Flats, 14 wells were monitored monthly, with additional wells checked periodically.

SURFACE WATER

The Snake River Plain within the reservation forms a separate hydrologic basin, due to the unique ground water flow conditions. The Gibson Terrace and Michaud Flats form the upper level of the Snake Plain basin. This terrace system is crossed by the four streams that drain the reservation lands: the Blackfoot River, Ross Fork, Portneuf River and Bannock Creek. Other than these streams, the terrace has no natural perennial surface drainage due to the high permeability of the subsoil. The Fort Hall Bottoms forms the lower level of the Snake Plain. This is the area of the large ground water discharge from the Snake Plain aquifer, second only to the Thousand Springs near Buhl. Numerous springs exist throughout the Bottoms; however, much of the discharge is concentrated in two areas. The largest discharge originates near the southwest side of Ferry Butte, giving rise to Diggie Creek and Spring Creek. The second area lies near the junction of the three terrace units on the Portneuf River, and gives rise to the Jimmy Drinks Springs and Wide Creek. The Snake River, which receives all surface runoff from the reservation, flows across the Bottoms, forming a portion of the reservation boundary. The hydrology of the springs is discussed first, followed by the tributary streams that cross the Snake Plain.

Hatchery Springs

Hatchery Springs is a group of several springs on the northwest side of Ferry Butte. There are three separate channel outlets to the Snake River, all of which are regulated by the commerical fish hatchery in operation there. A limited flow history is available for these springs. Hydrologists for the Bureau of Reclamation measured two springs in this area between 1926 and 1928, designated only as Indian Springs 1 and 2. It is not known if this represents the total flow of the springs. The combined mean flows, based on their summer measurements, were:

1926	44.9 cfs
1927	58,3 cfs
1928	69.3 cfs

These discharges are far below the current flows. The combined measurements of the three springs taken during this study are shown in Figure 61. These measurements, including two by the USGS, indicate an average flow of 103 cfs. Although the record is limited, it indicates the presence of a seasonal variation that matches the general ground water table fluctuation: low during the spring and high during the fall. However, insufficient data is available at this time to establish a meaningful flow history for this spring system.

Diggie Creek

Diggie Creek is formed by two tributary springs that originate on the west side of Ferry Butte. The two springs, Mud Slough and Diggie Creek, flow parallel, join, and enter the Snake River. Diggie Creek is susceptable to flooding from Snake River overbank flow, and was completely inundated by the Teton Flood of June, 1976. This spring is believed to be the Indian Spring #3 monitored by the Bureau of Reclamation between 1926 and 1928; however, the exact location of their measurements are not known. The mean summer flows were:

1926	115 cfs
1927	128 cfs
1928	164 cfs

This flow is extremely low in comparison with present flows, and may not represent the entire spring flow. The flow hydrograph of Mud Slough is shown in Figure 62, while the combined flow of the two tributaries is shown in Figure 63. Prior to 1975, the tributaries were measured separately. After 1975 the combined flow was measured by boat below the junction. Although the data is limited, the hydrographs indicate the presence of the seasonal cycle similar to the ground water table.

This spring is probably the largest spring on the Fort Hall

FIGURE 61.

FORT HALL BOTTOMS - HATCHERY SPRINGS

Location: 3S/34E 31d
Elevation: 4400 feet

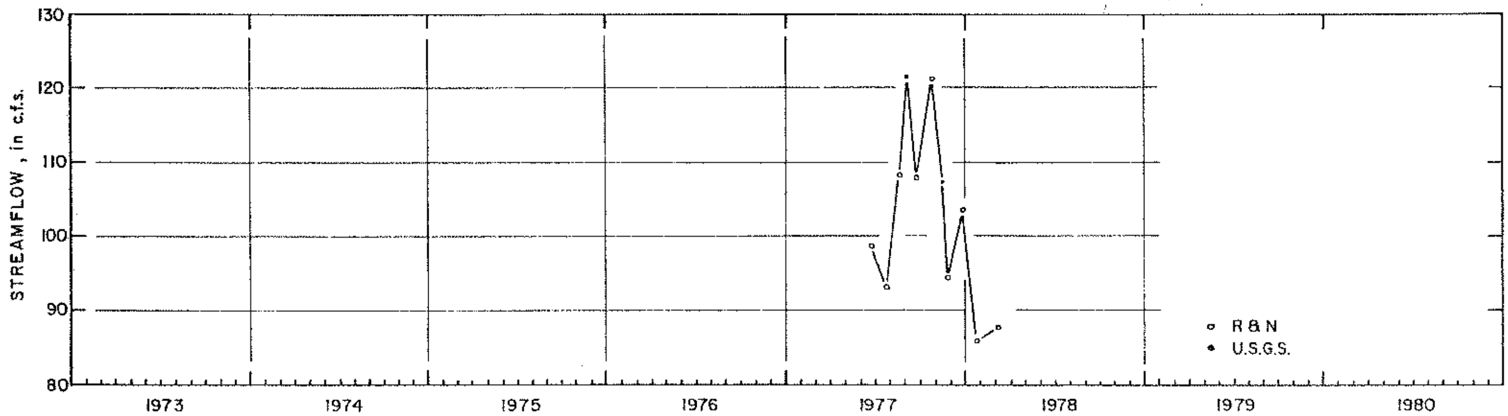


FIGURE 62.
FORT HALL BOTTOMS - MUD SLOUGH

Location: 4 S/34 E 7 aa
Elevation: 4400 feet

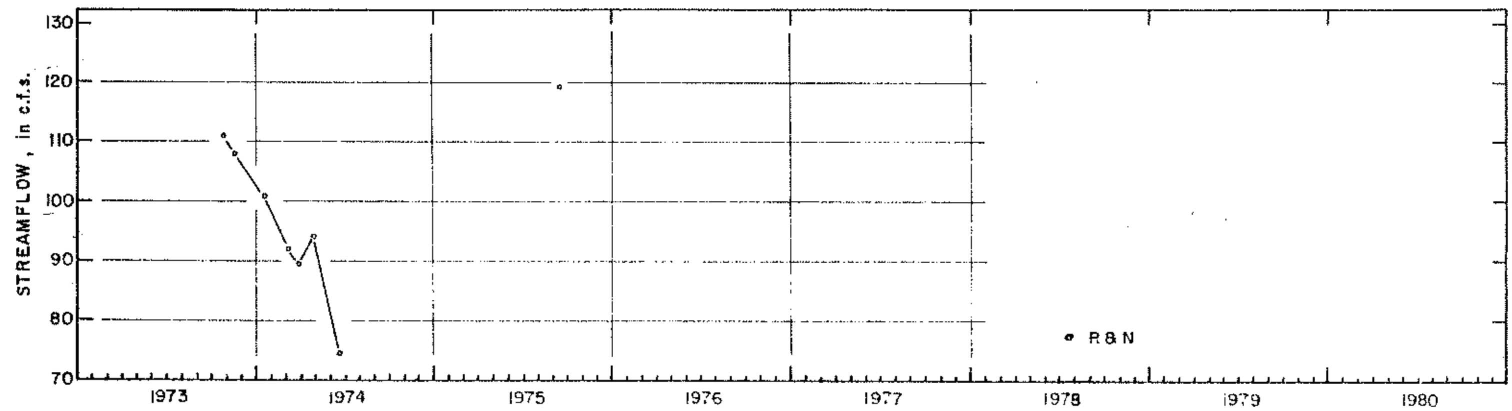
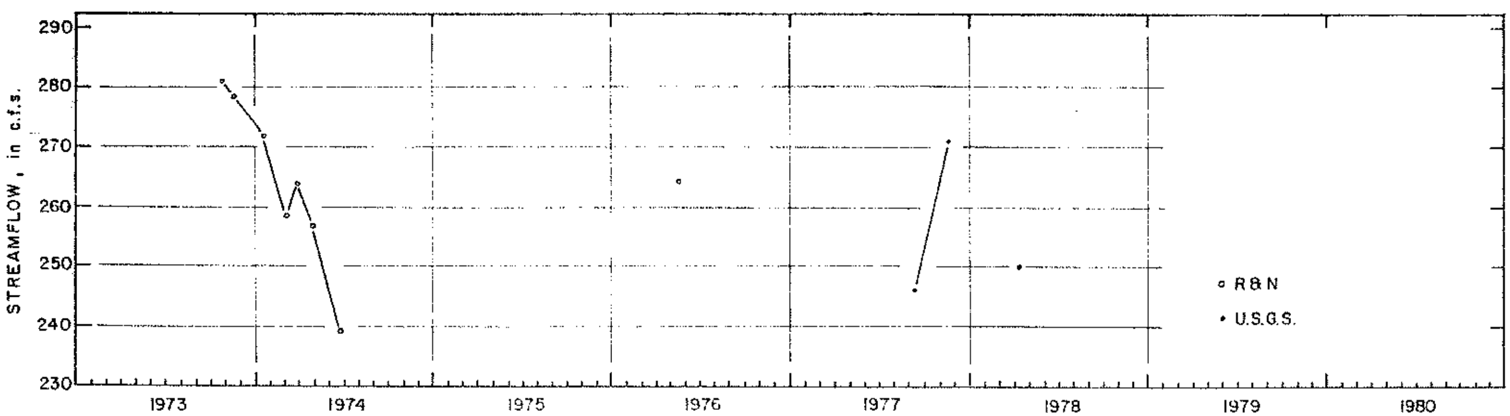


FIGURE 63.
FORT HALL BOTTOMS - DIGGIE CREEK

Location: 4 S/34 E 7 ac
Elevation: 4400 feet



Bottoms to directly enter the Snake River. Measurements ranged between 240 and 280 cfs. The average of all flows measured during this study, including two by the USGS in 1977, was 263 cfs.

Jeff Cabin Creek

Jeff Cabin Creek drains a relatively large area of the Bottoms between Diggie and Spring Creeks. The spring, however, has a very small discharge. It is believed to be the Indian Spring #5, measured during 1926 to 1928 by the Bureau of Reclamation. They recorded mean summer flows of:

1926	19.9 cfs
1927	22.1 cfs
1928	19.4 cfs

No flow measurements were made as a part of this study. The USGS twice measured the flow in 1977, recording 22.8 cfs on September 10, and 19.5 cfs on November 17. The lower portion of this spring is subject to flooding from the Snake River.

Spring Creek

Spring Creek is the largest spring-fed creek in the Fort Hall Bottoms, both in discharge and channel length. It originates on the southwest side of Ferry Butte, near the origin of Diggie Creek. It flows parallel to the Snake River, along most of the length of the Fort Hall Bottoms, then joins the Portneuf River about 4.5 miles upstream of its mouth. The channel is approximately 22 miles long, with an average slope of about four feet per mile. The downstream quarter is regularly inundated by the American Falls Reservoir. The flow measurements made during this study, along with the majority of the previous measurements, were made at the Cable Bridge, which lies near the halfway point, or about 11 miles downstream of the source.

The mean flow at the Cable Bridge, based primarily on the 50 years of summer measurements made by the USGS, is 466 cfs. The yearly average flows are shown in Figure 64. The majority of the flow is contributed in the upper stretch of the creek. Periodic measurements by the USGS indicate that approximately 320 cfs originates at the source, as measured at the Bronco Road Bridge. About 100 cfs is contributed between Bronco Road and Sheepskin Road, with about 50 cfs added between Sheepskin Road and the Cable Bridge. Measurements by the USGS at the mouth of Spring Creek indicate that no significant increase in flow occurs downstream of the Cable Bridge.

The overall pattern of the yearly flows (Figure 64) resembles the pattern of annual precipitation at the Pocatello station (Figure 6). Flows are noted to increase during times of above average precipitation. The majority of the average yearly flows are within ten percent of the mean flow.

Stage measurements made at the Cable Bridge indicate a slight seasonal variation that corresponds to the behavior of the Snake Plain aquifer. The total stage variation, based on measurements taken during this study, is only 0.23 feet (2-3/4 inches). This small variation accounts for an 80 cfs change in discharge. The stage measurements show the high discharges peak in September, with the low cycle reached between February and May. The individual flow measurements during the study are shown in Figure 65.

Spring Creek rarely experiences flooding, due to its greater distance from the Snake River. One natural flood of the Snake River is reported to have occurred during the 1860's which inundated the Bottoms. More recently, Spring Creek was inundated with flood waters resulting from the Teton Dam failure of June, 1976. The flood water reached the creek just south of Bronco Road, filling the entire channel. The flood waters entered the creek over a three day period. The only other outside influence on the flow is the contribution of irrigation return flow from the North Canal which enters Spring Creek near Bronco Road. This flow is rarely measured, but is probably in the neighborhood of several cfs.

Big Jimmy Creek

Big Jimmy Creek originates in a group of springs located in 4S/33E-26c, between Spring Creek and the Snake River. It flows southwest and enters Spring Creek just below the Cable Bridge. At one point, Jimmy Creek flows within 400 feet of the Snake River channel. Thus it is susceptible to receiving flood waters from the Snake. However, this is known to have occurred only once during this study, at the time of the Teton Flood. In the past, a significant portion of the Snake River flood flows diverted down Jimmy Creek. This affected measurements during the Bureau of Reclamation's study in 1925 and 1926. It had been feared that a significant portion of the normal Snake flow would

FIGURE 64.
FORT HALL BOTTOMS - SPRING CREEK
(U.S.G.S. NO. 130759.85)

Location: 5S/33E 9aca
Elevation: 4355 feet

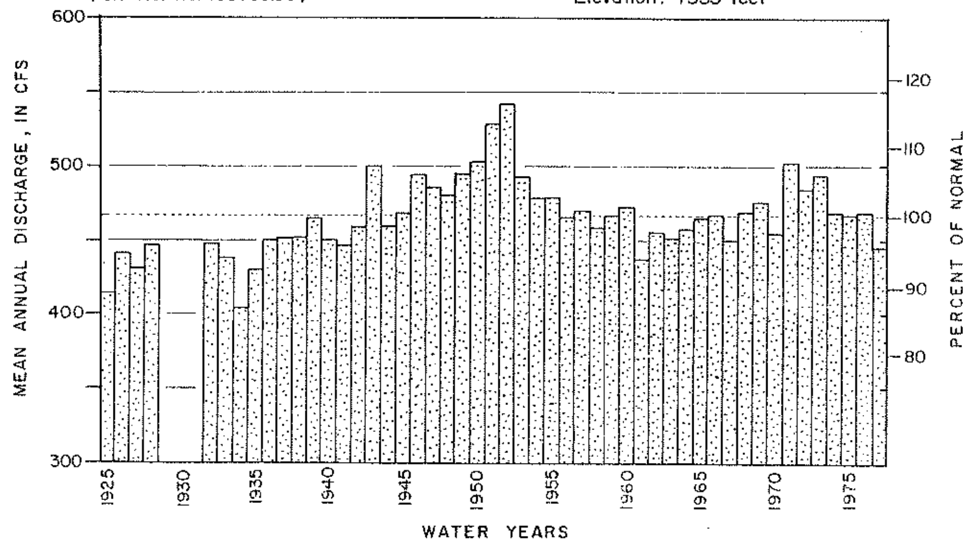
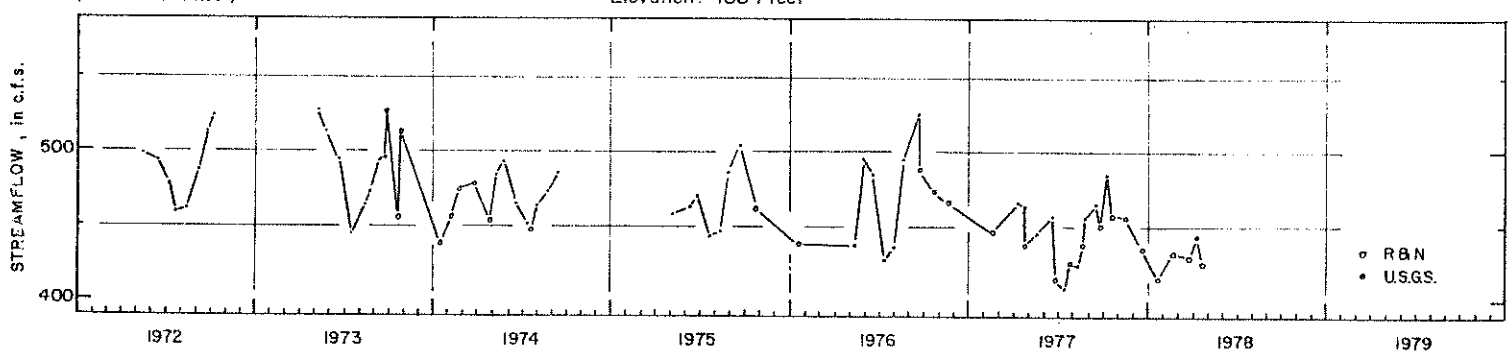


FIGURE 65.
FORT HALL BOTTOMS - SPRING CREEK
(USGS. 130759.85)

Location: 5 S/33 E 9aca
Elevation: 4354 feet



divert down the creek, due to channel migration connecting the two. However, subsequent channel erosion diverted part of the Snake River flow away from Jimmy Creek.

Flow measurements were made near the creek mouth in 5S/33E-4db. The average discharge, based on 48 years of summer measurements by the USGS, is 30.5 cfs. The majority of the annual flows were within ten percent of the mean flow (Figure 66). The flow pattern based on individual measurements (Figure 67) does not exhibit the same pattern as Spring Creek, in that the higher flows occur during the spring. It resembles more a pattern expected of the Snake River. This may indicate that the level of the Snake River is an overriding influence on the discharge through lateral bank seepage or actual surface water transfer. This could also account for the higher than normal turbidity levels found in Jimmy Creek.

Clear Creek

Clear Creek flows along the base of the Gibson Terrace, east of, and parallel to, Spring Creek. Unlike Spring Creek, Clear Creek increased in flow along its entire length. The creek joins with Ross Fork near the maximum extent of the American Falls Reservoir. After this junction, the creek enters the Portneuf River, between the two branches of Jimmy Drinks Spring. The creek receives some irrigation return flow from the Gibson Drain at about the channel's halfway point. This flow is usually not monitored, and may add several cfs during the irrigation season. The creek did receive overbank flow from the Snake River-Teton flood. However, this is the only known occurrence of flooding on the creek.

The mean flow of Clear Creek, based on the 50 years of available records, is 134 cfs. The mean annual flows (Figure 68) are generally within ten percent of the total average, as is usually found in these springs. The overall pattern is similar to Spring Creek, with above-average flows between 1945 and 1955, and between 1965 and 1975, corresponding to precipitation changes. There also seems to be a slight increase in discharge through this cycle. This may be due to impacts of land use changes on the Gibson Terrace, particularly with respect to irrigated agriculture, and the contribution of return flow from the Gibson Drain. The record of recent flow measurements (Figure 69) also suggests a seasonal flow pattern similar to Spring Creek, with higher discharges occurring in late summer.

FIGURE 66.
FORT HALL BOTTOMS - BIG JIMMY CREEK Location: 5S/33E 4db
(U.S.G.S. NO. 130759.9) Elevation: 4355 feet

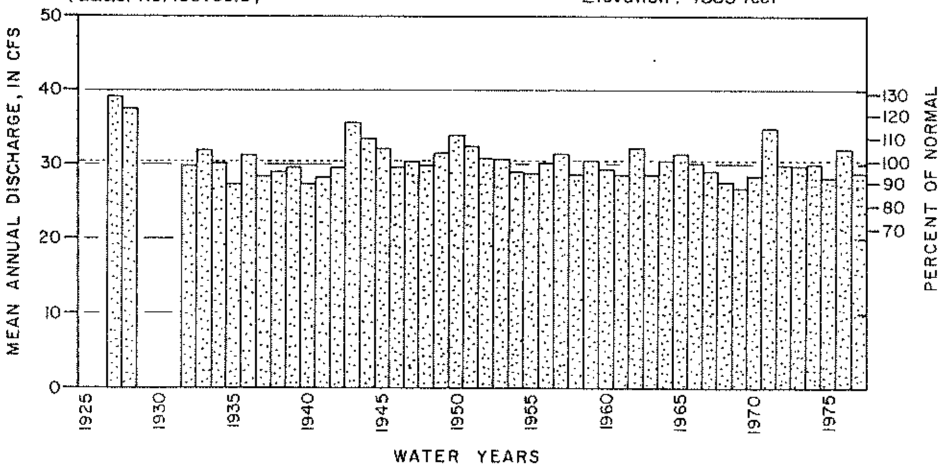


FIGURE 67.
FORT HALL BOTTOMS - BIG JIMMY CREEK Location: 5S/33E 4db
(U.S.G.S. 130759.9) Elevation: 4355 feet

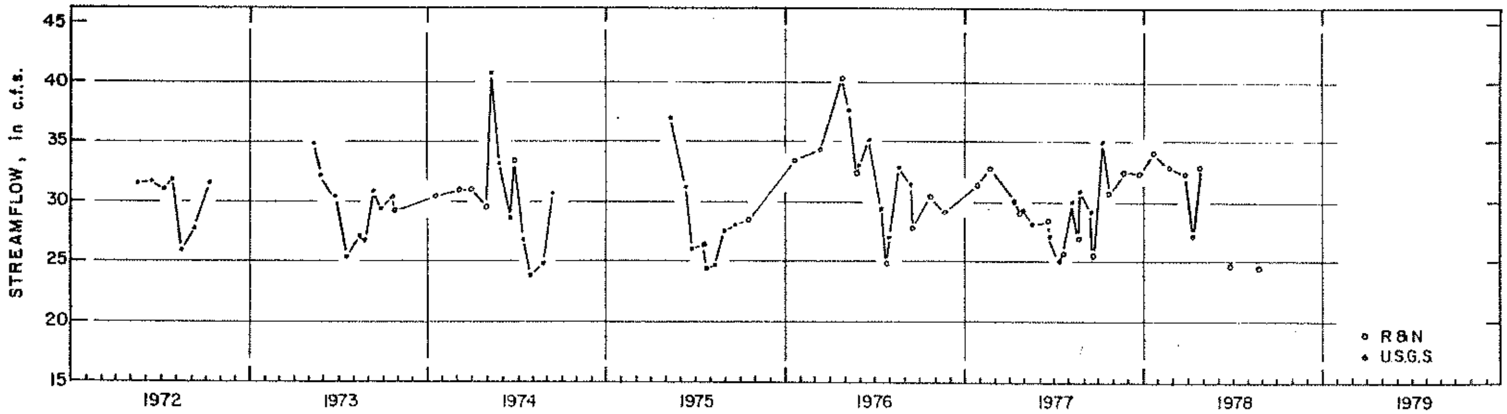


FIGURE 68.
FORT HALL BOTTOMS - CLEAR CREEK
(U.S.G.S. 130759.3 + 130759.4)
Location: 5S/33E 14bb
Elevation: 4353 feet

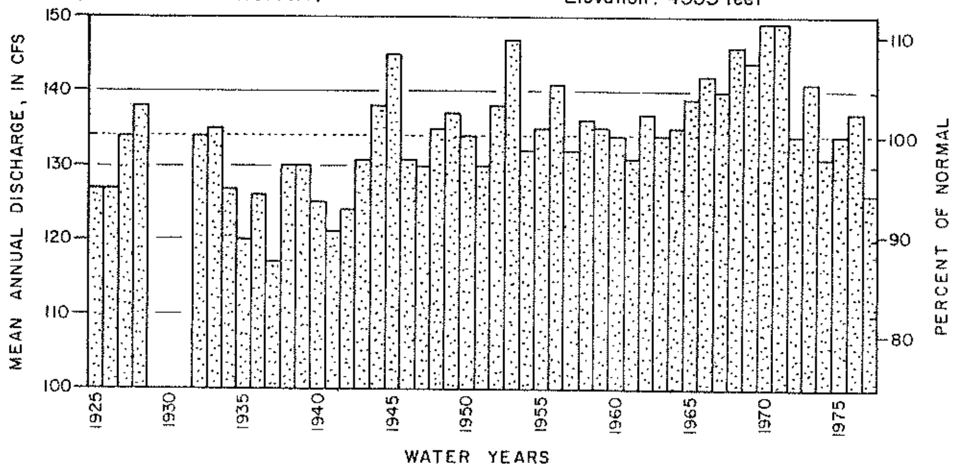
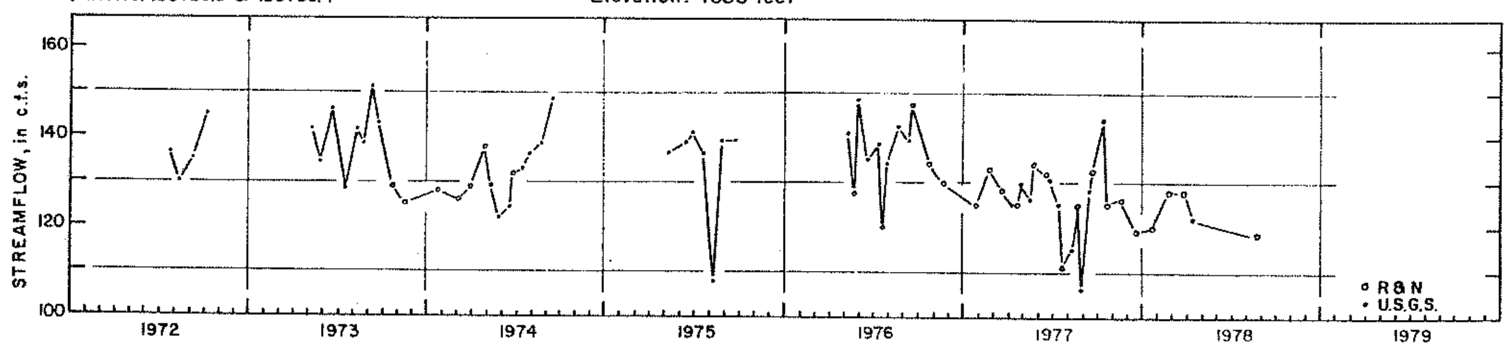


FIGURE 69.
FORT HALL BOTTOMS - CLEAR CREEK
(U.S.G.S. 130759.3 & 130759.4
Location: 5 S/33 E 14bb
Elevation: 4353 feet



The discharge measurements for this study were made downstream of Ford Creek, a small tributary. The USGS monitors both streams separately. Consequently, for this analysis the two USGS stations were combined. The creek probably receives additional flow below these stations. This would be accounted for in the gains to the lower Portneuf River.

Kinney Creek

Kinney Creek is a relatively small spring that flows between Clear Creek and Spring Creek. Approximately half of its channel is regularly inundated by the American Falls Reservoir. The creek enters the Portneuf River between Spring and Clear Creeks.

No measurements were made on the spring as a part of this study. The USGS has, however, measured summer flows since 1924, the average flow of which is 28.1 cfs. The yearly flows are very consistent (Figure 70), although the increase in flow evident in other springs around 1970 is not apparent. The 1977 mean flow is the lowest on record, being 87% of normal.

Batiste Spring - Papoose Spring

Batiste Spring is the first large spring on the Portneuf River as it enters the Bottoms area. It lies upstream of the reservation, and contributes a significant flow to the Portneuf. Few flow measurements have been recorded on this spring. The USGS has recorded four discharge measurements:

9/14/25	50 cfs (estimated)
6/10/70	46 cfs
10/6/70	32 cfs
9/29/71	7.2 cfs

The last measurement may have been affected by fish hatchery use of the spring and is assumed to be in error. For this study, a figure of 45 cfs will be used as the assumed average flow.

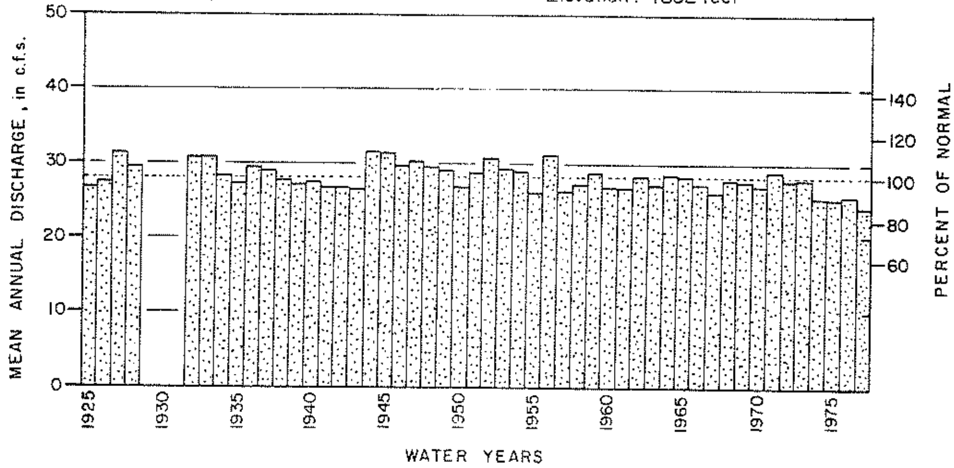
Papoose Spring straddles the reservation line on the west side of the Portneuf, and enters the river within the reservation. A fish hatchery is in operation on this spring. Only one published measurement of the flow is available. Stearns and others (1938, p.138) put the discharge at "about 75 cfs" on September 14, 1925.

FIGURE 70.

FORT HALL BOTTOMS - KINNEY CREEK (USGS 130759.7)

Location: 5S/33E 15 ac

Elevation: 4352 feet



Wide Creek

Wide Creek originates in a group of small springs named Twenty Springs, just north of the Michaud Pumping Station on the west side of the Portneuf River. It flows northwest, parallel to the Portneuf, and receives additional flow from Tindaha Spring to the west and Poongrah Spring to the east. Ground water inflow directly into the channel itself also increased the flow in the downstream direction. The creek joins the Portneuf River just upstream of Jimmy Drinks Spring, and is susceptible to flooding during high reservoir levels in the downstream reaches. Flow measurements were made downstream of the Tindaha Spring inflow.

Figure 71 shows the mean yearly flows since 1925, based on the available data. The mean flow, based on all measurements, is 57.4 cfs. Variation in the mean annual flows is usually within ten percent of the total mean. The graph shows the characteristic peak around 1950 that is representative of most springs on the Bottoms. However, the peak around 1970 is not evident. Rather, the yearly flows have been declining slightly since 1950. The plot of recent flow measurements (Figure 72) illustrates the characteristic seasonal variation, with lower flows during the spring and higher flows in the fall.

Jimmy Drinks Springs

Jimmy Drinks is a group of springs that rise west of Wide Creek and flow northward to enter the Portneuf River. It is the largest spring complex on the south side of the Portneuf. The springs diverge in two branches which were measured separately. To the author's knowledge, no previous measurements have been made on these springs by any government agencies, despite the extensive monitoring that has accompanied the existence of the American Falls Reservoir. Both springs are susceptible to inundation at the maximum reservoir stage.

The east branch is the larger, and was measured near its junction with the Portneuf River. The flow measurements are shown in Figure 73. The total average of these measurements is 103 cfs. The hydrograph illustrates the characteristic seasonal variation found in other springs. The west branch was measured near the reservoir's maximum fill line, about halfway along its channel. The discharge measurements are illustrated in Figure 74. The mean flow, based on all measurements, is 35.4 cfs. Some move-

FIGURE 71.
FORT HALL BOTTOMS - WIDE CREEK
(U.S.G.S. 130759.2)
Location: 5 S/33 E 26 bc
Elevation: 4354 feet

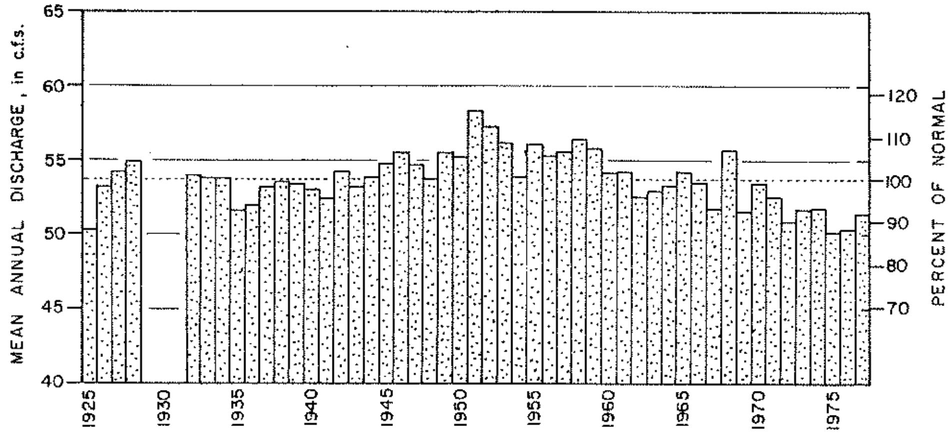


FIGURE 72.
FORT HALL BOTTOMS - WIDE CREEK
(U.S.G.S. 130759.2)
Location: 5 S/33 E 26 bc
Elevation: 4354 feet

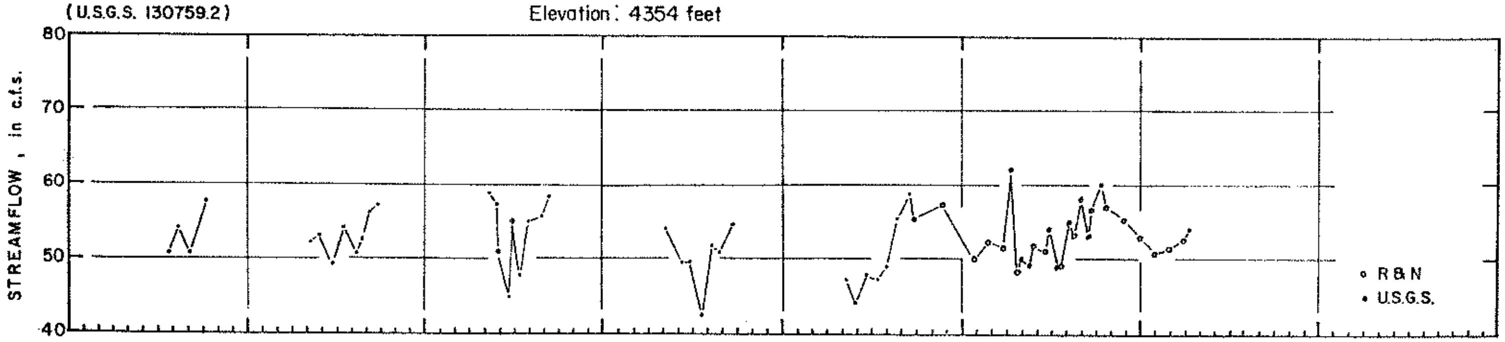


FIGURE 73.
FORT HALL BOTTOMS - JIMMY DRINKS EAST BRANCH

Location: 5S/33E 22 ddc
Elevation: 4355 feet

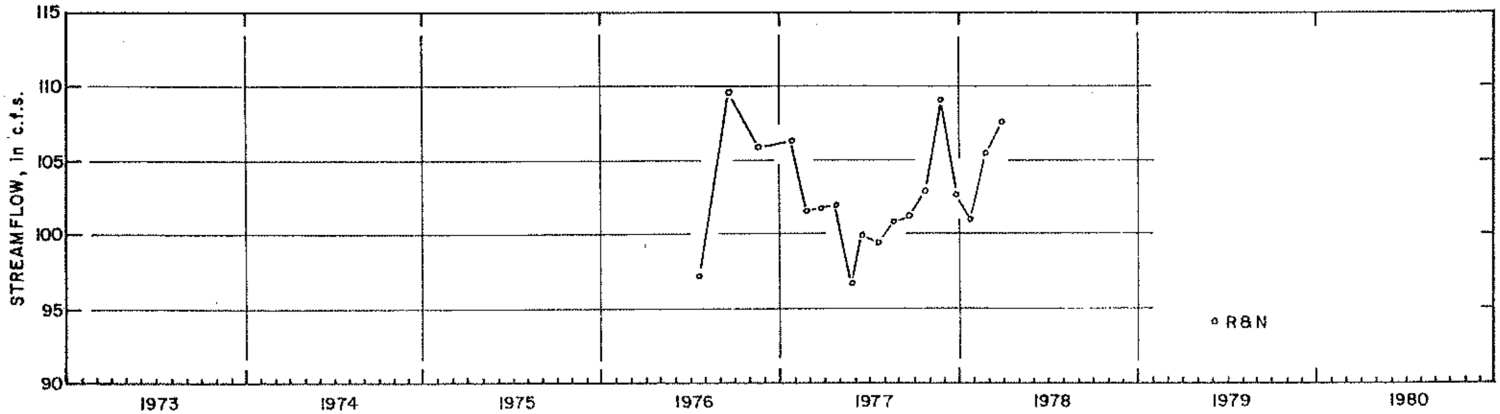
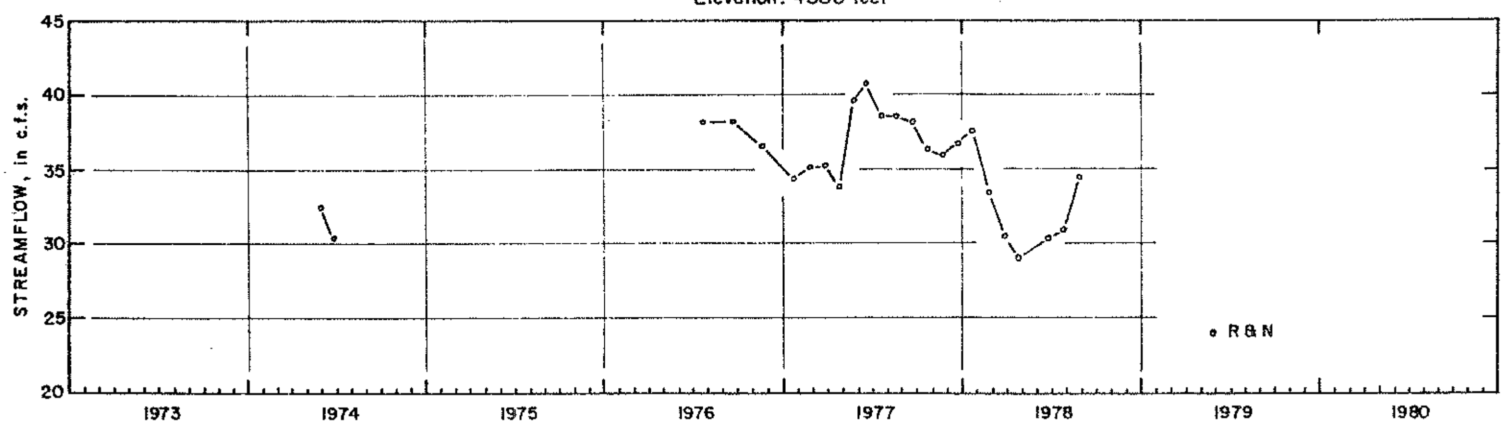


FIGURE 74.
FORT HALL BOTTOMS - JIMMY DRINKS WEST BRANCH

Location: 5S/33E 22 cad
Elevation: 4350 feet



ment of the measuring station occurred when the reservoir reached its maximum stage in 1978. This may have some effect on reducing the apparent discharge during the later spring and early summer, as ground water is contributed along its entire length.

Blackfoot River - Snake Plain Reach

The Blackfoot River flows across about 28 miles of the Snake Plain until it joins the Snake River at Ferry Butte. The channel is perched above the regional water table along this entire stretch. During the fall, when the water table is at its highest level, it is about 30 feet below the river near the town of Blackfoot. Given the pervious quality of the surficial material, the stream would be expected to lose water to the aquifer. However, this loss is not easily quantified, due to the number of irrigation diversions and drains that affect the flow of the lower Blackfoot. Studies by the USGS (Mansfield, 1920) have indicated that little water is lost from the river upstream of the Fort Hall Main Canal headgates. No such measurements have been made on the river below Blackfoot.

Ross Fork - Snake Plain Reach

Ross Fork is intersected by the Fort Hall Main Canal as it enters the Gibson Terrace portion of the Snake Plain. During non-irrigation seasons, the creek passes through the empty canal with little interference, although spring flood flows may be partially diverted into the canal. During the irrigation season, the creek enters the canal with excess canal water discharged down the Ross Fork channel. During low water years, as in 1977, little water is diverted down the channel.

The creek crosses the Gibson Terrace with little valley development until it reaches Siler Road, one mile west of Fort Hall. From this point, the creek has cut a valley into the Gibson Terrace sediments that gradually deepens until it joins the Fort Hall Bottoms. The creek channel is perched above the water table until it passes Fort Hall. Near Hawthorne Road the creek intersects the water table and begins to collect springflow from the valley sides. The discharge increases throughout the reach until the creek joins with Clear Creek. During the summer, the creek also receives irrigation return flow from several laterals and the Tyhee wasteway. This, coupled with the regulation of the stream at the Main Canal, exerts a strong influence on the discharge at the creek's mouth.

A measuring station was established just below the Main Canal crossing to provide information on the inflow to the Snake Plain area. The discharge measurements are shown in Figure 75. A station was established near the creek's mouth by the USGS in 1924 to measure flows during irrigation seasons. Additional measurements were made at this station as a part of this study. The average discharges based on all available data for each water year are shown in Figure 76. Individual measurements taken during this study are shown in Figure 77.

The discharge history shows a pattern different from other springs on the Bottoms. Prior to 1948, the discharge near the mouth averaged near 40 cfs. This suddenly increased in 1948 to near 60 cfs, and continued until 1967. The lower measurements may have been due to a portion of the flow being unmeasured by the USGS as noted in their records (USGS, 1970). The average flows again increased after 1967, gradually increasing each year until 1976. The most probably cause of this later increase is the development of extensive ground water irrigation north of the creek in the later 1960's.

During the non-irrigation seasons, measurements at the inflow and outflow stations indicate increases in flow of between 45 and 62 cfs, or an average of about 55 cfs. This is taken as the present average ground water inflow to the creek.

Portneuf River - Snake Plain Reach

The USGS maintains a gage on the Portneuf River at Pocatello, which records the river's discharge as it approaches the Snake Plain. The record of this station, showing mean annual discharges for each water year since 1912, is shown in Figure 78. This record shows a strong correlation with the precipitation records. The total mean flow at this station is 270 cfs.

Downstream from Pocatello the Portneuf channel falls below the regional water table. In the vicinity of Batiste Springs, the channel begins to collect ground water, either as distinct springflow from the valley sides or as seepage directly into the channel. The USGS, since 1924, has taken summer flow measurements at a site approximately one mile downstream of Siphon Road, or about 1.5 miles within the reservation. The water year mean flows are shown in Figure 79. The comparison of this station with the Pocatello gage offers some indication of the amount of ground water inflow in this stretch. These calculations are somewhat confused

FIGURE 75.
ROSS FORK BASIN - ROSS FORK below Main Canal   Location: 5S/35 E 5bbd   Drainage area: 167 sq. mi.
Elevation: 4490 feet

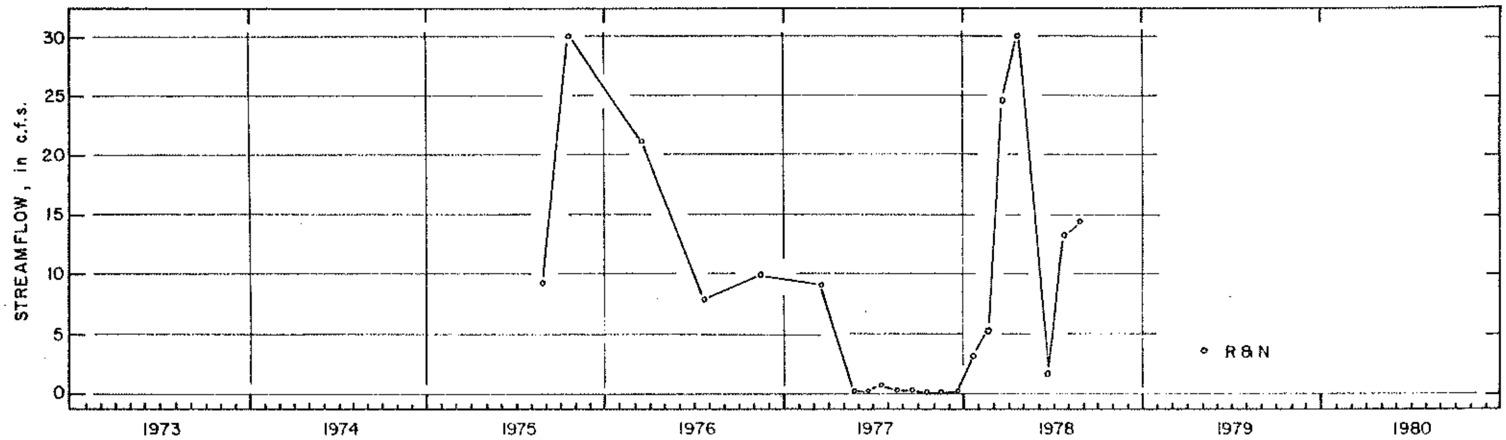


FIGURE 76.

FORT HALL BOTTOMS - ROSS FORK (U.S.G.S. NO. 130759.6) Location: 5S/33E 14ac Elevation: 4352 feet

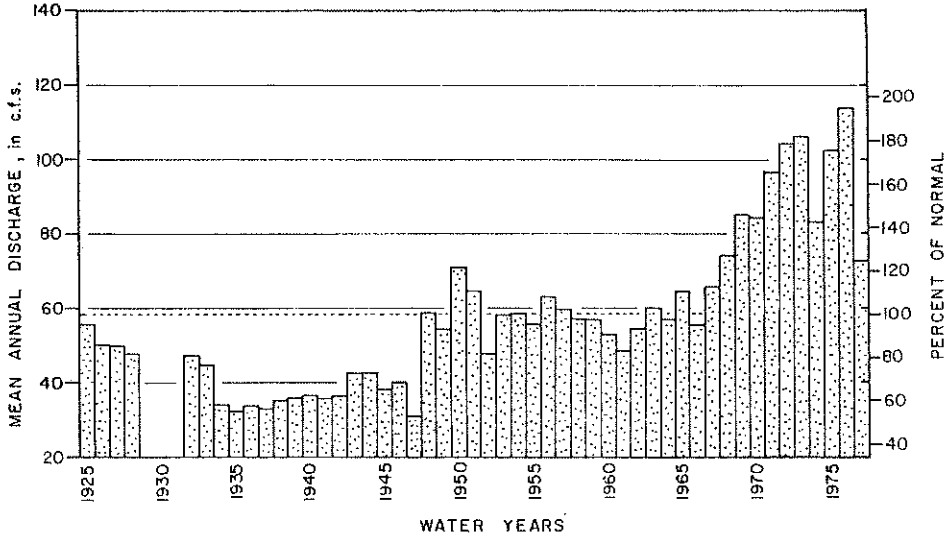


FIGURE 77.

FORT HALL BOTTOMS - ROSS FORK (U.S.G.S. 130759.6) Location: 5 S/33 E 14 ac Elevation: 4352 feet

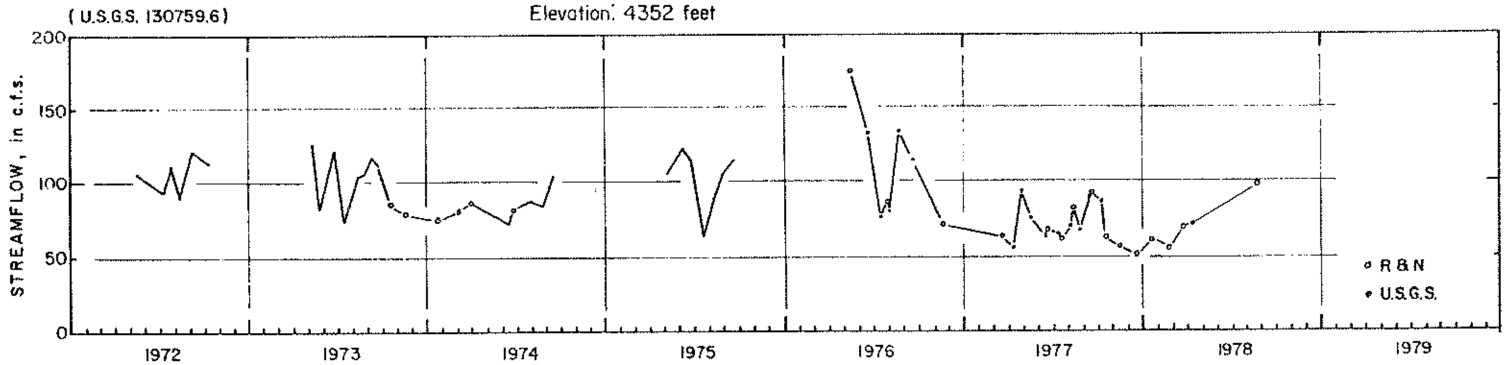


FIGURE 78.
PORTNEUF RIVER BASIN   Location: 6 S / 34 E 27 bd   Drainage Area: 1250 sq. mi.
PORTNEUF RIVER at Pocatello (U.S.G.S. 13075500)   Elevation: 4418 feet

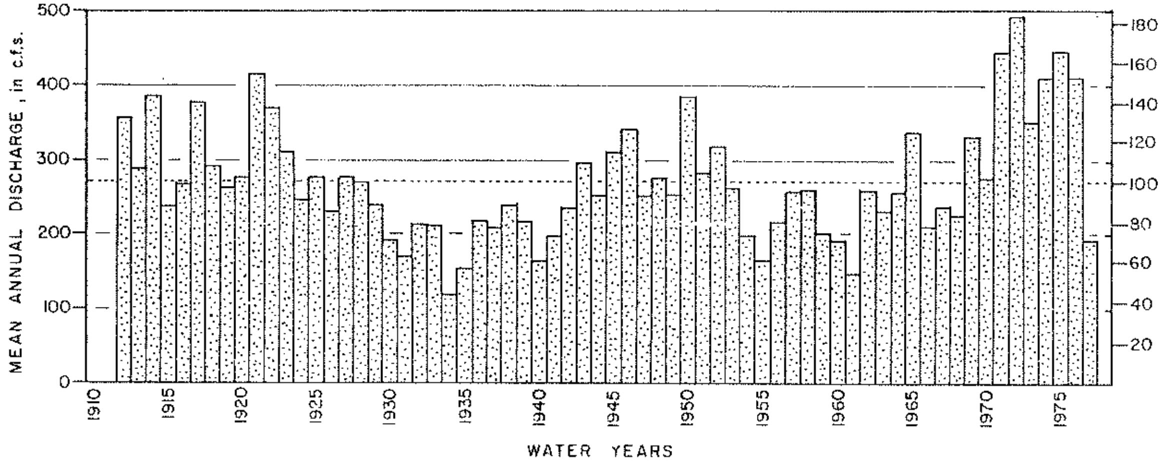
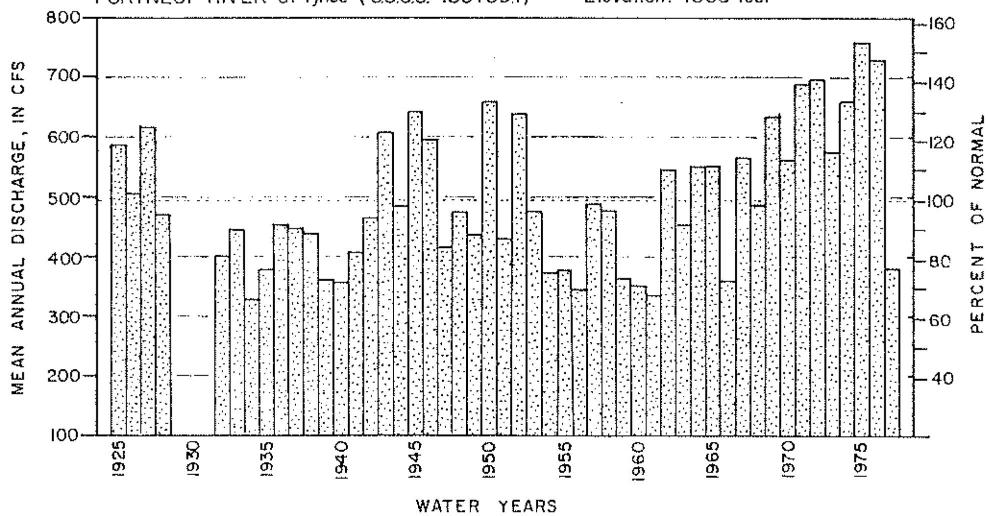


FIGURE 79.
FORT HALL BOTTOMS   Location: 5 S / 33 E 36a
PORTNEUF RIVER at Tyhee (U.S.G.S. 130759.1)   Elevation: 4360 feet



by other inflows in this area of the river. The foremost in volume is Pocatello Creek, which during the irrigation season drains off excess water from the Fort Hall Main Canal. No regular measurements are made of this flow. The second largest inflow volume is the industrial and municipal effluents discharged primarily from the two phosphate processing plants and the Pocatello sewage treatment plant. These flows were estimated at 17.5 cfs during 1975 (Perry, 1977). The only major withdrawal from the river is at the Michaud Pumping Station for the Michaud irrigation system. At a minimum, there appears to be an approximate 270 cfs gain in the Portneuf River between the two abovementioned stations. Accounting for various inflows, this indicates about 240 cfs of ground water contribution. There are indications that the gain increases during the summer, however it is not known if this is due to ground water inflow or increased irrigation return flow. It is apparent that about 120 cfs of this inflow is accounted for in the flows of Batiste and Papoose Springs. Thus an additional 120 cfs is contributed by other smaller springs and seepage directly into the channel. Data indicates that about 70 cfs of this is contributed between Pocatello and Siphon Road, with the remaining 50 cfs contributed between Siphon Road and the Tyhee Station.

In the stretch of the river between the Tyhee station and below the Jimmy Drinks spring, the Portneuf receives, in quick succession, several large spring inflows. Wide Creek and the two branches of Jimmy Drinks enter from the south of the river. Clear Creek and Ross Fork join from the north. These springs, based on their mean flows over a 50 year period, contribute 384 cfs to the Portneuf. For this study, two stations were established on the Portneuf to further quantify this inflow. One station was established at the Michaud Pumping Station near Siphon Road (Figure 80). The second was established approximately one half mile below the Jimmy Drinks West Branch (Figure 81).

Six sets of measurements at these stations were made. These measurements indicate that approximately 619 cfs is added to the Portneuf in this stretch. Of this inflow, 398 cfs is accounted for by the individual spring inflows. The remaining 220 cfs is springflow contributed directly to the Portneuf channel or the tributary springs below their measuring stations.

Of this 220 cfs, 50 cfs has been attributed to the stretch between Siphon Road and the Tyhee measuring station. This leaves about

FIGURE 80.
PORTNEUF RIVER BASIN
PORTNEUF RIVER at Siphon Road

Location: 5S/33E-36dcc
Elevation: 4367 feet

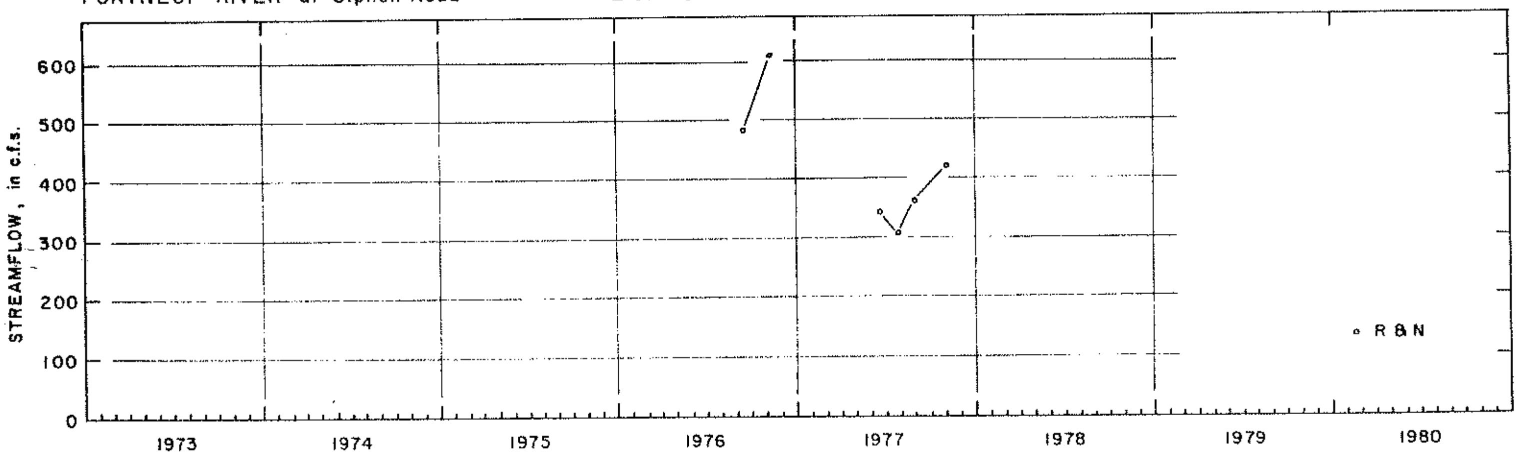
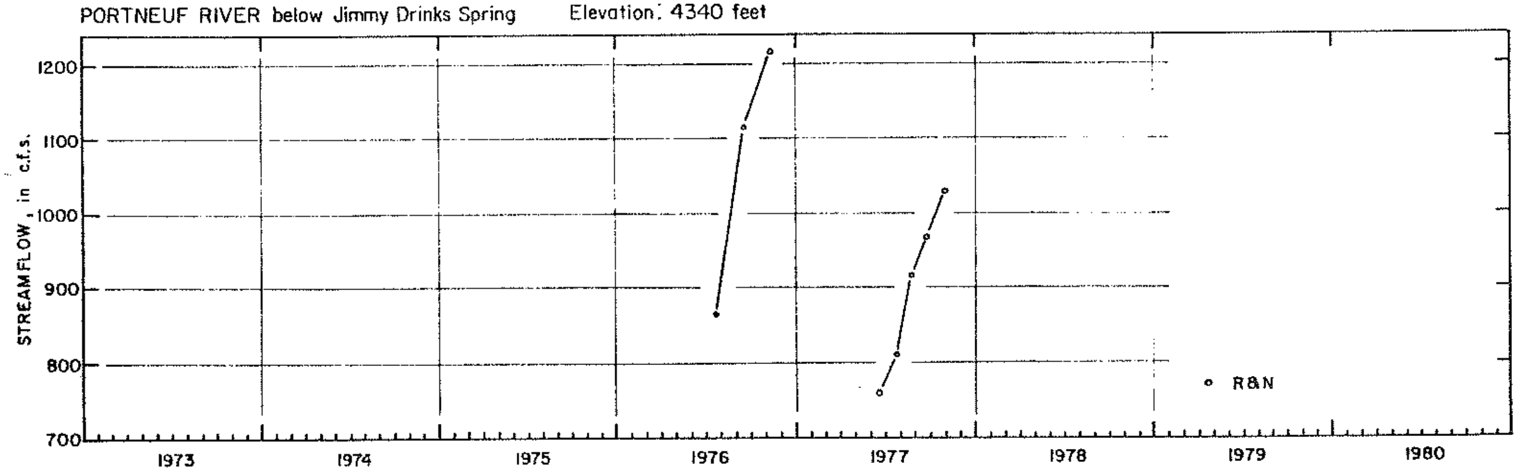


FIGURE 81.
PORTNEUF RIVER BASIN
PORTNEUF RIVER below Jimmy Drinks Spring

Location: 5S/33E 28 aab
Elevation: 4340 feet



170 cfs of ground water inflow to the Portneuf River between the Tyhee station and the station below Jimmy Drinks Spring.

The lowest stretch of the river, from the station below Jimmy Drinks Spring to the mouth, receives springflow from Kinney Creek and Spring Creek, including its tributary Big Jimmy Creek. Measurements along this stretch of the river are usually prohibited by the reservoir backwaters. However, during 1977, the reservoir was drained in connection with construction of the new American Falls Dam. This permitted a unique opportunity for inflow measurements in this reach.

The measurements near the river mouth made on September 29 and November 1, 1977, when compared with the upstream station, indicated gains of 671 and 637 cfs respectively. Discounting the flows in the three measured springs, the unaccounted gain amounted to 156 and 120 cfs for the respective dates. Lacking other comparable data, the average of these, or 138 cfs, is taken for the unmeasured ground water inflow to the river. Measurements by the USGS near the river mouth during this period substantiate these conclusions.

To summarize, an average of 983 cfs is contributed to the Portneuf by springs monitored within the reservation. An additional 45 cfs is contributed by Batiste Spring upstream of the reservation. The unaccounted gain to the Portneuf has been measured at 428 cfs. This includes 70 cfs which enters the river upstream of Siphon Road and 358 cfs which enters below Siphon Road. The total ground water contribution to the Portneuf River is calculated to be 1450 cfs of which about 1340 cfs enters within the reservation.

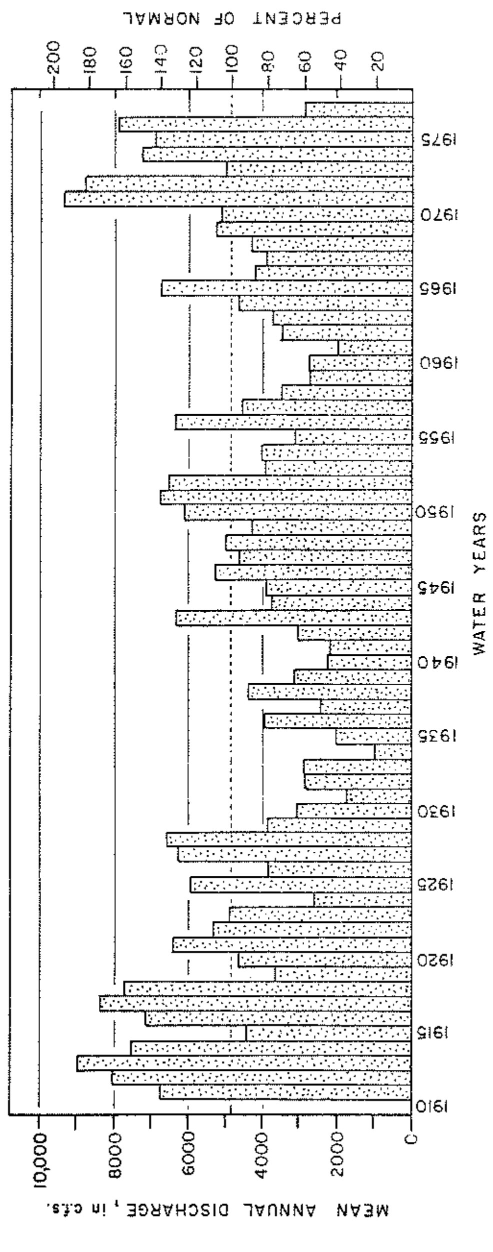
Snake River

The Snake River forms a portion of the reservation's boundary; from the mouth of the Blackfoot River to the mouth of the Portneuf River. The Snake is the largest drainage in Idaho, and receives all runoff from the reservation. The USGS maintains a gage just below the mouth of the Blackfoot River. The hydrograph (Figure 82), showing the mean annual discharge for each water year since 1911, exhibits a strong correlation with the precipitation record. The mean flow for this 67 year period is 4800 cfs. The river above the gage station is perched above the water table. As it passes the gage, however, the river drops to the elevation of the water table and begins to receive ground water inflow.

FIGURE 82.
SNAKE RIVER BASIN - SNAKE RIVER
near Blackfoot (U.S.G.S. No. 13069500)

Location: 3 S/34 E 30dd
Elevation: 4400 feet

Drainage area: 11,310 sq.mi.



Three spring systems discussed above drain from the Fort Hall Bottoms directly into the Snake River. These are Hatchery Springs, Diggie Creek, and Jeff Cabin Creek. The approximate mean flow of these springs is 387 cfs. Measurements by the USGS in 1977 indicate a gain of 648 cfs to the Snake River between the gage near Blackfoot and the reservoir boundary. They also recorded 72 cfs that entered the Snake from springs on the northwest side. This leaves about 185 cfs that enters the Snake directly, although from which side is not known. For this analysis, it will be assumed that half, or 92 cfs, enters from the reservation lands. Further downstream, on land that is usually inundated by the American Falls Reservoir, the Portneuf River joins the Snake, delivering with it the remainder of the ground water discharge from the reservation lands. Thus the total spring discharge from reservation lands in the Fort Hall Bottoms is approximately 1820 cfs.

The USGS maintains a gage on the Snake River just downstream of the American Falls Reservoir, at Neeley. The total gain in the river between the gages at Blackfoot and Neeley was estimated at 2500 cfs by Stearns and others (1938), and at 2072 cfs by Mundorff and others (1964). Springflow identified in this report totals about 2100 cfs, of which 1820 originate from reservation lands.

GROUND WATER

Foothills

The area designated as foothills are those portions of the uplands that drain directly toward the Snake River Plain. They do not contribute runoff to any of the Snake River tributaries discussed in this report. Typically, the areas are underlain by either the Tertiary rhyolite and ash deposits or the more recent basalt. They may also be covered by alluvial fan deposits and loess. The areas have no perennial surface drainages due to the rather high permeabilities of the soils and the small drainage areas. Consequently, any precipitation that infiltrates into the soil is recharged directly to the ground water.

The foothills area of the reservation includes an area of 91 square miles. It receives approximately 11 inches of precipitation per year, but most if not all is expected to be consumed by evapotranspiration. The water tables beneath the foothills are generally continuous with that of the Snake Plain aquifer. Recharge to aquifers beneath the foothills is assumed to be predominately from the Snake Plain aquifer. The analysis by Mundorff and others (1964) indicates that only one inch of precipitation is available for runoff, accounting for 6.7 cfs (4853 acre feet).

Some ground water development has occurred in these areas. Much of this is in the benchland area west of Bannock Creek where both private wells and the BIA's Owl Canal supplemental wells withdraw irrigation water from the sand, gravel and volcanic ash formations underlying the bench. Also, limited private development for irrigation has occurred on the benchlands north of Pocatello. The specific capacities of these wells range between 40 and 55 gpm/ft. of drawdown (West and Kilburn, 1963).

Gibson Terrace

Numerous wells were monitored on the Gibson Terrace to determine the behavior of the ground water system. The aquifer in this area is one of the most productive in the State of Idaho. In the northern portion of Gibson Terrace, the water table shows a strong response to the surface water irrigation that occurs both on the terrace itself and along the Blackfoot and Snake Rivers upstream of Blackfoot. The water table usually reaches a low point in April. It then rises during the summer due to the irrigation water recharge. Part of this water is probably contributed by the Equalizing Reservoir on the Blackfoot River. The highest water level is usually reached in September, when much of the recharge ceases at the end of the irrigation season. The magnitude of this fluctuation increases in the northeast direction toward Blackfoot, reaching as much as 30 feet between spring and fall. It is most pronounced in wells 3S/35E-8dbdc (Figure 83), 10cbc (Figure 84), and 18daaa (Figure 85). The magnitude of this cycle is reduced in the downstream direction, indicating an increase in the aquifer's transmissivity. Wells to the southwest of the three previously mentioned exhibit generally less than five feet of fluctuation. These are located at 3S/34E-27dda (Figure 86), 33dcd (Figure 87), 4S/34E-2aa (Figure 88), and 15bbbb (Figure 89).

Well 4S/34E-5ccdc (Figure 90) has been monitored since 1955 by the USGS. It is located near the sources of Diggie Creek and Spring Creek on the Fort Hall Bottoms. It exhibits only a two-foot fluctuation. This well showed a strong response to the

FIGURE 83.
WELL: 3S/35E 8 dbdc   Depth: 83 feet   Open bottom: 83 feet   Land surface: 4475 feet   Measuring point: 4475'

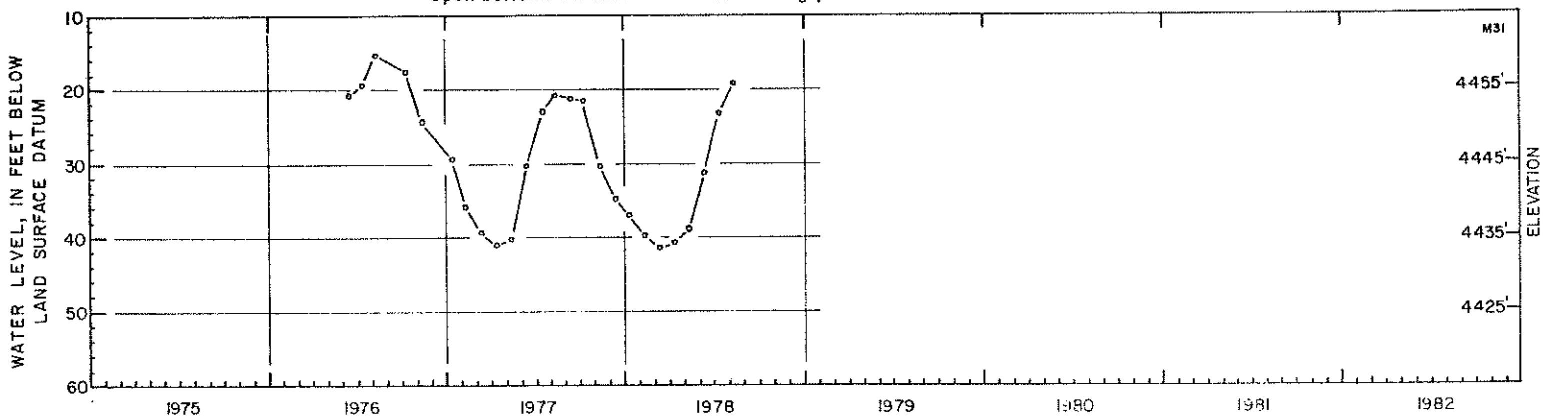


FIGURE 84.
WELL: 3S/35E 10 cbc   Depth: 91 feet   Open hole: 56-91 feet   Land surface: 4492 feet   Measuring point: 4492'

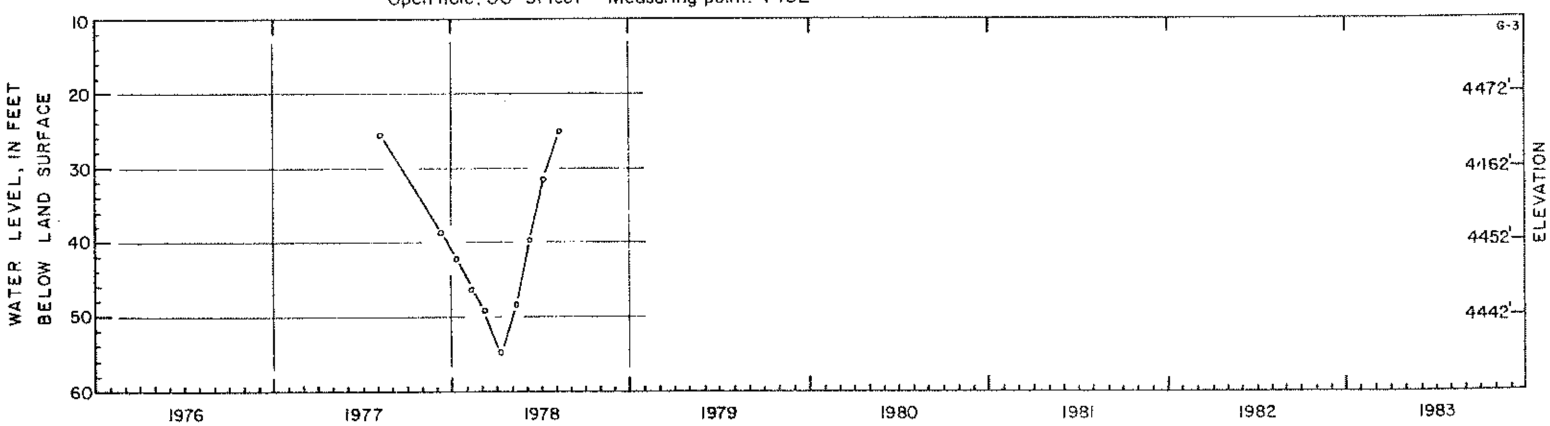


FIGURE 85.
WELL: 3 S/ 35 E 18 daaa   Depth: unknown   Land surface: 4468 feet
Measuring point: .2' above ground

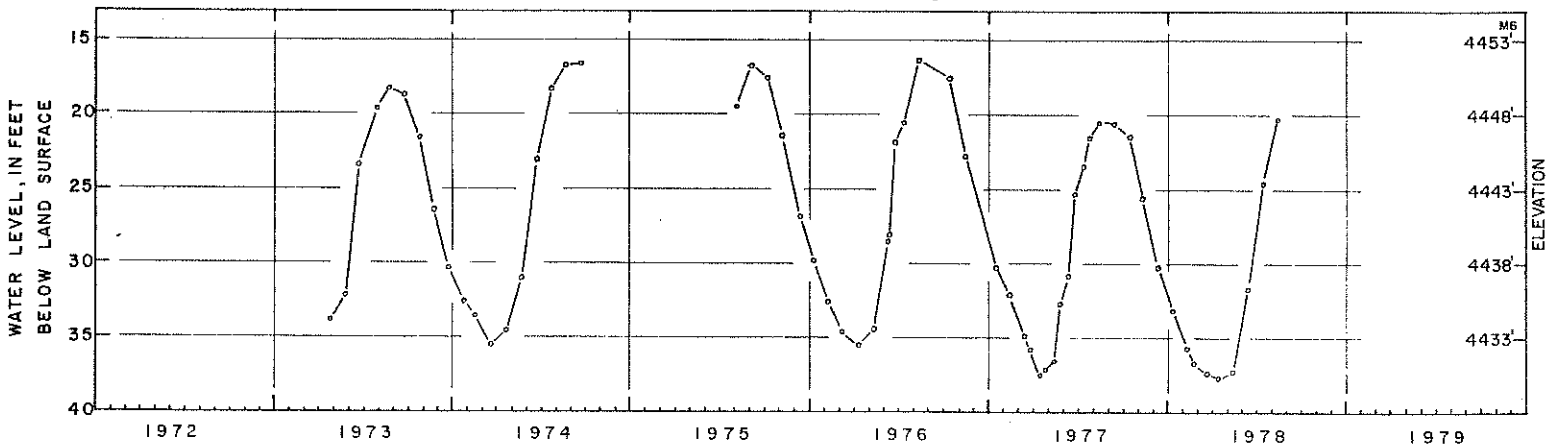


FIGURE 86.
WELL: 3 S/34E 27 dda   Depth: unknown   Land surface: 4450 feet
Measuring point: 4450'

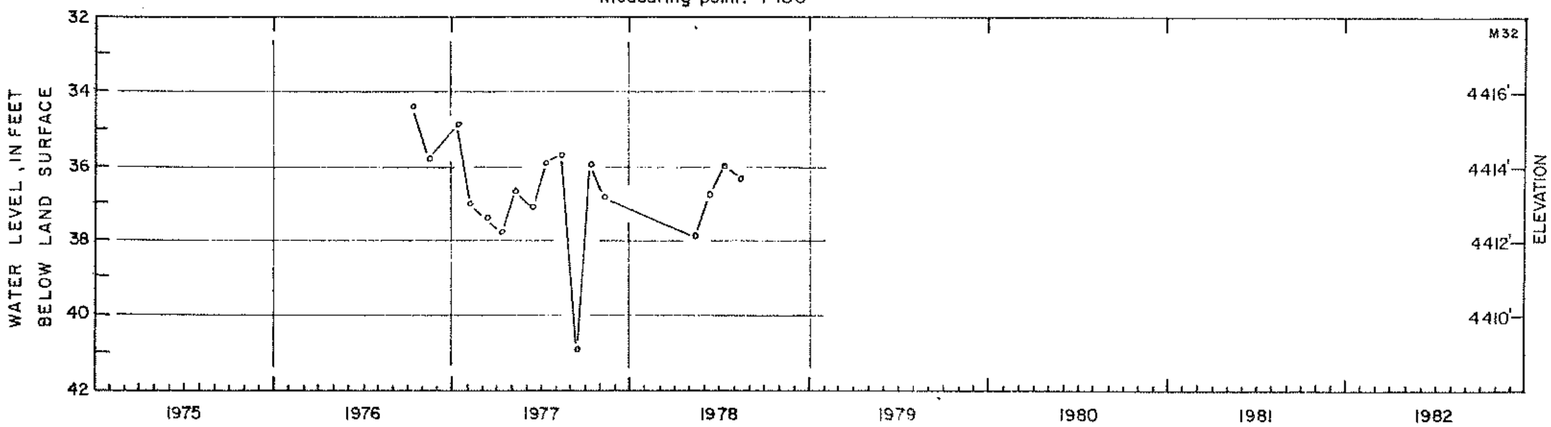


FIGURE 87.
WELL: 3S/34E 33dcd   Depth: 233 feet   Open hole: 47-233 feet   Land surface: 4650 feet   Measuring point: .75' above ground

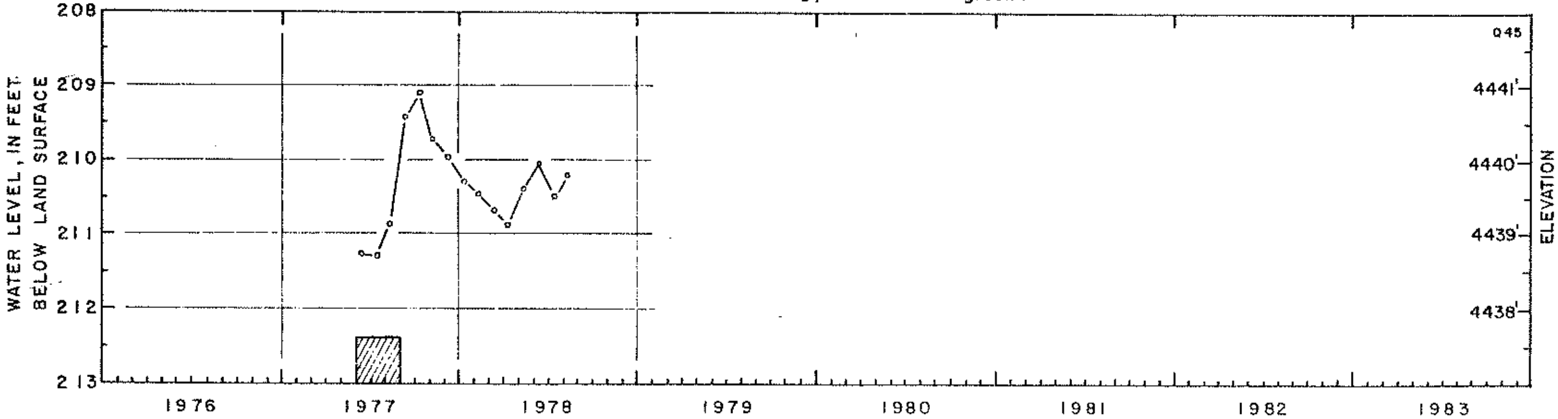


FIGURE 88.
WELL: 4S/34E 2aa   Depth: unknown   Land surface: 4451 feet   Measuring point: 1.1' above ground

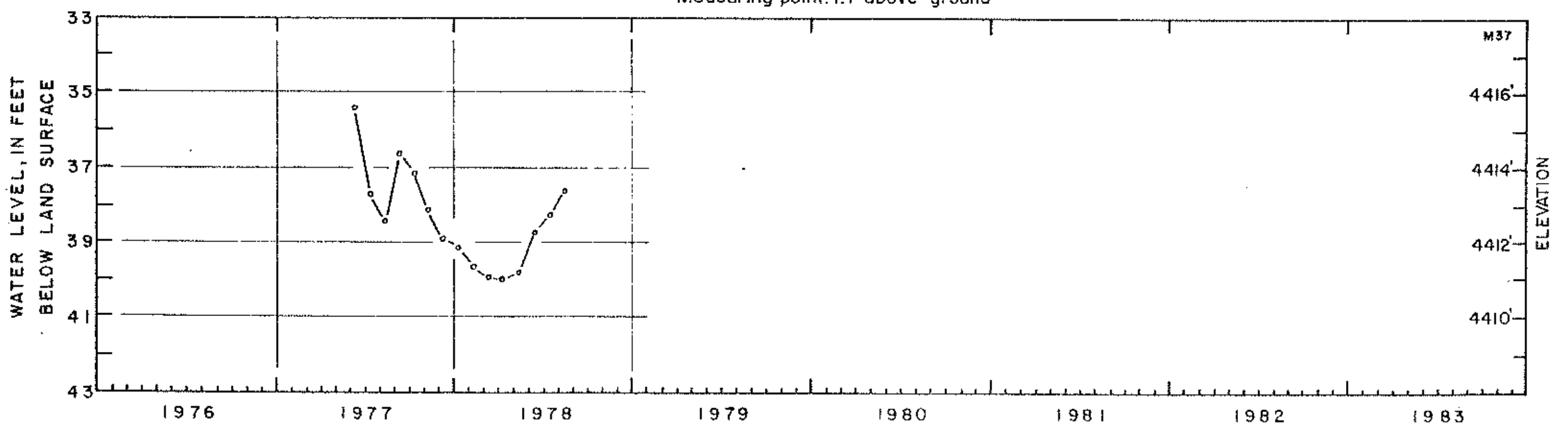


FIGURE 89.

WELL: 4S/34E 15 bbbb

Depth: 73 feet
Open bottom: 73 feet

Land surface: 4438 feet
Measuring point: .1' above ground

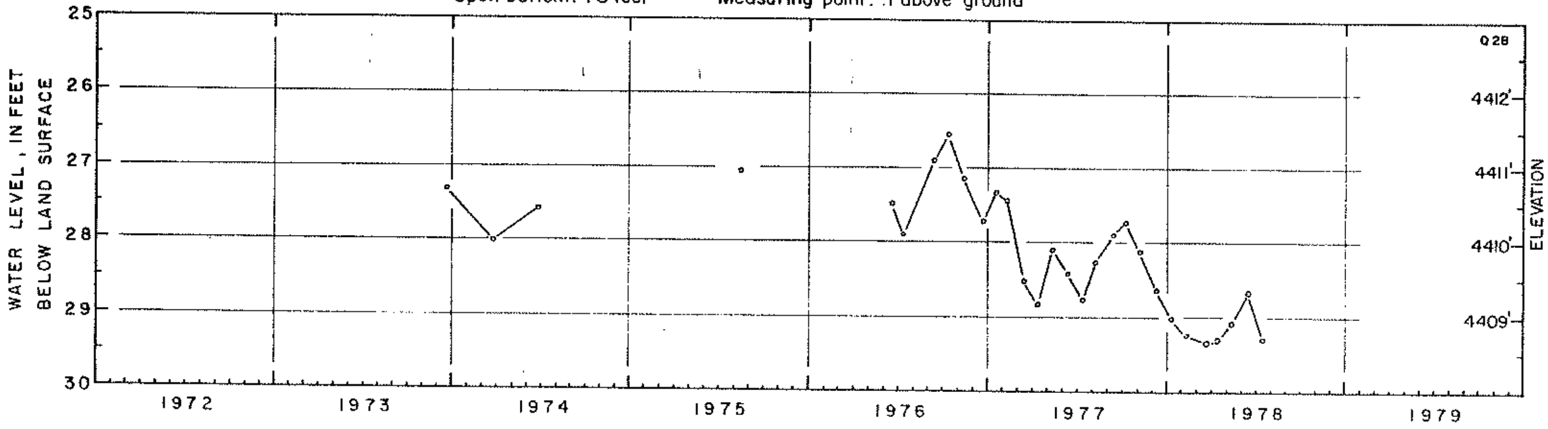
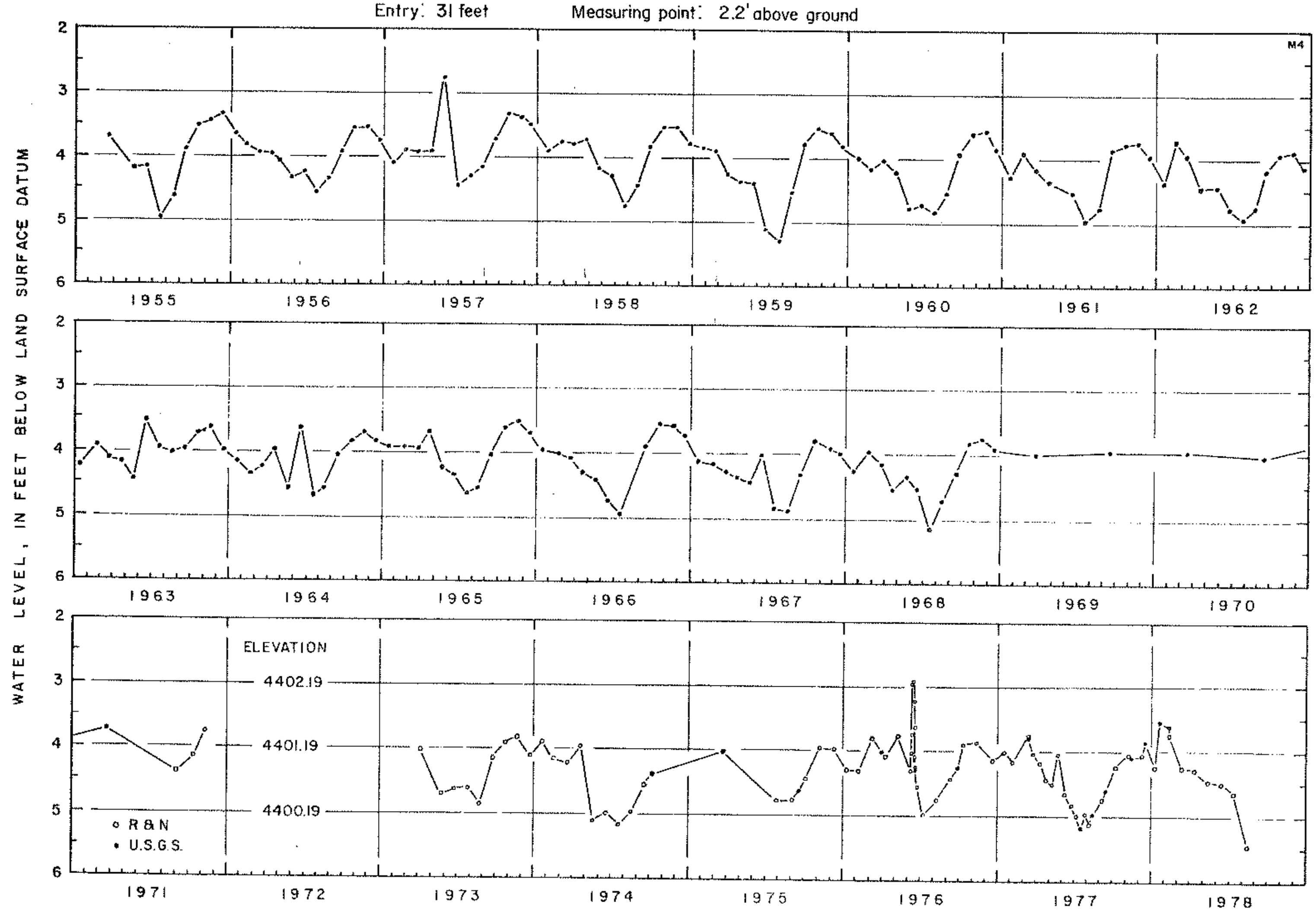


FIGURE 90.

WELL: 4 S/34 E 5 ccdc — Depth: 31 feet — Entry: 31 feet — Land surface: 4405.19 feet — Measuring point: 2.2' above ground



Teton Flood of June, 1976. The ground water level peaked approximately 24 hours after the flood peak passed the Snake River's Blackfoot gage. The water table rose about 1.5 feet due to the recharge effect of the flood waters. This rise was also noted in well 3S/35E-18daaa (Figure 85), however the continued rise somewhat masks the effect. Additional information on the hydrologic effects of the Teton Flood is available in Ray and Kjelstrom (1978).

North of Ferry Butte Road, most wells are finished in the basalt which lies between 50 and 100 feet beneath the surface. The overlying gravel contains significant amounts of water, however the basalt comprises the majority of the aquifer thickness in this area. Irrigation wells drilled in this area for the drought relief program of 1977 were completed in the basalt and generally had specific capacities greater than 200 gpm/ft. of drawdown. They are capable of producing over 3000 gpm (Dow, 1978).

In the northern portion of Gibson Terrace, the water table elevation ranges between 4410 feet near Ferry Butte and 4460 feet near Blackfoot during the fall. During the low portion of the cycle, the range is between 4410 feet and 4440 feet, respectively. A slight decline in the water table over the study period is noted in several wells, and is due to the declining amounts of precipitation received during the 1970's.

In the central portion of the Gibson Terrace, between Ferry Butte and Ross Fork, much of the land has been developed with ground water irrigation. The wells in this area have perhaps the highest capacities of any on the reservation. The water table in this area ranges between 4410 and 4420 feet in elevation. Only toward the western edge of the terrace does the level fall below 4400 feet. Under much of the terrace the water level is less than 30 feet beneath the ground surface. The water table shows the characteristic cycle of low during the spring and high during the fall, however, the range is usually within two to three feet. Figures 91 through 101 illustrate the water table behavior in wells frequently monitored in this area. The irrigation wells usually have pumping levels only five feet below the static level. Well 4S/35E-17adb (Figure 101) best illustrates the seasonal cycle. Very little interference is caused by the surrounding irrigation wells. The slight decline over the study period is due to the decreasing amounts of precipitation.

FIGURE 91.
WELL: 4 S/ 33 E 36 aac — Depth: unknown — Land surface: 4405 feet — Measuring point: 4405 feet

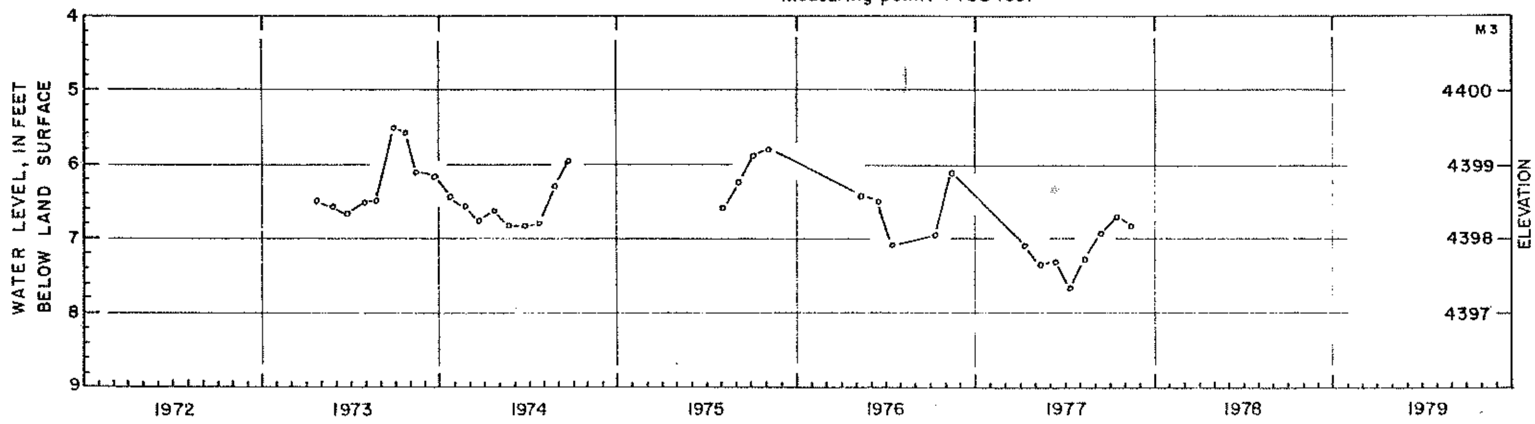


FIGURE 92.
WELL: 4 S/ 34 E 13 ddba — Depth: 324 feet — Open hole: 217'-324' — Land surface: 4442 feet — Measuring point: .9' above ground

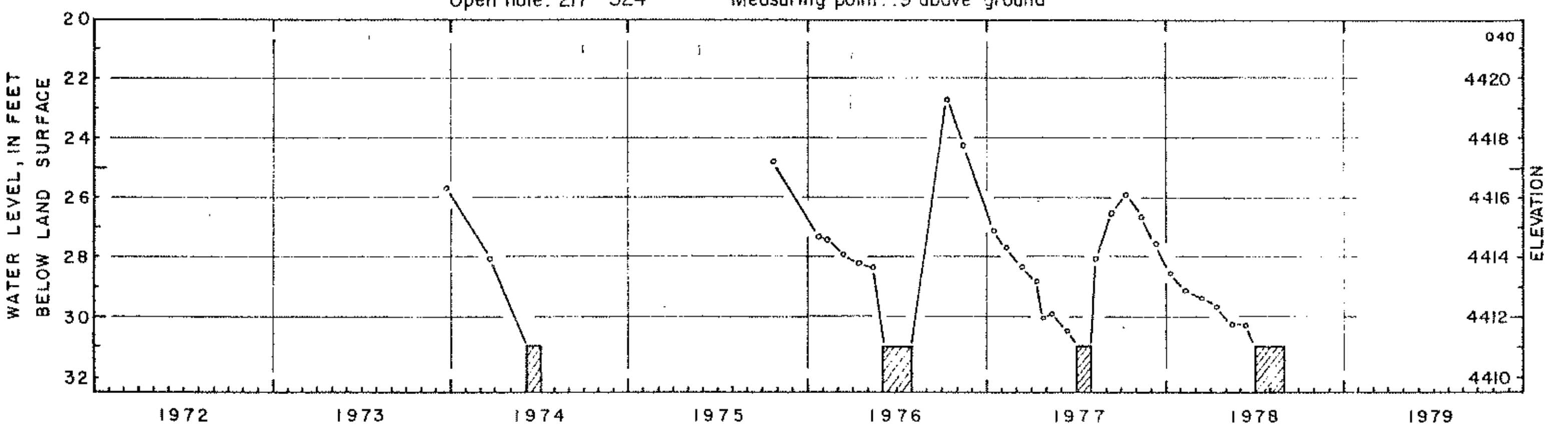


FIGURE 93.
WELL: 4 S/34 E 20 dddb	Depth: unknown	Land surface: 4436 feet
Measuring point: .4' above ground

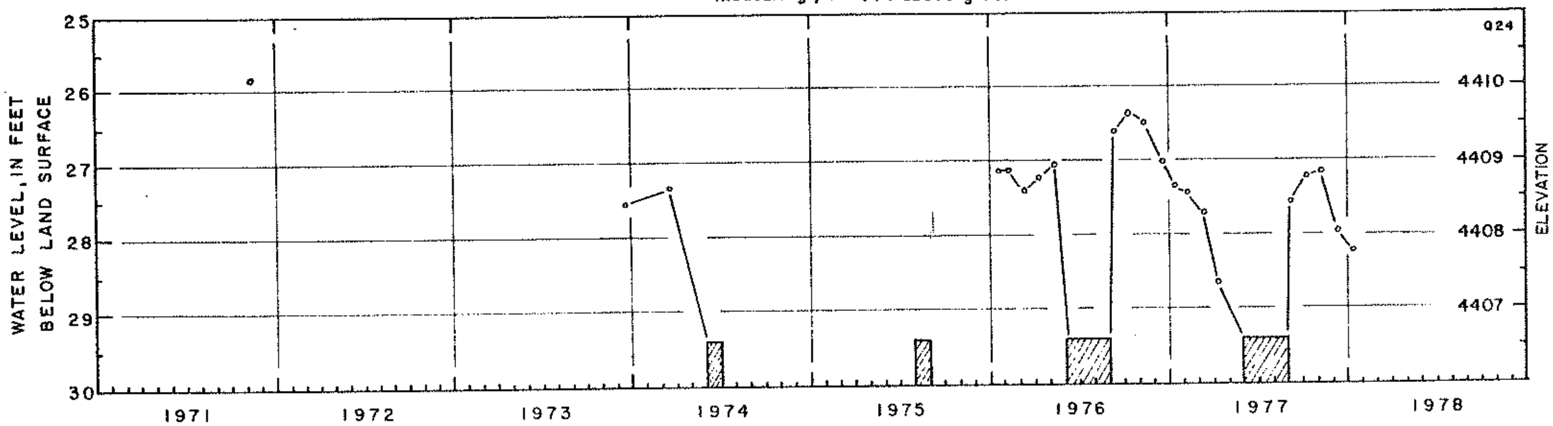


FIGURE 94.
WELL: 4 S/34 E 22 aacc	Depth: 355 feet	Land surface: 4440 feet
Open hole: 224-355 feet	Measuring point: 1.6' above ground

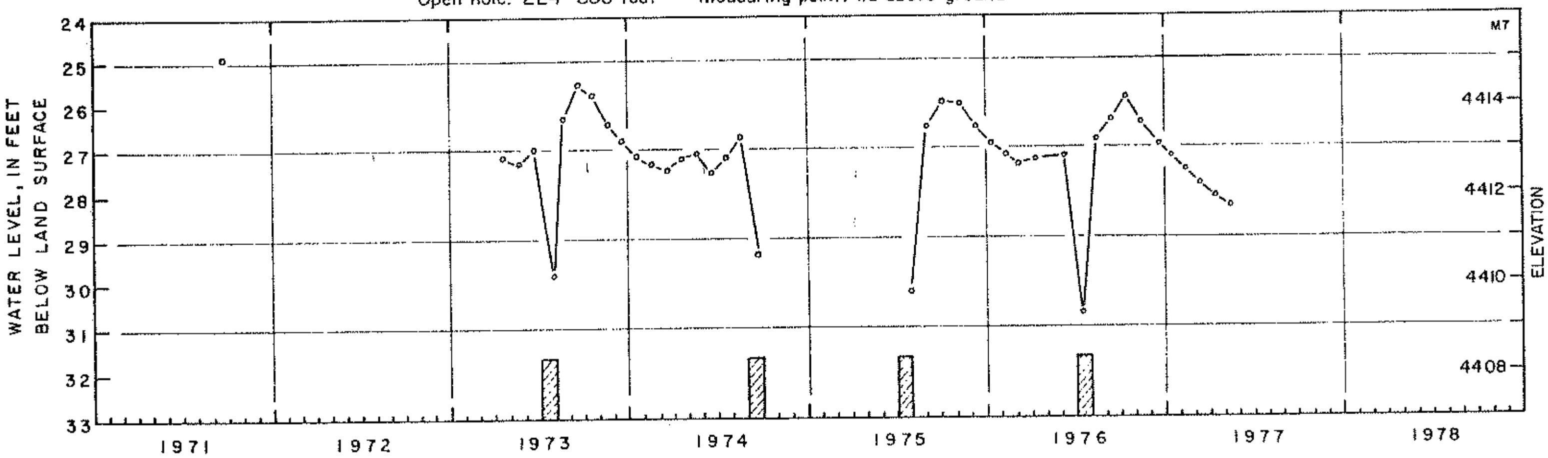


FIGURE 95.
WELL: 4 S/34 E 26 bacd Depth: unknown Land surface: 4429 feet
Measuring point: .9' above ground

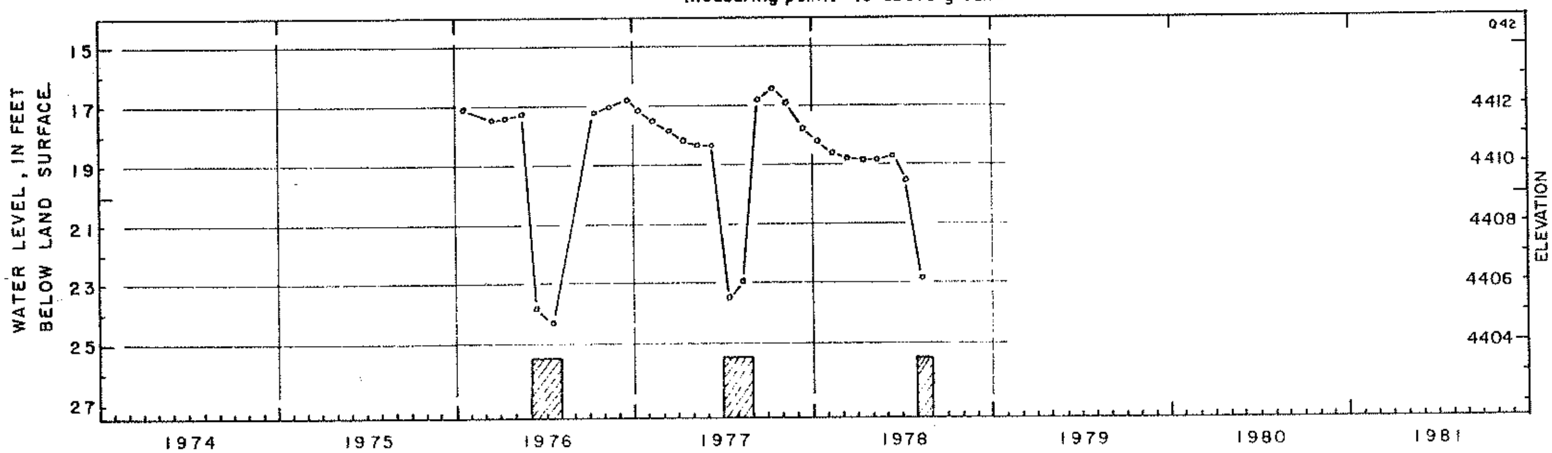


FIGURE 96.
WELL: 4 S/34 E 27 aabb Depth: 330 feet Land surface: 4435 feet
Open hole: 190-330 feet Measuring point: 1.6' above ground

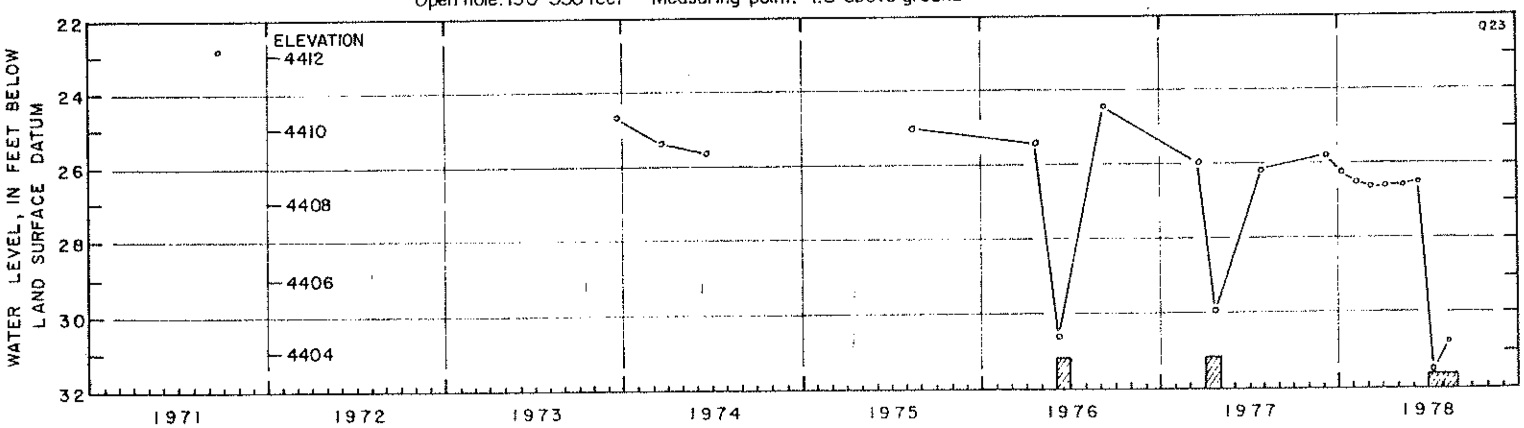


FIGURE 97.
WELL: 4S/34E 32 adaa   Depth: unknown   Land surface: 4423 feet
Measuring point: .7' above ground

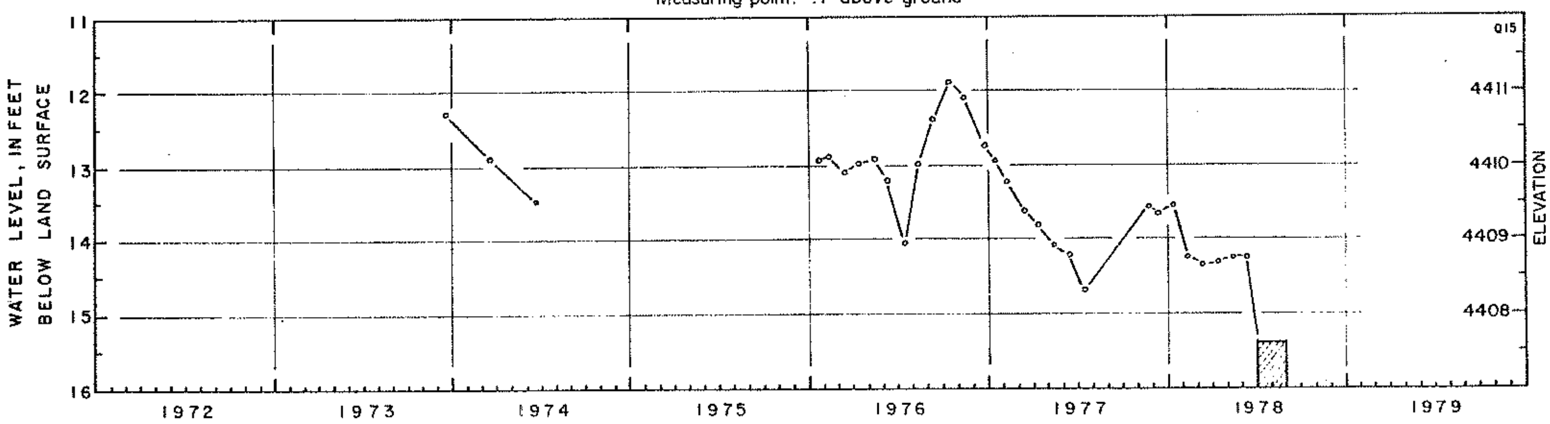


FIGURE 98.
WELL: 4S/34E 34 cabb   Depth: unknown   Land surface: 4425 feet
Measuring point: .3' above ground

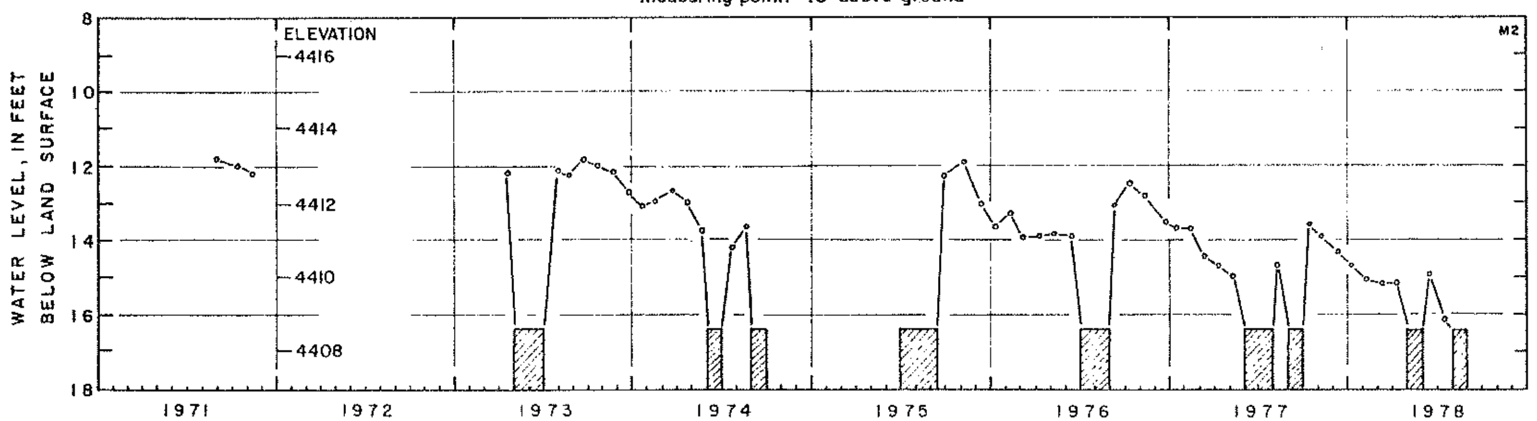


FIGURE 99.
WELL: 4 S / 34 E 36 baab   Depth: 70 feet   Open bottom: 70 feet   Land surface: 4445 feet   Measuring point: .3' above ground

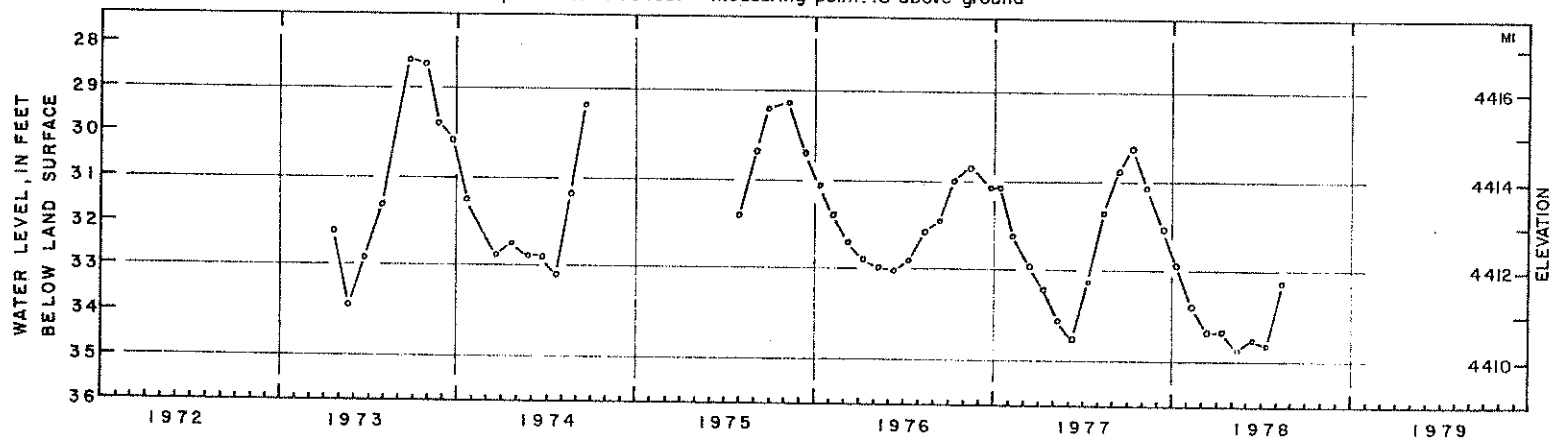


FIGURE 100.
WELL: 4S/35E 5 bbab   Depth: unknown   Land surface: 4470 feet   Measuring point: .3' above ground

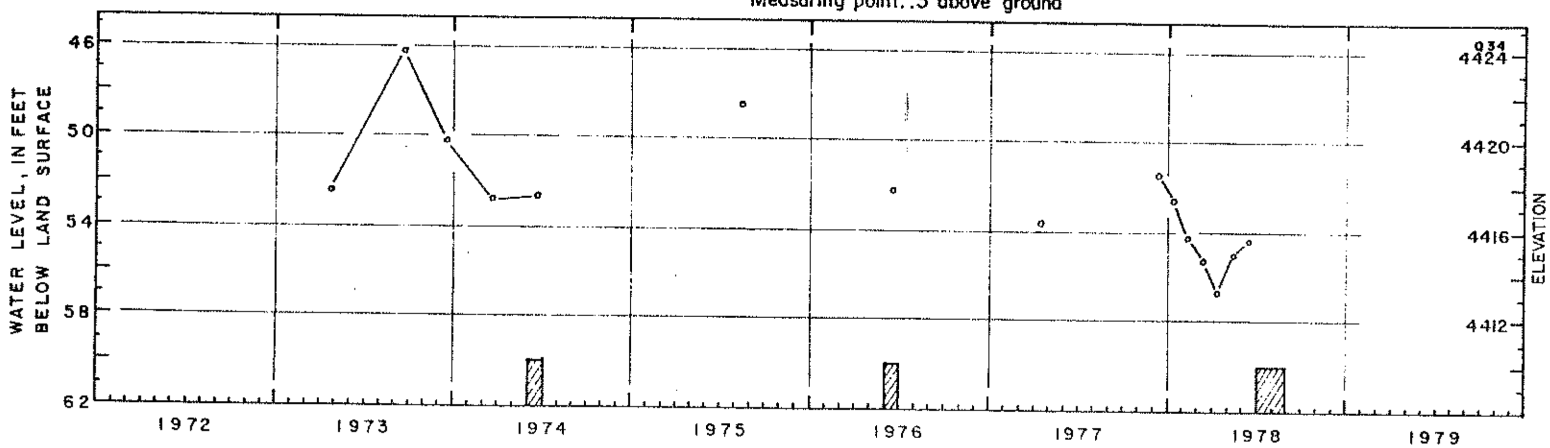
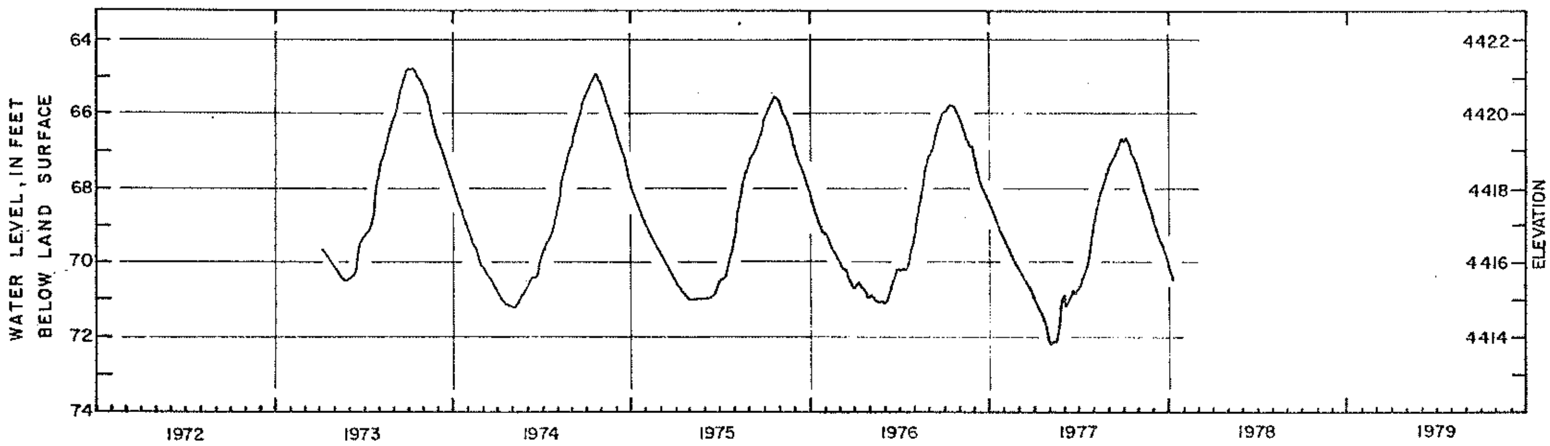


FIGURE 101.
WELL: 4S/35E 17 adb   Depth: unknown   Land surface: 4486 feet
Measuring point: 4486 feet



In this central portion of the terrace, the basalt is generally found between 100 and 200 feet beneath the surface (Figure 59). Most of the overlying gravel sequence is saturated and forms a very good aquifer; however, almost all irrigation wells penetrate through this gravel to withdraw water from the cinder layers within the basalt. Specific capacities of these wells are usually several hundred gpm/ft. of drawdown. A few wells have been noted to exceed 1000 gpm/ft. of drawdown.

The area of Gibson Terrace south of Ross Fork is predominately under surface water irrigation. A few irrigation wells have been developed on the benchlands to the east. The basalt in this area lies at greater depths, and almost all domestic wells are finished in the overlying gravels. The elevation of the water table ranges between 4400 and 4415 feet, and lies approximately 50 feet beneath the ground surface under much of the area. The water table fluctuates about two to three feet, exhibiting the characteristic seasonal pattern usually found on the Snake Plain. Figures 102 through 106 show the hydrographs of the wells monitored in this area. Well 5S/34E-20cbbb (Figure 104) has been monitored by the USGS since 1964 and provides a longer history.

Michaud Flats

The Michaud Flats aquifer, between the Portneuf River and Bannock Creek, has been extensively developed for irrigation and industrial uses. Most of the water is withdrawn from the gravel deposits of the lower Raft Formation (Figure 60). The underlying basalt lies near a depth of 200 feet beneath the eastern portion of the flats. The basalt slopes to the west and exceeds 300 feet in depth toward the western end. Several of the irrigation wells in the eastern portion do penetrate into this basalt.

The water table beneath the eastern portion of Michaud Flats remains near 4402 feet in elevation throughout the year. Only near the terrace edge along the Portneuf River does it fall off slightly. Wells monitored in this area are located at 5S/33E-28ccbb (Figure 107), 35ccdd (Figure 108), 35dcdc (Figure 109), 6S/33E-1dacc (Figure 110), 5 cacc (Figure 111), and 22babb (Figure 112). The static levels in these wells fluctuate only about two to three feet seasonally, with a cycle similar to that found on Gibson Terrace. The wells that penetrate into the basalt have specific

FIGURE 102.

WELL: 5 S / 34 E 15 aaa Depth: unknown Land surface: 4459 feet
Measuring point: .2' above ground

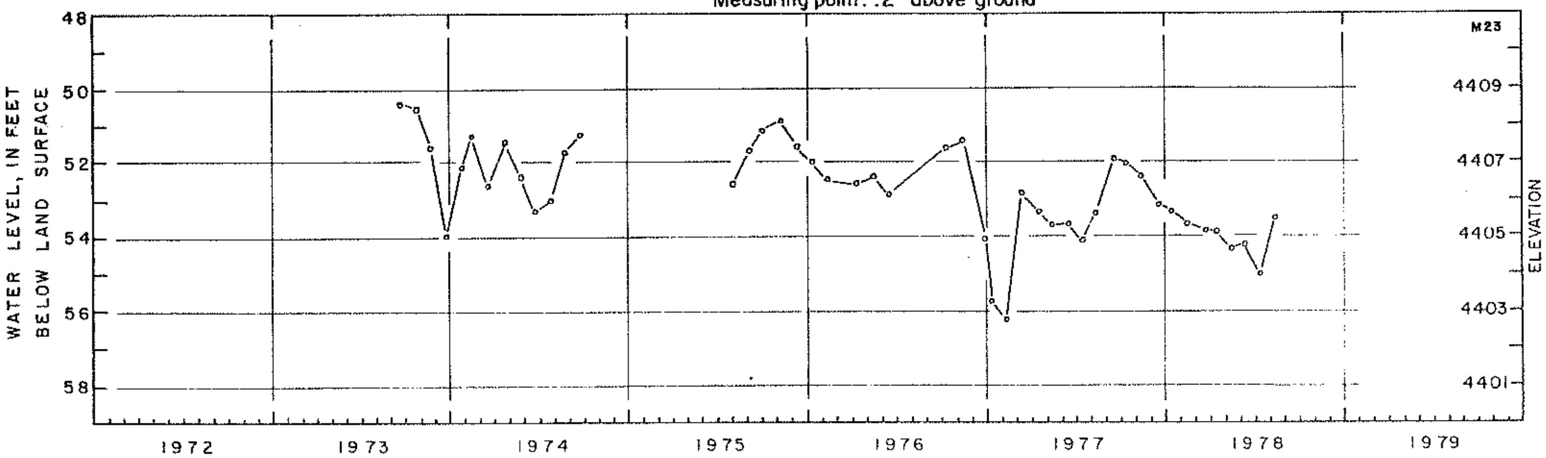


FIGURE 103.

WELL: 5S / 34E 16 bbbb Depth: unknown Land surface: 4428 feet
Measuring point: .8' above ground

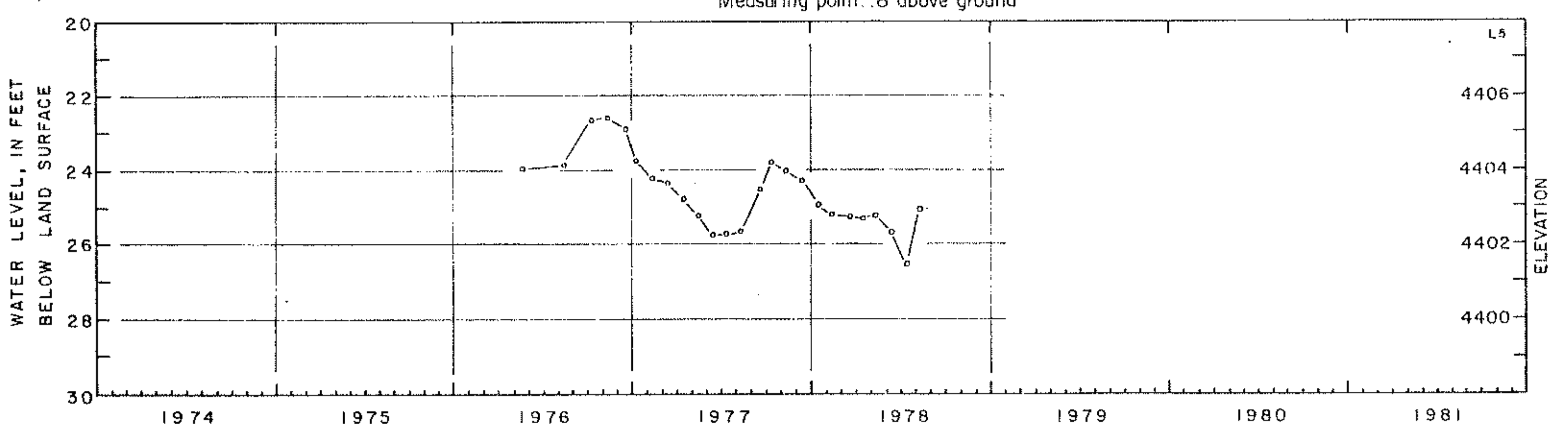


FIGURE 104.

WELL: 5S/34E 20 cbbb

Depth: 155 feet
Open bottom: 155 feet

Land surface: 4455 feet
Measuring point: .60' above ground

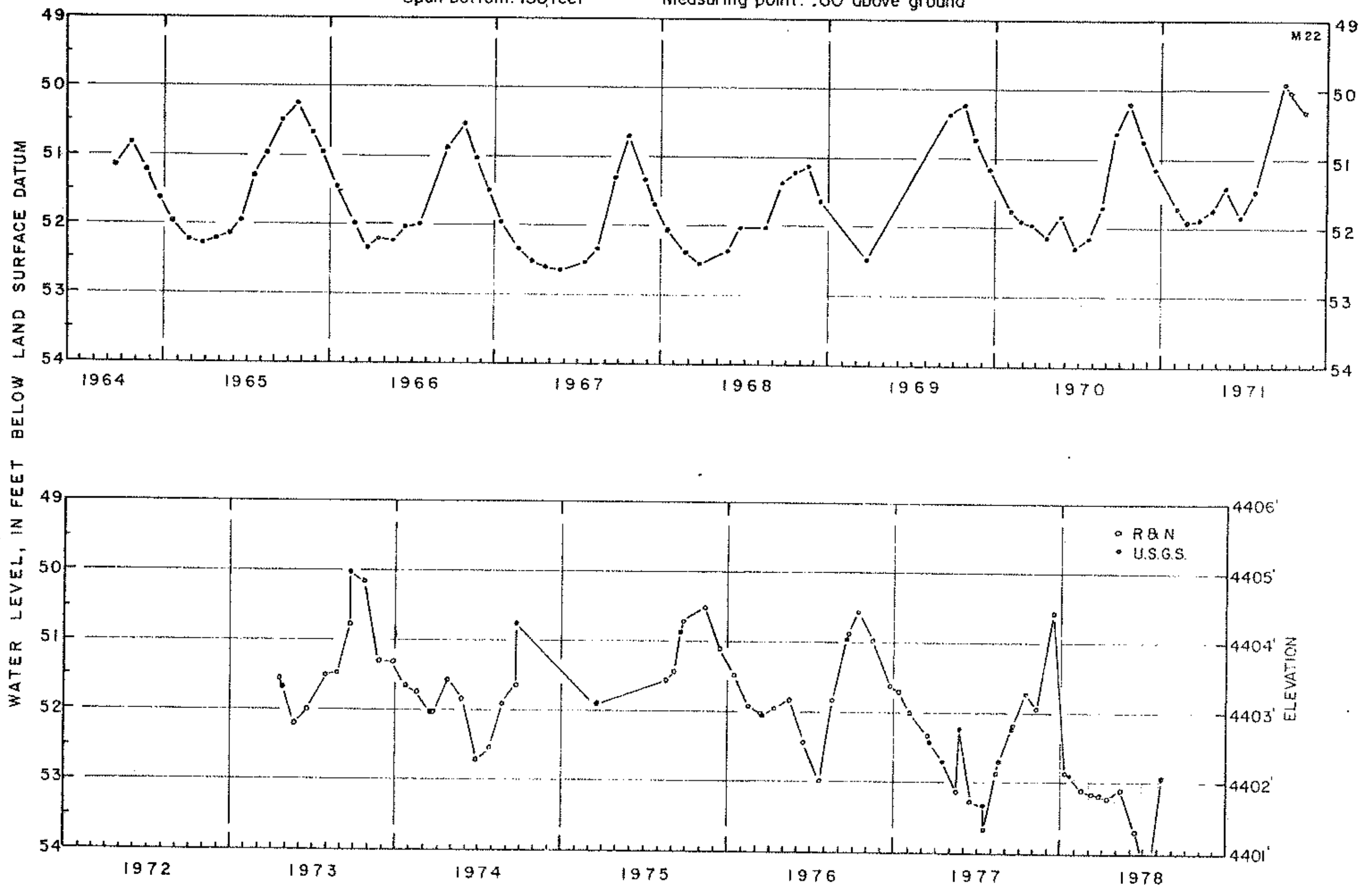


FIGURE 105.
WELL: 5 S/34 E 21 dcdd   Depth: unknown   Land surface: 4470 feet
Measuring point: .7' above ground

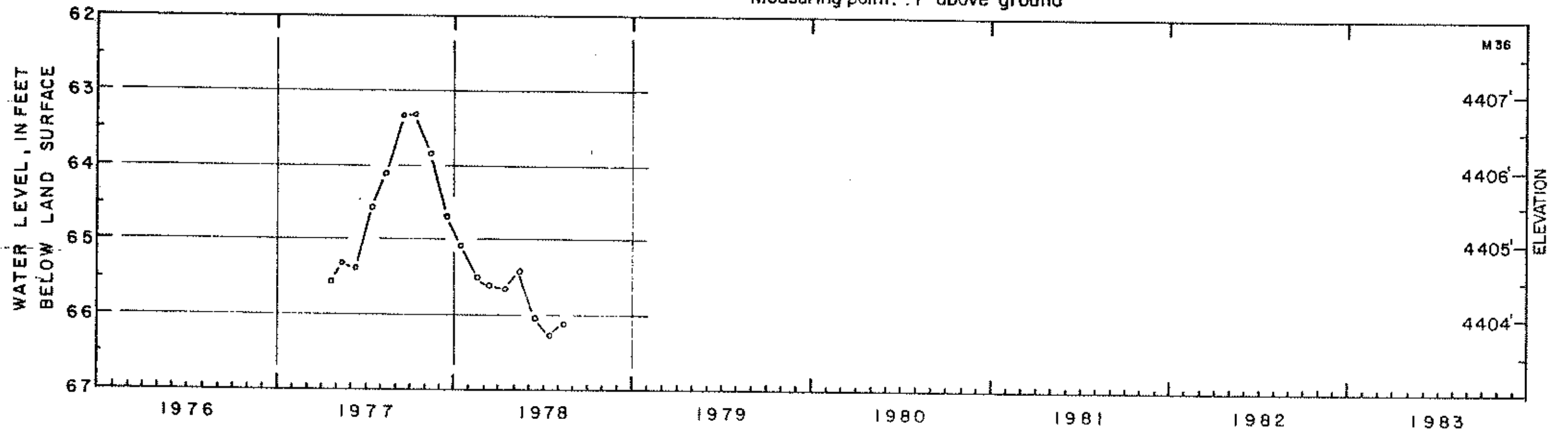


FIGURE 106.
WELL: 5 S/35 E 7 ccbd   Depth: unknown   Land surface: 4580 feet
Measuing point: .45' above ground

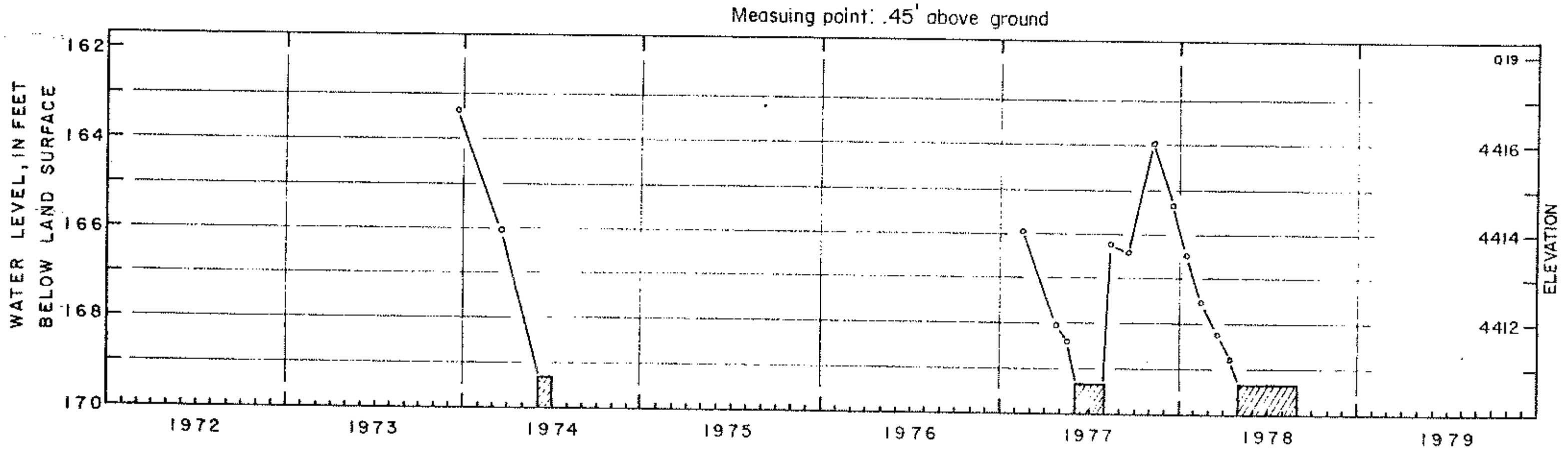


FIGURE 107.

WELL: 5 S / 33 E 28 ccbb

Depth: 210 feet
Perforations: 160'-205'

Land surface: 4431 feet
Measuring point: .2' above ground

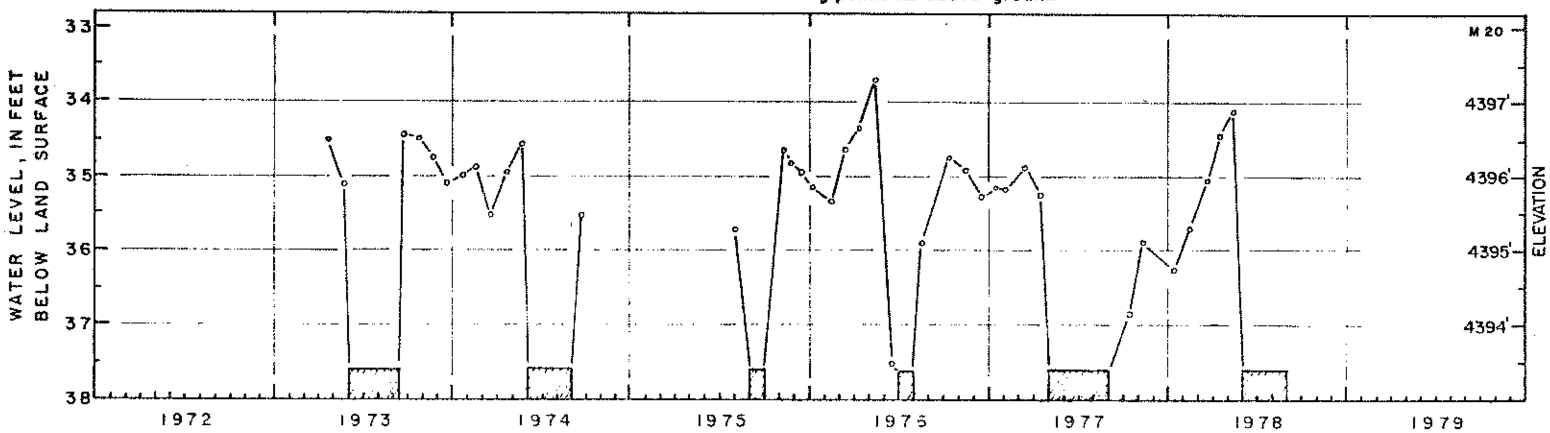


FIGURE 108.

WELL: 5S/33E 35 ccdd — Depth: 60 feet — Entry: 60 feet — Land surface: 4424.58 feet — Measuring point: 2.10' above ground

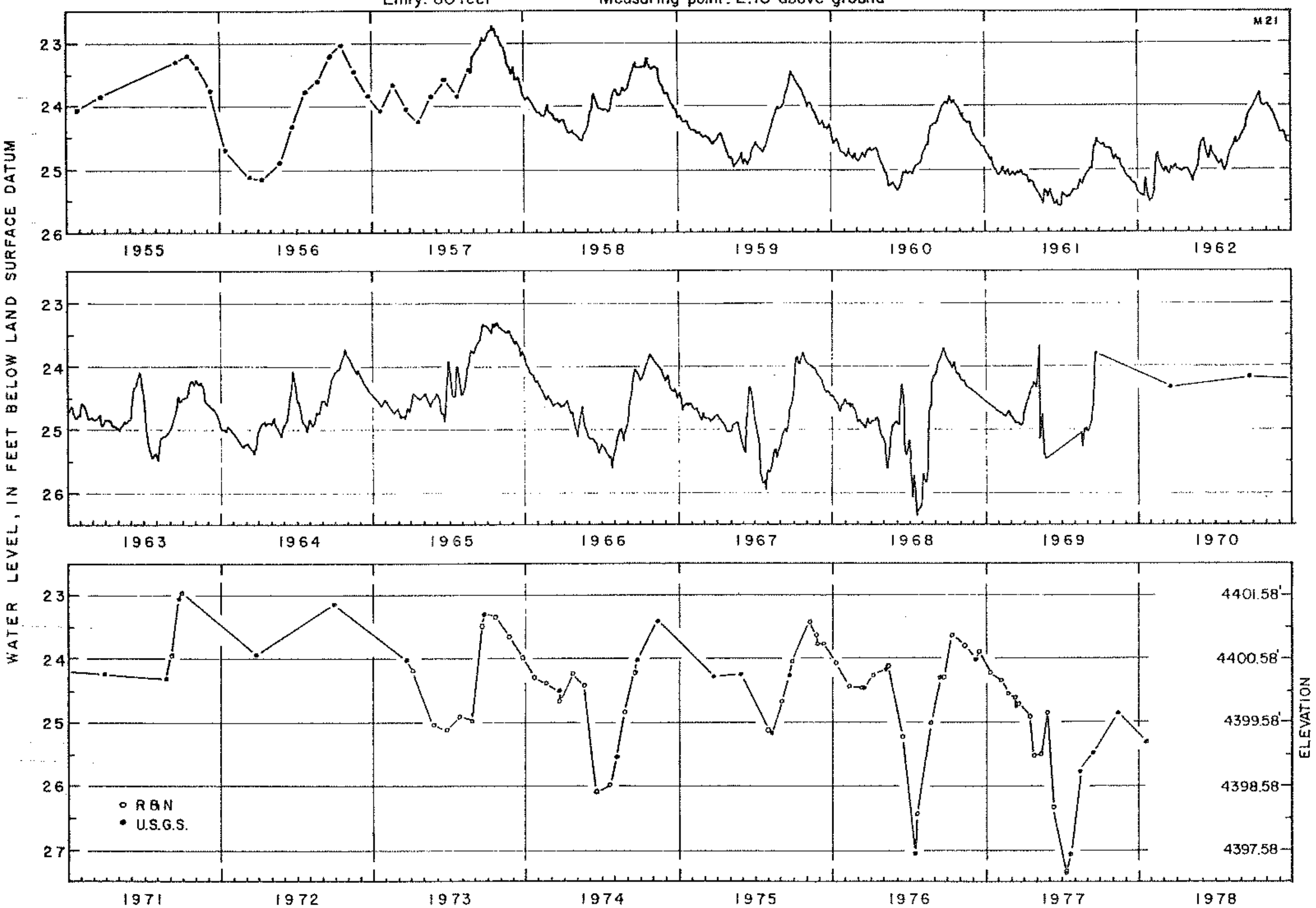


FIGURE 109.

WELL: 5S/33 E 35 dcdc   Depth: 260 feet   Land surface: 4414 feet

Open hole: 197'-260'   Measuring point: .4' above ground

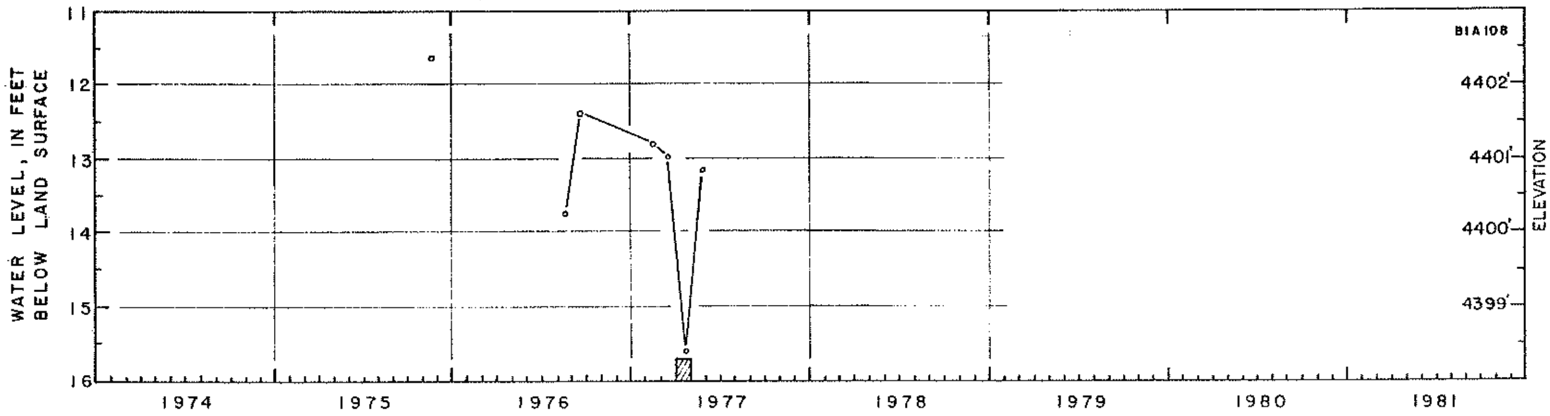


FIGURE 110.

WELL: 6S/33 E 1 dacc   Depth: 240 feet   Land surface: 4424 feet

Open hole: 166'-240'   Measuring point: .3' above ground

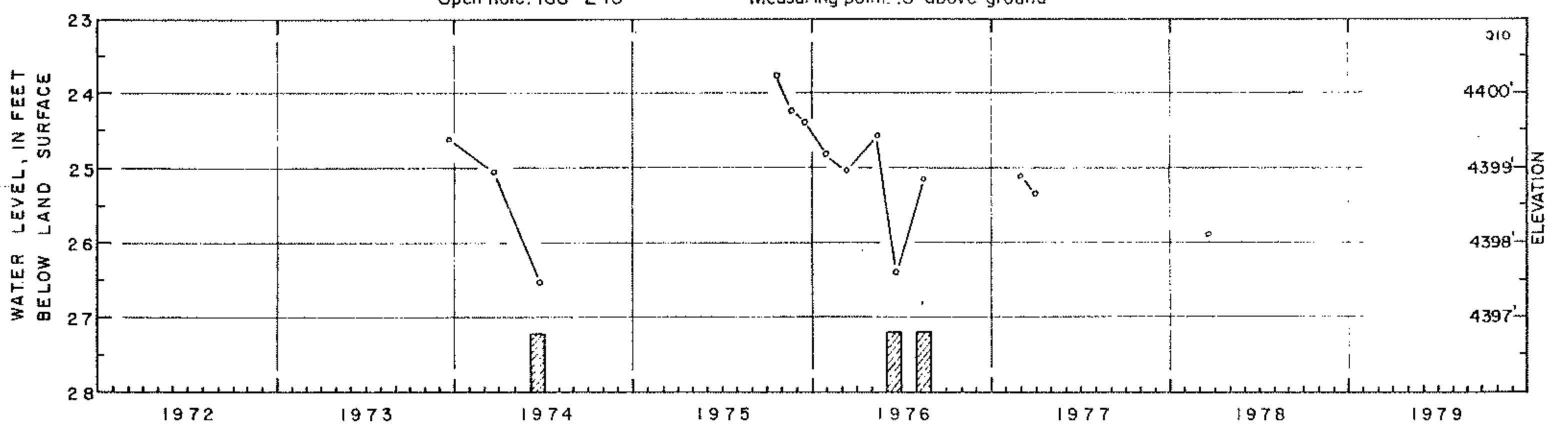


FIGURE 111.

WELL: 6S/33E 5 cacc   Depth: unknown   Land surface: 4423 feet   Measuring point: .7' above ground

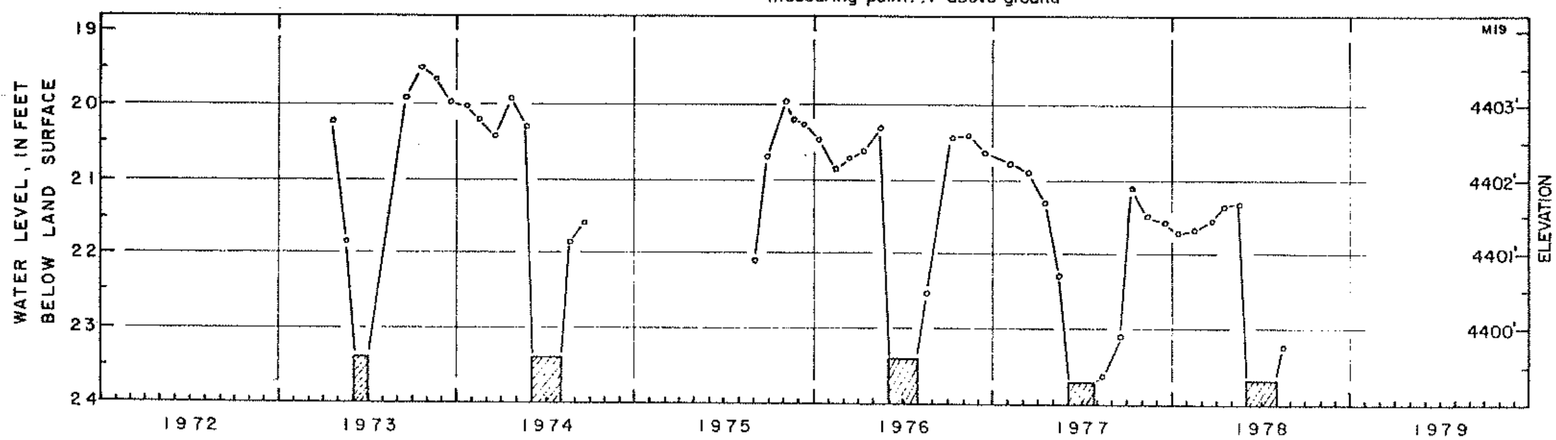
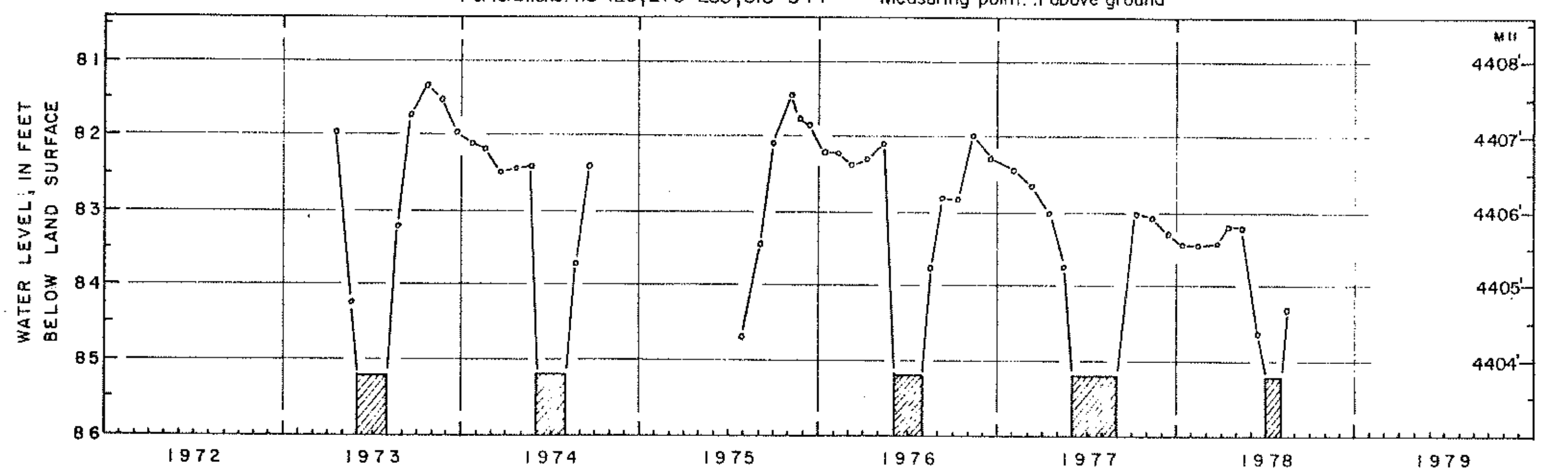


FIGURE 112.

WELL: 6S/33E 22 babb   Depth: 360 feet   Perforations: 115'-120', 270'-280', 318'-344'   Land surface: 4489 feet   Measuring point: .1' above ground



capacities of several hundred gpm/ft. of drawdown.

Toward the western edge of Michaud Flats, the aquifer appears to decrease in capacity due to the increasing presence of clay layers and decreasing thickness of basalt. The water table in this area respondsdifferently than the Gibson Terrace water table. Here, the water reaches its highest level during the spring, prior to the irrigation season. The estimated withdrawal of 62 cfs (44,700 ac. ft/yr.) of ground water in the Michaud area greatly depresses the water table toward the western end by as much as 40 feet. Upon completion of the irrigation season, the water table begins to recover; steadily increasing until the spring. Wells monitored in this area are located at 5S/32E-36cddd (Figure 113), and 6S/32E-14aabb (Figure 114). During the spring, the water level ranges between 4370 feet along the western edge of Michaud and 4400 feet near the western edge of the Pocatello airport. Near the end of the irrigation season, the static level along the western edge is lowered to about 4340 feet, while the static near the airport remains near 4400 feet. The wells developed in the gravels in this western portion have specific capacities that generally range between 30 and 50 gpm/ft. of drawdown. This reduction may reflect the decreased capacity of the gravel aquifer, but may also be due in part to the method of well construction. In most of these wells, perforated casing is used rather than well screens. This greatly reduces the water entry area in each well and may restrict capacity. The gravel aquifer of the Michaud area has presented well construction problems not common to the basalt aquifer of the Gibson Terrace. Local drilling and development methods used are insufficient to construct efficient sand-free wells from this high-potential aquifer.

A portion of Michaud Flats lies south and west of Bannock Creek between the foothills and the American Falls Reservoir. All of the irrigation wells in this area withdraw water from the gravels of the Raft Formation, except for those along the Owl Canal which may penetrate the Tertiary volcanic deposits. The basalt, if it exists in this area, exceeds 500 feet in depth. The water table here is a continuation of that found to the north of Bannock Creek. The highest level occurs during the spring, prior to the irrigation season. The withdrawal of the ground water decreases the water table over 20 feet near the western reservation border. After the irrigation season, the water table recovers. In the southeastern portion, the water table recovers rapidly. This is

FIGURE 113.
WELL: 5 S / 32 E 36 cddd
Depth: 225 feet
Perforations: 180'-210'
Land surface: 4412 feet
Measuring point: .2' above ground

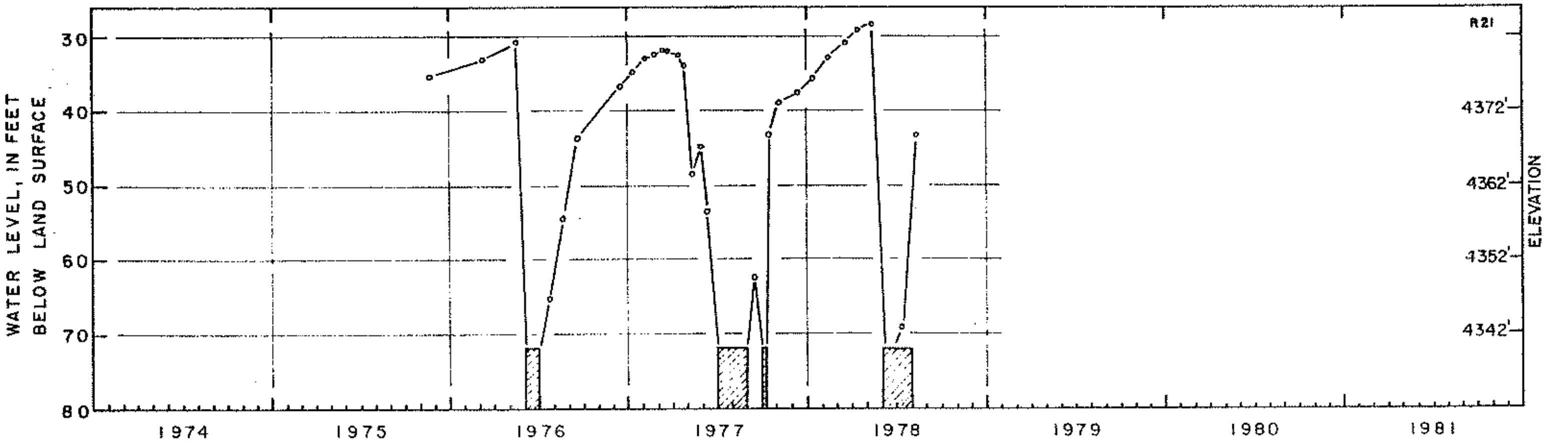
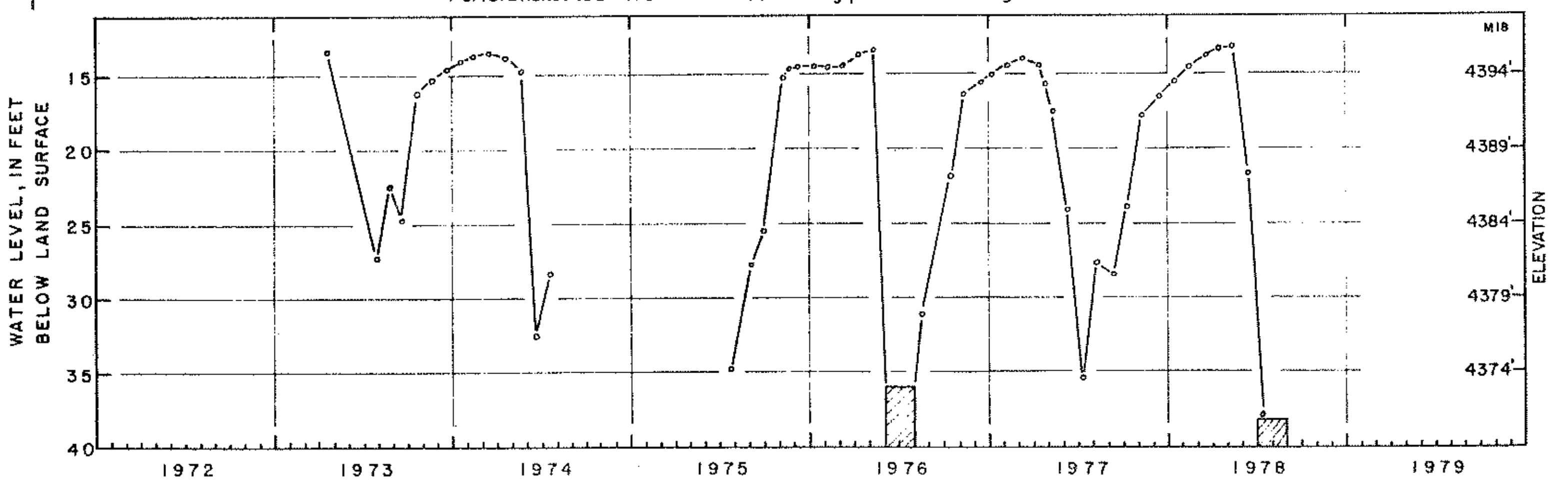


FIGURE 114
WELL: 6 S / 32 E 14 aabb
Depth: 175 feet
Perforations: 158'-175'
Land surface: 4409 feet
Measuring point: 1.3' above ground



illustrated by wells 6S/33E-30ccbb (Figure 115), 7S/32E-3dbd (Figure 116) and 7S/33E-6cdab (Figure 117). To the northwest, closer to the reservoir, the water table continues to recover throughout the winter. This is illustrated by wells 6S/32E-22cacc (Figure 118), 24bddd (Figure 119), 26ba (Figure 120), 27aacc (Figure 121), 27adca (Figure 122), and 33bbb (Figure 123).

WATER BUDGET

The Snake Plain portion of the reservation straddles a portion of the vast ground water flow within the basalt and gravel aquifer associated with the plain. The ground water in this area within the reservation is supplied by four main sources. In decreasing order of importance, these are:

1. Ground water inflow to the reservation within the Snake Plain aquifer.

2. Irrigation recharge from the Fort Hall Canal system.

3. Ground water from the tributary basins (Ross Fork, Portneuf River, etc.).

4. Precipitation recharge onto the plain and foothills within the reservation.

The following table lists the contributions made by reservation lands to the aquifer:

TABLE 22

Preciptation	19.8 cfs
Blackfoot River basin ground water	23.3 cfs
Ross Fork basin ground water	26.7 cfs
Upper Portneuf River basin ground water	9.6 cfs
Bannock Creek basin ground water	35 cfs
(37% of total) TOTAL	114 cfs

The total recharge to the aquifer in the reservation stretch, including off-reservation sources, is shown in Table 23.

FIGURE 115.
WELL: 6 S/33 E 30 ccbb — Depth: unknown — Land surface: 4435 feet — Measuring point: .7' above ground

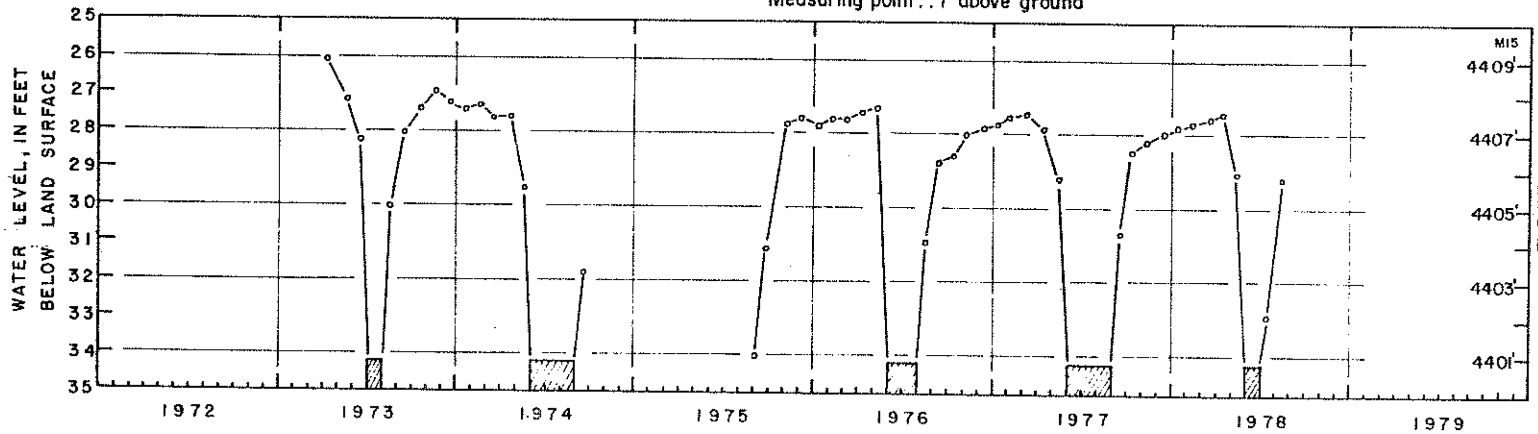


FIGURE 116.
WELL: 7S/32 E 3 dbd — Depth: 540 feet — Perforations: 223'-264', 340'-368', 419'-534' — Land surface: 4440 — Measuring point: .4' above ground

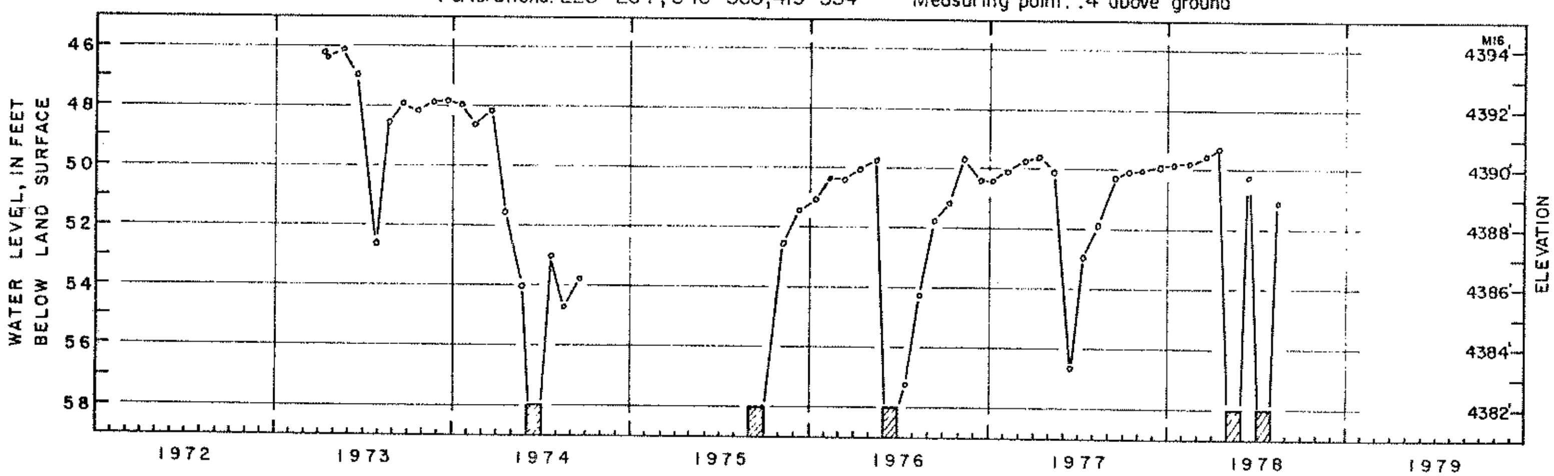


FIGURE 117.
WELL: 7S/33E 6 cdab Depth: 405 feet Perforations: 137'-267' Land surface: 4460 feet Measuring point: .7' above ground

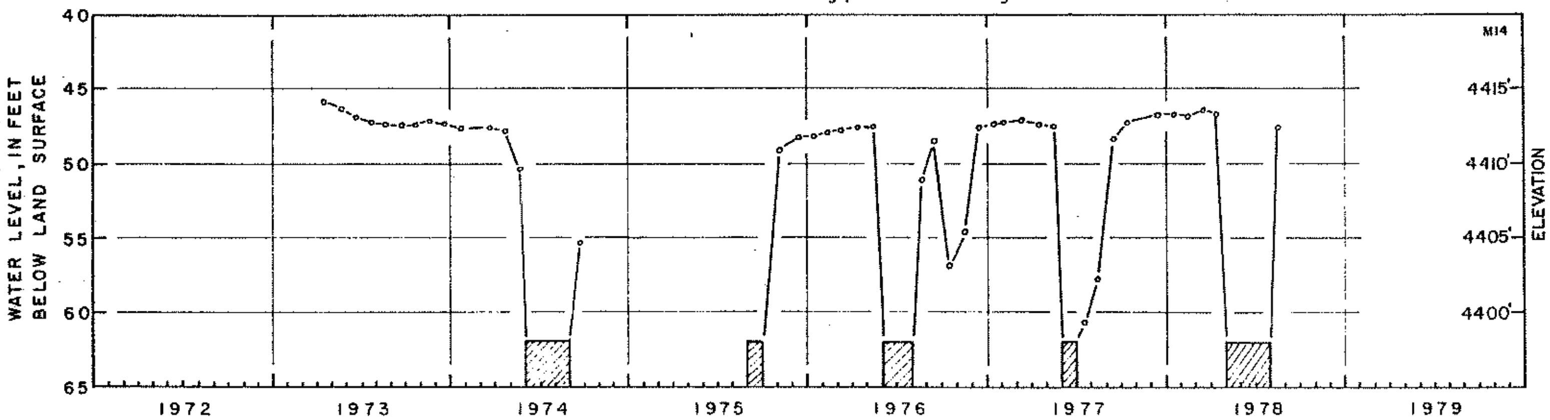


FIGURE 118.
WELL: 6S/32 E 22 cacc Depth: 207 feet Land surface: 4407 feet Measuring point: .2' above ground

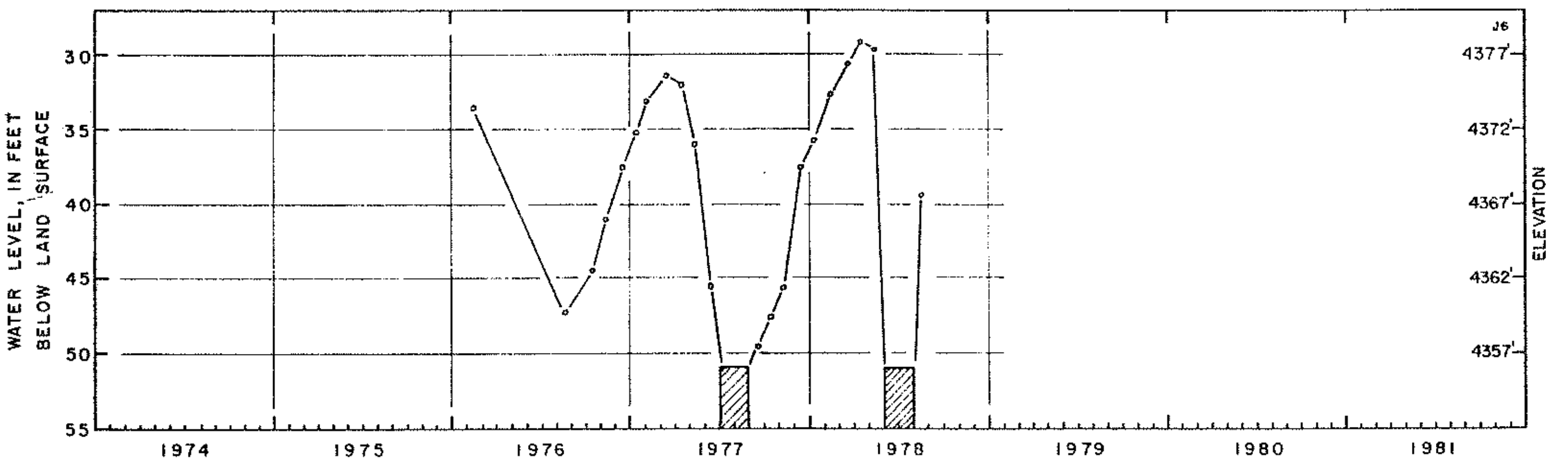


FIGURE 119.
WELL: 6 S / 32 E 24 bddd
Depth: 500 feet
Land surface: 4427 feet
Perforations: 169'-209', 226'-241', 266'-317', 420'-494'
Measuring point: .6' above ground

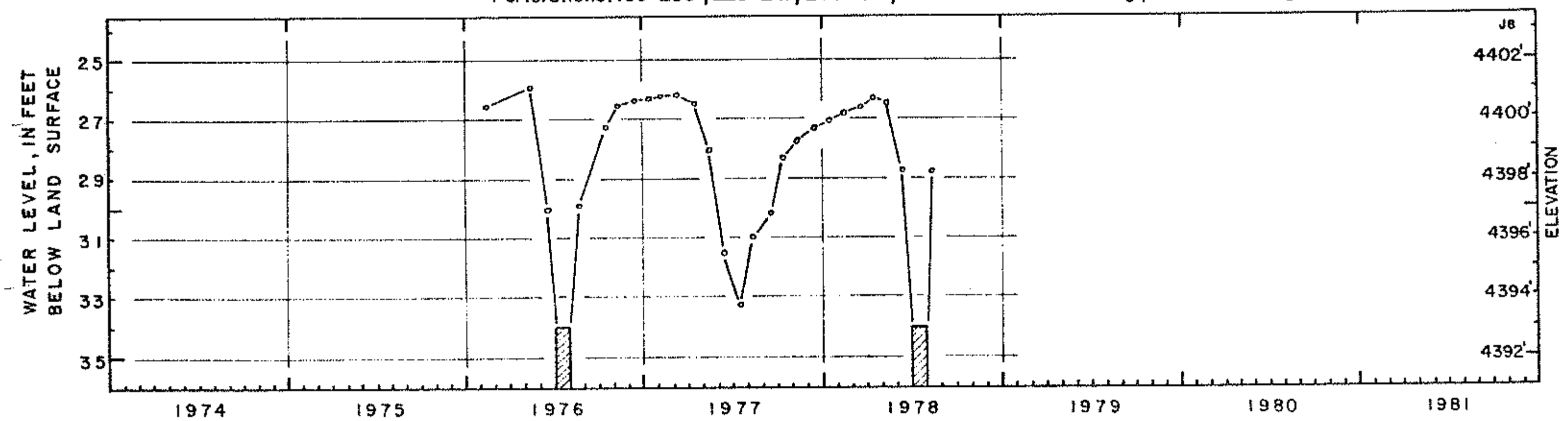


FIGURE 120.
WELL: 6S / 32 E 26 ba
Depth: 208 feet
Land surface: 4425 feet
Measuring point: 4425 feet

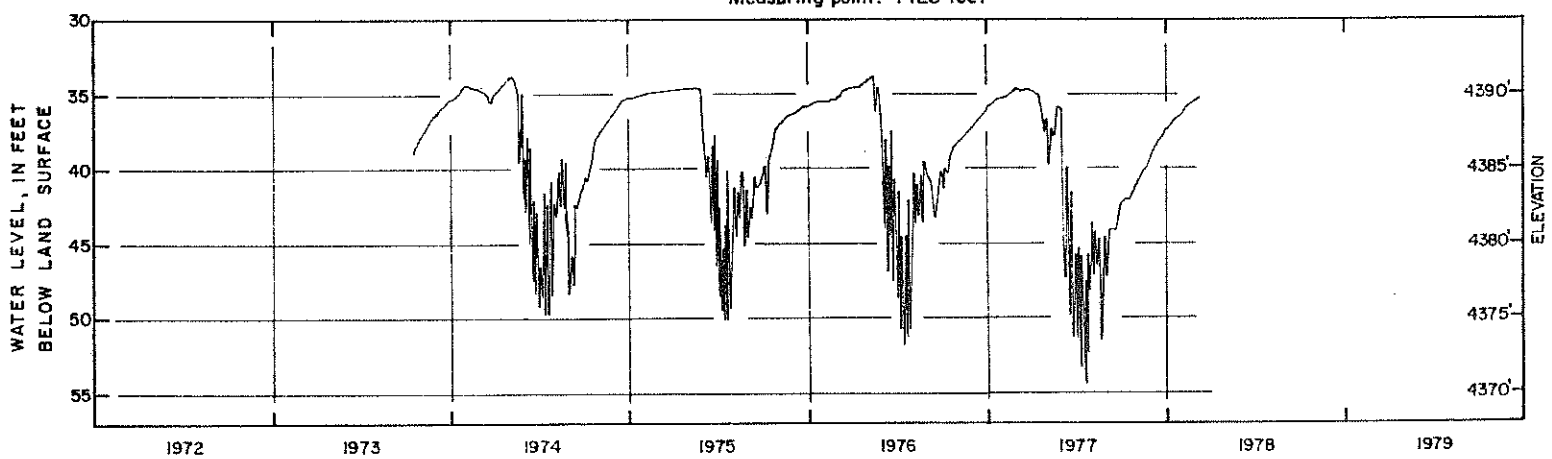


FIGURE 121.
WELL: 6S/32E 27 aacc   Depth: 202 feet   Land surface: 4409 feet
Measuring point: 4409'

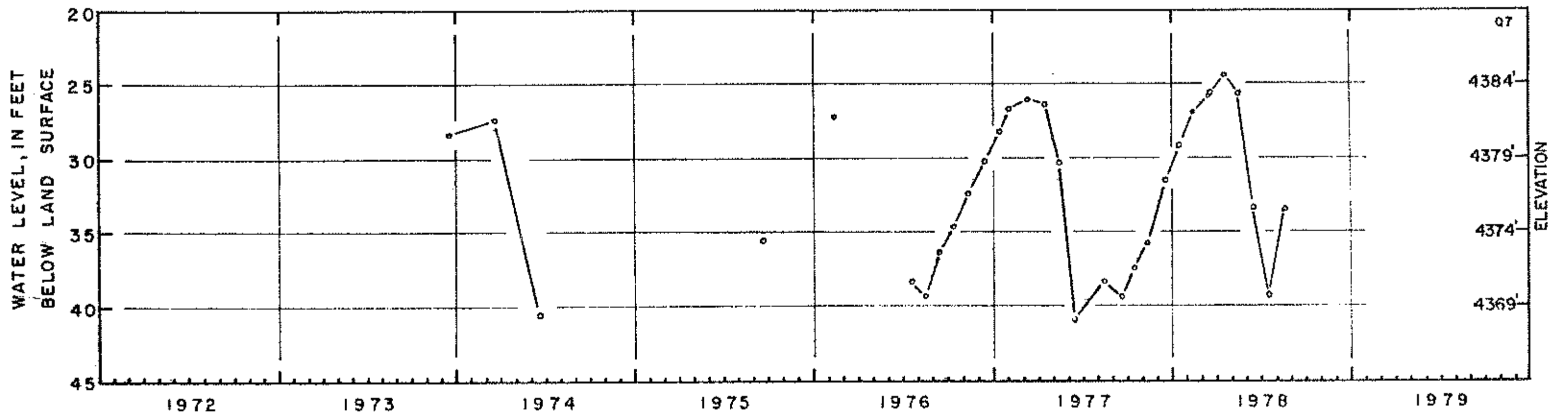


FIGURE 122.

WELL: 6S/32E 27 adca | Depth: 85 feet | Perforations: 63'-66' | Land surface: 4416.70 feet | Measuring point: 2.3' above ground

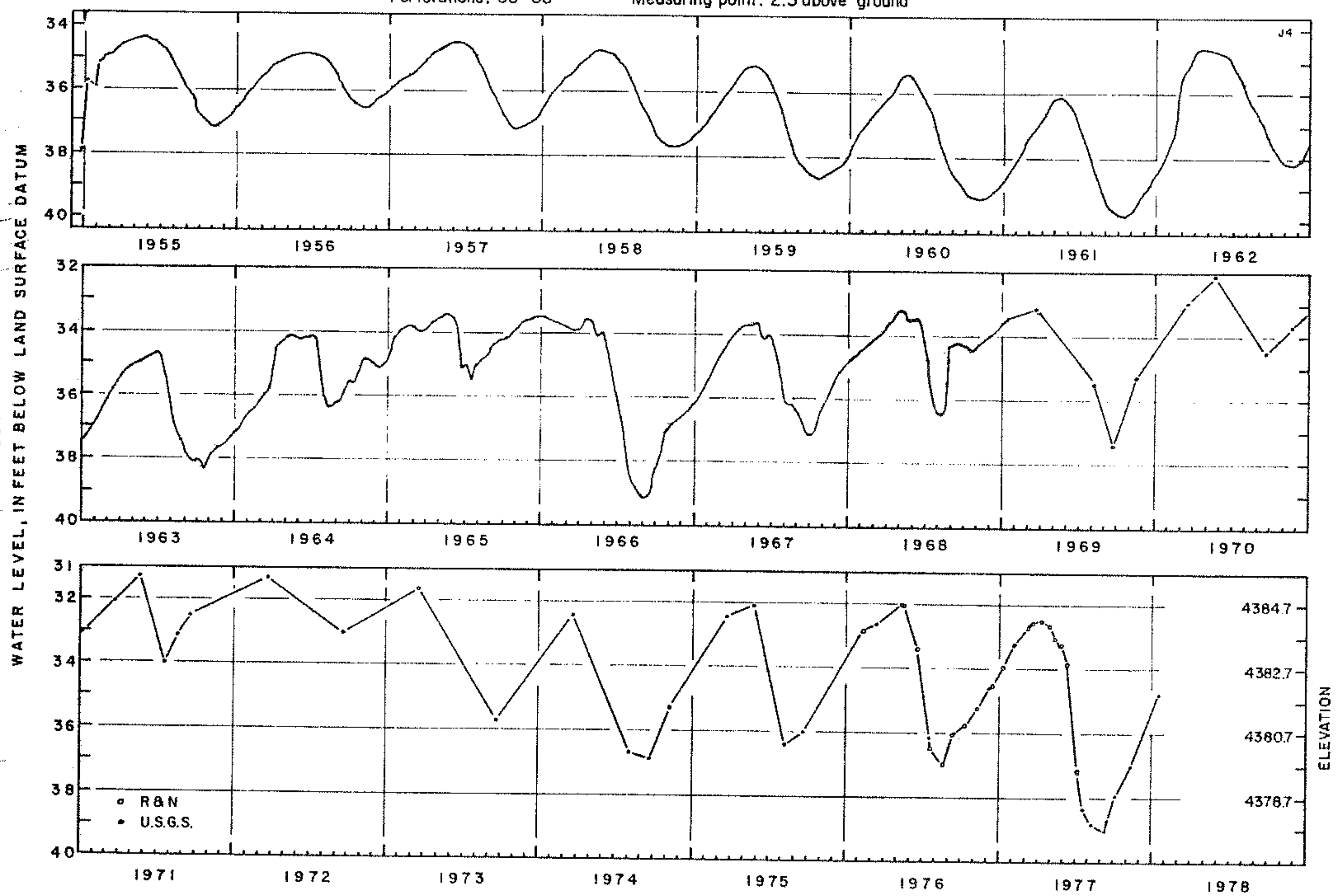


FIGURE 123.
WELL: 6S/32 E 33 bbbb   Depth: 202 feet   Land surface: 4408 feet
Measuring point: .25' above ground

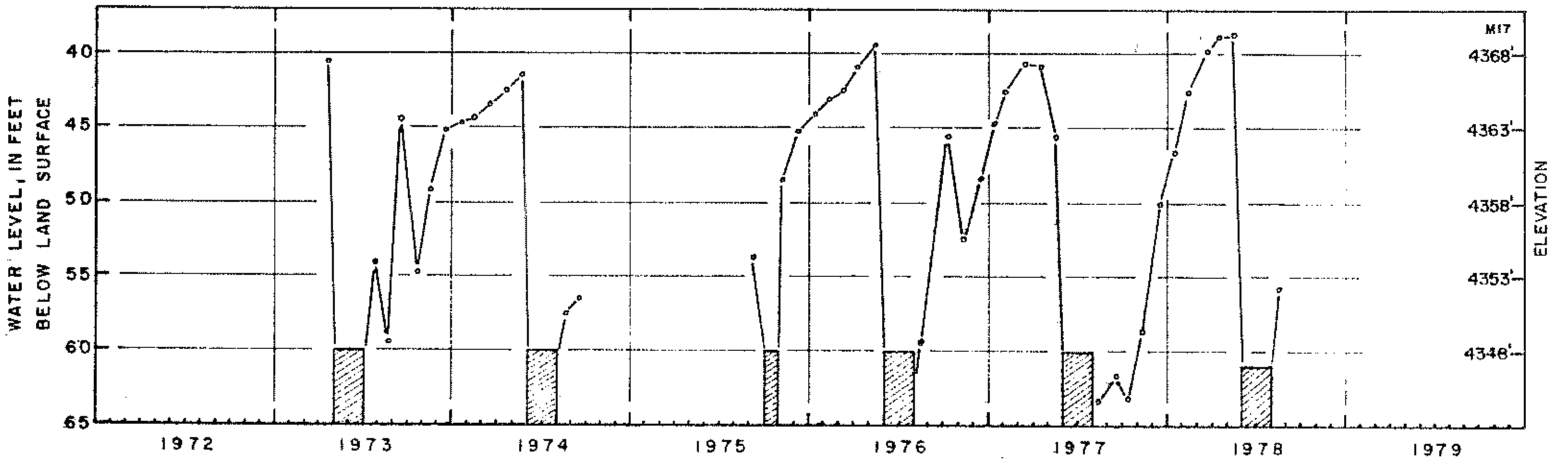


TABLE 23

Precipitation (270 sq. mi.)	19.8 cfs (1 in over 270 mi²)
Blackfoot River basin ground water (124 sq. mi.)	23.3 cfs
Ross Fork basin ground water (166 sq. mi.)	26.7 cfs
Portneuf River basin ground water (1250 sq. mi.)	190. cfs
Bannock Creek basin ground water (413 sq. mi.)	94.5 cfs
Surface irrigation recharge	207. cfs
TOTAL	561. cfs

The irrigation recharge was estimated by West and Kilburn (1963). Significant increases in irrigation have been made since that time. However, most of that water has been from ground water sources so net increases may not be large. The Michaud-Owl Canal system represents the only major surface water system developed since that time. Therefore, West and Kilburn's estimate may be somewhat low under current conditions.

The precipitation value is based on an estimated 1.0 inch that recharges into the plain and foothills area of the reservation. This is related to an annual average precipitation of 10.8 inches. The total area of the Snake Plain and foothill regions within the reservation is 270 square miles.

It has been documented in this report that 1820 cfs discharges from the aquifer as springflow within the reservation. An additional withdrawl of about 150 cfs is made within the reservation for irrigation and industrial uses. An unknown additional quantity also continues as unseen ground water that leaves the reservation at the downstream end. This flow cannot yet be accurately quantified, as there is inadequate information on the transmissivity of the aquifer. The values are too high, particularly within the basalts, to be measured by conventional techniques. During this study several attempts were made to measure transmissivity in pumping wells but the pumping levels stabilized too rapidly to provide meaningful results. The study by Mundorff and others (1964) showed transmissivities ranging between 3 million gpd/ft near Blackfoot to over 20 million gpd/ft under much of the Gibson Terrace. No estimates were made for Michaud Flats. The available ground water information does indicate that the amount leaving as ground water is relatively small, however. Thus the total ground water flow identified is at least 1970 cfs, and may exceed 2000 cfs.

Thus at least 1410 cfs enters the reservation as ground water inflow within the Snake Plain aquifer. As shown in Table 23, the Snake Plain aquifer receives a gain of 560 cfs (405,000 ac. ft./yr.) as it passes through the reservation.

Interpretation of water table maps prepared in this study show that a large portion of the ground water enters the reservation upstream of Blackfoot. The water here flows almost entirely within the basalt. The remaining portion enters the reservation south of Blackfoot, flowing generally parallel to the Snake and Blackfoot Rivers. The water flows generally southeast toward Ferry Butte, with the upper portion of the aquifer discharging in the Fort Hall Bottoms near Ferry Butte. The ground water also flows through the Buckskin Basin and Gibson Butte areas, then reenters the Snake Plain on Gibson Terrace, and gradually turns to flow generally parallel with the Fort Hall Bottoms. The main flow continues toward the Portneuf River with the upper portion discharging into the Clear Creek, Ross Fork and the lower Portneuf River springs. Throughout the flow path across the Gibson Terrace the gravel sequence thickens with a corresponding greater depth to the basalt. Thus, the ground water continually flows from the cinder zones in the basalt into the gravels.

The Portneuf valley underflow appears to pass partially beneath the headlands to the west of Pocatello and contributes to the Snake Plain flow. These headlands are composed of Tertiary volcanic deposits and could allow a significant flow through the rock. The main body of ground water under Michaud Flats gradually turns to a more westerly direction of flow. The northern portion continues to discharge into the Portneuf River. The aquifer diminishes in capacity toward the western end of Michaud, with the ground water principally flowing in the gravels of the lower Raft Formation. No evidence is available on the existence or character of the basalt in this area. It appears that the water in the gravel zones may continue in a westerly direction beneath the American Falls Reservoir to reenter the basalts of the Snake River Plain downstream of the reservation.

WATER QUALITY

SURFACE WATER QUALITY

Tables 24 and 25 list the averaged chemical analyses for the Fort Hall Bottoms Springs and Portneuf Bottoms Springs respectively. Individual analyses are listed in Appendix D.

Fish Hatchery Springs

This group of springs is located on the northwest side of Ferry Butte and is utilized by the Indian Springs Fish Hatchery. The samples were taken at the mouth of the southernmost and largest spring at 3S/34E-31d. Most of the water from the other springs is diverted through to this spring by the hatchery. Only three samples were taken; there is no indication of seasonal variations. The water is representative of the average Bottoms water, with slightly lower chloride and fluoride levels. Based on this preliminary sampling, there is no indication of any adverse impacts caused by the fish hatchery.

Diggie Creek - Mud Slough

These two creeks originate on the west side of Ferry Butte and flow parallel to the Snake River, then join before entering the Snake about 2.5 miles below the spring sources. Mud Slough is a tributary of Diggie Creek. The average quality of Diggie Creek is representative of the Bottoms water, although the individual analyses were somewhat erratic. Diggie Creek occasionally receives overbank flow from the Snake River which would temporarily affect the quality of the creek.

Jeff Cabin Creek

Jeff Cabin Creek is a relatively small spring that flows into the Snake River in 4S/33E-23b. Its flow was measured by the USGS in 1977 at 21 cfs. The one sample taken was during the Teton Flood when the spring was inundated by the floodwaters.

Spring Creek

Spring Creek is the major spring on the Fort Hall Bottoms. It originates on the southwest side of Ferry Butte and flows parallel with the Snake River. The creek was sampled primarily at the Cable Bridge near the downstream end. Additional samples

TABLE 24

FORT HALL BOTTOMS SPRINGS

AVERAGED WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/1 $CaCO_3$	Total Hardness mg/1 $CaCO_3$	Chloride mg/1 Cl	Sulfate mg/1 SO_4	Ortho Phosphate mg/1 PO_4	Nitrate mg/1 N	Ammonia mg/1 N	Iron mg/1 Fe	Fluoride mg/1 F	Dissolved Oxygen mg/1	Number of Samples
Fish Hatchery Springs 3S/34E - 31 d	0	53	518	-	222	228	14	29	0.23	0.7	0.04	0.02	0.75	7	3
Mud Slough 4S/34E - 7 aaa	0	52	515	8.05	200	220	25	30	-	-	-	0.05	-	-	2
Diggie Creek 4S/34E - 7 acb	1	52	504	7.96	208	227	22	30	0.10	1.0	0.02	0.04	0.81	8	4
Jeff Cabin Creek 4S/33E - 13 c	102	60	580	8.00	190	220	30	37	0.20	0.5	0.21	0.07	0.82	-	1
Spring Creek-Bronco Rd. 4S/34E - 5 dccc	0	-	525	8.05	200	240	30	33	-	-	-	0.04	-	-	1
Spring Creek-Sheepskin Rd. 4S/33E - 25 cbb	1	-	520	7.90	200	-	30	32	-	-	-	-	-	-	3
Watercress Spring 5S/33 E - 3 c	0	-	530	7.73	200	230	30	39	-	-	-	0.04	-	-	1
Spring Creek-Fish Weir 5S/33E - 3 a	1	-	520	8.10	210	-	25	33	-	-	-	-	-	-	1
Spring Creek 5S/33E - 9 acad	1	50	528	8.08	200	216	24	34	0.14	0.8	0.01	0.03	0.88	10	14
Jimmy Creek 5S/33E 4 dba	4	52	561	7.93	198	226	29	42	0.23	0.8	0.03	0.03	0.87	11	17
Clear Creek-Sheepskin Rd. 4S/33E - 25 dcac	3	48	595	8.05	210	235	35	38	0.14	1.0	-	0.04	-	-	2
Clear Creek 5S/33E - 14 bbb	2	51	558	8.02	196	225	30	37	0.15	0.8	0.02	0.02	0.93	10	15

TABLE 25

PORTNEUF BOTTOMS SPRINGS

AVERAGED WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Batiste Spring 6S/34E - 7 acdb	0	59	1248	7.04	276	438	66	225	5.97	5.48	1.35	0.04	0.72	3	17
Papoose Spring 6S/33E - 1 aa	1	52	590	7.80	215	230	33	29	0.19	1.1	-	0.02	-	-	3
Syphon Road Spring 6S/33E - 1baaa	2	46	510	7.90	190	210	22	36	0.12	0.8	-	0.02	-	-	1
Wide Creek-East 5S/33E - 36 cabd	0	52	488	8.34	192	202	20	30	0.24	0.8	0.00	0.02	0.89	-	2
Twenty Springs-East 5S/33E - 36 cabc	0	52	500	7.88	191	206	19	30	0.16	0.9	0.01	0.03	0.86	-	16
Twenty Springs-West 5S/33E - 36 cbad	0	51	948	7.69	206	322	72	147	0.18	0.8	0.01	0.03	0.98	-	16
Willow Spring 5S/33E - 36 cbb	5	40	3612	8.14	301	1008	665	500	0.38	0.2	0.12	0.04	1.11	-	4
Tindaha Spring 5S/33E - 26 cdcc	2	54	542	8.20	178	200	32	44	0.20	0.8	0.02	0.02	-	-	2
Wide Creek 5S/33E - 25 bca	1	56	494	8.12	178	202	26	38	0.17	0.7	0.02	0.02	0.91	11	12
Jimmy Drinks Spring-East 5S/33E - 22 ddc	0	54	488	7.81	173	197	25	37	0.17	0.9	0.01	0.02	0.86	9	12
Jimmy Drinks Spring-West 5S/33E -22 cad	0	54	477	8.04	169	195	25	38	0.17	0.8	0.02	0.02	0.84	11	12
Dunn Spring 5S/33E - 22 ccc	2	63	570	7.68	190	205	25	39	0.09	0.3	0.01	0.03	0.86	7	1

were also taken at the Fish Weir, the Sheepskin Road Bridge, and the Bronco Road Bridge near the source. At the Cable Bridge, dissolved mineral levels were found to be fairly constant throughout the year. Samples taken at the other stations on the creek indicated that no significant changes in chemistry occur in the downstream direction. Ground water inflow along the channel maintains a moderate temperature throughout the year, ranging between 40°F and 60°F at the Cable Bridge. The water is classified as hard, and contains fairly high levels of fluoride, relative to most reservation streams. Turbidity is very low throughout the year, as very little snowmelt runoff enters the creek.

The only flooding to occur on Spring Creek, apparently in this century, was due to the Teton Flood, which inundated the creek downstream of the Bronco Road Bridge. Little change in chemistry resulted; however, turbidity levels were greatly increased for approximately three days.

Spring Creek is also sampled frequently by various government agencies. The USGS sampled at the Bronco Road Bridge until 1971, then moved to the Cable Bridge. The EPA sampled the creek at Bronco Road from 1972 to 1974. Also the Bureau of Reclamation sampled at the Sheepskin Road Bridge during 1968 for a reservoir quality study. The creek is also sampled by various state agencies.

Watercress Spring

This is a small spring located near the Spring Creek Fish Weir. It flows into Spring Creek and was sampled once to invesitgate downstream inflow to the Creek. Its chemical levels were found to be almost identical with Spring Creek.

Jimmy Creek

Jimmy Creek was sampled at the flow measuring station at 5S/33E-4dba, above the confluence with Spring Creek. The chemistry was found to be stable throughout the year, and fairly similar to Spring Creek. The levels of some constituents were, on the average, higher than Spring Creek, while some turbidity was usually noted in the water.

Clear Creek

Clear Creek was monitored at the flow measurement station at 5S/33E-14bbb, above its confluence with Ross Fork. The creek flows along the edge of Gibson Terrace, and receives agricultural runoff through the Gibson Drain.

The chemical quality was found to be fairly consistent with Spring Creek, and exhibited little seasonal variation. The creek was also influenced by the Teton floodwaters along its lower reach, which resulted in a slight dilution in dissolved minerals and a large increase in turbidity.

A study of pesticide and PCB contamination following the Teton Flood (Perry, 1977) found high levels of both DDT and PCB in fish of the Fort Hall Bottoms. The higher levels were noted in Clear Creek. The source of this contamination is at present unknown.

Kinney Creek

Kinney Creek is from a relatively small spring and flows between Clear Creek and Spring Creek. It was not sampled during this study, although it was checked by the USGS in 1970 and 1971. Their analyses indicated that it is similar in quality with the other springs in that area.

Batiste Spring

Batiste Spring is located at 6S/34E-7acdb on the west side of the Portneuf River. It is the uppermost spring of the Portneuf Bottoms area. The Union Pacific Railroad withdraws some water from the spring house at the source, and a fish hatchery is operated on the lower reach of the spring. The spring itself is upstream of the reservation, but was monitored due to the erratic chemical quality and large influence on the Portneuf River quality.

Samples taken during this study indicate high levels of hardness, chloride, sulfate, phosphate, nitrate and ammonia. The parameters were very erratic during the study period, with not all parameters showing similar behavior. Nutrient levels, along with sulfate, approach or exceed recommended levels for drinking water.

Sampling of this spring by various agencies has occurred intermittently since 1930. The accumulated data shows a very definite increase in mineral and nutrient levels over the years. The older analyses show quality similar to the quality now found in most Bottoms Springs.

Recent studies have detected significant amounts of mercury, arsenic, and cadmium; that, while not exceeding drinking water standards, exhibit fluctuating concentrations (Goldstein, 1979).

Papoose Spring

Papoose Spring straddles the reservation boundary upstream of the Siphon Road Bridge. A fish hatchery is operated on this spring. The few samples taken here indicate the quality is similar, but slightly higher, than the average bottoms water. The spring is only one mile downstream from Batiste, but shows no similarity with the chemical quality of that spring.

Siphon Road Spring

This small spring originates on the west side of the Portneuf River just south of Siphon Road in 6S/33E-1baaa. It was sampled once and found to contain the normal level of dissolved minerals and nutrients for Bottoms Spring water.

Twenty Springs East, Wide Creek East

Wide Creek has its source just north of Siphon Road in 5S/33E-36c in a group of small springs named Twenty Springs. The easterly group of springs is here referred to as Wide Creek East, while the westerly group is referred to as Twenty Springs East. A small spring that joins Twenty Springs East is referred to as Twenty Springs West.

Both Wide Creek East and Twenty Springs East have nearly identical quality, and represent approximately 90 percent of the total flow from Twenty Springs. The levels of dissolved solids are slighly lower than the average Bottoms water quality. No noticeable seasonal variations were evident, as the levels were very uniform throughout the study period.

Twenty Springs West

The quality of the water in this branch of Twenty Springs is strikingly different from the other branches. While the nutrient levels and temperature are identical, the other parameters such as hardness, chloride, sulfate, and fluoride are significantly higher. There is also an erratic pattern to these levels, which tend to indicate higher concentrations during the winter, although this is not completely consistent.

Willow Spring

Willow Spring is the name given to a small spring that flows from the western valley wall of the Portneuf Bottoms at 5S/33E-36cbb. The water contains perhaps the highest levels of dissolved solids found on the reservation. The nutrient levels were slightly higher than those found in the other Portneuf Bottoms Springs. As with Twenty Springs West, the significant increases are with hardness, chloride, sulfate and fluoride. The water is on the order of four times as mineralized as Twenty Springs West. Sufficient sampling has not been completed to detect any seasonal variations, although continued study has been underway by Goldstein (1979). It has been found that arsenic and manganese are also present in higher than normal quantities.

Willow Spring only discharges a small amount of water, which ponds on the Portneuf Bottoms before reaching Wide Creek. The water apparently flows from the perched layer above the American Falls Lake Beds.

Tindaha Spring

Tindaha Spring flows down the west side of the Portneuf Bottoms and enters Wide Creek. It was sampled twice at 5S/33E-26cdcc, and showed a near normal chemical quality relative to the Fort Hall Bottoms water.

Wide Creek

Wide Creek was sampled at the flow measuring station in 5S/33E-26bca. The water was found to be slightly less mineralized than the normal Bottoms water, although it is still classified as hard. There was no discernible seasonal variation in chemistry levels. The chemistry here is similar to the upstream source springs of Wide Creek East and Twenty Springs East. The very hard water in Twenty Springs West appears to have only a slight effect on the downstream quality. The spring was also sampled by the USGS in 1970-71.

Jimmy Drinks Springs

The East and West Branches of these springs, along with Wide Creek, are the major springs of the Portneuf Bottoms area. Both branches originate in the same area in 5S/33E-27aa and diverge to enter the Portneuf River at different locations. The East Branch was sampled at the flow measurement station where it enters the Portneuf River in 5S/33E-22ddc; while the West Branch was sampled at 5S/33E-22cad. The water in both springs is similar in quality, and neither exhibits a significant seasonal variation. The water is of fairly good quality. Although the water is classified as hard, it is the least mineralized water found in the Fort Hall Bottoms. The spring has also been sampled by the Bureau of Reclamation during a 1968 study of the American Falls Reservoir. Both their samples and a 1952 sample by the State of Idaho indicate little chemistry change during the past 25 years.

Dunn Spring

Dunn Spring is a very small spring that flows on the west side of the Portneuf Bottoms and enters the river below Jimmy Drinks. It was sampled once in 5S/33E-22ccc, and found to have similar chemistry with the Jimmy Drinks Springs, although with a higher alkalinity level.

Lower Ross Fork

The averaged chemical analyses of these four stations are listed in Table 26. Individual analyses are found in Appendix D.

Ross Fork - Below Main Canal - Water samples were taken just downstream of the Ross Fork Crossing of the Fort Hall Main Canal. During the irrigation season, the creek intermixes with the canal water. Consequently, the water discharged downstream is that of Blackfoot River-Snake River origin. All but two of the samples taken at this site were essentially canal water.

The levels of most constituents are lower than the levels of the Ross Fork station above the canal. Two samples taken during the irrigation season by the EPA in 1974 showed similar levels to those found in this study.

TABLE 26

LOWER ROSS FORK BASIN

AVERAGED SURFACE WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Ross Fork-below Main Canal 5S/35E - 5 bac	92	50	409	7.97	166	181	23	22	0.24	0.3	0.03	0.06	0.60	9	7
Ross Fork Spring #1 5S/34E - 4 dbcc	12	40	1010	7.68	335	445	44	117	0.77	1.3	0.46	0.03	1.09	-	2
Ross Fork Spring #2 5S/34E - 8 bcc	0	54	540	7.81	220	230	15	29	0.12	1.0	0.00	0.03	0.86	-	1
Ross Fork-above Clear Creek 5S/33E - 14 ac	15	52	558	8.08	212	225	24	36	0.24	0.7	0.03	0.04	0.80	9	10

Ross Fork Spring #1 - This spring is located on the north side of the Ross Fork valley west of Fort Hall in 5S/34E-4dbcc. The flow was measured at 0.08 cfs on August 23, 1976. The water was found to be very hard with higher than normal nutrient levels. It is notable that the summer sample shows almost twice the levels found during the winter. The two parameters that should be noted are fluoride and ammonia nitrogen. Both are near or exceed the drinking water standards. While the water is not used for any domestic supplies, it is available for stock water.

The spring is believed to originate from the perched water layer that occurs just beneath the land surface north and west of Fort Hall. It is locally known as the Frog Pond area. The higher summer levels are probably due to the infiltration each summer of irrigation water into the perched zone. The chemistry of the spring is similar to some of the ponds which occur to the north.

Ross Fork Spring #2 - This spring is located approximately 1.7 miles downstream from Spring #1, again on the north side of Ross Fork. This spring water, however, has none of the characteristics of the perched water to the north, and may instead be discharged from the main Snake Plain aquifer. The quality is similar to the regional ground water for all of the parameters tested.

Ross Fork - Above Clear Creek - The downstream reach of Ross Fork was sampled at the flow measurement station, near its confluence with Clear Creek. The qaulity here is greatly influenced by the large amount of ground water inflow in that area. Also, during the summer, irrigation return flow from the Fort Hall Irrigation System enters the creek through the Tyhee Wasteway. Consequently, the quality of the water is similar to, but slightly more mineralized than, the majority of the Bottoms Springs. The quality varied somewhat throughout the year, depending on the various discharges of the contributing flows.

Lower Portneuf River

Table 27 lists the averaged chemical analyses of the Lower Portneuf stations.

TABLE 27

LOWER PORTNEUF RIVER BASIN

AVERAGED SURFACE WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity μ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Portneuf River-Rt. 30 6S/34E - 8 ccd	18	53	685	8.28	265	272	40	34	0.36	0.6	0.10	0.02	0.59	-	2
Portneuf River- Swanson Rd. 6S/34E - 7 dba	29	72	870	8.18	260	240	50	84	31.2	3.2	1.48	0.02	3.30	-	1
Portneuf River- Syphon Rd. 5S/33E - 36 dccc	9	54	744	7.81	271	278	40	49	1.58	1.7	0.51	0.03	0.90	9	16
Portneuf River- at Wide Cr. 5S/33E - 26 aac	13	52	725	7.80	280	280	40	47	0.89	1.0	-	0.08	-	7	1
Portneuf River- below Clear Cr. 5S/33E - 28 aabd	5	57	587	8.03	214	234	31	40	0.51	1.0	0.06	0.02	0.84	9	8
Portneuf River - at mouth 6S/32E - 9 aac	20	-	580	8.06	210	235	29	42	0.45	0.8	0.01	0.02	0.80	-	2

Portneuf River - Rte. 30 - As the lower Portneuf River returns toward the reservation it receives a large amount of industrial and municipal waste water near the Interstate 15W crossing. The Rte. 30 station is above this discharge area, and was sampled to determine the magnitude of change due to these discharges. It was found that the water here was somewhat similar to the upper Portneuf River above the Portneuf Reservoir, with only slightly higher nutrient and turbidity levels.

Portneuf River - Swanson Road - This station is located just downstream of the waste water discharge points of the two phosphate processing plants. Only one sample was taken here in response to high levels detected downstream at Siphon Road. Compared with the sample taken the same day at the upstream Rte. 30 station, the largest increases were found in the sulfate, phosphate, nitrate, fluoride, and ammonia levels; chemicals that can be directly attributed to the waste water. It is probable that at this station, complete mixing of the waste water and river water is not complete, and this may account in part for the high levels. The phosphate, ammonia, and fluoride levels all exceeded the drinking water standards, all by approximately three times.

Portneuf River - Siphon Road

The river at this point shows the impact of the wastewater discharges in the phosphate, nitrate, fluoride, and ammonia levels. These levels show a fairly erratic pattern over time, not necessarily in conjunction with variations in the other parameters. The ammonia levels are commonly over the recommended level for drinking water (0.5 mg/l) while the fluoride levels occasionally exceed the standard.

Another impact on the quality of the Portneuf River in this area is the inflow of Batiste Spring, which enters the river from the west, downstream of the Interstate. This spring also contributes high concentrations of sulfate, phosphate, nitrate, ammonia, and hardness. The origin of these chemicals appears associated with the phosphate plants' waste disposal ponds.

Several government agencies test the Portneuf River at this point. These include the USGS, the Bureau of Reclamation, the EPA and the Idaho Department of Health and Welfare. Their data show similar levels to those found in this study. It should be noted that a sample taken on August 10, 1977, by the Idaho Department of Health and Welfare indicated a mercury level of 0.0054 mg/1, almost three times the level recommended for drinking water.

Portneuf River at Wide Creek - One water sample was taken on the Portneuf River above its confluence with Wide Creek. Between Wide Creek and Siphon Road there appears to be no major spring inflow. Consequently the water chemistry remains fairly unchanged along this stretch.

Portneuf River - Below Clear Creek - This station is located below the confluence of Clear Creek, Ross Fork, Wide Creek, and the Jimmy Drinks Springs, which contribute at least 400 cfs to the river. Consequently the quality of the river water more nearly resembles the spring water quality. The variations in the river chemistry are more stabilized. Occasionally a noticeable increase in fluoride and ammonia occurs at this station, which probably originates with the waste discharges upstream of Siphon Road. This station is usually submerged by the reservoir during the spring and early summer.

Portneuf River - Mouth - Two samples were taken at this station when the reservoir was drained during 1977. The river at this point contains all of the spring flow from the Fort Hall Bottoms, except that which enters the Snake River directly near Ferry Butte. Consequently the Portneuf River water accounts for only about 20 percent of the flow in this area. The chemistry, as expected, resembles the average Bottoms water chemistry.

Surface Water Quality Impacts

Except for the Snake River, the Portneuf probably receives the heaviest use of any river associated with the reservation. The upstream portion, within the reservation, has minimal land use impacts on the river quality. Nevertheless, the water is harder than average, primarily due to spring water inflow such as Qeedup that is very high in dissolved solids. Most of the tributary streams, however, are very low in dissolved solids, particularly those flowing from the Mt. Putnam region.

Just downstream of the reservation, the river is impounded within the Portneuf Reservoir for irrigation use. This activity acts to increase the dissolved solids and turbidity levels of the river. In the main reach of the river between Chesterfield and Pocatello, the Portneuf also receives treated municipal wastes from each town along its channel. The combined impact of irrigation return flows and municipal wastes, along with non-point source runoff from agricultural lands, contributes to a buildup of nutrients, bacteria, and turbidity, particularly with the inflow of Marsh Creek. These impacts are to a degree mitigated by the inflow of several tributaries that are low in turbidity and dissolved solids. In the reach between Pocatello and the reservation border, the river receives treated municipal waste and storm-water runoff from Pocatello and industrial wastewater from the phosphate processing plants operated by FMC and the J.R. Simplot Co. Additional impacts in the form of heavy metals and nutrients are contributed by springs such as Batiste that are contaminated by the waste disposal ponds of the phosphate plants. The Portneuf in this area has been studied extensively in recent years, with sampling done by both the State of Idaho and several Federal Agencies. Efforts are now being made to remove both the Pocatello municipal waste and phosphate processing waste from the river. Additional effort should also be directed to the spring flow contamination in that area.

Downstream of Siphon Road, the Portneuf receives practically all of the springflow of the Fort Hall Bottoms before joining the Snake River. This springflow amounts to several times the flow of the Portneuf. Thus, with the succeeding inflows of Jimmy Drinks, Clear Creek, and Spring Creek, the Portneuf approaches the quality of the spring water. However, the objectionable materials in its flow are still delivered to the American Falls Reservoir.

A major impact on the Bottoms Springs water quality is the presence of PCB (polychlorinated biphenyls) and pesticide residues found accumulated in the fish of the Bottoms Springs. This was studied subsequent to the Teton Flood of 1976 by the

Idaho Department of Health and Welfare (Perry, 1977). At present, the origin of this contamination has not been pinpointed. Possible contributers include the flood waters that partially inundated the Bottoms area in 1976, the agricultural chemicals used on the Gibson Terrace area which may drain into the Bottoms, and a general buildup of contaminants in the ground water from sources upstream of the reservation. Additional study to delineate the sources is recommended.

Regarding surface water that flows across the Snake Plain area of the reservation, the EPA classifies both the Portneuf and Upper Snake Rivers as polluted and not able to meet Federal quality goals. In their Idaho technical supplement for the Environmental Quality Profile (1976, p. 22) they state that these two rivers are "probably too polluted to meet federal goals for water quality sufficient for propagation of native fish and for unrestricted recreational use."

For the Portneuf River, they list bacteria, turbidity, phosphate, and a dissolved oxygen deficiency as the contributing factors to this condition. For the Upper Snake River, they list bacteria, turbidity, phosphate, heavy metals, pesticides, and a dissolved oxygen deficiency. They classify these parameters as presently stable, but with no improvement likely within at least five years. The condition of these rivers heavily impacts the quality of the water in American Falls Reservoir.

GROUND WATER QUALITY

Water chemistry of the Snake Plain aquifer in the Gibson Terrace area was sampled at 29 locations and found to be somewhat variable over the area (Table 28). Conductivities ranged between 440 and 780 µmhos/cm, and hardness generally between 200 and 300 mg/l. However, most of the analyses tended toward a quality similar to the Bottoms Spring water. The higher levels of mineralization tend to be located in specific areas, such as just south of Blackfoot and near Reservation Road, The area near Reservation Road may be affected by geothermal activity that has been reported in the Tyhee-Chubbuck area. Several warm-water and highly mineralized wells have been reported in this area.

TABLE 28

GIBSON TERRACE

AVERAGED GROUND WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Well 3S/34E - 27 dda	0	52	578	7.52	272	276	14	22	0.30	0.8	0.04	0.03	0.62	-	4
Well 3S/34E - 32 adda	-	52	440	7.50	200	205	12	26	-	-	-	0.02	-	-	1
Well 3S/35E - 8 dbdc	0	56	632	7.37	280	285	15	25	0.19	1.2	0.00	0.04	0.50	-	2
Well 3S/35E - 9 cdda	1	59	620	7.47	255	290	28	27	0.51	2.3	0.03	0.00	0.64	-	1
Well 3S/35E - 16 b	0	57	650	7.60	275	290	15	25	0.13	1.1	-	0.09	0.43	-	1
Well 3S/35E - 30 bcdc	1	52	540	7.41	240	250	10	22	0.23	0.9	0.02	0.09	0.63	-	1
Well 3S/35E - 30 ddd	0	54	560	7.50	215	220	15	28	0.16	1.9	-	0.02	-	-	1
Well 3S/35E - 32 b	0	55	505	7.65	220	240	18	22	0.22	0.9	0.01	0.06	0.69	-	1
Well 4S/33E - 36 aacc	0	45	505	7.59	185	217	31	36	0.19	0.9	0.00	0.03	1.00	-	3
Well 4S/34E - 17 cbca	-	-	640	7.65	260	250	28	38	0.06	1.3	-	0.02	-	-	1
Well 4S/34E - 20 dddb	0	57	710	7.84	230	250	25	36	0.18	3.8	0.02	0.03	0.68	-	1
Well 4S/34E - 26 bacd	0	60	530	7.68	180	205	18	29	0.12	3.9	0.02	0.04	0.51	-	1
Well 4S/34E - 27 aabb	0	56	570	7.75	220	235	18	26	0.14	1.3	0.02	0.03	0.62	-	1
Well 4S/34E - 34 cabb	0	55	583	7.71	205	233	22	35	0.23	3.3	0.00	0.03	0.68	-	3
Well 4S/34E - 36 ad	1	50	560	7.60	240	230	15	25	0.17	2.7	-	0.07	-	-	1
Well 4S/34E - 36 baab	0	55	485	7.69	216	221	15	22	0.26	1.2	0.01	0.04	0.56	-	4
Well 4S/34E - 36 cb	0	57	532	7.65	218	232	26	24	0.14	1.6	0.02	0.02	0.58	-	3

TABLE 28 (Cont'd.)

GIBSON TERRACE

AVERAGED GROUND WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Dissolved Oxygen mg/l	Number of Samples
Well 4S/35E - 5 bbab	0	57	540	8.00	210	225	15	23	0.16	1.2	-	0.03	0.51	-	1
Well 4S/35E - 17 dccc	-	-	700	7.80	-	200	-	23	0.27	16.2	-	0.03	-	-	1
Well 4S/35E - 29 adbb	-	-	525	7.75	-	230	-	25	0.17	1.9	-	0.03	-	-	1
Well 5S/33E - 12 dbba	0	52	610	7.94	180	210	30	38	0.08	0.9	0.00	0.02	0.95	-	1
Well 5S/33E - 24 cac	0	49	460	7.73	175	200	25	34	0.15	0.8	0.01	0.08	1.01	-	2
Well 5S/34E - 7 bdab	0	52	570	7.83	185	200	22	32	0.10	0.9	0.00	0.03	0.97	-	1
Well 5S/34E - 15 aaaa	0	-	695	7.70	270	275	30	47	0.17	1.2	0.03	0.05	0.52	-	1
Well 5S/34E - 15 c	0	54	780	7.70	280	205	20	75	0.22	1.2	-	0.04	-	-	1
Well 5S/34E - 16 bbbb	0	-	525	7.80	202	215	16	28	0.17	1.0	0.00	0.14	0.78	-	2
Well 5S/34E - 21 dcdd	0	56	905	7.66	350	220	42	77	0.45	1.2	0.01	0.02	0.64	-	1
Well 5S/34E - 26 aacb	0	66	595	7.55	210	170	40	32	0.74	0.6	0.02	0.02	1.63	-	1
Well 5S/35E - 7 ccbd	0	59	510	7.54	200	190	30	24	0.62	0.5	-	0.02	0.62	-	1

Insufficient information is available at this time to correlate different chemical characteristics with different zones of the aquifer. The majority of the irrigation wells in this area penetrate into the basalt, while most of the domestic wells tap the higher gravel zone. There is also little indication of a significant seasonal variation in chemical character, which corresponds to the behavior of the Bottoms Springs water quality.

On Michaud Flats, the chemical quality of the Snake Plain ground water is slightly less mineralized than that found in the Gibson Terrace area (Table 29). The water is generally similar to the lower Portneuf Bottoms springs such as Jimmy Drinks. In comparison with the Gibson Terrace ground water, the conductivity, alkalinity, and hardness were generally lower, while the chloride, sulfate, and fluoride were generally higher. Most of the wells in this area withdraw water from the gravel aquifer above the basalt.

Again, there was little indication of seasonal variations in water chemistry. Also, the quality was fairly uniform over much of the Flats, with two areas of higher mineralization near the southern edge. One area is located west of Bannock Creek as it enters the Snake Plain. The water in this area was found to be higher in hardness and chloride. Wells in this area are generally 200 to 300 feet deep, withdrawing water from sandstone or volcanic ash. The second area of high mineral concentrations is north of the phosphate processing plants and is discussed below.

The two areas where human impacts appear to be affecting the quality of the ground water are in the perched zone northwest of Fort Hall known as the Frog Ponds, and the area north of the phosphate processing plants on Michaud Flats. Both of these impacts are predominately confined to the upper levels of the aquifer. This has an effect on the quality of the spring water where these aquifers discharge into the Bottoms area. At present, these areas are apparently confined to the upper Portneuf Bottoms and the Ross Fork Valley area. Both situations are summarized here.

Frog Pond Area

The Frog Pond area, north and west of Fort Hall on the Gibson Terrace, has developed some unusual water quality characteristics,

TABLE 29

MICHAUD FLATS

AVERAGED GROUND WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity μ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Disolved Oxygen mg/l	Number of Samples
Well 5S/32E - 36 cddd	0	54	460	8.00	140	165	25	40	0.12	0.6	0.04	0.02	0.78	-	1
Well 5S/33E - 28 ccbb	1	53	468	7.69	172	205	26	43	0.23	0.8	-	0.04	0.87	-	2
Well 5S/33E - 34 addd	-	-	420	7.80	160	200	30	42	0.08	0.8	-	0.02	-	-	1
Well 5S/33E - 36 cdcd	0	41	471	7.92	182	202	18	30	0.15	0.9	0.02	0.06	0.86	-	4
Well 6S/32E - 1 abaa	0	54	495	8.13	140	165	22	38	0.11	0.7	0.00	0.02	0.87	-	1
Well 6S/32E - 14 aabb	0	-	475	7.98	145	175	22	38	0.12	0.6	0.00	0.03	0.88	-	1
Well 6S/33E - 1 dacc	0	54	485	7.98	205	215	22	30	0.12	1.0	0.00	0.04	0.81	-	2
Well 6S/33E - 2 cab	0	44	3200	8.57	240	670	625	290	1.18	4.1	0.01	0.03	0.54	-	1
Well 6S/33E - 3 acdd	2	52	450	7.76	150	175	25	42	0.25	0.7	0.00	0.03	0.82	-	1
Well 6S/33E - 5 cacc	0	-	510	7.95	155	190	25	42	0.12	0.9	0.00	0.04	0.90	-	1
Well 6S/33E - 12 bbcc	0	54	640	7.85	160	200	52	56	0.12	0.9	0.02	0.02	0.73	-	1
Well 6S/33E - 12 ccdc	0	56	1350	7.53	236	394	186	104	0.28	2.9	0.07	0.07	0.74	-	14
Well 6S/33E - 12 dadc	1	58	500	7.85	160	180	32	43	0.16	0.8	-	0.10	-	-	1
Well 6S/33E - 15 accd	0	47	670	7.69	185	260	64	47	0.19	2.2	0.00	0.08	0.68	-	2
Well 6S/33E - 22 babb	0	60	480	7.67	170	160	30	34	0.62	0.7	-	0.01	0.81	-	1

partially due to the irrigation agriculture practiced in that area. A perched water zone exists on top of the American Falls Formation in that area, and has risen above land surface in many low areas. This increase is due to the irrigation systems developed in recent years. Associated with this has been an apparent buildup of chemicals added to, and resulting from, the irrigation process. The following areas were sampled to investigate the problem; with the averaged chemical analyses listed in Table 30.

Gibson Pond - This pond is located at the end of a lateral ditch and receives excess canal water from the Main Canal System. The pond drains after each irrigation season, and is a probable source of part of the perched water. The water was sampled once in 4S/34E-23dccd, and was found to contain a fairly low level of dissolved minerals and nutrients, indicative of the surface water irrigation system.

Rio Vista Frog Pond - One sample was taken from a pond near Rio Vista Road in 5S/34E-5bbb, and is fairly representative of the perched water zone in this area. Levels of most parameters tested were usually high. The ammonia nitrogen level exceeds the drinking water recommended limit, although is not a danger to livestock at present levels.

Emma Canal - This is a branch of the Gibson Canal that channels excess irrigation water into the Bottoms area. One sample taken at 4S/34E-30cdc indicated fairly low levels of minerals, somewhat similar to the Gibson Pond sample.

Gibson Drain - This drain collects water from both a small spring draining the perched layer and excess irrigation water from the Gibson Canal. Consequently, the quality was found to be significantly better during the summer. The two winter samples taken at Sheepskin Road exhibit the increased levels in hardness, sulfate, nitrate, and ammonia indicative of this perched zone.

Drain Wells - Two drain wells in 4S/34E-28 collect the perched water and were found to contain the highest levels of dissolved chemicals found in the perched zone. These wells are located near the center of the Frog Pond Area and are closest to the active farming areas. The water

TABLE 30

GIBSON TERRACE IRRIGATION DRAINAGE SYSTEM

AVERAGED WATER QUALITY

Location	Turbidity FTU	Temperature °F	Conductivity µ-mhos per cm	pH	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chloride mg/l Cl	Sulfate mg/l SO_4	Ortho Phosphate mg/l PO_4	Nitrate mg/l N	Ammonia mg/l N	Iron mg/l Fe	Fluoride mg/l F	Dissolved Oxygen mg/l	Number of Samples
Gibson Pond 4S/34E - 23 dccd	4	70	250	9.04	100	105	12	19	0.03	0.3	0.06	0.02	0.66	-	1
RioVista Pond 5S/34E - 5 bbb	38	55	1130	7.29	295	310	85	155	0.35	0.3	0.82	0.08	0.96	-	1
Emma Canal 4S/34E - 30 cdc	15	-	380	8.20	175	180	15	20	-	-	-	-	-	-	1
Gibson Drain 4S/34E - 31 daaa	10	44	543	7.93	208	262	23	66	0.29	2.5	0.27	0.10	0.72	-	3
Drain Well 4S/34E - 28 cdcc	2	44	1270	8.18	320	560	70	192	0.45	7.0	0.09	0.03	0.54	-	1
Drain Well 4S/34E - 28 cacc	2	51	1275	7.62	350	515	52	178	0.79	9.0	0.21	0.03	0.74	-	2

here contains high levels of hardness, chloride, sulfate, nitrate, and alkalinity.

In summary, it appears that the sources of the perched water zone themselves contain no unusually high levels of chemicals. These sources include the ground water pumped for the irrigation systems and the overflow and leakage from the surface water canal system.

The high levels probably result from the addition of agricultural chemicals to the irrigation water, and the evaporation of the water which concentrates the chemicals in the remaining water. The perched water probably discharges into Ross Fork and Clear Creek through numerous small seeps. The quality found in Ross Fork Spring #1 supports this.

Michaud Flats

A serious water quality problem exists in the upper zones of the alluvial aquifer in the Michaud Flats area. Water quality has been seriously degraded in an area of about seven square miles bounded by the Portneuf River to the northeast, the Pocatello Municipal Airport to the west and the phosphate processing plants (FMC and J.R. Simplot, Inc.) to the south. Current investigation has been limited to sampling wells and springs in the area to determine the magnitude and extent of the affected area, and the study of the water quality history of the area.

This study has shown various wells and springs to have very high concentrations of hardness, chloride, sulfate, phosphate, nitrate, and ammonia in this area. Additional investigation by the State of Idaho has also detected very high levels of arsenic, cadmium, manganese, and fluoride.

The springs that exhibit these characteristics are Batiste Twenty Springs West, Willow, and possibly Papoose. These have been described earlier. The affected wells sampled in this study are the Lindley domestic well (6S/33E-12ccdc), the Crockett domestic well (6S/33E-2caba), and possibly the Lindley irrigation well (6S/33E-12bbcc), and the Pocatello Airport well (6S/33E-15accd). Additional wells found affected by the State of Idaho include the Pilot House Cafe well (6S/33E-12dadc) and numerous phosphate plant industrial wells.

The most serious problem in the area appears to be with arsenic. A study conducted by the Idaho Department of Health and Welfare in 1972 and 1973 closely monitored the water quality in that area. The highest arsenic concentrations occurred in the FMC area. Table 31 lists the arsenic levels found during their study in that vicinity. The highest values were detected in the Pilot House Cafe well, which continually exceed the allowable limit for drinking water of 0.05 mg/l for over a year.

Drinking water standards were also exceeded for cadmium, manganese, fluoride, and total solids in numerous wells in the area. The highest levels continually occurred in the Pilot House Cafe well and the phosphate industries wells. Despite these numerous violations, the Department of Health and Welfare stopped sampling in 1973, apparently took no corrective action, and did not notify the well owners of their water quality problems. This situation existed until 1976 when the Pilot House Cafe well was condemned for an arsenic concentration of 0.056 mg/l.

Based on an analysis of the existing information, it appears that two aquifer zones contain contaminated water. The one zone is apparently a semi-perched layer on top of the American Falls Formation. This water is not tapped by any known wells in the area, but is believed to supply several of the springs, including Batiste and Willow. The second zone is below the American Falls Formation and is the upper part of the main Raft Formation aquifer. This zone is tapped by several of the shallow wells in the area, including the Pilot House well, Lindley well, and probably the Crockett well. The contaminated water travels mainly in a horizontal direction, with some seeping lower into the aquifer in a diluted form.

The obvious sources of the contamination are the industrial waste ponds maintained south of the two phosphate processing plants. According to the Department of Health and Welfare, none of the ponds are lined. Both industries store liquids in the ponds that contain very high levels of those chemicals contaminating the aquifer.

The ponds are maintained at the base of the foot hills of Michaud Flats. It appears that the clay layer of the American Falls Formation thins out as it reaches this hill, indicating the

TABLE 31. ARSENIC CONCENTRATIONS FROM SELECTED WELLS ON MICHAUD FLATS

DATE	PILOT HOUSE WELL 6S/33E-12dadc	LINDLEY DOMESTIC WELL 6S/33E-12cc	FMC WELL 4 6S/33E-13ba	FMC WELL 1 6S/33E-12cd	FRONTIER WELL 6S/34E-7d
10/27/72	< 0.10 mg/l	< 0.10 mg/l	0.10 mg/l	0.35 mg/l	< 0.10 mg/l
11/21/72	7.48	0.02	0.22	0.22	3.08
12/14/72	5.72	—	0.33	0.22	—
12/18/72	0.28	—	4.40	< 0.01	—
1/12/73	0.16	—	—	—	—
1/18/73	0.29	0.06	0.07	—	—
1/22/73	0.29	0.06	0.09	—	—
1/26/73	0.16	0.01	0.04	—	—
1/29/73	0.26	< 0.01	0.02	—	—
2/1/73	0.20	< 0.01	0.03	—	—
2/6/73	0.16	0.01	0.02	—	—
2/8/73	0.14	0.01	0.02	—	—
2/12/73	0.20	0.01	0.01	—	—
2/20/73	0.13	—	0.04	—	—
2/26/73	0.14	0.02	0.01	—	—
3/28/73	0.16	0.01	0.01	—	—
4/5/73	0.29	0.02	0.06	—	—
4/17/73	0.16	0.01	0.01	—	—
5/2/73	0.25	0.01	0.05	—	—
8/29/73	< 0.01	< 0.01	< 0.01	—	< 0.01
11/13/73	0.11	0.01	< 0.01	—	—
12/10/73	0.04	0.01	0.01	—	—

NOTE:

All analyses by the State of Idaho
US Public Health Service Recommended Limit — 0.01 mg/l As
US Public Health Service Maximum Allowable Limit — 0.05 mg/l As

southern extent of the ancestral American Falls Lake. Any pond leakage would therefore be able to enter both above and below this formation. The new Pilot House well was drilled to a depth of about 200 feet, almost twice the depth of the old well. No indication of contamination was found at that level, indicating a probable surface source of the contamination.

The concentrations of contaminants found in the 1972-1973 study are not as high at present. However, sampling of the Lindley domestic well and Batiste Spring over a two year period indicated large fluctuations in chemistry. Present investigations of the area by Goldstein (1979) continues to document the presence of trace metals in the aquifer.

GLOSSARY

acre-foot The volume of water that covers one acre to a depth of one foot.

alluvial fan A fan shaped deposit of sediments formed where a stream flows from a mountainous area onto a lowland.

andesite A fine-grained igneous (volcanic) rock midway in composition between rhyolite and basalt.

aquifer A geologic unit that is capable of transmitting water through its pore spaces, in enough quantity to yield water to wells or springs.

basalt A fine-grained, dark colored, igneous (volcanic) rock.

baseflow The discharge of a stream that originates from ground water inflow to the channel.

caldera A roughly circular, steep sided, volcanic basin.

channel migration The lateral movement of a stream channel by erosion and deposition of the floodplain sediments.

cinder zone A zone of uncemented volcanic ejecta that separates individual basalt flows. They are noted to contain large ground water flows.

consumptive use Water used during the irrigation process through transpiration and evaporation.

cubic foot per second The principal unit for measuring stream discharge. One cubic foot per second equals 1.98 acre feet per day.

dolomite A sedimentary rock composed of calcium and magnesium carbonate.

drawdown The lowering of the water table caused by pumping.

effluent A discharge of water degraded by physical, chemical or biological contaminants.

<u>ephemeral stream</u> A stream that flows only during certain times of the year, such as during snowmelt or rainfall periods.

<u>evapotranspiration</u> The amount of water that evaporates directly plus the amount that is used by plants. The remaining water is available for runoff as ground water or surface water.

<u>gaging station</u> The location on a stream where the discharge or water height is measured.

<u>gaining stream</u> A stream that lies below the water table and receives ground water discharge to increase the streamflow along its course.

<u>ground water</u> Subsurface water that is contained in an aquifer system. Ground water is usually in a state of motion and moves down gradient from areas of recharge to areas of discharge.

<u>hydrograph</u> A graph that shows a property of water with respect to time, such as flow, or water level.

<u>infiltration</u> The flow of water through the soil into the ground water supply.

<u>joint</u> A fracture in the rock, usually near vertical, along which ground water may flow.

<u>limestone</u> A sedimentary rock that is composed chiefly of calcium carbonate.

<u>loess</u> A homogeneous, nonstratified deposit of silt deposited by the wind. Commonly forms the soil in the higher elevations.

<u>loosing stream</u> A stream that flows above the water table and contributes water into the ground water system.

<u>mean annual discharge</u> The average flow of a stream during a one year period.

<u>metasedimentary rock</u> Sedimentary rocks that have been partially metamorphosed due to deep burial within the earth.

<u>non-point source</u> A pollution source that is distributed over a wide area, such as sediment erosion from agricultural runoff.

perched water table The upper surface of a body of ground water that is separated from an underlying ground water body by an impermeable rock or clay zone.

perennial stream A stream that flows throughout the year.

permeability The capacity of a rock or soil to transmit water. It depends on the size and shape of the pores and interconnections within the rock.

porosity The ratio of the total volume of void spaces within a rock or soil to its total volume, expressed as a percentage.

precipitation The input of water, both as rainfall and snowfall, to the hydrologic cycle.

pumping level The water level in a well when the pump is running.

quartzite A metamorphic rock composed chiefly of quartz. Usually formed by deep burial of sandstones within the earth.

recharge The process by which precipitation or surface water is added to the ground water.

return flow Excess irrigation water and runoff that re-enters a stream.

rhyolite A fine-grained, generally light colored, igneous (volcanic) rock.

sandstone A sedimentary rock composed mainly of cemented sand grains.

sedimentary rock Rocks formed from the accumulation and compaction of sediment in water. Usually has a layered structure.

shale A sedimentary rock composed mainly of clay.

solution cavity Void spaces in rock, usually limestone, caused by the removal of rock when dissolved by the ground water.

specific capacity The yield of a well expressed as gallons per minute per foot of drawdown.

stage The elevation of the water surface above a chosen datum.

static water level The water level in a well during non-pumping conditions.

stratigraphy The relationship of different rock units to one another.

surficial material The unconsolidated sediments lying on top of the bedrock.

transmissivity The mathematical definition of the ability of an aquifer to transmit water. Expressed as gallons per day that would flow through a one mile wide section of the entire aquifer thickness, when subjected to a gradient of one foot per mile, and at field temperature.

tributary A stream that contributes water to another stream.

tuff A rock formed by the compaction of volcanic ash.

underflow The movement of ground water through an aquifer.

volcanic ash The unconsolidated deposits of volcanic material less than 4 mm in size.

water table The upper surface of a ground water body under unconfined conditions.

water year A year that begins on October, 1, and ends on September 30. (Water year 1976 began on October 1, 1975, and ended on September 30, 1976).

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