Hydrology

AW

REPLACEMENT GROUND WATER SUPPLY

FIRST PHASE - LOWER TETON DIVISION

TETON BASIN PROJECT, IDAHO

By

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Department of the Interior
Bureau of Reclamation
Region 1
Boise, Idaho

October 1968

Also see Hackett Groundwater for Salmon Falls Project

1977

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ABSTRACT

The authorized Lower Teton Division, Teton Basin Project, Idaho, is located along the Henrys Fork River from Ashton to near the mouth and along the lower reaches of the Teton River. The First Phase of the Division will require up to 400 cubic feet per second flow and 175,000 acre-feet per year of ground water on a cyclic basis. The ground water will replace surface water stored and diverted adversely to downstream rights in dry years. Ideally, the ground water should be made available within the Division service area.

The southwestward flowing lower Henrys Fork River divides a predominantly silicic volcanic terrace and foothill area on the southeast from basaltic lava terrain of the Snake River Plain on the northwest. Extensive alluvial deposits overlie the silicic volcanic and basaltic rocks in the lower Henrys Fork and lower Teton valleys in the St. Anthony-Rexburg-Plano area. Investigations reveal that the basalt beneath the alluvium is thick and widespread. Generally the silicic volcanics yield water in small to large amounts, whereas the basalt yields very large amounts.

The general slope of regional water table is west-southwestward across the area. Regional static water level depth in the basalt ranges from a few feet near the mouth of the Henrys Fork to more than 125 feet near St. Anthony. Annual recharge to the regional aquifer has been estimated at approximately 725,000 acre-feet. A perched water table, which supports widespread subirrigation and domestic supplies, has developed in the alluvium.

Two test wells have been drilled in basalt of the St. Anthony-Rexburg-Plano area and subsequently pumped at yields up to 11.5 cubic feet per second with less than 6 feet of drawdown. Analysis of test results indicates that transmissibility of the basalt is 1,000 to 2,000 feet^2/minute (1 to 2 x 10^7 gallons per day per foot) and the coefficient of storage is less than 1 x 10^{-5}.

The transmissibility of the basalt is great enough to support wells of almost unlimited capacity, but practical considerations limit the yield to about 18 cubic feet per second maximum. Provision for 27 wells of 14.8 cubic feet per second each would satisfy the demand for 400 cubic feet per second maximum flow. Wells of this yield will be 24 inches in diameter and about 400 feet in depth including about 225 feet of open hole in basalt. The wells will be located along, and discharge into, the rivers and larger existing canals. Average pumping lift under long-term cyclic conditions will not exceed 70 feet.

Replacement pumping will affect water levels in the basalt aquifer in the Division area and elsewhere in the Snake River Plain. Ground

water inflow to American Falls Reservoir will be depleted and spring flow and ground water levels will decline in the Mud Lake-Market Lake basins. With present level of knowledge of Snake Plain aquifer conditions, a reliable quantitative estimate of the magnitude of the effects of pumping is not feasible. However, available data indicate that increased recharge due to Division operations will nearly offset any adverse effects of pumping.

Perched water levels in the Division area probably will not be markedly affected by replacement pumping.

INTRODUCTION

The Lower Teton Division, Teton Basin Project, Idaho, is somewhat unique among irrigation projects because surface water will be used when plentiful and ground water used indirectly during dry years when surface supplies are fully appropriated. During these dry years, such as occurred in the 1930's, much of the ground water will be pumped into the Henrys Fork River and tributaries to replace river flows depleted by diversions to Division lands.

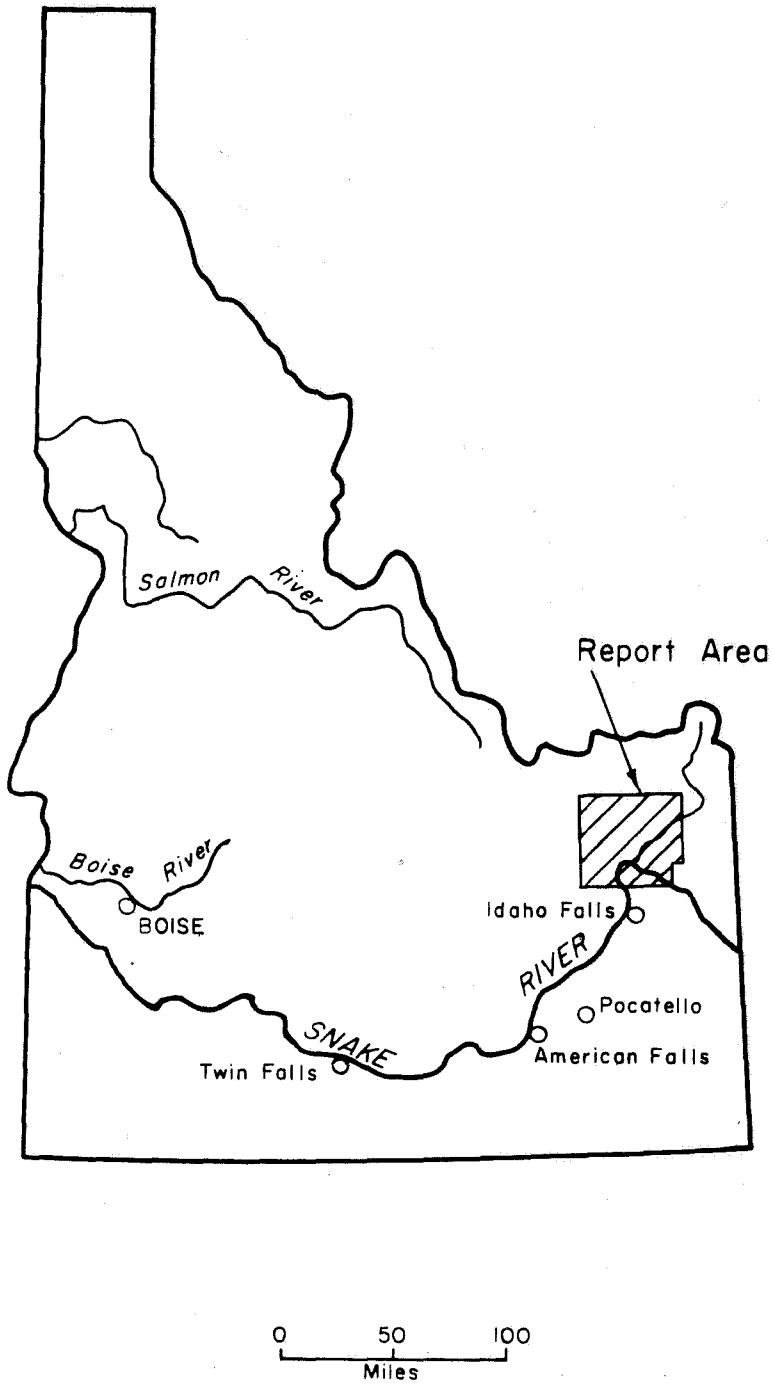
The Lower Teton Division, First Phase, will require maximum 400 cubic feet per second flow and 175,000 acre-feet annually for direct replacement. During many years, pumping will not be required; the average will be 25,000 acre-feet annually. Ideally, the replacement water should be provided within the service area to maintain optimum operational flexibility and insure physical integrity of the constructed facilities. In addition to operational features, the service area seems to offer very distinctive advantages with respect to availability of ground water and costs associated with developing and utilizing it. However, other well field locations on the Snake River are available if needed.

The present investigation is concerned with substantiating the feasibility of obtaining the required supply of ground water from the Division service area and determining the optimum design and location of the facilities, the costs associated with construction of and the performance of these facilities. In addition, the effects of replacement pumping on ground water conditions locally and regionally are considered.

The Geological Survey has undertaken a reconnaissance cooperative investigation of the ground water aspects of the Division area which has been released as an open-file report (Crosthwaite and others, 1967). Material from this investigation has been cited by Authorizing House Document No. 208 as the basis for the ground water features of the Division. The present report generally upgrades and supplements the work done by the Geological Survey. It substantiates the availability of the ground water and revises earlier estimates on design and costs of facilities. Principal reliance is based on data from an extensive program of subsurface exploration and well testing.

Acknowledgments

The author gratefully acknowledges the assistance provided by personnel of the Geological Survey, other Federal and State agencies, and well owners, drillers, and others who cooperated in collection of data for this report. Special appreciation is extended to Messrs.


Salmon River
Report Area
Boise River
BOISE
Idaho Falls
RIVER
Pocatello
SNAKE
American Falls
Twin Falls
0
50
100
Miles

John W. Frink, Loren D. Hampton, Robert T. Pittard, and Lyman G. Rogers of the Bureau of Reclamation for their assistance in data collection and report preparation and review.

HYDROGEOLOGY

Geologic and Physiographic Setting

The southwestward trending Henrys Fork River separates the general area into several distinct subareas. (See geologic map.) An alluvial lowland subarea has developed along the margins of the river, especially downstream from St. Anthony. The river presently meanders in a flood plain that is flanked in part by alluvial terraces. To the northwest, Egin Bench, a distinctively flat terrace, lies between the flood plain and a lava plain subarea. To the southeast, the Teton River divides into two forks in crossing alluvial terraces and fans that separate the flood plain from a terrace and foothill subarea to the southeast.

This latter subarea consists of incised, structurally-controlled terraces and foothills that rise toward the Big Hole Mountains to the southeast. The subarea is underlain principally by silicic volcanic rocks which overlie older volcanic and sedimentary rocks that comprise the Big Hole Mountains and which are warped beneath the younger rocks to the northwest (Crosthwaite and others, 1967).

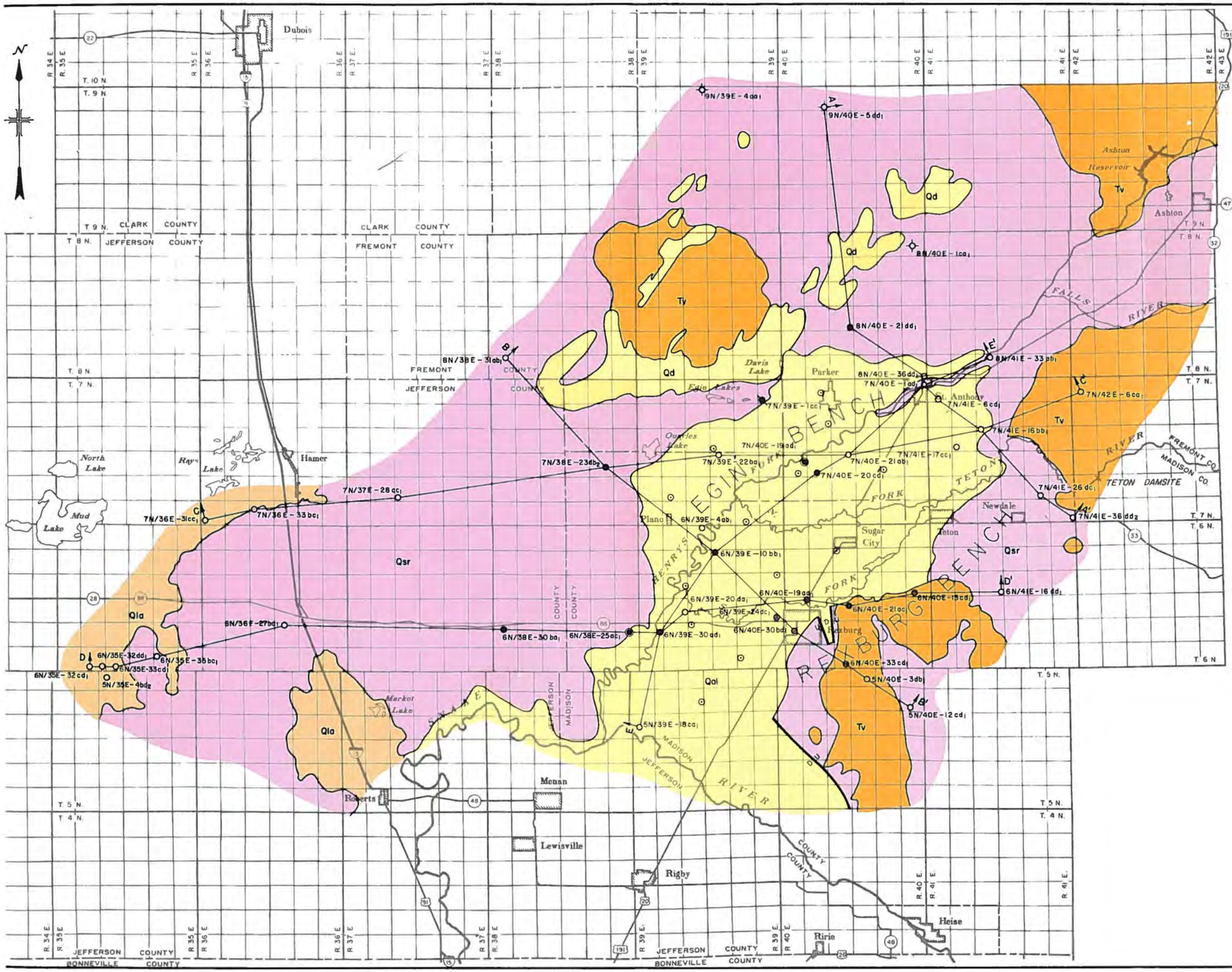
The younger rocks to the northwest are principally basaltic lava flows of the Snake River Plain. This plain, which rises unevenly to the north and northwest, is locally highly irregular and partly veneered with windblown silt and sand, including active sand dunes. Protruding above the plain are several prominent features including Menan Buttes, which are twin volcanic cones near the mouth of the Henrys Fork. Northwest of St. Anthony are Juniper Buttes, which, according to Stearns and others (1939, p. 21), are structurally complex arched inliers of older rocks rising above the lava plains.

Elevations in the area range from 4800 feet at the mouth of Henrys Fork to 5300 feet near Ashton and to a maximum of about 6200 feet at the summit of Juniper Buttes.

Geologic Units and Their Water Bearing Characteristics

Silicic Volcanic Rocks

The silicic volcanic rocks that generally underlie the subarea to the southeast of the Henrys Fork lowlands to an unknown depth are also exposed in Big Bend Ridge, near Ashton Reservoir, and in Juniper Buttes (Mundorff and others, 1964). In addition, silicic volcanic rocks were encountered at depths of 584 and 350 feet from the surface in Wells 6N/39E-10bb1 and 7N/40E-20cd1, respectively (see geologic section E-E'). Water table conditions indicate that silicic volcanic rocks probably lie near the surface in T. 8 N., R. 41 E. and R. 42 E. northeast of St. Anthony.



EXPLANATION

PLEISTOCENE TO RECENT

Qd — SAND DUNES - Recent shifting sand; fine-grained, windblown, quartz sand in dunes to 200 feet high. Above the water table.

Qal — ALLUVIUM - Recent and older unconsolidated sedimentary deposits of the Lower Henrys Fork and Teton Rivers; includes undifferentiated heterogeneous to poorly stratified recent channel and flood-plain material and older fan, terrace, and possible eolian and lacustrine deposits; generally sand and gravel with lesser silt and clay. Thickness ranges from a few to over 300 feet. Locally interbedded with basalt. Yields small to large quantities of ground water.

Qla — LACUSTRINE and ALLUVIAL DEPOSITS - Recent and older unconsolidated sedimentary deposits of the Mud Lake-Market Lake area; includes stratified lake sediments with fewer stream deposits, generally clay and silt with locally coarser material. Maximum thickness unknown. Locally interbedded with basalt. Yields small quantities of ground water.

PLIOCENE (?)

Qsr — BASALT - Aphanitic to porphyritic basalt of the Snake River Group, includes pyroclastics; cindery and scoriaceous to dense. Yields very large quantities of ground water from scoriaceous or cindery zones which normally occur at the contact between basalt flows.

Tv — SILICIC VOLCANIC ROCK - Undifferentiated rhyolitic flows and pyroclastics with lesser amounts of basalt and sediments. Yields small to large quantities of ground water.

GEOLOGIC CONTACT

FAULT (U / D)

A — A' GEOLOGIC SECTION

● U.S.B.R. EXPLORATORY CORE DRILL HOLE

U.S.B.R. DRILL HOLE (No core)

U.S.B.R. TEST WELL

U.S.B.R. SHALLOW OBSERVATION WELL

REHABILITATED WELL

SELECTED PRIVATE WELL

Geology from Crosthwaite, Mundorff, and Walker 1967 and modified from Stearns, Bryan, and Crandall 1939

0 1 2 3 4 5
SCALE OF MILES

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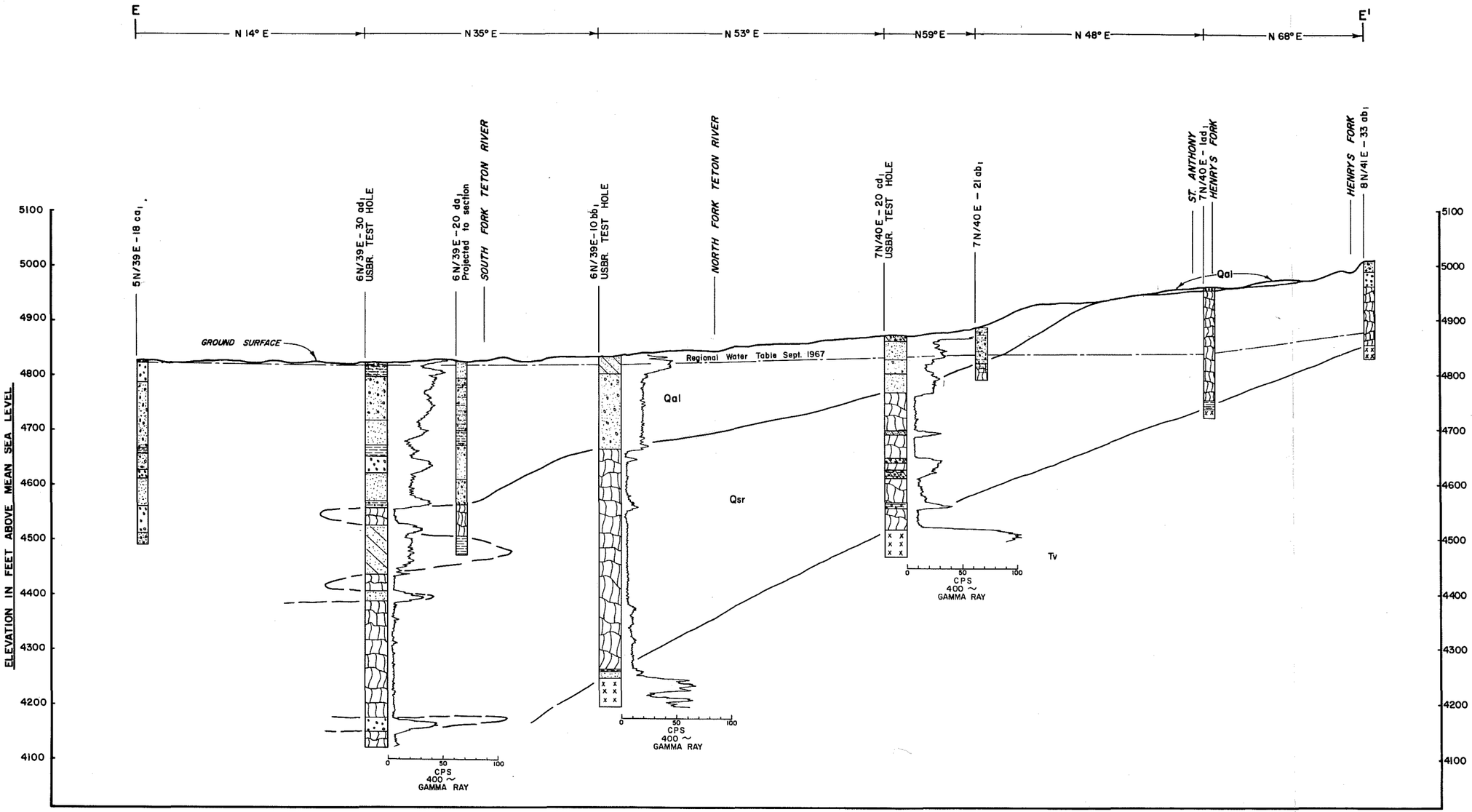
TETON BASIN PROJECT – IDAHO, WYOMING
LOWER TETON DIVISION – IDAHO

GROUND WATER INVESTIGATIONS

GEOLOGIC MAP

DRAWN L. H. BOISE, IDAHO

JAN. 1968 549-125-221



EXPLANATION

GENERAL GEOLOGY

PLEISTOCENE TO RECENT

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GEOLOGIC CONTACT (Dashed where inferred)

FAULT (Dashed where inferred)

WELL LOGS

8N/41E-5dc

U.S.B.R. EXPLORATORY CORE DRILL HOLE Lithology interpreted from core, geophysical log and driller's log. (Entire hole was not cored, see log for details)

U.S.B.R TEST WELL Lithology interpreted from driller's log and drill samples.

DRILLER'S LOG Lithology interpreted from driller's nomenclature

GEOPHYSICAL LOG

0 50 100
CPS
400 ~
GAMMA RAY

GRAVEL
SAND
SILT
CLAY
BASALT
SILICIC VOLCANIC ROCK

1 0 1 2
SCALE OF MILES

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LOWER TETON DIVISION — IDAHO

GROUND WATER INVESTIGATIONS

GEOLOGIC CROSS SECTION E-E'

DRAWN L. H. BOISE, IDAHO

DEC. 1967 549-125-202

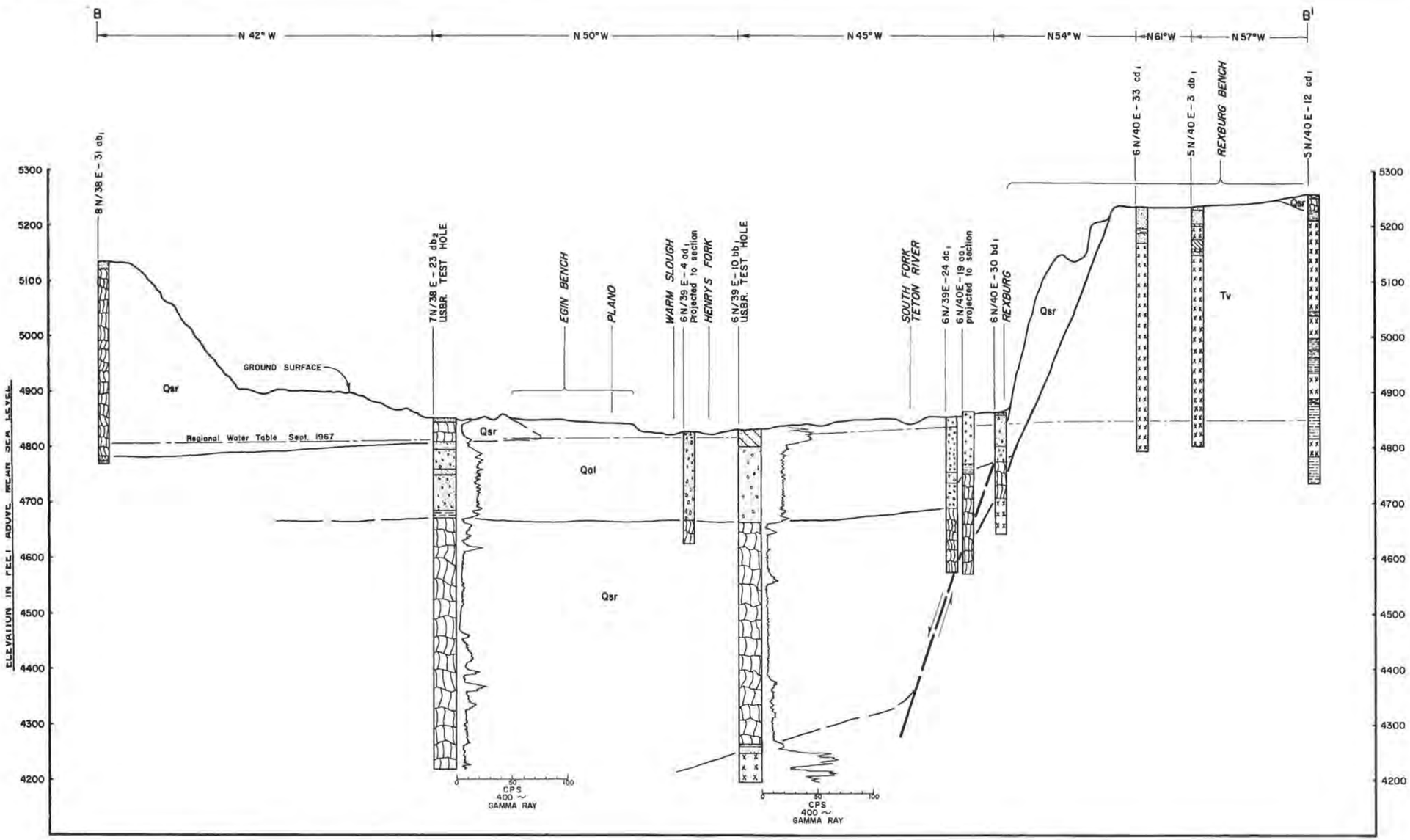
Presumably, these rocks underlie the basalt and alluvium at depth everywhere northwest of the Henrys Fork. Crosthwaite and others (1967, p. 22) classify the silicic volcanic rocks as lightly compacted to well indurated welded tuff or welded ash flows and interbedded basalt, ash, and sedimentary materials. Examination of drill cores from Wells 6N/39E-10bb1 and 7N/40E-20cd1 indicate that the silicic volcanic rock encountered consists of rhyodacite porphyry (tuff?) and obsidian porphyry (tuff?). Both rock types are dense but generally moderately to highly jointed.

The silicic volcanic rocks apparently have highly variable water bearing properties. Where significant thicknesses of interbedded ash, basalt, cinders or other similar materials are present, the unit transmits large quantities of water. In the area east and southeast of Rexburg, where logs of wells indicate the presence of these materials, yields of wells ranging up to several thousand g.p.m. (gallons per minute) with a few feet of drawdown are reported (Crosthwaite and others, 1967). However, where the silicic volcanic rocks are relatively unbroken by interbedded materials, as in the Newdale to Ashton area, the yields of wells generally are inadequate for irrigation purposes.

Snake River Basalt

Basalt of the Snake River Group is exposed northwest of the Henrys Fork alluvial lowlands and is interbedded with and overlies silicic volcanic rocks in some areas to the southeast (Crosthwaite and others, 1967, p. 23). In the latter area, much of the basalt apparently originated from local sources and its relationship to the basalt to the northwest is not entirely known.

Results of exploratory and other drilling indicate the basalt underlies the alluvial sediments of the lowlands in an east-southeastward thinning mass that laps upon and possibly is faulted against silicic volcanic rocks of Rexburg Bench and in the Ashton area (see geologic sections B-B' and C-C'). In the latter area and extending downstream nearly to St. Anthony, the basalt apparently is thin and possibly discontinuous. West-northwestward from Rexburg Bench and the Ashton area, the formation thickens so that at Plano it is estimated to be approximately 500 feet thick and at Well 9N/40E-5dd1 it is more than 750 feet thick (see geologic section A-A'). To the immediate north of Egin Bench, the basalt is relatively continuous to depths of over 450 feet without interruption by other material except for a very limited lateral extension of sediments that comprise Egin Bench. In the area west of Egin Bench and extending downstream to the mouth of Henrys Fork, the basalt overlies and is interbedded with relatively thick sedimentary beds (see geologic section D-D'). At Well 6N/38E-30ba1 sedimentary materials comprise about 60 percent of total 638 feet penetrated by drilling. Depth to the top of the uppermost basalt flow ranges from surface outcrop to more than 330 feet near the mouth of Henrys Fork where the basalt is overlain by alluvial material.



EXPLANATION

GENERAL GEOLOGY

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GEOLOGIC CONTACT (Dashed where inferred)

FAULT (Dashed where inferred)

WELL LOGS

8N/41E-5dc

USBR EXPLORATORY CORE DRILL HOLE Lithology interpreted from core, geophysical log and driller's log. (Entire hole was not cored, see log for details)

USBR TEST WELL Lithology interpreted from driller's log and drill samples.

DRILLER'S LOG Lithology interpreted from driller's nomenclature

GEOPHYSICAL LOG

0 50 100
CPS
400 ~
GAMMA RAY

GRAVEL
SAND
SILT
CLAY
BASALT
SILICIC VOLCANIC ROCK

1 0 1 2
SCALE OF MILES

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GROUND WATER INVESTIGATIONS

GEOLOGIC CROSS SECTION B-B'

DRAWN L. H. BOISE, IDAHO

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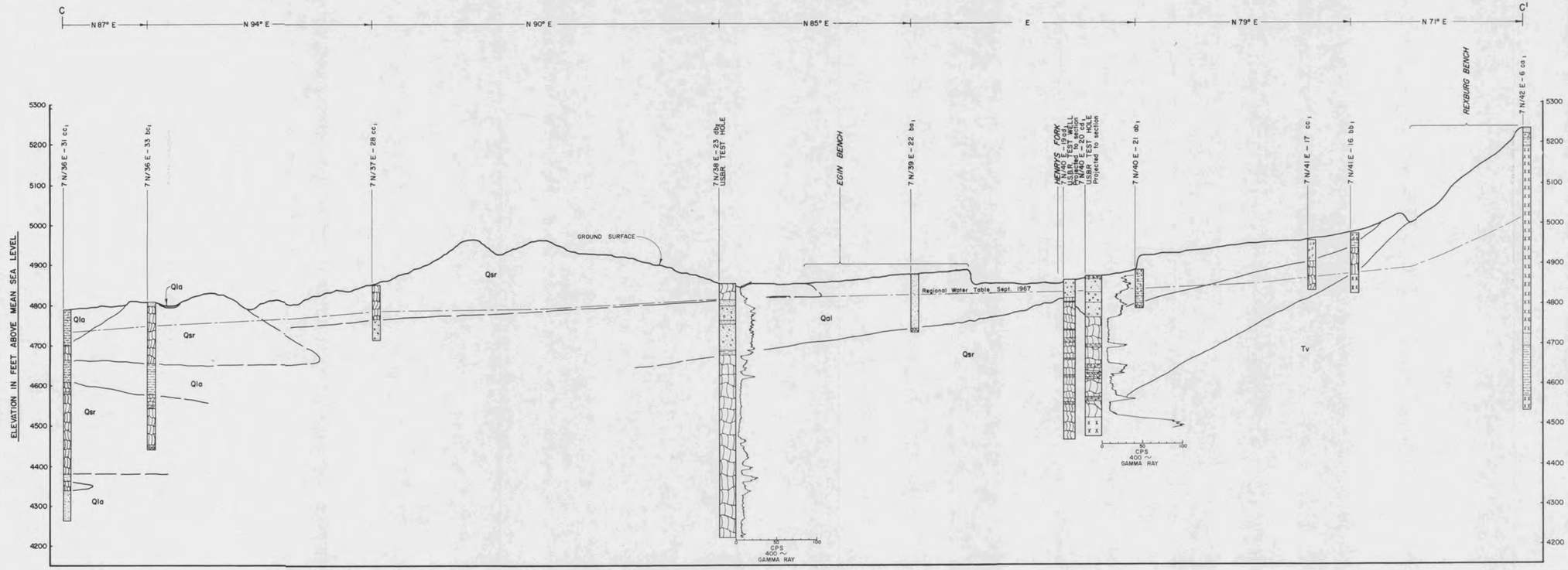

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WELL LOGS

8N-41E-5ab

U.S.B.R. EXPLORATORY CORE DRILL HOLE Lithology interpreted from core, geophysical log and driller's log. (Entire hole was not cored, see log for details)

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GEOPHYSICAL LOG

0 50 100
CPS
400 ~
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0 1 2
SCALE OF MILES

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GROUND WATER INVESTIGATIONS

GEOLOGIC CROSS SECTION C-C'

DRAWN L. K. BOISE, IDAHO

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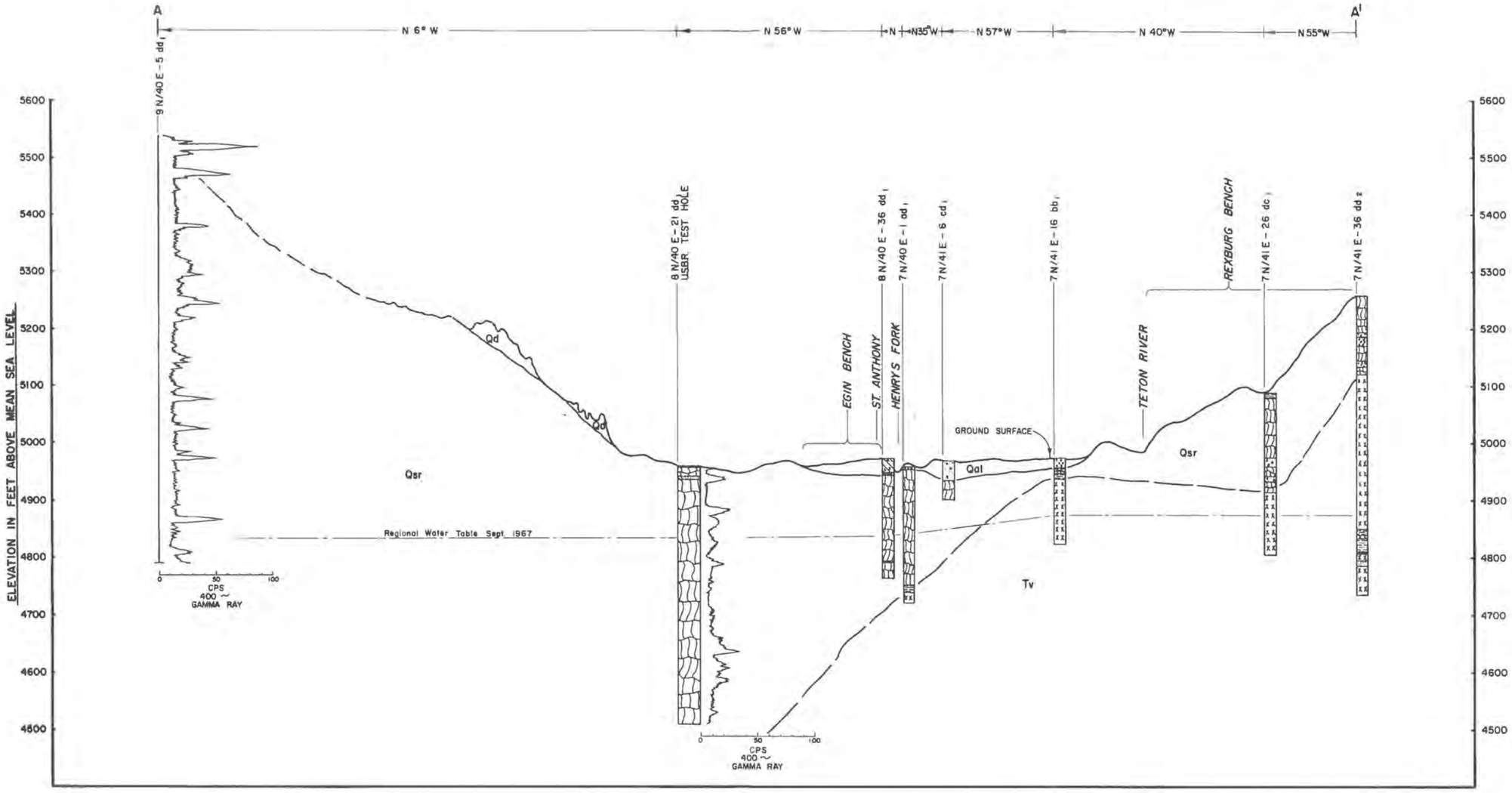

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GROUND WATER INVESTIGATIONS

GEOLOGIC CROSS SECTION A-A'

DRAWN L. H. BOISE, IDAHO

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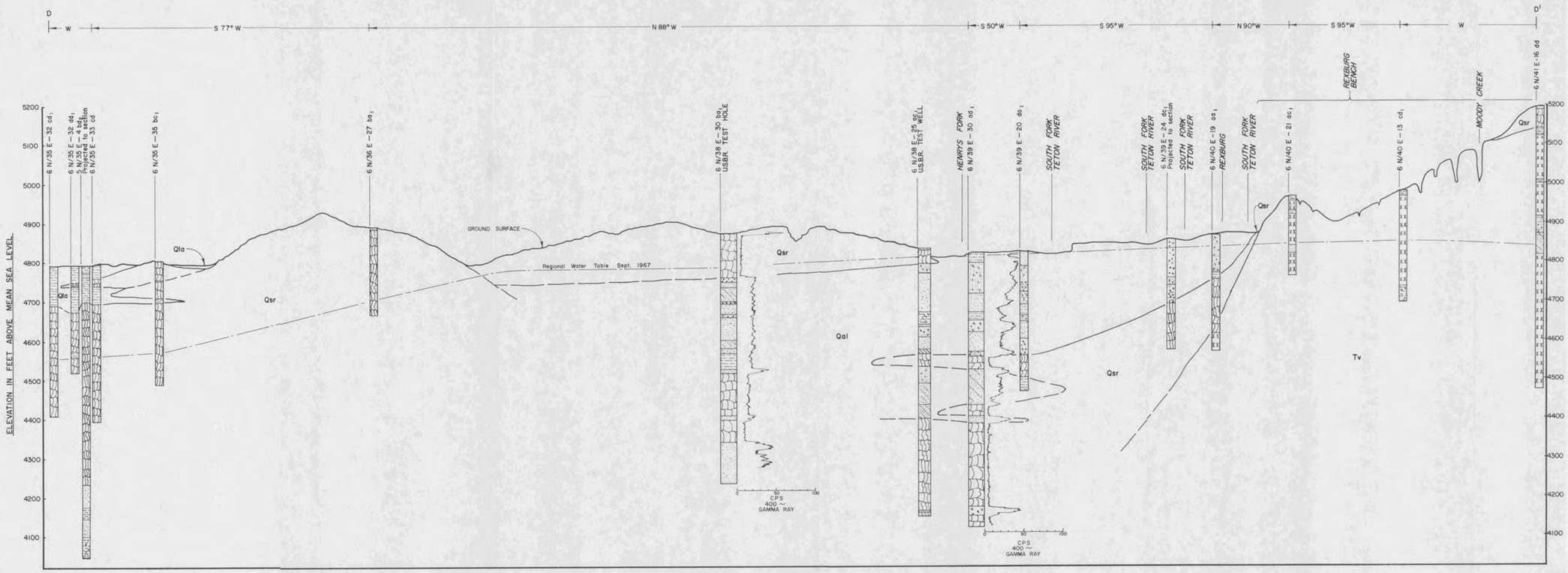

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GENERAL GEOLOGY

Qd — SAND DUNES - Recent shifting sand; fine-grained, windblown, quartz sand in dunes to 200 feet high. Above the water table.

Qal — ALLUVIUM - Recent and older unconsolidated sedimentary deposits of the Lower Henrys Fork and Teton Rivers; includes undifferentiated heterogeneous to poorly stratified recent channel and flood-plain material and older fan, terrace, and possible eolian and lacustrine deposits; generally sand and gravel with lesser silt and clay. Thickness ranges from a few to over 300 feet. Locally interbedded with basalt. Yields small to large quantities of ground water.

Qla — LACUSTRINE and ALLUVIAL DEPOSITS - Recent and older unconsolidated sedimentary deposits of the Mud Lake-Market Lake area; includes stratified lake sediments with fewer stream deposits, generally clay and silt with locally coarser material. Maximum thickness unknown. Locally interbedded with basalt. Yields small quantities of ground water.

PLEISTOCENE TO RECENT

Qsr — BASALT - Aphanitic to porphyritic basalt of the Snake River Group, includes pyroclastics; cindery and scoriaceous to dense. Yields very large quantities of ground water from scoriaceous or cindery zones which normally occur at the contact between basalt flows.

PLIOCENE (?)

Tv — SILICIC VOLCANIC ROCK - Undifferentiated rhyolitic flows and pyroclastics with lesser amounts of basalt and sediments. Yields small to large quantities of ground water.

GEOLOGIC CONTACT (Dashed where inferred)

FAULT (Dashed where inferred)

WELL LOGS

6N/41E-5dc

U.S.B.R. EXPLORATORY CORE DRILL HOLE Lithology interpreted from core, geophysical log and driller's log. (Entire hole was not cored, see log for details)

U.S.B.R. TEST WELL Lithology interpreted from driller's log and drill samples.

DRILLER'S LOG Lithology interpreted from driller's nomenclature

GEOPHYSICAL LOG

0 50 100
CPS
400 ~
GAMMA RAY

GRAVEL
SAND
SILT
CLAY
BASALT
SILICIC VOLCANIC ROCK

1 0 1 2
SCALE OF MILES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

TETON BASIN PROJECT – IDAHO, WYOMING
LOWER TETON DIVISION — IDAHO

GROUND WATER INVESTIGATIONS

GEOLOGIC CROSS SECTION D-D'

DRAWN L. H. BOISE, IDAHO

DEC. 1967 549-125-203

The basalt examined in outcrop and drill core generally is a gray, reddish-gray, or reddish-brown, fine-grained, olivine bearing, extrusive rock. The sections cored during exploratory drilling consist of numerous flows that range in thickness from a few feet to more than 40 feet. Each flow is superimposed on the next older flow or flows beneath it. Because of the limited areal extent of some flows and the paucity of distinctive features, subsurface correlation by flow characteristics generally is difficult. A typical flow consists of an upper vesicular, scoriaceous, rubbly or cindery surface, a lower surface that is somewhat vesicular, and an internal mass that is dense but generally jointed. Many flows, however, are entirely composed of highly vesicular or scoriaceous material and/or are highly brecciated, whereas others are dense and massive and exhibit few of the typical characteristics.

In the Mud Lake-Market Lake area, basalt is interbedded with thick sequences of predominantly fine-grained sediments.

The Snake River basalt generally is a highly productive source of ground water. Where wells penetrate cindery, scoriaceous, or cavernous basalt, the yields generally range upward to several thousand g.p.m. per foot of drawdown. Where the unit is composed of thick, dense flows and/or fine-grained interbedded sedimentary material, the productivity commonly is much lower.

Lacustrine and Alluvial Deposits

Exposed in the Mud Lake and Market Lake basins are lake bed sediments composed principally of silt and clay which Stearns and others (1939) attribute to lava blocked drainage accentuated by faulting and glacial melt waters in case of the former and overflow from the Snake River in the latter. The lake beds interfinger with basalt and possibly interfinger with, or are an extension of, the coarser alluvium of the Snake and Henrys Fork Rivers to the east and southeast and streams to the north. Because of its fine-grained nature, the lacustrine material would be expected to be relatively impermeable.

Alluvium

Underlying the Henrys Fork lowlands, principally in the area below St. Anthony, are extensive deposits of sand and gravel with lesser silt and clay. This alluvium ranges in thickness from a featheredge, where it pinches out on basalt to the north of St. Anthony, to in excess of 330 feet near the mouth of Henrys Fork. Upstream from St. Anthony, the thickness probably does not exceed a few tens of feet. To the east and southeast, the alluvium pinches out on, or is faulted against, basalt and silicic volcanic rocks. To the west and southwest, alluvium of the lower Henrys Fork area apparently coalesces and interfingers with alluvial material from the Snake River and with basalt. As previously mentioned, it possibly interfingers with lacustrine beds of the Mud Lake-Market Lake basin and also with sediments from streams to the north. In Well 6N/38E-30bal, beds of sand, silt, and clay with minor

gravel have been found interbedded with basalt to a depth in excess of 630 feet. Generally, the alluvium of the lower Henrys Fork is coarsest in the area southeast of the river and becomes progressively finer to the north and west.

Water bearing characteristics of the alluvium are not well known. Although many small diameter wells draw from the alluvium, large capacity installations are not known to be in use. Based on descriptions in well logs, the alluvium would be expected to transmit small to large quantities of water, depending on texture and nature of the material. Where clean, uncemented gravel predominates, the yield to wells would be substantial. On the other hand, wells in fine or cemented material would produce only small quantities.

Sand Dunes

Active sand dunes up to 200 feet high occur several miles north and northwest of St. Anthony and on and around Juniper Buttes. Also, much of the area is veneered with light, windblown silt and fine sand. These materials generally lie above the water table.

GROUND WATER CONDITIONS

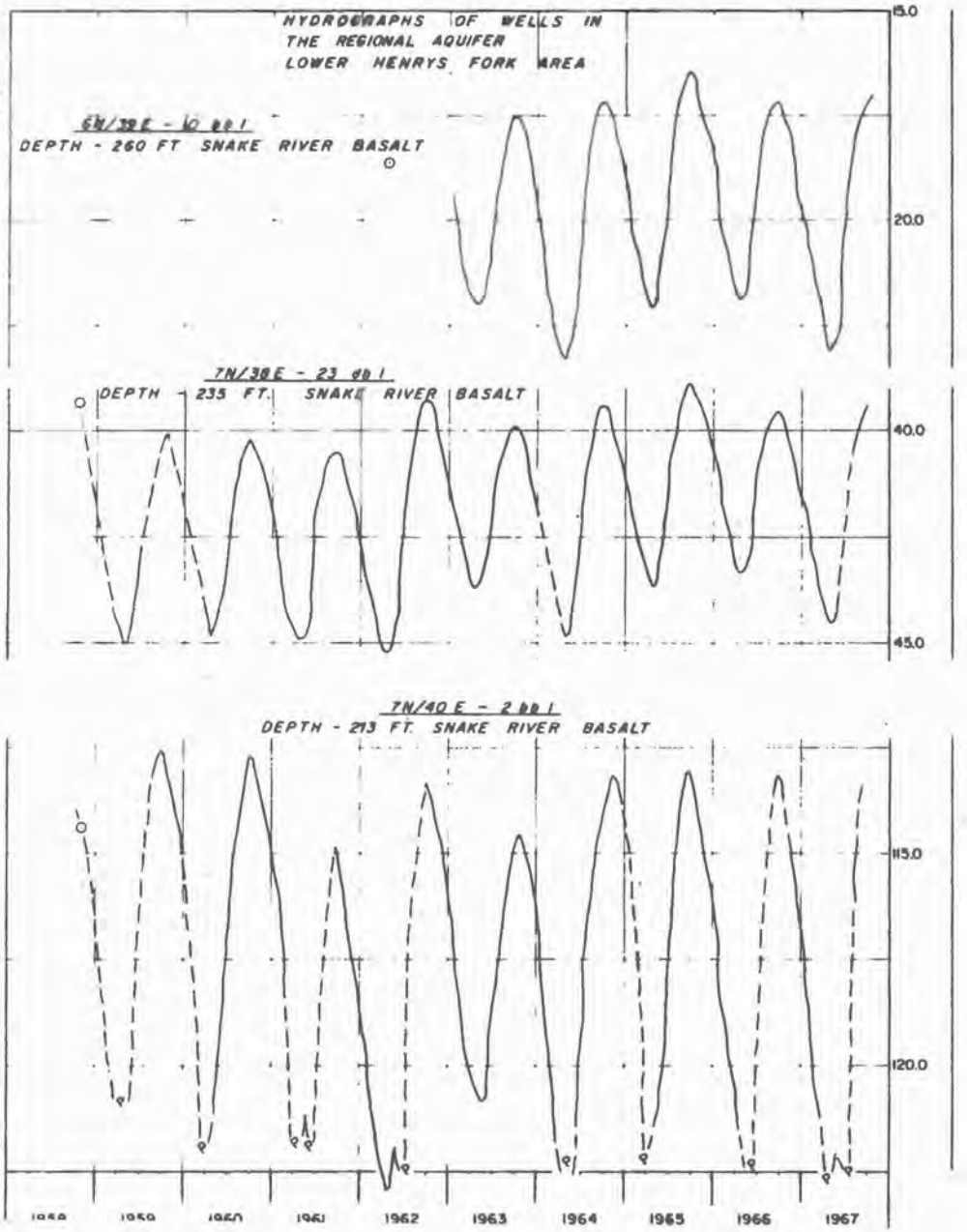
Occurrence and Fluctuation

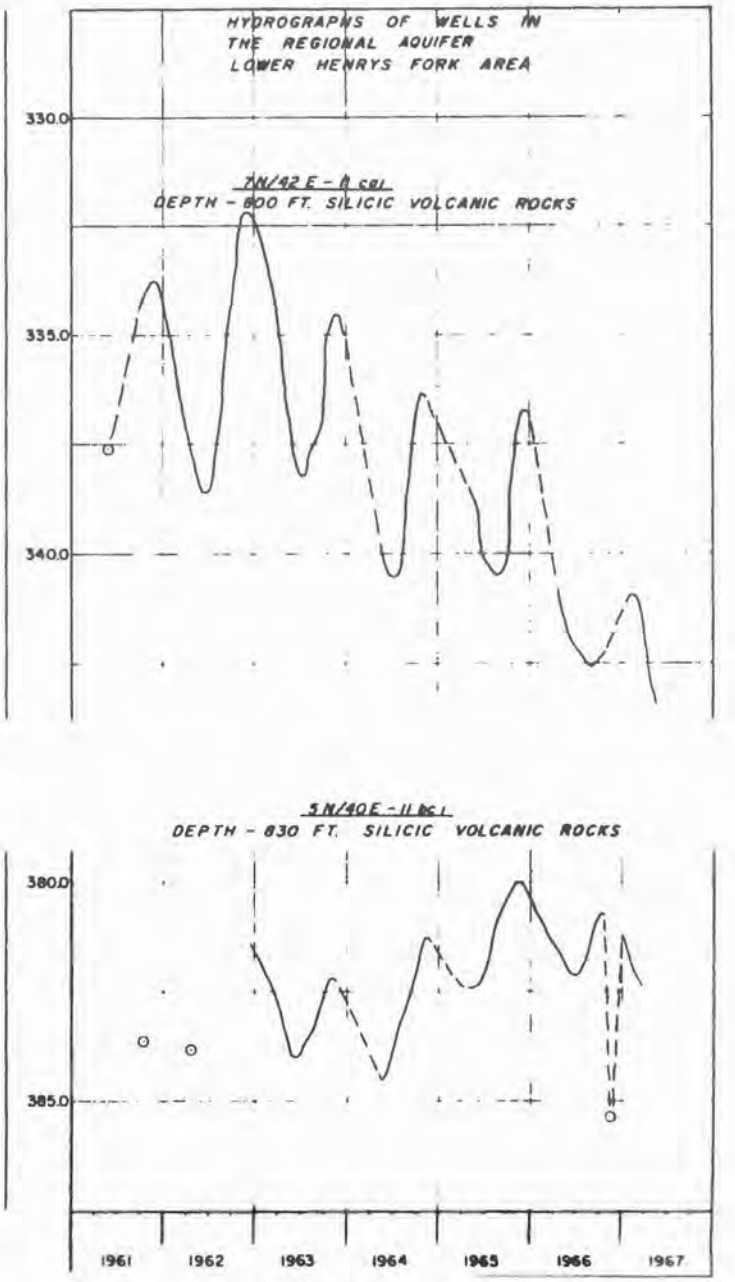
Ground water in the lower Teton area occurs under regional and perched water conditions. The regional water table, which marks the upper limit of uninterrupted saturated subsurface material, generally slopes west-southwestward across the area toward the Mud Lake-Market Lake basins (see water table contour map). In the areas of predominantly silicic volcanic rocks, the water table gradient is relatively high, ranging from 10 to more than 50 feet per mile. Where basalt is the principal rock, the gradient ranges from 2 to 5 feet per mile. A wide, seemingly incongruous area of low gradient occurs in a transition zone of basalt and sedimentary material between the lower Henrys Fork valley and the Mud Lake-Market Lake basins. Between these two basins and extending westward from the former, a zone of very high gradient, known as the Mud Lake barrier, is found. Between Ashton and the Mud Lake-Market Lake basins, the regional water configuration is relatively independent of the ground surface topography and essentially consists of two high gradient steps separated by a wide zone of low gradient.

The depth to the regional water table from the land surface ranges from less than 10 feet near the mouth of the Henrys Fork to over 700 feet northeast of Juniper Buttes and over 500 feet in some of the higher margins of Rexburg Bench. Within the lower Henrys Fork alluvial lowlands, the depth ranges from less than 10 feet to a maximum of about 150 feet (see map of depth to water table and depth to basalt in St. Anthony-Rexburg-Plano area).

Within a portion of the last-named area and extending westward toward the Mud Lake-Market Lake basins, the regional ground water body is partially confined by the mass of alluvial material. The water levels in wells that terminate in basalt overlain by alluvium stand at a regional level which may be up to several hundred feet higher than the buried basalt surface. Elsewhere the regional ground water body apparently is free and the static level varies only slightly with increasing depth.

Continuous observations of the regional water table have been limited to about 10 years duration except Well 7N/37E-14cb1, in the Hamer area, which has been observed since 1950 and at several times in the 1920's (see hydrograph of wells in the regional aquifer). In addition, spot readings have been made of many other wells by the Geological Survey. The annual fluctuations in the alluvial lowland area have ranged from about 4 to 8 feet, with the peaks coming in September-October and the lows in April-May. In silicic volcanic rocks of Rexburg Bench, the annual water table range has been less than in the basalt of the lowlands. In the Mud Lake-Market Lake area the fluctuations generally are less than one foot and with the extremes occurring about two months later than in the area to the east. An exception is Well 5N/36E-21da1, in which the annual fluctuation has been from 3 to 5 feet.





DEPTH TO WATER TABLE
IN FEET BELOW LAND SURFACE

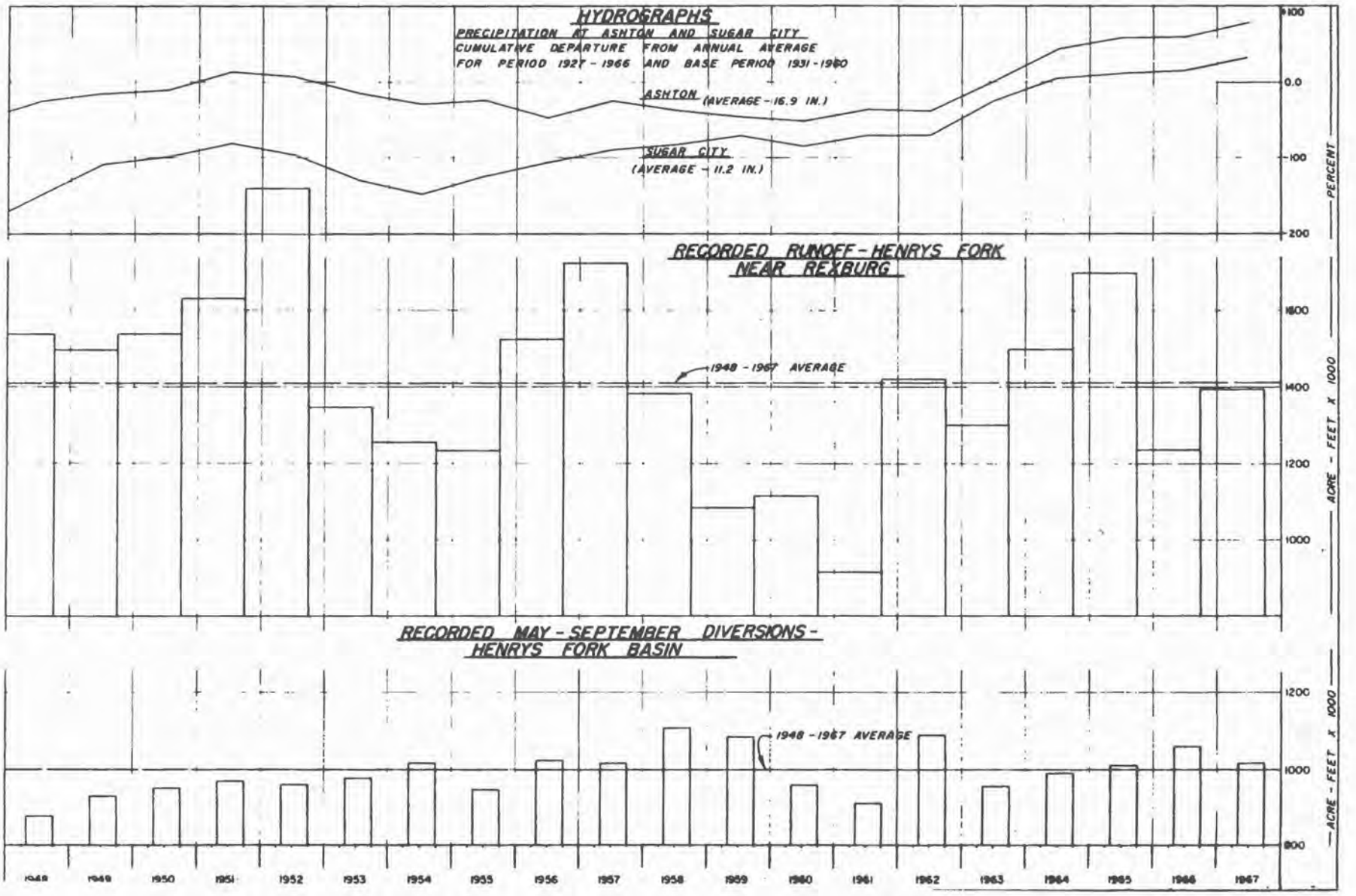
Generally, there has been a rising trend in regional ground water levels since 1961 but with slight declines in 1963 and 1967. The trends appear to be more closely associated with basin runoff than any other factor (see hydrographs of precipitation, runoff, and diversion, Henrys Fork Basin). Near absence of long term observations essentially precludes examination of earlier trends. However, Stearns and others (1939, p. 60) report that prior to the beginning of irrigation of Egin Bench in 1895, the water level stood at more than 100 feet below the surface at Parker and Camas. The levels rose to a few feet and about 20 feet, respectively, but it is not clear whether these are perched or regional water table levels. Undoubtedly, ground water levels have risen appreciably since the advent of irrigation in the lower Teton area, but the magnitude of rise is not known because of the lack of pre-irrigation water level data.

Perched water tables have formed in several areas under differing conditions. In the alluvial lowlands, a perched water table has developed in the alluvium. The configuration of this water table during peak periods resembles that of the land surface. The depth to the perched water ranges from less than one foot to more than 40 feet. The perched and regional water tables seemingly merge somewhere in west one-half of R. 38 E. west of Egin Bench. Eastward, they diverge so that in the St. Anthony and Sugar City areas the regional water tables lies more than 100 and 50 feet, respectively, below the perched water table. In the Ashton area, a perched water table has developed on top of the silicic volcanic rocks that underlie the basalt (Crosthwaite and others, p. 28, 1967). Also, perched water has been encountered during drilling in areas of Rexburg Bench where interbedded sedimentary materials occur. In portions of the Mud Lake-Market Lake area, ground water is found at shallow depths, possibly the result of perching on lacustrine sediments as related by Stearns and others (1939, p. 50) and Mundorff and others (1964 p. 134).

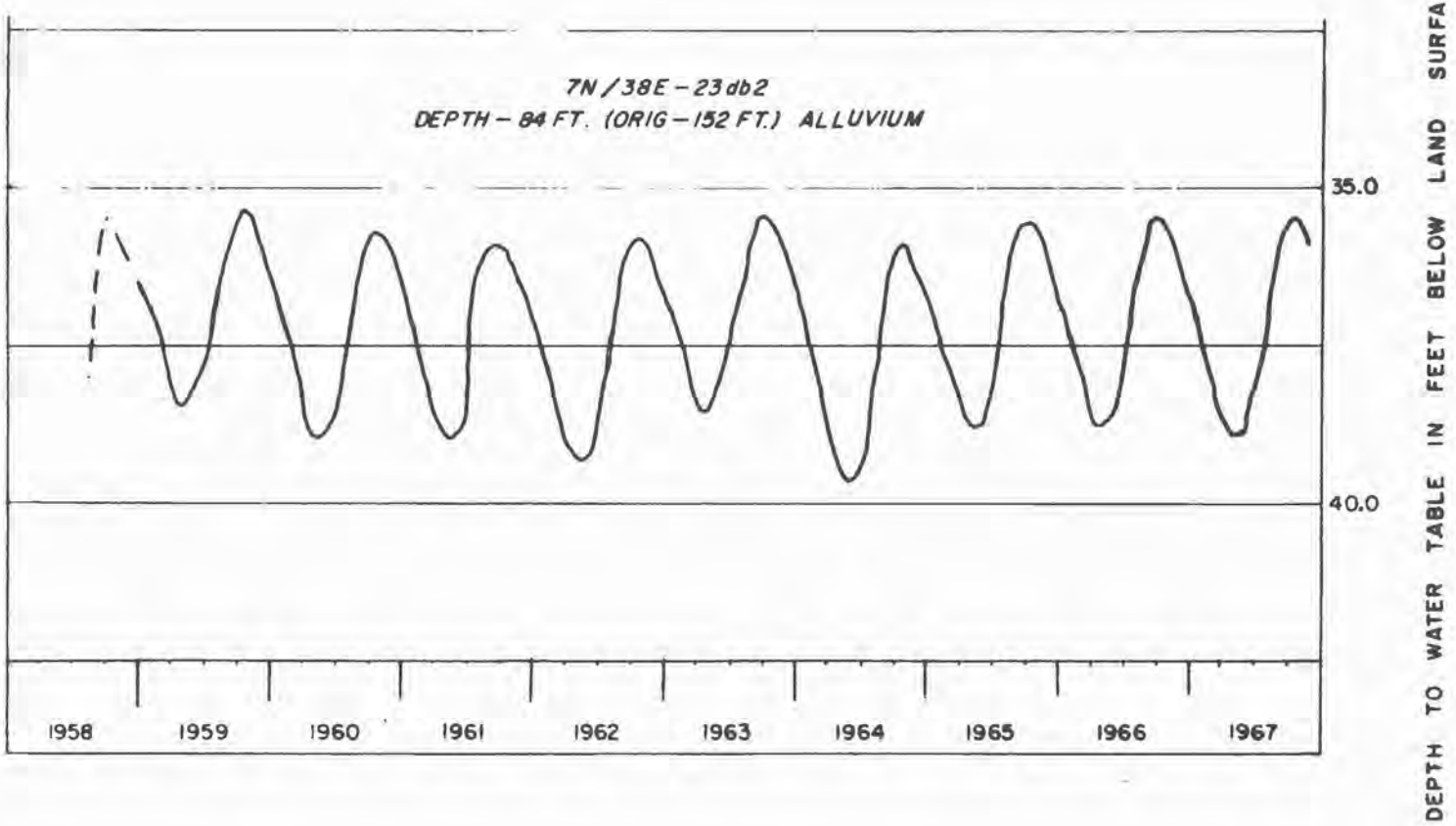
Continuous observations of the perched water table in the lower Teton area have been limited. Stearns and others (1937, p. 62) display hydrographs of several wells on Egin Bench during the period 1921-25. More recently, the Geological Survey has maintained continuous observations of Well 7N/38E-23db3 since 1958 (see hydrograph of Well 7N/38E-23db2) and presently is observing 13 shallow observation wells installed by the Bureau of Reclamation in the Henrys Fork alluvial lowlands. These and other observations indicate that the perched water table fluctuates as much as 35 feet annually from peaks at or very near the land surface to lows greater than 50 feet below the land surface. The former generally occur in September-October, whereas the latter take place in April or May (see hydrographs of wells in the perched aquifer).

Recharge and Discharge

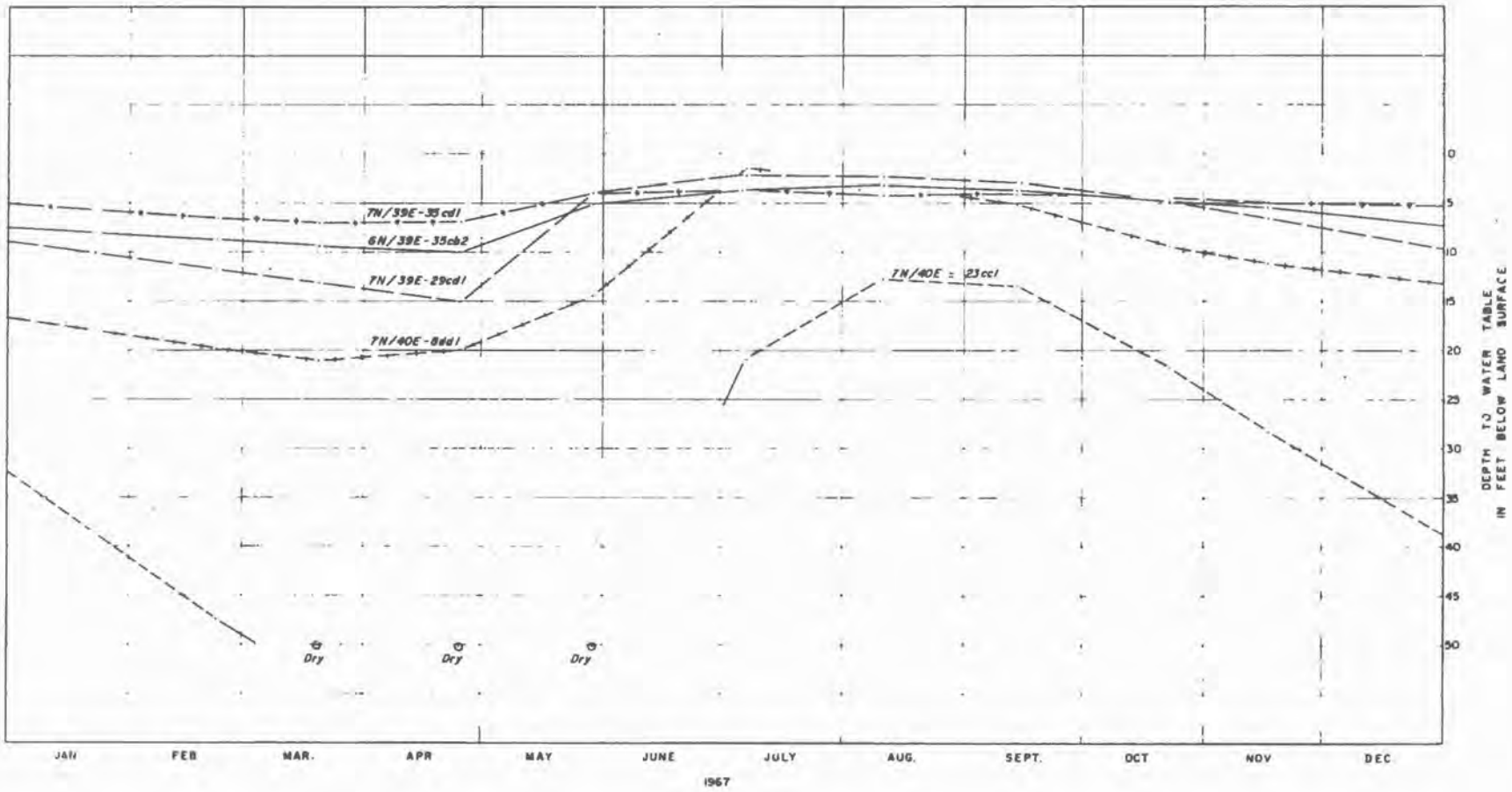
Examination of the water table contour map indicates that the general flow of the regional ground water body is west-southwest following the


HYDROGRAPHS
PRECIPITATION AT ASHTON AND SUGAR CITY
CUMULATIVE DEPARTURE FROM ANNUAL AVERAGE
FOR PERIOD 1927 - 1966 AND BASE PERIOD 1931 - 1960
ASHTON (AVERAGE - 16.9 IN.)
SUGAR CITY (AVERAGE - 11.2 IN.)
+100
0.0
-100
-200
PERCENT
RECORDED RUNOFF - HENRYS FORK NEAR REXBURG
1948 - 1967 AVERAGE
1600
1400
1200
1000
ACRE - FEET X 1000
RECORDED MAY - SEPTEMBER DIVERSIONS - HENRYS FORK BASIN
1948 - 1967 AVERAGE
1200
1000
800
ACRE - FEET X 1000
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967

HYDROGRAPH OF WELL IN
THE PERCHED AQUIFER
LOWER HENRYS FORK AREA



HYDROGRAPHS OF WELLS IN THE
PERCHED AQUIFER
HENRYS FORK ALLUVIAL LOWLANDS



trend of the prevailing gradient. Recharge to and discharge from the ground water body may occur anywhere within the area depending on geologic, hydrologic, and other conditions.

Crosthwaite and others (1967, p. 28) suggest that an average of approximately 550,000 acre-feet of recharge annually originates as deep percolation from irrigation which enters the perched water table and which ultimately descends to the regional water table. An additional 175,000 acre-feet of recharge is said to originate from infiltration of precipitation that falls within the basin.

Mundorff (1962, p. 24) estimates that average annual ground water discharge by underflow from the lower Henrys Fork area, through the basalt aquifer between Roberts and Hamer, is about 725,000 acre-feet. This estimate is based on flow-net studies described by Mundorff and others (1964, p. 196). Crosthwaite and others (1967, p. 28) suggest that about 325,000 acre-feet of perched ground water and surface return flows enter the river system during an average year.

Present Use of Ground Water

Ground water is widely used in the lower Teton area for domestic and municipal supplies. The larger communities commonly use water from wells in basalt or silicic volcanic rocks whereas the smaller communities and individual farmsteads rely on wells in alluvium.

Widespread use of ground water for irrigation is almost entirely limited to Rexburg Bench where wells tap silicic volcanic rocks and basalt. Crosthwaite and others (1967, p. 37) estimate that the total pumpage on Rexburg Bench during 1962 was 25,000 acre-feet which approximates their estimate of annual recharge for the pumped area. Many irrigation wells have been drilled on Rexburg Bench since 1962, so the annual rate of pumping has undoubtedly increased.

In the alluvial lowlands, few wells of any sizable capacity are used for irrigation. Only three are known to tap the basalt. Large scale industrial use of ground water is limited to a few installations. Table 1 gives details of the known wells of any sizable capacity that presently are drawing water from the basalt beneath the alluvial lowlands.

Table 1. Summary of larger wells in basalt of the alluvial lowlands

Well Number	Use	Depth	Diameter	Yield	Specific Capacity	Penetration in Saturated Basalt	Sp. Capacity + Saturated Penetration	Static Water Level
		(ft)	(in)	(gpm)	(gpm/ft)	(ft)	(gpm/ft)	(ft)
6N/39E-4ab1	Irr.(U)	199	18	600	30	41	0.7	10
-20da1	Irr.	353	20	3500	1400	90	15.6	10
6N/40E-4db1	P.S.	183	12					30
-19aa1	Ind.	296	20			138		30
-30bd1	P.S.	172	24			85		20
-30da1	P.S.	142	16			22		110
7N/38E-23db1	Test	236	16	1820	440	59	7.5	40
7N/40E-1ac1	P.S.	248 ?	10	1250				45 ?
-1ad1	P.S.	238		850		83		125
-1ad2	P.S,	238	8	1250				80
-22ad1	Irr.(U)	200	14					80
8N/40E-36dd	P.S.	209	20	2790	5600	66	85	145

Irr. - Irrigation, P.S. - public supply, Ind. - Industrial, (U) - Unused

Refer to Table 3 for data on wells 6N/38E-25ac1 (Test Well 1) and 7N/40E-19ad1 (Test Well 2).

REPLACEMENT WATER SUPPLY

Division Requirements

Estimates made by others (Bureau of Reclamation, 1968, unpublished data) indicate that the maximum requirement for replacement pumping of ground water for Lower Teton Division, First Phase, will be 400 c.f.s. flow and 175,000 acre-feet annually (Table 2). The average annual requirement will be 25,000 acre-feet, and the total requirement for the 34-year period 1928-61 will be approximately 850,000 acre-feet. In order to insure optimum operating conditions, not less than 30 percent of the maximum annual requirement should be made available to the existing distribution system of the Fremont-Madison Irrigation District. The remaining 70 percent could be made available wherever conditions permit.

Table 2. First phase ground water replacement pumping schedule for period 1928-61 (by month and calendar year) Units - 1,000 acre-feet

Year	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Annual Total
1928-30	None									
1931					9.5	20.0	23.8			53.3
1932			24.6	23.8	24.6	24.6	23.8			121.4
1933			10.0	15.0	20.0	24.6	23.8			93.4
1934			24.6	23.8	24.6	24.6	23.8	24.6	9.9	155.9
1935	20.0	23.8	24.6	23.8	24.6	24.6	23.8	10.0		175.2
1936			15.0	15.0	10.0	10.0	7.2			57.2
1937			24.6	23.8	24.6	24.6	23.8			121.4
1938-40	None									
1941				10.0	10.0	10.0	5.7			35.7
1942-60	None									
1961				10.0	10.0	10.0	6.4			36.4
Total 1928-1961										849.9
Annual Average										25.0

General Considerations

Replacement ground water for the Lower Teton Division will be required only during dry years when a water shortage occurs in the Snake River basin above Milner dam. Ground water withdrawn for replacement purposes will have to be tributary principally below Milner dam in order

to minimize depletion of the Snake River in the upper basin. Any such depletion will have to be offset by additional ground water withdrawals unless increased recharge due to Division operations is adequate to overcome the depletion. Thus, an overriding factor in the general location of replacement wells for the Lower Teton Division is the location with respect to depletion, or lack thereof, of the Snake River and tributaries above Milner dam.

In addition, the requirement for ground water replacement pumping of the magnitude involved demands consideration of several other hydrologic and geologic factors that bear directly on economic and engineering feasibility. Field locations, design and construction features, and resultant costs and operation and maintenance features and costs will directly depend on the factors which follow:

1. Presence of an aquifer at reasonable depth that is productive enough to yield ground water in the necessary quantities and at reasonable drawdowns.

2. Adequate storage in and recharge to the aquifer to permit the necessary withdrawals without excessive declines in the water level.

3. Static water levels that are favorable enough to support reasonable well depths and pumping lifts.

4. Field locations of wells that permit diversion of discharge to existing distribution facilities and to the river system without excessive construction of conveyance systems.

5. Areal distribution of sites that would minimize interference between wells, but without sacrificing reasonable spacing for power distribution, access, and other facilities.

6. Presence of ground water that is physically and chemically suitable for irrigation and other uses.

In addition to the above factors which bear directly on economic and engineering feasibility, there are others which must be considered:

1. The effects in the Division area of replacement pumping on ground water conditions on the aquifer under draft and also on other aquifers presently supporting domestic and other supplies, subirrigation, and/or streamflow.

2. The effects on other areas to which the aquifer is tributary.

St. Anthony-Rexburg-Plano Pumping Area

Replacement pumping for the Lower Teton Division could take place anywhere in the upper basin so long as an excessive portion of the ground water is not tributary to the Snake River above Milner dam and the ground

water could be made available where needed to replace adverse diversions from Teton Reservoir. However, location of the replacement wells within the Division area has several distinct advantages, as follow, without consideration of hydrologic and geologic factors:

1. Preservation of the physical integrity of the Division with respect to construction, operation and maintenance, and power facilities.

2. Preservation of potential downstream well sites for future projects requiring replacement ground water.

In addition, the Division area offers conditions which satisfy most of the geologic and hydrologic demands. Investigiations described hereafter indicate that within the Division area, the alluvial lowland subarea roughly encompassing the communities of St. Anthony-Rexburg-Plano offers the most appropriate location for replacement wells. The favorable conditions of this subarea are as follows:

1. Presence of highly productive basalt aquifers up to 500 feet thick lying from 100 to 450 feet below the surface (see map of thickness of saturated basalt and depth to saturated basalt in St. Anthony-Rexburg-Plano area).

2. Availability of a large portion of the estimated 550,000 acre-feet of deep percolation from irrigation which enters the basalt within the subarea thus assuring a reliable source of recharge.

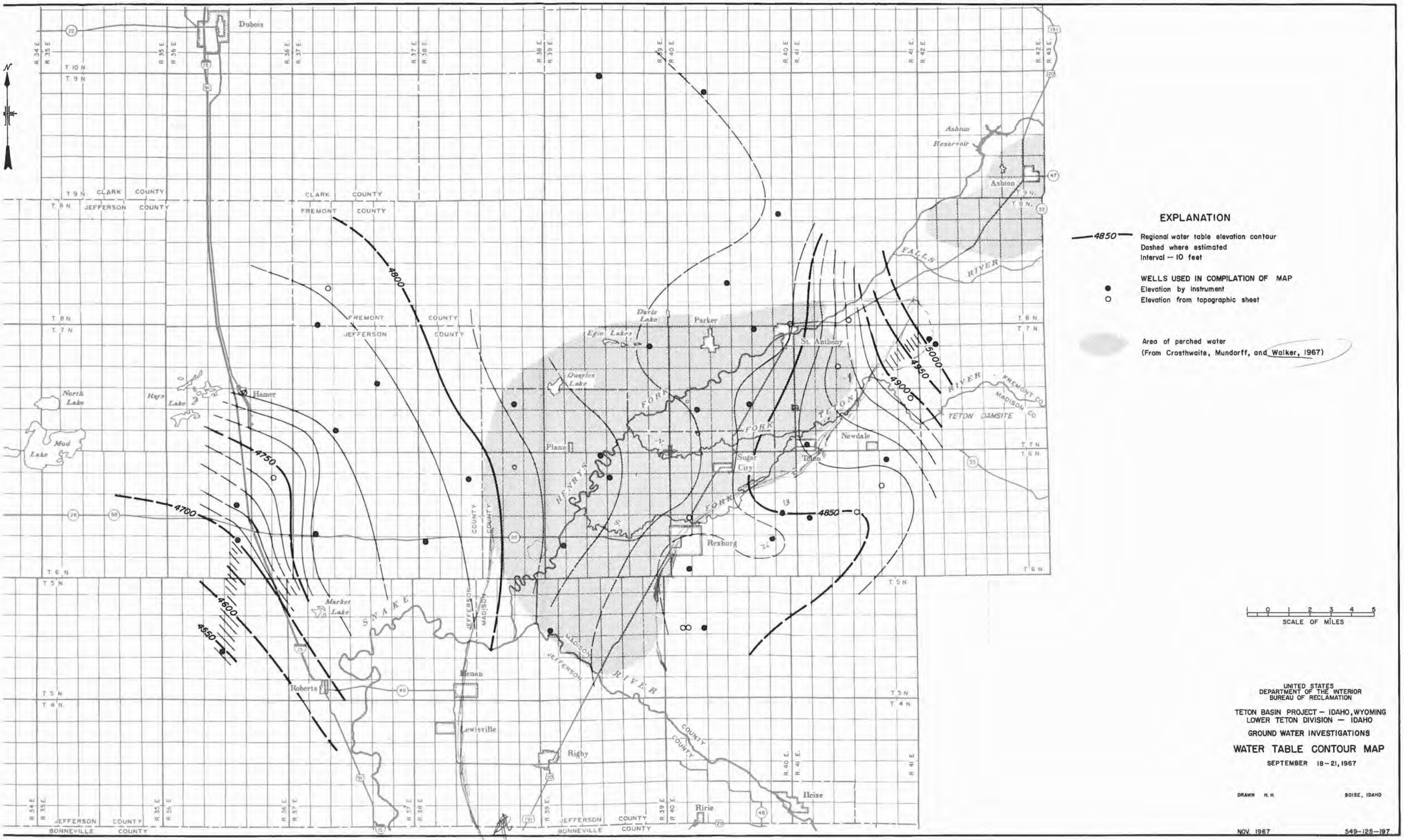
3. Presence of static water levels in the basalt that range from less than 10 to about 150 feet below the land surface. In much of the subarea, the static water level is less than 50 feet.

4. Proximity to the river system and existing irrigation distribution system which offers sites that would permit adequate spacing of wells but with a minimum of conveyance and discharge facilities.

5. Presence of ground water of suitable quality.

Crosthwaite and others (1967, unpublished data) state that the best location for pumping of replacement ground water would be that portion of the St. Anthony-Rexburg-Plano area lying north of the South Fork of the Teton River and west of U. S. Highway 191. This estimate is, however, based on relatively few data.

Several other areas within the Division have been suggested as potential pumping sites. The Ashton area is considered unsuitable because of the perched condition of the ground water in the basalt. According to Crosthwaite and others (1967, p. 39), this perched water is tributary to the Henrys Fork; thus, pumping would directly deplete ground water inflow to the river. Some areas of Rexburg Bench are highly productive. However, withdrawals in the area apparently are approaching recharge, and no assurance can be made regarding the effectiveness of


EXPLANATION
4850 Regional water table elevation contour
Dashed where estimated
Interval — 10 feet
WELLS USED IN COMPILATION OF MAP
Elevation by instrument
Elevation from topographic sheet
Area of perched water
(From Crosthwaite, Mundorff, and Walker, 1967)
SCALE OF MILES
0 1 2 3 4 5
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
TETON BASIN PROJECT — IDAHO, WYOMING
LOWER TETON DIVISION — IDAHO
GROUND WATER INVESTIGATIONS
WATER TABLE CONTOUR MAP
SEPTEMBER 18-21, 1967
DRAWN H. H.
BOISE, IDAHO
NOV. 1967
549-125-197
4800
4750
4700
4600
4550
4850
4900
4950
5000
Dubois
Ashton Reservoir
Ashton
Hamer
Hays Lake
North Lake
Mud Lake
Market Lake
Roberts
Menan
Lewisville
Rigby
Ririe
Heise
Rexburg
Plano
Sugar City
Newdale
Teton
St. Anthony
Parker
Egin Lakes
Davis Lake
Quagles Lake
FALLS RIVER
TETON DAMSITE
HENRYS FORK
SNAKE RIVER
MADISON RIVER
CLARK COUNTY
FREMONT COUNTY
JEFFERSON COUNTY
MADISON COUNTY
BONNEVILLE COUNTY
See Hydrologic Atlas #703 - 1987

EXPLANATION
90 Line of equal depth in feet to regional water table. Dashed where approximated. Interval - 10 feet
100 Line of equal depth in feet to saturated basalt. Dashed where approximated. Interval - 50 feet
Well used in compilation of map.
SCALE OF MILES
1 0 1 2
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
TETON BASIN PROJECT - IDA. & WYO.
LOWER TETON DIVISION - IDAHO
GROUND WATER INVESTIGATIONS
DEPTH TO WATER TABLE
SEPTEMBER 18 - 21, 1967
AND
GENERALIZED DEPTH TO SATURATED BASALT
1967
DRAWN H.H. & L.H.
BOISE, IDAHO
FEB. 1968
549-125-225
HENRYS
FORK
TETON
RIVER
NORTH
FORK
TETON
RIVER
SOUTH
FORK
TETON
RIVER
PARKER
ST ANTHONY
SUGAR CITY
REXBURG
Egin
Egin Lakes
Rouglas Lake
Mockets Pond
Hibbard
Burton
Wilford
Salem
Idaho
JEFFERSON CO.
MADISON CO.
FRMT. CO.
MADISON CO.
U.P.R.R.
ST. ANTHONY
REXBURG
TEXAS
SLOUGH
CANAL
EGIN
ST ANTHONY
UNION
CANAL
INDEPENDENT
CANAL
LAST CHANCE
CANAL
SALEM
UNION
CANAL
EGIN
GROVES
CANAL
FRIENDS
CANAL
FALLS
RIVER
CHESTER
CANAL
SOUTH BRANCH
CANAL
FALLS RIVER
CANAL
ENTERPRISE
CANAL
EAST TETON
CANAL
FARMERS
CONSOLIDATED
CANAL
SALEM
ISLAND
CANAL
JOHNSON
CANAL
T.7N.
T.6N.
T.5N.
T.8N.
R.37E.
R.38E.
R.39E.
R.40E.
R.41E.
188
191
20
30
40
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70
80
90
100
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120
130
150
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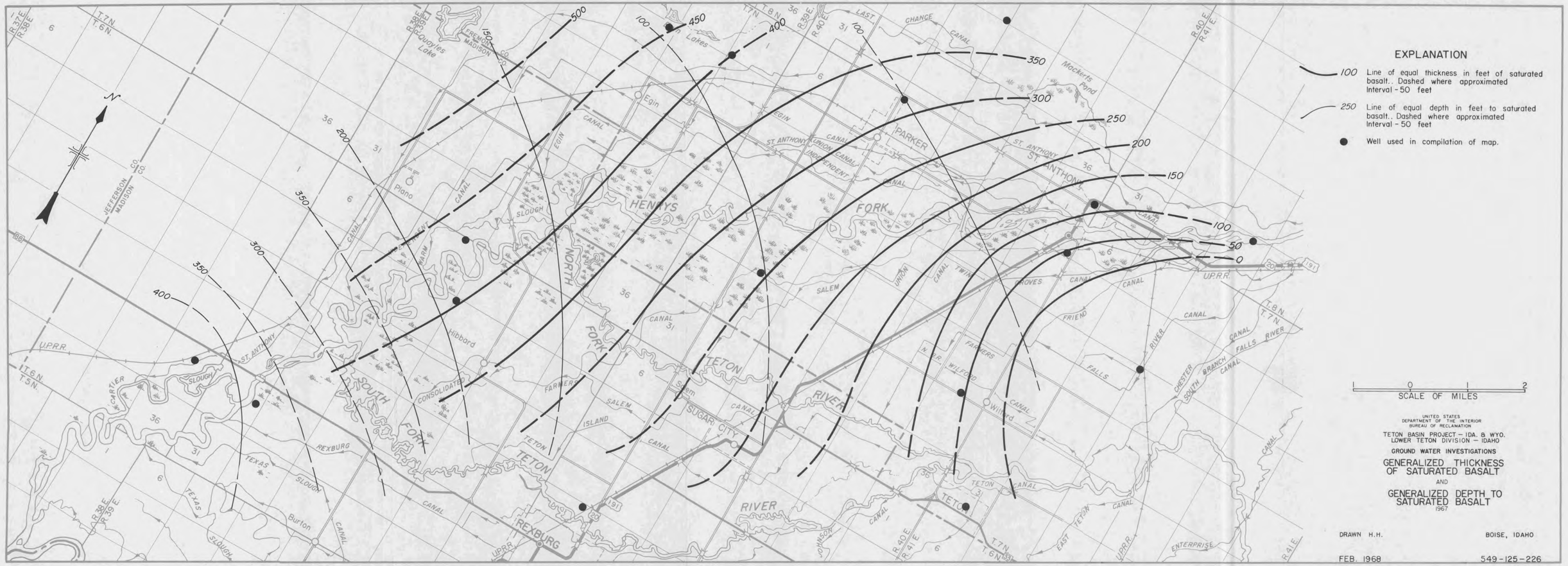
250
300
350
400


EXPLANATION
100 Line of equal thickness in feet of saturated basalt. Dashed where approximated Interval - 50 feet
250 Line of equal depth in feet to saturated basalt. Dashed where approximated Interval - 50 feet
Well used in compilation of map.
SCALE OF MILES
1 0 1 2
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
TETON BASIN PROJECT — IDA. & WYO.
LOWER TETON DIVISION — IDAHO
GROUND WATER INVESTIGATIONS
GENERALIZED THICKNESS OF SATURATED BASALT
AND
GENERALIZED DEPTH TO SATURATED BASALT
1967
DRAWN H.H.
BOISE, IDAHO
FEB. 1968
549-125-226
N
JEFFERSON CO.
MADISON CO.
FREMONT CO.
Poudre Lake
Lakes
Egin
Plano
Hibbard
Burton
REXBURG
SUGAR CITY
Salem
Willard
PARKER
ST. ANTHONY
Mockerts Pond
HENRYS
FORK
NORTH
SOUTH
TETON
RIVER
U.P.R.R.
ST. ANTHONY
REXBURG
CANAL
SLOUGH
CONSOLIDATED
FARMERS
SALEM
ISLAND
TEXAS
CARTIER
EGIN
UNION
TWIN
GROVES
FRIEND
FALLS
WILFORD
CHESTER
SOUTH BRANCH
FALLS RIVER
EAST TETON
ENTERPRISE
JOHNSON
LAST CHANCE
ST. ANTHONY UNION INDEPENDENT
R.37E.
R.38E.
R.39E.
R.40E.
R.41E.
T.7N.
T.6N.
T.5N.
T.8N.
T.7N.
T.6N.
T.7N.
T.6N.
T.7N.
T.6N.
36
31
6
1
100
150
200
250
300
350
400
450
500
50
0
20
191
33
166

recharge by surface water application under the proposed second phase of the Division plan. In addition, static water levels in the areas commonly lie more than 200 feet below the ground surface. Elsewhere in the Division area, aquifers are not productive enough or locations are too remote from existing facilities or the river system to be useful.

Preliminary Subsurface Investigations

Preliminary investigations have been undertaken to determine geologic and ground water conditions in the St. Anthony-Rexburg-Plano area and vicinity. Among the data sought by these investigations were:

1. Thickness, areal extent and nature of the alluvium.

2. Thickness, areal extent and nature of the Snake River basalt.

3. Ground water conditions including levels and fluctuations at successive depths in the alluvium and basalt.

4. Relationship of the alluvial and basalt aquifers.

5. Quality of ground water.

6. Relationship of the basalt and alluvium of the lower Henrys Fork alluvial lowlands to similar material of the Mud Lake-Market Lake basins.

As previously mentioned, 13 shallow observation wells were installed in selected locations in the lowlands area to monitor fluctuations of the perched water table.

Subsequently, eight combination cable tool-diamond drill exploratory holes up to 700 feet deep were drilled to obtain information on the Snake River basalt. Cores were taken wherever feasible in order to obtain maximum data. Completion of each deep hole included installation of permanent piezometers set at successive depths (see logs of exploratory holes).

In addition, three old, unused stock wells located 5 to 15 miles north and northwest of St. Anthony were rehabilitated to facilitate the taking of water level measurements in this remote area.

Six of the exploratory holes and the three rehabilitated wells were subsequently logged by geophysical methods by personnel of the Geological Survey-National Reactor Testing Station staff. Gamma ray logs of the former are shown on the geologic sections.

Test Wells

Following completion and based on findings of the foregoing preliminary investigations, two large capacity test wells and companion

LOG OF WELL

Project: Lower Teton Division Feature: Exploratory Hole & Piezometer Bank State: Idaho

Well No: 6N/38E-30ba 1 (Site 1) Location: Approx. 230' West and 1120' South of N. ¼ Corner

Total Depth: 638' Begun: 6/12/67 Completed: 8/11/67 Drilling Method: Churn & Rotary Drill

Static Water Level: 90' approx. ~~(above)~~ (below) Meas Pt: Original ground Date: 7/67

Elevation (ground): 4873.1' W L Meas Pt: See below ( )

Yield: No test Drawdown: Other Data: Geologist detail log book, driller's and inspector's reports, and geophysical logs

Logged By: L. Hampton Geophysical Log: Gamma and Gamma-Gamma by U.S.B.R.T.S./U.S.G.S. Drilled By: Justice Core Drilling Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Well Diagram	Depth	Log	Core Recov.	Samp Type	Description and Physical Data
Churn drill hole 0.0' - 360.0' Wireline diamond drill core hole 360.0' - 638.0' under Specs. 100C-920	Two 3/4" I.D. B.I. Piezometer pipes installed as shown					None	0.0' - 113.0' - BASALT; no samples.
	Elevation top of 3/4" pipes Piezo A 4874.54 B 4874.86 3/4" coupling 4874.08 R.P. in concrete 4873.17		50				
Water-surface elevations 9/5/67 Piezo. A 4804.86 B 4788.65 6" Csg. 4783.01		6" dia.	100			CT & D	113.0' - 123.0' - GRAVEL; gray, cinders. 123.0' - 138.0' - SAND; brownish gray, basaltic, rhyolitic. 138.0' - 173.0' - SILTY SAND; gray, rhyolitic, basaltic.
			150				173.0' - 178.0' - SAND and GRAVEL; gray, rhyolitic, basaltic. 178.0' - 204.0' - SAND; gray, basaltic, rhyolitic.
Packer test 7/26/67 Hole depth 484.9' compression-type rubber packer @ 381.5' Water level below packer 86.62' above packer 90.75'			200				204.0' - 209.0' - SANDY GRAVEL; gray, rhyolitic, basaltic. 209.0' - 211.0' - SAND; gray, basaltic, rhyolitic. 211.0' - 214.0' - SILTY SAND; gray, rhyolitic, basaltic.
	260.0' - 270.0' perforated 6" Csg.		250				214.0' - 271.0' - SAND; gray, rhyolitic, basaltic, quartzose.
							271.0' - 291.0' - SILTY SAND; gray, rhyolitic, basaltic, quartzose.
Piezo B A R.P. 6" Csg.			300				291.0' - 305.0' - SAND; gray, rhyolitic, quartzose.
	308' Grout						305.0' - 346.0' - SANDY CLAY; gray.
	340' 6" Csg.		350				346.0' - 359.0' - SAND; gray, basaltic.
6" Csg.	355' Gravel						359.0' - 466.0' - BASALT; grayish red purple to gray, aphanitic to equigranular, scoriaceous to dense, highly jointed to massive, fresh to decomposed.
4" concrete slab	392' Grout		400		95%	CR	
	430' Gravel	3½" dia.					
	445' ℄ perforations Piezometer B		450				466.0' - 477.0' - SAND; yellowish brown, quartzose.
					10%		477.0' - 533.6' - BASALT; grayish red purple to gray, aphanitic to equigranular, scoriaceous to dense, jointed to massive.
			500		98%		

Key: Core Recovery; Drillers Log; GRAVEL; SAND; SILT; CLAY; BASALT

LOG OF WELL

Project: Lower Teton Division Feature: Exploratory Hole & Piezometer Bank State: Idaho

Well No: 6N/38E-30ba 1 (Site 1) Location: Approx. 230' West and 1120' South of N. ¼ Corner

Total Depth: 638' Begun: Completed: 8/11/67 Drilling Method: Churn & Rotary Drill

Static Water Level: 90' approx. ~~(above)~~ (below) Meas. Pt: Original ground Date: 7/67

Elevation (ground): 4873.1' W.L. Meas. Pt: See below ( )

Yield: No test Drawdown: Other Data: Geologist detail log book, driller's and inspector's reports, and geophysical logs

Logged By: L. Hampton Geophysical Log: Gamma and Gamma-Gamma by N.R.T.S./U.S.G.S. Drilled By: Justice Core Drilling Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Well Diagram	Depth	Elev.	Core Recov.	Sample Type	Remarks
			500			CR	Continued from sheet 1.
		3½" dia.			98%		
	543.5' Grout		550			CT & D	533.6' - 638.0' - SAND; yellowish gray, arkosic medium to fine.
	575' Gravel 590' ± Perforations Piezometer A						
	600' Sand (caved)		600				
		2½" dia.	650	TD 638'			

Note: Scoriaceous, cindery, and highly vesicular zones shown by vertical ticks on log.

Sand Gravel Clay Other Materials: GRAVEL, SAND, SILT, CLAY, BASALT

LOG OF WELL

Project: Lower Teton Division | Feature: Exploratory Hole and Piezometer Bank | State: Idaho

Well No: 6N/39E-10bbl (Site 3) | Location: Approx. 500 ft. East and 120 ft. South of NW¼ Corner Section 10, T. 6 N., R. 39 E., B.M.

Total Depth: 636.8 ft. | Begun: 5/26/67 | Completed: 6/8/67 | Drilling Method: Wireline diamond drill & churn drill

Static Water Level: 17.5 ft. (general) ~~(above)~~ (below) | Meas Pt.: Original ground | Date: 8/67

Elevation (ground): 4834.0 | W L Meas. Pt.: See below ( )

Yield: No test | Drawdown: | Other Data: See geologic log book, driller's and inspector's reports and geophysical logs

Logged By: H. Hom | Geophysical Log: Gamma and Gamma-Gamma by U.S.G.S. | Drilled By: Justice Core Drilling Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Depth	Samp Type	Classification and Physical Condition
Churn drill hole to 260.0. Drilled 1962. Specs. 100C-577 Wireline diamond drill cored hole 260.0 to 636.8. Specs. 100C-920 Water-surface elevations - 8/28/67 6" Csg. - 4816.56 Piezo A - 4817.81 B - 4816.55 C - 4816.56	Three 3/4" I.D. B.I. Piezometer pipes installed as shown in Nx hole and existing 6" well Elevations: Top at 1¼" coupling - 4836.00 Top of 3/4" pipes Piezo A-4835.94 B-4836.22 C-4836.52 R.P. in concrete 4834.23 168 6" Csg.	50 100 150	D	0.0 to 30.0 - SILT and SAND. 30.0 to 96.0 - SAND and GRAVEL, coarse. 96.0 to 105.0 - SAND, small amount of gravel. 105.0 to 168.0 - SAND and GRAVEL.
Surface details Piezo. B C A M.P. 6" Csg. 6" Csg. 1.6' 4" conc. slab	Temp. Nx Csg. Temp. 4" Csg. 260 6" hole 290 Grout ℄ Perforations Piezometer C 310 317 Gravel 339 Grout ℄ Perforations 379 Piezometer B	168.0 to 210.0 - BASALT, black, Snake River basalt. 200 210.0 to 230.0 - CINDERS, black and red Snake River basalt. 230.0 to 240.0 - BASALT & CINDERS, Snake River basalt. 240.0 to 260.0 - BASALT, black, gray, and red, Snake River basalt. 250 95% CR 260.0 to 566.0 - BASALT, gray, brown, purple, and red. Aphanitic to porphyritic. Massive to highly jointed and brecciated. Dense to highly vesicular and scoriaceous. Generally olivine-bearing. Fresh to decomposed. (Snake River Basalt.) 300 Scoriaceous, cindery, and highly vesicular zones shown by vertical ticks on log. 350 400 450 500	
Attempted packer tests in open hole with compression-type rubber packer - generally unsuccessful due to bridging and hang-ups.				

SAMPLE TYPE
CR = Core
CT = Cuttings
D = Drillers log

SAND | SILT | MUDSTONE & BRECCIA | SANDSTONE & BRECCIA | BASALT | RHYOLITIC ROCKS

LOG OF WELL

Project: Lower Teton Division — Feature: Exploratory Hole and Piezometer Bank — State: Idaho

Well No: 6N/39E-10bb1 (Site 3) — Location: Approx. 500 ft. East and 120 ft. South of NW¼ Corner Section 10, T. 6 N., R. 39 E., B.M.

Total Depth: 636.8 ft. — Begun: 5/26/67 — Completed: 6/8/67 — Drilling Method: Wireline diamond ~~drill & churn drill~~

Static Water Level: 17.5 ft. (general) — ~~(above)~~ (below) Meas Pt: Original ground — Date: 8/67

Elevation (ground): 4834.0 — W L Meas Pt: See below ( ) — Yield: No test — Drawdown: — Other Data: See geologic log book, driller's and inspector's reports, and geophysical logs Gamma and Gamma-Gamma

Logged By: H. Ham — Geophysical Log: by N.R.T.S./U.S.G.S. — Drilled By: Justice Core Drilling Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Well Diagram	Depth	Log	Core Recov	Samp Type	Classification and Physical Condition
	545 Gravel 552 Packer Test		550				
	570 Grout ℄ Perforations 595 Piezometer A 560 Gravel		600		100% 25% 50%	CR CR CR	566.0 to 570.0 - MUDSTONE grading downward into BRECCIA. Reddish-brown. Some quartz and feldspar sand with fragments of rhyolitic rocks. 570.0 to 584.0 - SANDSTONE grading downward into sand and ROCK FRAGMENTS. Light brown to orange. Quartz and feldspar sand and fragments of rhyolitic rocks.
	Hole caved Bottom of Rx hole		630				584.0 to 636.8 - RHYOLITIC ROCKS including alternating layers of OBSIDIAN PORPHYRY And RHYO-DACITE PORPHYRY, gray and brown. Porphyritic. Massive to highly jointed. Dense. Phenocrysts of quartz and plagioclase and inclusions of pumice. Fresh to decomposed. 636.8 - Total depth ft.

SAMPLE TYPE
CR - Core
CT - Cuttings
D - Drillers Log

SAND — SILT — MUDSTONE & BRECCIA — SANDSTONE & BRECCIA — BASALT — RHYOLITIC ROCKS

LOG OF WELL

Project: Lower Teton Division | Feature: Exploratory Hole & Piezometer Bank | State: Idaho

Well No: 7N/38E-23dd3 (Site 4) | Location: Approx. 1,440 ft. West and 730 ft. South of E¼ Corner section 23, T. 7 N., R. 38 E., B.M.

Total Depth: 632.5 ft. | Begun: 6/10/67 | Completed: 6/26/67 | Drilling Method: Wireline diamond core drill & churn drill

Static Water Level: 40 ft. (general) ~~(above)~~ (below) Meas. Pt.: Original ground | Date: 8/67

Elevation (ground): 4859.9 | W. L. Meas. Pt.: See below ( )

Yield: | Drawdown: | Other Data: See geologic log book, driller's and inspector's reports, and geophysical logs

Logged By: H. Ham | Geophysical Log: Gamma & Gamma-Gamma by N.R.T.S./U.S.G.S. | Drilled By: Justice Core Drilling Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Depth	Core Recov	Samp Type	Classification and Physical Condition
Churn drill hole to 201.5. Drilled 1958. Specs. 100C-329 Obs. Well 12B Diamond drill Nx wireline cored hole 201.5 to 632.5 Specs. 100C-920	Three - 3/4" I.D B.I. Piezometer pipes installed in Nx hole and existing 8" well Elevations: Top of 1¼" coupling - 4860.32 Top of pipe Piezo A - 4860.33 B 4860.40 C 4860.67			D	0.0 - 6.5 - SAND 6.5 - 36.0 - BASALT (Snake River Basalt)
		50			36.0 - 50.0 - SAND 50.0 - 175.0 - SAND and GRAVEL.
Water-surface elevations 8/28/67 8" Cag. 4819.64 Piezo A 4816.06 B 4815.93 C 4815.51	RP in concrete - 4856.89	100			
		150			
	10" Hole 181 8" Cag.				175.0 - 190.0 - BASALT (Snake River Basalt)
Water sample taken from adjacent well 23db1 - 6/22/67 pH - 7.68 E.C. 249×10^6 SAR - 0.68	Temp. 4" Cag. 201.5 8" Hole	200	91%	CR	190.0 - 195.0 - SAND and GRAVEL (?); silty. 195.0 - 201.5 - BASALT, CINDERS, GRAVEL. 201.5 - 632.5 - BASALT; grey, brown, purple, and red. Aphanitic to porphyritic. Massive to highly jointed and brecciated. Dense to highly vesicular and scoriaceous. Generally olivine-bearing. Fresh to decomposed (Snake River Basalt).
	230 Grout	250			
Surface details Piezo C B A M.P. 8" Cag. 3.2' 8" Cag. concrete slab	293 Gravel				Scoriaceous, cindery, and highly vesicular zones shown by vertical ticks on log.
	313 Grout ℄ Perforations 320 Piezometer C	300			
		350			
	395.0 Temp. Nx Cag.	400			
	426 Gravel				
	451 Grout ℄ Perforations 470 Piezometer B	450			
		500			

SAMPLE TYPE
CR = Core
CT = Cuttings
D Drillers Log

SAND | SILT | SAND & GRAVEL | BASALT

LOG OF WELL

Project: Lower Teton Division Feature: Exploratory Hole & Piezometer Bank State: Idaho

Well No: 7N/38E-23dd3 (Site 4) Location: Approx. 1,440 ft. West and 730 ft. South of E¼ Corner, section 23, T. 7 N., R. 38 E., B.M.

Total Depth: 632.5 ft. Begun: 6/10/67 Completed: 6/26/67 Drilling Method: Wireline diamond core drill & churn drill

Static Water Level: 40 ft. (general) ~~(above)~~ (below) Meas Pt: Original ground Date: 8/67

Elevation (ground): 4859.9 W L. Meas. Pt: See below (See geologic log book, driller's ~~and inspector's~~ reports, and geophysical logs)

Yield: Drawdown: Other Data:

Logged By: H. Hess Geophysical Log: Gamma & Gamma-Gamma by N.E.T.S./U.S.G.S. Drilled By: Justice Core Drilling Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Well Diagram	Depth	Log	Core Recov	Samp Type	Classification and Physical Condition
			550				
	595 Gravel		600				
	613 Grout						
	℄ Perforations						
	625 Piezometer A						
	Bottom of Hole						Total depth - 632.5 ft.
			650				

SAMPLE TYPE
CR = Core
CT = Cuttings
D = Drillers Log

SAND SILT
SAND & GRAVEL BASALT

PROJECT: Lower Teton Division - Teton Basin Project WELL NO. 7N/38-23dd3 (Site 4)

LOG OF WELL

Project Lower Teton Division Feature Observation Wells State Idaho

Well No 7/39-1ccl (Well A) ~~7/38-1cc2 (Well B)~~ Site 5 Location Approx. 600 ft. East and 141 (Well A) and 151 (Well B) ft. North of SW Corner section 1, T. 7 N., R. 39 E., B.M.

Total Depth Well A - 122 ft. ~~B - 55 ft.~~ Begun 6/29/67 Completed 7/5/67 Drilling Method Air rotary

Static Water Level Well A - 72.5 ft ~~B - 29.0 ft.~~ (above/below) Meas Pt Original ground Date 8/67

Elevation (ground) 4904.3 W L Meas. Pt See below ( )

Yield Drawdown Other Data See driller's and inspector's reports

Logged By Driller Geophysical Log Drilled By Cope Drilling Co. ~~Justice Core Drilling Co.~~

Drilling Data Pump Tests Water Samples	Description of Well Completion	Well Diagram B A	Depth	Log	Core Recov	Samp Type	Classification and Physical Condition
Drilled under Specs. 100C-920	Puddled surface seal					D	0.0 - 16.0 - TOPSOIL and SAND.
	19 6" I.D. Csg.						16.0 - 55.0 - BASALT and CINDERS; red and gray. (Snake River Basalt)
Water-surface elevations 8/28/67	55 8" Hole		50				55.0' - 68.0' - CLAY; soft.
Well A - 4831.9 B - 4875.3	6" I.D. Csg. 84.3 w/shoe						68.0' - 122.0' - BASALT and CINDERS; gray. (Snake River Basalt)
			100				
	122 8" hole						Total depth - 122 ft.
			150				
	Elevations Well A - Top of Csg. - 4904.86						Cinder zones shown by vertical ticks on log.
	Well B - Top of Csg. - 4905.41						

SAMPLE TYPE
CR = Core
CT = Cuttings
D Drillers Log

SAND
CLAY
BASALT & CINDERS

PROJECT Lower Teton Division - Teton Basin Project

WELL NO 7N/39E-1ccl & (Site 5)

LOG OF WELL

Project: Lower Teton Division — Feature: Exploratory Hole and Piezometer Bank — State: Idaho

Well No: 8N/40E-21dd1 (Site 6) — Location: Approx. 80 ft. North and 100 ft. West of SE Corner Section 21, T. 8 N., R. 40 E., B.M.

Total Depth: 450' — Begun: 6/26/67 — Completed: 8/10/67 — Drilling Method: Wireline diamond core drill and air rotary

Static Water Level: 132 ft. (general) (above) (below) — Meas Pt: Original ground — Date: 8/67

Elevation (ground): 4963.7' — W L Meas. Pt: See below ( )

Yield: — Drawdown: — Other Data: See geologic log book, driller's and inspector's reports and geophysical logs

Logged By: H. Hem — Geophysical Log: Gamma & Gamma-Gamma by N.R.T.S./U.S.G.S. — Drilled By: Cope Drilling Co. Justice Core Drilling Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Well Diagram	Depth	Log	Core Recov	Samp Type	Classification and Physical Condition
Air rotary hole to 163.5. Wireline diamond drill hole 163.5 - 450.0. Specs. 100C-920	Three - 3/4" B.I. Piezometer pipes installed in 6" and Nx hole	Back-fill				D	0.0 - 3.0 - TOPSOIL 3.0 - 18.0 - BASALT; gray (Snake River Basalt). 18.0 - 27.0 - SAND and CLAY; red. 27.0 - 160.5 - BASALT; gray and brown (Snake River Basalt).
	Elevations Top of pipe Piezo A 4964.57 B 4964.71 C 4964.93 R.P. (conc.) 4963.65		50				
Water-surface elevations 8/28/67 Piezo A 4830.98 B 4831.27 C None	Perforations Piezometer C 75 80 Gravel		100				
	105 Grout						
Water sample taken by bailer 7/6/67 pH - 7.78 E.C. - 246×10^6 SAR - 0.63	Temp. 6", 4", Nx 163.5 Cag. 175 Gravel		150		92%	CR	163.5 - 450.0 - BASALT; gray, red, and purple. Aphanitic; massive to highly jointed and brecciated. Dense to highly vesicular and scoriaceous. Generally olivine bearing. Fresh to moderately decomposed. (Snake River Basalt.) Scoriaceous, cindery, and highly vesicular zones shown by vertical ticks on log.
	192 Grout Perforations 210		200				
Piezo C B A 4" concrete slab	Piezometer B		250				
			300				
			350				
	382 Gravel						
			400				
	423 Grout Perforations Piezometer A 440						
	450 Gravel Bottom of Nx hole		450				Total depth - 450 ft.

SAMPLE TYPE
CR - Core
CT - Cuttings
D - Drillers Log

CLAY — SAND — BASALT

LOG OF WELL

Project: Lower Teton Division Feature: Exploratory Hole and Piezometer Bank State: Idaho

Well No.: 6N/39E-30ad (Site 7) Location: Approx. 607' North & 1197' West of the E. ¼ Corner (See drilling data)

Total Depth: 699.7' Begun: 7/10/67 Completed: 7/25/67 Drilling Method: Rotary

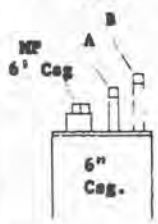
Static Water Level: 1.8 (above) (below) Meas. Pt: Original ground Date: 9/5/67

Elevation (ground): 4816.8 W.L. Meas. Pt: Top of pipe ( )

Yield: No test Drawdown: Other Data: Geologist detail log book, driller's and inspector's reports, and geophysical logs

Logged By: L. Hampton Geophysical Log: Gamma and Gamma-Gamma by U.S.R.T.S/U.S.G.S. Drilled By: Jack Alexander, Justice Core Drilling Co.

Drilling Data, Pump Tests, Water Samples	Description of Well Completion	Depth	Core Interval	Sample Type	Description of Formations
Original private water well 295.0' deep drilled by J. Alexander 1962.	Two 3/4" I.D. B.I. Piezometer pipes installed as shown.				0.0' - 25.0' - SAND AND SILT.
				D	25.0' - 75.0' - SAND AND GRAVEL.
Wireline diamond drill core hole 295.0' - 699.7' by Justice under Specs. 100C-920	Elevation top of 3/4" pipes Piezo A 4818.95' B 4819.12' Top of 1¼" coupling 4818.92'	50			
No pump test					75.0' - 105.0' - SAND AND PEA GRAVEL.
		100			
Water-surface elevations 9/ 5/67 Piezo A 4816.26' B 4815.42' 6" Csg. 4817.05'					105.0' - 150.0 - SAND.
		150			150.0' - 165.0' - CLAY; gray brown.
					165.0' - 170.0' - CLAY; gray blue.
					170.0' - 200.0' - GRAVEL AND SAND; cemented.
		200			200.0' - 250.0' - SAND; brown.
		250			250.0' - 262.0' - PEA GRAVEL AND SANDY YELLOW CLAY.
Water sample @ 699.7' Temp. 52°F. Cond. 516 Ex10^6	263' 6" blank casing				262.0' - 292.0' - LAVA; gray. 292.0' - 294.0' - GRAVEL; coarse. 294.0' - 295.0' - LAVA. 295.0' - 345.0' - SAND; light gray, rhyolitic, basaltic, quartzose.
	297' gravel	300			
Attempted packer tests in open hole with compression type packer, generally unsuccessful.				CT & D	
		350			345.0' - 381.0' - SILTY SAND; light gray, rhyolitic, basaltic, quartzose.
	385' Grout				381.0' - 384.5' - SANDY SILT; yellowish brown.
		400		98%	384.5' - 413.1' - BASALT; gray to greyish red purple, aphanitic, highly vesicular to dense, jointed to massive, olivine common.
	406' Gravel				413.1 - 431.2' - SAND
				0%	431.2' - 647.1' - BASALT; gray to greyish red purple, aphanitic to equigranular, scoriaceous to dense, jointed to massive.
	Piezometer B 440' ℄ of 5' perforations	450		95%	
		500			



SAMPLE [illegible]
C Core
CT Cuttings
D Drillers
G

GRAVEL SILT BASALT
SAND CLAY

LOG OF WELL

Project: Lower Teton Division Feature: Exploratory Hole and Piezometer Bank State: Idaho

Well No: 6N/39E-30ad (Site 7) Location: Approx. 607' North & 1197' West of the E. ¼ Corner (see drilling data)

Total Depth: 699.7' Begun: 7/10/67 Completed: 7/25/67 Drilling Method: Rotary

Static Water Level: 1.8' ~~(above)~~ (below) Meas Pt: Original ground Date: 9/5/67

Elevation (ground): 4816.8' W L Meas Pt: Top of pipe ( )

Yield: No test Drawdown: Other Data: Geologist detail log book, driller's and inspector's reports, and geophysical logs

Logged By: L. Hampton Geophysical Log: Gamma and Gamma-Gamma by N.R.T.S/U.S.G.S. Drilled By: Jack Alexander ~~Justice Core Drilling Co.~~

Depth	Description of Well Completion	Well Diagram	Log	Core Recovery	Sample Type	Description of Physical Properties
			500			Continued from page 1.
			550		CR	
			600			
	620' Grout					
	638' Gravel		650	28%		647.1' - 670.0' - GRAVEL; gray, porphyritic basalt, angular, clayey.
	Piezometer A 680' ℄ of 5' perforations		700	98%		670.0' - 699.7' - BASALT; grayish red to gray, porphyritic (plagioclase), moderately vesicular, moderately fractured.
			TD 699.7			

Note: Scoriaceous, cindery, and highly vesicular zones shown by vertical ticks on log.

GRAVEL SILT BASALT
SAND CLAY

PROJECT: Lower Teton Division - Teton Basin Project WELL NO. 6N/39E-30adc (Site 7)

LOG OF WELL

Project: Lower Teton Division Feature: Exploratory Hole and Piezometer Bank State: Idaho

Well No: 7N/40E-20cd1 (Site 8) Location: Approx. 842' West and 78' North of E. ¼ Corner

Total Depth: 399.6 ft. Begun: 8/2/67 Completed: 8/22/67 Drilling Method: Churn & Rotary Drill

Static Water Level: 36 ft. approx. (above) (below) Meas Pt: Original ground Date: 8/67

Elevation (ground): 4875.6 ft. W L Meas Pt: Top of 3/4" pipes

Yield: No test Drawdown: Other Data: Geologist detail log book, driller's and inspector's reports, and geophysical logs

Logged By: L. Hampton Geophysical Log: Gamma & Gamma-Gamma by B.R.T.S./U.S.G.S. Drilled By: Justice Core Drilling Co.

Pump Tests Water Samples	Description of Well Completion	Depth	Core Recov	Sample Type	Class of Phys. Condition
Churn drill hole 0.0' - 125.5'. Wireline diamond drill core hole 125.5' - 399.6' under Specs. 100C-920	Three 3/4" I.D. B.I. Piezometer pipes installed as shown. Elevation top of 3/4" piezometers Piezo A 4876.38 B 4876.65 C 4876.83 R.P. in concrete base 4875.91				0.0' - 8.0' - SILTY SAND AND GRAVEL.
					8.0' - 37.0' - SAND.
					37.0' - 66.0' - SANDY GRAVEL
		50		D	
Water-surface elevations 9/5/67					66.0' - 103.0' - SAND.
		100			
Piezo A 4830.10 B 4831.28 C 4840.84	63' Grout				103.0' - 124.3' - BASALT; medium gray.
	78' Gravel				124.3' - 171.0' - BASALT; grayish red-purple to gray, aphanitic, scoriaceous to dense, jointed and massive.
	Piezometer C ℄ of 5' perforations 90.0'	150	98%		
Water sample @ 125.5' Temp. 53°F. Cond. 182 Kx10^6			63%		171.0' - 177.8' - SANDY SILT; light brown.
	189' Grout	200	98%	CR	177.8' - 222.0' - BASALT; medium gray, equigranular (1 mm), moderately vesicular to dense; jointed to massive.
	220' Gravel		69%		222.0' - 228.0' - SILTY GRAVEL; moderate pink, basaltic.
Piezometer C B A	235.0' Piezometer B ℄ of 5' perforations	250	90%		228.0' - 242.0' - BASALT; grayish red-purple to gray, equigranular, highly vesicular to slightly vesicular, jointed to massive. 242.0' - 257.8' - CLAYEY, SILTY GRAVEL; brown to gray, basaltic. 257.8' - 302.8' - BASALT; grayish red-purple to gray, equigranular (1 mm), scoriaceous, and highly to moderately jointed.
concrete slab		300	25%		302.8' - 312.0' - CLAYEY GRAVEL.
	356' Grout	350	95%		312.0' - 349.0' - BASALT; grayish red-purple to gray, porphyritic plagioclase crystals to 10 mm, scoriaceous to vesicular, highly to slightly jointed.
	378' Gravel				349.0' - 399.6' - RHYOLITIC ROCKS; reddish-orange to light gray, welded tuff or rhyolite porphyry with quartz and plagioclase phenocrysts to 3 mm; badly altered 349.0' - 355.7'; grades to fresh rock 371.0'.
	Piezometer A ℄ of 5' perforations 391.5'	400			
		TD 399.6'			
					Note: Scoriaceous, cindery, and highly vesicular zones shown by vertical ticks on log.
		450			
		500			

Sample Type: R Core; T Cuttings; D Drillers Log

GRAVEL SILT BASALT
SAND CLAY RHYOLITIC ROCKS

observation wells were drilled in the St. Anthony-Rexburg-Plano area. These wells, Test Well 1 (6N/38E-25ac1) and Test Well 2 (7N/40E-19ad1), were drilled specifically to obtain the following data:

1. General well performance.

2. Aquifer characteristics.

3. Reaction of the perched water table to withdrawals in the basalt aquifer.

4. Design and construction criteria.

5. Operational criteria.

Well Performance

The test wells were cased through the alluvial overburden and penetrated several hundred feet of saturated basalt (see logs of test wells). Each was accompanied by an observation well of similar depth and by two observation wells terminating in the overburden (see logs of observation wells). Following completion of drilling, each test well was developed by pumping and surging. Prior to testing, water level recorders and a barograph were installed to obtain pre-test conditions. Testing of the wells consisted of a step-drawdown test of five steps of 90 to 120 minutes per step and a constant yield test of 48 hours duration (see yield-drawdown graph).

Included with the analysis of the test wells are data from the testing of Well 7N/38E-23db1 which was drilled under contract by the Bureau of Reclamation as a part of the Snake Plain Recharge Project investigations of the late 1950's. Data on Wells 7N/38E-23db1 and db3 included in this report are taken from Mundorff (1960).

Well performance analyses, taken principally from step-drawdown tests, show that wells drilled several hundred feet into saturated basalt would have a specific capacity of more than 1,000 gallons per minute per foot of drawdown at yields up to 5,000 g.p.m. (Table 3).

Aquifer Characteristics

Constant yield tests were conducted on Test Wells 1 and 2 principally to determine aquifer characteristics and reaction of the perched aquifer to withdrawals from the basalt aquifer. Each test was run continuously for 48 hours at a constant yield of approximately 5,000 g.p.m. During the tests, water level in the test wells was measured periodically by tape; recorders were operated on companion observation wells. Water level data were subsequently corrected for seasonal trends and barometric influence.

LOG OF WELL

Project: Lower Teton Division Feature: Test Well State: Idaho

Well No: 6N/38E-25ac1 (Test Well 1) Location: Approx. 2180 ft. West and 1900 ft. South of the NE Corner Section 25, T. 6 N., R. 38 E.

Total Depth: 685 Begun: 1-10-68 Completed: 6-18-68 Drilling Method: See Below

Static Water Level: 18.05 ft. (above/below) Meas Pt: Top of casing, SW side Date: 6/16/68

Elevation (ground): 4825.4 W L Meas Pt: 4826.41 ( )

Yield: See Below Drawdown: See Below Other Data: See driller's and inspector's reports and geologic field log

Logged By: H. Ham Geophysical Log: Drilled By: Ralph C. Denton Drilling Co. Cope Drilling & Pump Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Well Diagram	Depth	Log	Core Recov	Samp Type	Classification and Physical Condition
Drilled under Specs.100C-958 by Denton, sub. by Cope. Cable tool 0-40, reverse rotary 40-269, cable tool 269-685. Two previous holes .135 and 278 ft. deep were abandoned.	40 in. hole 0.0 to 41, 40 in. temp. csg. 0.0 to 6.0, cement grout 1.0 to 30 — 40 —					CT	0.0 to ' SILTY SAND; tan
	39 in hole 41 to 269, 30 in. csg. 1.0 to 269.		50				5 to 13 BASALT; dark gray, aphanitic, dense to vesicular, olivine-bearing (Snake River Basalt)
							13 to 18 SAND; gray, fine-grained, basalt and quartz with silicic volcanics, few gravels.
							18 to 39 BASALT; dark gray, aphanitic, dense, olivine bearing, (Snake River Basalt)
Developed by surging with test pump for 2.5 hrs. Sediment reduced to 0.05 ml. at 5000 gpm. max.	Near-Surface Details: welded 1¼ in. pipe steel ring; 24 in. csg.		100				39 to 6' SAND AND GRAVEL; sub-rounded to sub-angular obsidian porphyry with basalt and other silicic volcanics, decreasing obsidian and increasing quartz sand content with depth.
Step drawdown test 6/15/68			150				65 to 163 SAND; gray, fine to coarse grained, quartz and silicic volcanics with basalt, few gravels of similar composition
							163 to 184 SILTY CLAY; tan, plastic, sticky,
							184 to 195 SILTY CLAY; gray, plastic, sticky
			200				195 to 201 SILTY SAND; tan, very fine-grained mostly quartz.
							201 to 226 SAND; tan, medium to coarse grained, quartz with silicic volcanics, few gravels possibly partly cemented.
Continuous test -120 min. per step.	30 in. csg. grout		250				
							226 to 259 SAND; tan and gray, very fine to fine grained, micaceous quartz with silicic volcanics, silty top and bottom
Constant yield test 6/16/68 - 6/18/68.	— 269 —						
			300				259 to 269 SILTSTONE; tan, sandy, moderately indurated, distinct bedding planes upper part, contains angular fragments of dark gray, vesicular basalt 260-269
Transmissibility- 1.2 x 10^3 to 2.1 x 10^3 ft.^{2}/min. (1.3 to 2.3 x 10^1 gpd/ft.) Coefficient of storage - less the 1.0 x 10^{-5}.							269 to 300 (±) BASALT; dark gray, aphanitic, dense to moderately vesicular, olivine bearing (Snake River Basalt)
	29 in. hole 269 to 450 24 in. O.D., .500 in. wall csg. 1.0 to 450.6 Factory shoe at 450.6 cement grout 437 to 450.6		350				
Quality sample 6/17/68 pH - 7.72 Spec.Cond.-469 x 10^{-6} mho B - 0.06 ppm HCO_3 - 4.06 mc./1. Residual $NaCO_3$ - (-) 0.56 mc./1. SAR - 0.45							300 (±) to 345 SAND AND SAND AND GRAVEL; tan, interbedded, fine to coarse quartz sand, sub-rounded to sub-angular silicic volcanic gravel
			400				345 to 400 (±) SILTY SAND; tan fine to medium grained quartz with basalt
	— 450.6 —						400 (±) to 435 SANDY SILT; tan, contains very fine-grained quartz sand.
			450				435 to 670 (±) BASALT; gray to brown to red, aphanitic, dense to scoriaceous, olivine bearing (Snake River Basalt)
			500				

Samples: Type — Core — Cuttings — Drillers

CLAY SILT SAND GRAVEL BASALT

LOG OF WELL

Project Lower Teton Division Feature Test Well State Idaho

Well No 6N/38E-25acl (Test Well 1) Location Approx. 2180 ft. West and 1900 ft. South of the NE Corner Section 25, T. 6 N., R. 38 E.

Total Depth 685 Begun 1-10-68 Completed 6-18-68 Drilling Method See Below

Static Water Level 18.05 ft. (above) (below) Meas Pt Top of casing, SW side Date 6/16/68

Elevation (ground) 4825.4 W L Meas Pt 4826.41 ( )

Yield See Below Drawdown See Below Other Data See driller's and inspector's reports and geologic field log

Logged By H. Ham Geophysical Log Drilled By Ralph C. Denton Drilling Co. Cope Drilling & Pump Co.

Water Samples	Description of Well Completion	Well Diagram	Depth	Log	Core Recov	Samp Type	Description of Formation
			550				
			600				
			650				670 (±) to 675 (±) SILTY SAND; tan, fine grained quartz, clayey
	685						675 to 685, BASALT; dark gray to black, lathy textured, scoriaceous to vesicular, olivine bearing, caving reported (Snake River Basalt)
	Bottom of 23 in. hole		700				Total Depth - 685 ft.

SAMPLE TYPE
R Core
C Cuttings
D Drillers Log

CLAY SAND BASALT
SILT GRAVEL

PROJECT Lower Teton Division

WELL NO 6N/38E-25acl (Test Well 1)

LOG OF WELL

Project: Lower Teton Division Feature: Test Well State: Idaho

Well No: 7N/40E-19ad1 (Test Well 2) Location: Approx. 415 ft. North and 200 ft. West of the E¼ Corner Section 19, T. 7 N., R. 40 E., B.M.

Total Depth: 394.7 Begun: 5/9/68 Completed: 8/2/68 Drilling Method: Cable tool

Static Water Level: 30.83 ft. (above/below) Meas Pt: Top of casing, S. side Date: 7/31/68

Elevation (ground): 4857.0 W L Meas Pt: 4858.01 ( )

Yield: See below Drawdown: See below Other Data: See driller's and inspector's reports and geologic field log.

Logged By: H. Ham Geophysical Log: Drilled By: Ralph C. Denton Drilling Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Well Diagram	Depth	Log	Core Recov	Samp Type	Description of Physical Characteristics
Drilled under Specs. 100C-958 Developed by surging with test pump for 10 hrs. at 5000 gpm max. Step drawdown test 7/30/68. Disch. Dd. 1000 gpm 0.69 ft. 2000 1.26 3000 2.31 4000 3.83 5000 5.76 Continuous test 90 min. per step Constant yield test 7/31/68 - 8/2/68. Transmissibility - 1.6 X 10^3 to 2.7 X 10^3 ft.^{2}/min. (1.7 to 2.9 X 10^1 gpd./ft.) Coefficient of storage - less than 1.0 X 10^{-5} Quality sample 8/1/68 pH - 7.96 Spec. Cond. - 290 X 10^{-6} mho B - 0.06 ppm HCO_3 - 2.89 me./l. Residual Na_2CO_3 - 0.12 me./l. SAR - 0.34 Sediment after pumping C.Y. for 48 hrs. - less than 0.01 ml.	34 in. hole 0.0 to 40, 34 in. csg. 2 to 40, cement grout 2 to 42 40 30 in. hole 40 to 124, 30 in. temp. csg 0 to 124, 27 in. hole 124 to 160. 24 in. O.D., 500 in. wall csg. 42 to 160, Cement grout 154-160, factory shoe at 160. 160 23 in. hole 160 to 198.5 20 in. O.D., .312 wall liner 145 to 198.5 198.5 Near surface details 1¼ in. pipe 24 in. csg. grout 34 in. csg. 394.7 Bottom of 19 in. hole.		50 100 150 200 250 300 350 400			CT	0.0 to 42 SAND, GRAVEL AND COBBLES, rounded to subangular basalt, quartzite and silicic volcanics up to 150mm., basalt and quartz sand increasing with depth, silty 30 42. 42 to 51, BASALT, light gray, aphanitic, mostly dense, olivine - bearing (Snake River Basalt). 51 to 52 SAND AND GRAVEL, similar to that at 0 42. 52 to 142 BASALT, gray, brown, reddish, aphanitic, dense to highly vesicular, olivine - bearing. Driller reports sand 120-123 (Snake River Basalt). 142 to 153 SILTY SAND, reddish brown, fine to coarse grained, principally subrounded to subangular quartz and silicic volcanics. 153 to 194 BASALT, similar to 52 to 142. Thin zone of SILTY SAND near 175-180 (Snake River Basalt). 194 to 197 SILTY SAND, reddish-brown, fine-grained, principally quartz. 197 to 236 BASALT, gray, lathy with few phenocrysts grading to aphanitic, dense to scoriaceous, olivine-bearing (Snake River Basalt). 236 to 241 SANDY SILT, reddish-brown, fine of coarse grained quartz and basalt sand, numerous fragments of basalt and alteration material. 241 to 302 BASALT, gray, aphanitic, dense to vesicular olivine-bearing, (Snake River Basalt). 302 to 307 SANDY SILT, dark brown, fine grained quartz and basalt sand, numerous basalt fragments and alteration material. 307 to 394.7 BASALT, gray, reddish, aphanitic, dense to scoriaceous, olivine-bearing, much alteration material at 394 (Snake River Basalt). 394.7 - Total Depth

SAMPLE TYPE: CT - Core; CT - Cuttings; D - Drillers Log

CLAY | SILT | SAND | GRAVEL | BASALT

LOG OF WELL

Project Lower Teton Division (Observation Wells 1A, 1B & 1C) Feature Observation Wells at Test Well Site 1 State Idaho
Approx. 2180 ft. West and 1870 ft. South of the NE Corner Section 25,
Well No 6N/38E-25ac2, ac3 & ac4 Location T. 6N., R. 38 E.
Total Depth 1A - 681 ft., 1B - 246.3, 1C - 50.0 Begun 12-28-67 Completed 6-18-68 Drilling Method Cable Tool
Static Water Level See below (above/below) Meas Pt See below Date
Elevation (ground) Average 4826.7 W L Meas Pt See below ( )
Yield Drawdown Other Data See driller's and inspector's reports and geologic field log
Logged By Taken from log of Test Well No. 1 Geophysical Log Drilled By Ralph C. Denton Drilling Co.

Drilling Data Pump Tests Water Samples	Description of Well Completion	Well Diagram 1C 1B 1A	Depth	Log	Core Recov	Samp Type	Classification and Physical Condition
Drilled under Specs. 100C-958 Developed by surging with bailer.	Well 1C 8 in. I.D., .277 in. wall csg. + 0.5 42.5 41.0 2.0 ft.- 4 in. I.D. blank csg. with lead swedge seal 43.0 5.0 ft.-4 in. I.D. #12 slot wire wound screen 48.0 2.0 ft.-4 in. I.D. blank csg. with steel plate bottom 50.. El.O.G.@ 4826.6 top of csg. - 4827.34 s.w.l. 6/16/68 16.28 (El.4811.06) Radius - 27.5 ft.		50 100 150 200				Refer to log of Well 6N/38E-25ac1 (Test Well No. 1) for approximate classification and physical condition. Graphic log at left taken from log of Well 6N/38E-25ac1.
	Well 1B 8 in. I.D. .277 wall csg. + 1.0 to 237 csg. set in backfilled 3 7/8 in. hole to 135 234.7 2.0 ft.-4 in. I.D. blank csg., with lead swedge seal 236.7 5.0 ft.-4 in. I.D. #12 slot wire wound screen 241.7 2.0 ft.-4 in. I.D. blank csg. with steel plate bottom 243.7 El.O.G.-4826.7 top of csg. - 4827.48 s.w.l. 6/16/68 24.24 (El. 4803.24) Radius - 25.0 ft.		250 300 350 400 450				
	Well 1A 8 in. I.D. .277 in. wall csg. + 1.3 to 483.3		500				

SAMPLE TYPE
Core
Cuttings
Drillers Log

CLAY SAND BASALT
SILT GRAVEL

PROJECT Lower Teton Division

WELL NO 6N/38E-25ac2 ac3 & ac4
Obs. Wells 1A, 1B & 1C

LOG OF WELL

Project: Lower Teton Division Feature: Observation Wells at Test Well Site 1 State: Idaho

Well No: 6N/38E-25ac2, ac3 & ac4 (Observation Wells 1A, 1B & 1C) Location: Approx. 2180 ft. West and 1870 ft. South of the NE Corner Section 25, T. 6N, R. 38 E.

Total Depth: 1A - 681 ft. 1B - 246.3 1C - 50.0 Begun: 12-28-67 Completed: 6-18-68 Drilling Method: Cable Tool

Static Water Level: See below (above/below) Meas Pt: See below Date:

Elevation (ground): Average - 4826.7 W L Meas Pt: See below ( )

Yield: ------- Drawdown: -------- Other Data: See driller's and inspector's reports and geologic field log

Logged By: Taken from log of Test Well No. 1 Geophysical Log: Drilled By: Ralph C. Denton Drilling Co.

Pump Tests Water Samples	Description of Well Completion	Well 1C 1B 1A	Depth	Log	Core Recov	Samp Type	Class Location and Physical Condition
	Well 1A Cont'd. Temp. 14 in csg. to 6 ft. 12 in. to 274. 10 in. to 439 - all removed El.O.G. - 4826.8 top of csg. - 4827.42 s.w.l. 6/16/68 18.98 (El. 4808.44) Radius - 39.5 ft. 483.3 Bottom of 8 in. csg. and grout		550				
			600				
			650				
	681.0 Bottom of 8 in. hole.		700				

Legend: CLAY, SILT, SAND, GRAVEL, BASALT

PROJECT Lower Teton Division

WELL NO 6N/38E-25ac2 ac3 & ac4 Obs. Wells 1A, 1B & 1C

LOG OF WELL

Project Lower Teton Division Feature Observation Wells at Test Well Site 2 State Idaho

Well No 7N/40E-19 ad2, ad3 & ad4 (Obs. Wells 2A, 2B & 2C) Location Approx. 415 ft. North and 230 ft. West of the E. ¼ Corner Section 19, T. 7 N., R. 40 E., B.M.

Total Depth 2A-355.0, 2B-40.5, 2C-20.5 Begun 3/28/68 Completed 5/7/68 Drilling Method Cable tool

Static Water Level See below (above/below) Meas Pt See below Date

Elevation (ground) Average 4856.7 W L Meas Pt See below ( )

Yield Drawdown Other Data

Logged By Taken from log of Test Well 2 Geophysical Log Drilled By Ralph C. Denton Drilling Co.

Pump Tests Water Samples	Description of Well Completion	Well Diagram	Depth	Log	Core Recov	Samp Type	Classification and Physical Condition
Drilled under Specs. 100C-958 Developed by surging with bailer.	**Well 2C** 8 in.,.277 wall csg. +0.9 to 10.7, 4 in.screen assembly 9.0 - 20.5. #12 slot screen 13.5 to 18.5, lead swedge seal, steel plate bottom. El. O.G.-4857.1 El. top of csg.-4858.02,s.w.l. 7/31/68, 3.11 (El. 4854.91). Radius - 31.8 ft.	2C 2B 2A	50 100 150 200 250 300 350 400			CT	Refer to log of Well 7N/40E-19ad1 (Test Well 2) for approximate classification and physical condition. Graphic log at left taken from Well 7N/39E 19ad1.
	Well 2B 8 in., .277 wall csg. 0.9 to 31.3, 4 in. screen assembly 29.0 to 40.5. #12 slot screen 33.5 to 38.5, lead swedge seal, steel plate bottom. El.O.G.-4856.4 El. top of csg.-4857.29, s.w.l. 7/31/68, 13.72 (El. 4843.55) Radius - 29.4 ft.						
	Well 2A 10 in. hole 0 to 102, 10 in. temp. csg. 0 to 41 (0-18.8 remaining), 8 in. 277 csg. + 0.7 to 107, 8 in. hole 102 to 355, 6 in. csg. + 0.9 to 144, grout 135(±) to 144 El. O.G.-4856.3 El. top of 6 in. csg. - 4857.17, s.w.l. 7/31/68, 28.82 (El.4828.35) Radius - 31.0 ft.						

SAMPLE TYPE
CR Core
C Cuttings
D Drillers Log

CLAY SILT SAND GRAVEL BASALT

PROJECT Lower Teton Division WELL NO 7N/40 19ad2, ad3 & ad4 Obs.Wells 2A,2B&2C

YIELD - DRAWDOWN GRAPHS OF TEST WELLS 1 AND 2 AND WELL 7N/38E-23dbl

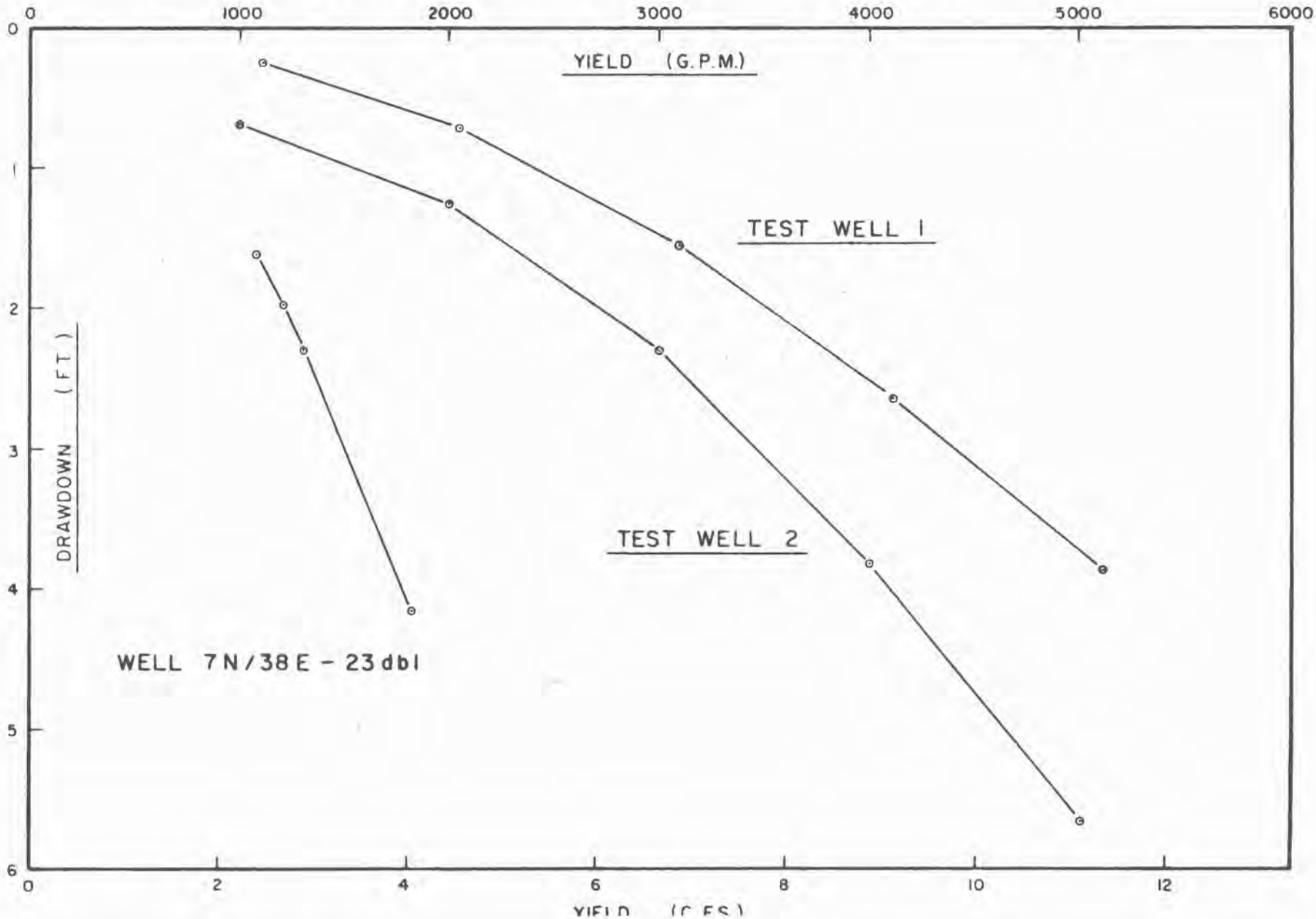


Table 3. Summary of well construction and performance, Test Wells 1 and 2 and Well 7N/38E-23db1

	Test Well 1	Test Well 2	Well 7N/38E-23db1
Total depth (feet)	685	395	236
Depth and diameter of casing (feet-inches)	450-24	198-24/20	177-20/16
Penetration in saturated basalt - open hole (feet)	235	197	59
Range of yield during testing (g.p.m.)	1,115-5,125	1,000-5,000	1,080-1,820
Range of drawdown during testing (feet)	0.25-3.87	0.67-5.76	1.69-4.20
Yield per foot of penetration per foot of drawdown - at 1,000 and 5,000 g.p.m. (g.p.m./ft. ^{2})	23.6-5.46	7.25-4.41	12.3-

The relationship of drawdown in the several wells to yield of the test well in terms of time and distance was analyzed. (See semilog time-drawdown graph of Test Well 1 and log log time-drawdown graph of Test Well 2.) Aquifer characteristics considered are transmissibility (the ability of the aquifer to transmit water) and coefficient of storage (the ability to release water from storage). Determination of such characteristics seldom is precise because the ideal conditions imposed by the analytical methods are not found in nature. The Snake River basalt aquifer in the St. Anthony-Rexburg-Plano area is especially difficult to analyze because of several characteristics, some of which follow:

1. Extremely high transmissibility.

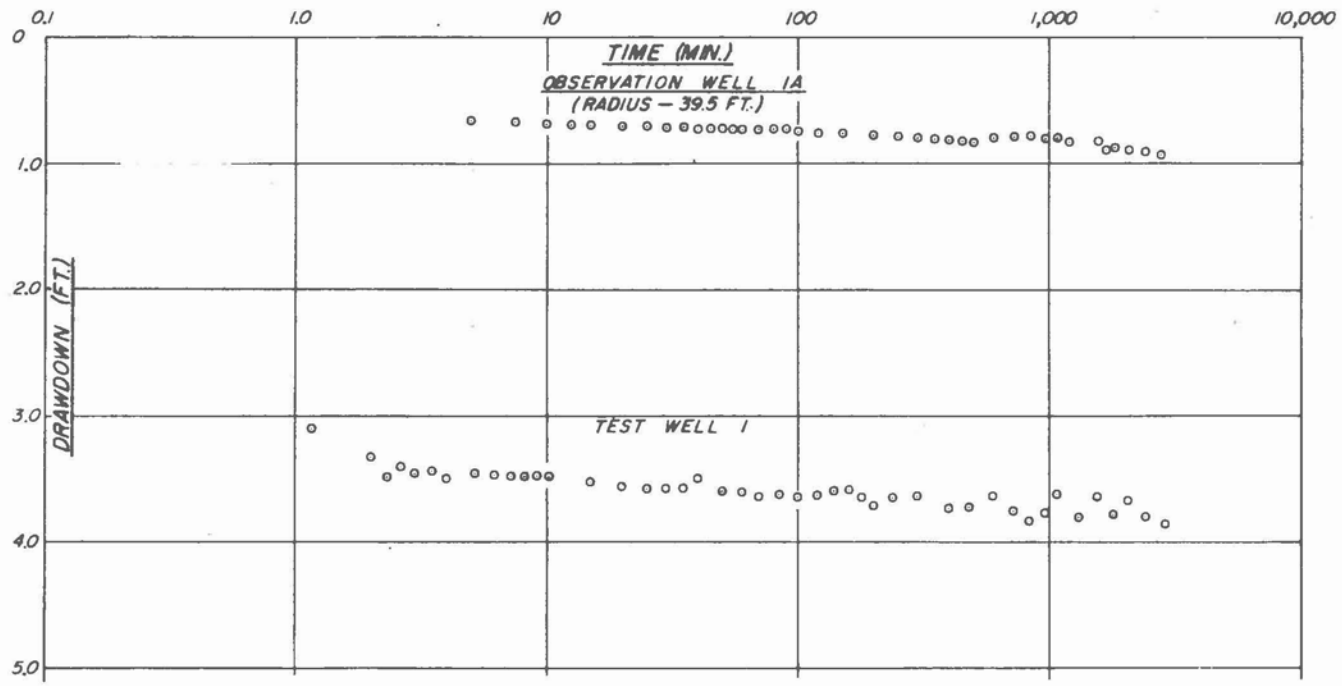
2. Anisotropy and large variations in permeability.

3. Great aquifer thickness.

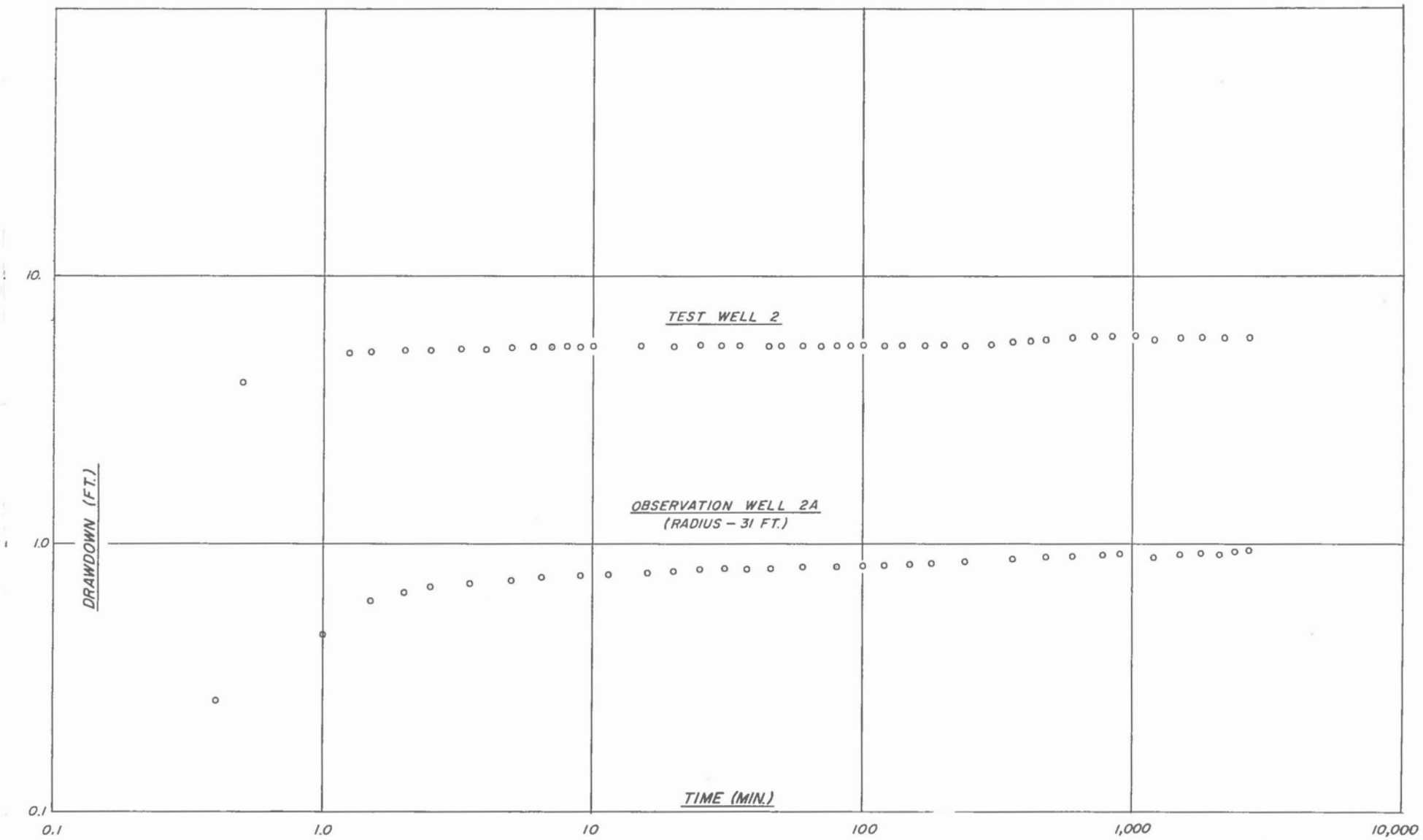
4. Extremely low coefficient of storage.

Despite the difficulties, a relatively reliable range of transmissibility, as summarized in Table 4, has been determined. However, the only reliable rate of coefficient of storage originated from the test of Wells 7N/38E-23db1 and 7N/38E-23db2. No indications of boundary conditions

SEMILOG TIME-DRAWDOWN GRAPH OF CONSTANT YIELD TEST-TEST WELL 1



LOG LOG TIME-DRAWDOWN GRAPH OF CONSTANT YIELD TEST-TEST WELL 2



were detected during the testing of Test Wells 1 and 2. Boundaries possibly were encountered; but the effects were slight enough so as to be masked by barometric influences, variations in pumping rates, or other factors.

Table 4. Summary of aquifer characteristics, Test Wells 1 and 2 and Wells 7N/38E-22db1 and 7N/38E-23db3

	Transmissibility ft.^{2}/min. and (/g.p.d./ft.)	Coefficient of Storage
Test Well 1	1200-2100 (1.3 - 2.3 x 10^7)	1 x 10^{-11}
Obs. Well 1A	1400-1450 (1.5 - 1.6 x 10^7)	1 x 10^{-8}
Test Well 2	1500-1640 (1.6 - 1.8 x 10^7)	6.0 x 10^{-8}
Obs. Well 2A	1740-2170 (1.9 - 2.4 x 10^7)	6.0 x 10^{-11} - 1.6 x 10^{-13}
Well 7N/38E-23db1	520 (5.7 x 10^6)	6.5 x 10^{-3}
Well 7N/38E-23db3	1000-1250 (1.08 - 1.35 x 10^7)	1.6 - 1.8 x 10^{-5}

The pumping tests and subsequent analysis reveal that the basalt underlying the St. Anthony-Rexburg-Plano area has a transmissibility in excess of 1,400 feet^2/min. (1.5 x 10^7 g.p.d./ft.) which is extremely high and generally comparable to much of the rest of the Snake Plain aquifer. The coefficient of storage, which probably is less than 1.0 x 10^{-5} is very small and evidently reflects the confined nature of aquifer in the area as contrasted to a free or semiconfined condition elsewhere. With these characteristics, wells drawing from the basalt aquifer will yield large volumes of water with very small drawdowns. The zone of influence created in the aquifer by withdrawal from wells will be fast moving, widespread, and proportionally large in comparison to the drawdown in the well.

Effects on the Perched Aquifer

During the testing of Test Wells 1 and 2, the perched water table was monitored by means of tape measurements and recorders. At each test site two observation wells were drilled into the alluvial overburden. One well was bottomed a few feet below the perched water table, whereas the other was drilled to a deeper level. The test sites were selected to reduce, insofar as possible, outside influences on the perched aquifer during the tests. However, despite the precautions, fluctuations of the Henrys Fork River during a period of flooding did significantly affect the perched aquifer at Test Well 1. Fortunately, river level records were available from a nearby gaging station so the influence of the river was recognizable.

Hydrographs of water table depths in the basalt and perched aquifers at Test Well 1 and of the river level indicate an absence of measurable influence on the perched aquifer from pumping from the underlying basalt aquifer. (See hydrographs of Henrys Fork River level and water table depths - Test Well 1.)

At Test Well 2 the perched water did not vary more than a few hundredths of a foot during the period prior to and during the test pumping, thus indicating an absence of measurable influence of this site also.

Quality of Water

Laboratory analyses have been made of samples of water from eight wells in basalt that underlies the alluvial lowlands, one well in alluvium between Henrys Fork and Mud Lake-Market Lake basins, and one from the Henrys Fork River near its mouth (Table 5). The analyses indicate that the ground water samples from basalt is suitable for irrigation and is slightly corrosive to corrosive to ferrous metals.

Ranges of important characteristics are as follows:

Temperature (F.)	51 to 56
pH	6.99 - 7.98
Specific Conductance (10^{-6} mho)	182 - 516
Boron (ppm)	0.02 - 0.08
HCO_3 (me/l)	1.72 - 4.06
Residual $NaCO_3$ (me/l)	(-)0.60 - 0.92
SAR	0.29 - 0.91
Langelier Index	(-)1.62 - (+)0.34

Replacement Water Supply Wells

Design and Costs

Results of pumping tests as previously described and data from other sources indicate that an adequate source of ground water is available in the St. Anthony-Rexburg-Plano area. Because of the extremely high transmissibility, the aquifer is capable of supplying wells of almost unlimited capacity with reasonable drawdowns. There are, however, several factors which tend to limit the size and capacity of wells in the area. Among these are:

1. Ability of drilling contractors to drill and case extra large wells without specialized equipment.

2. Rapidly rising costs associated with drilling extra large wells.

3. Pump limitations as explained below.

HYDROGRAPH OF HENRYS FORK RIVER LEVEL AND WATER TABLE DEPTHS PRIOR TO AND DURING PUMPING TEST – TEST WELL 1

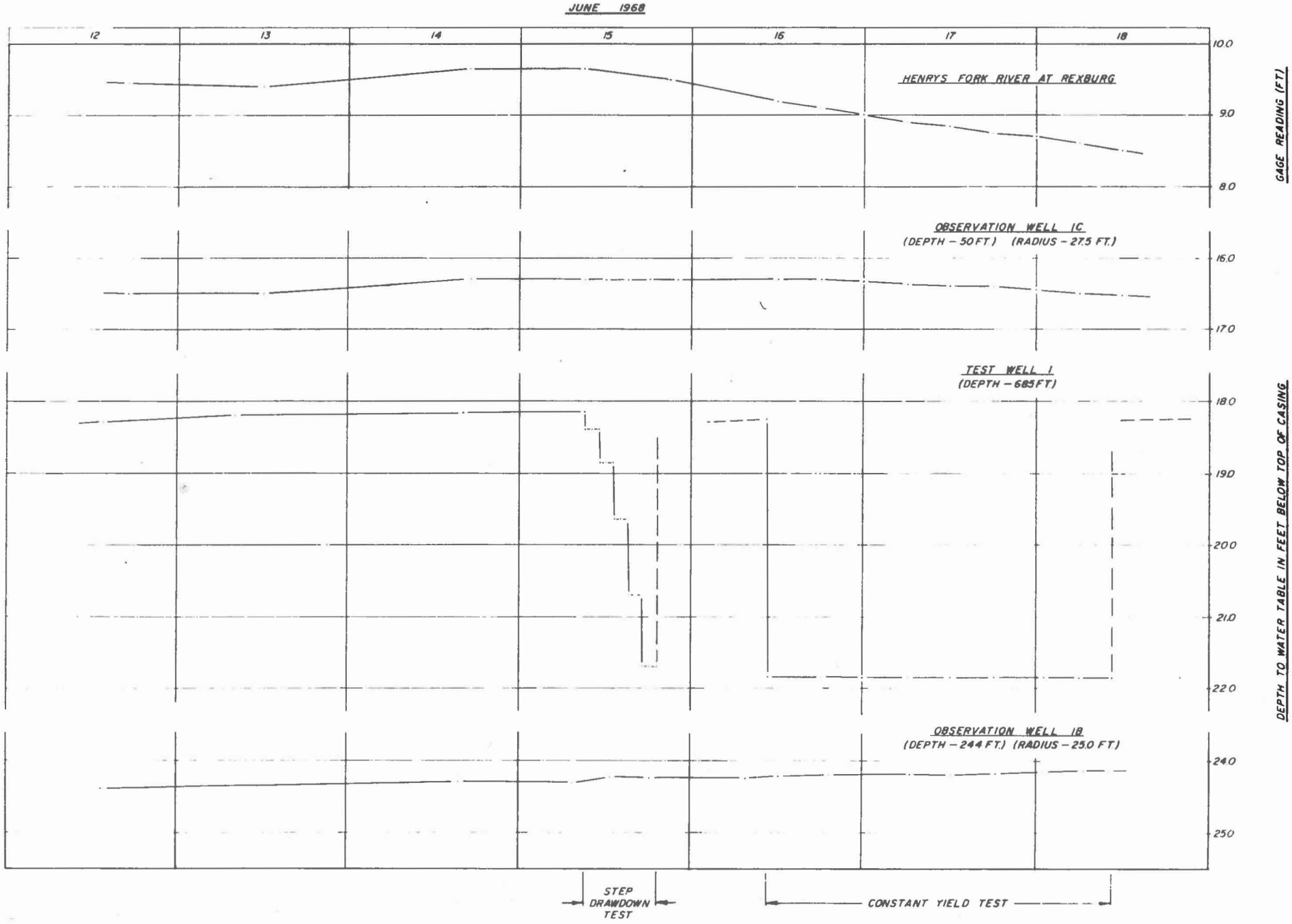


Table 5. Chemical analyses of water from 9 wells and Henrys Fork River

Source Well No.	Date	Temp. °F.	pH	E.C.x10^6 at 25° C.	B ppm	Anions, me/l CO_3	HCO_3	Cl	SO_4	NO_4
6N/38E-25ac1	6/17/68	51	7.72	469	0.07	0.00	4.06	0.37	0.88	0.04
* 6N/38E-30ba2	6/22/67	52	7.58	271	0.09	0.00	2.46	0.17	0.15	0.01
6N/39E-30ad1	7/20/67	52	7.98	516	0.04	0.00	4.04	0.35	0.98	0.09
6N/40E-30bd1	7/6/67	54	7.66	410	0.06	0.00	3.91	0.18	0.24	0.08
7N/38E-23db1	6/22/67	55	7.68	249	0.08	0.00	2.15	0.15	0.15	0.02
7N/40E-19ad1	8/1/68	53	7.96	290	0.06	0.00	2.89	0.19	0.10	0.04
7N/40E-20cd1	8/10/67	53	6.99	182	0.02	0.00	1.43	0.13	0.22	0.06
8N/40E-21dd1	7/6/67	56	7.78	246	0.06	0.00	2.06	0.14	0.21	0.05
8N/40E-36dd	7/6/67	56	7.40	204	0.06	0.00	1.72	0.16	0.12	0.04
Henrys Fork Near North Fork Bridge	7/20/67	69	8.04	209	0.04	0.00	1.92	0.07	0.14	0.03

Source Well No.	Cations me/l Ca	Mg	Na	K	Residual Na_2CO_3 me/l	SAR	PO_4 ppm	Free CO_2 ppm	Langelier Index
6N/38E-25ac1	3.29	1.33	0.68	0.11	(-)0.56	0.45	0.01	8.0	(+)0.09
* 6N/38E-30ba2	1.15	0.80	0.76	0.06	0.51	0.77		6.9	(-)0.69
6N/39E-30ad1	3.28	1.36	0.68	0.04	(-)0.61	0.44	tr.	4.3	(+)0.43
6N/40E-30bd1	2.69	1.24	0.40	0.08	(-)0.02	0.29	tr.	8.9	(-)0.04
7N/38E-23db1	1.27	0.51	0.64	0.06	0.37	0.68		4.5	(-)0.56
7N/40E-19ad1	1.95	0.82	0.40	0.06	0.12	0.34	0.00	3.2	0.0
7N/40E-20cd1	0.87	0.10	0.64	0.08	0.46	0.91	0.00	15.0	(-)1.62
8N/40E-21dd1	1.14	0.63	0.59	0.07	0.92	0.63	tr.	3.5	(-)0.51
8N/40E-36dd	0.92	0.48	0.62	0.10	0.32	0.74	tr.	6.9	(-)1.07
Henrys Fork Near North Fork Bridge	1.17	0.58	0.42	0.04	0.17	0.45	tr.	1.7	(+)0.01

* From Alluvium

Experience gained in the drilling of Test Wells 1 and 2 indicate that drilling of wells in excess of 24 inches probably would not be practicable nor justified from a cost standpoint. In addition, the depth of overburden which must be cased off is a major construction and cost item. In view of these factors, wells should be limited to a maximum of 24-inch diameter and not more than about 200 feet of overburden.

Wells of 24-inch diameter will yield 20 c.f.s. or more with reasonable drawdown. The pump capacity of this size well is, however, the limiting factor. The maximum reasonable pump capacity utilizing 16-inch coupled column is about 18 c.f.s. Beyond this, flanged column, which is costly and requires an overly large casing, must be used.

An expected range of well and pump capacities using 16-inch column would be 12 to 18 c.f.s. with an average of about 15 c.f.s. Based on the requirement for 400 c.f.s. maximum flow, 27 wells of 14.81 c.f.s. each would satisfy the demand. The yields would not have to be adjusted for a given service area, but would only have to meet the total demand in the river or supplement to an existing canal. Thus, all or a major share of the wells and pumps could be standardized to about 15 c.f.s. Where high yielding areas with low pumping lifts are found, the yields could be increased to the maximum to meet emergency or other unexpected demands.

The provision for the 27 wells includes Test Wells 1 and 2 which are adaptable to production use and any additional test wells which may be drilled subsequent to this report.

Basic maximum, average, and minimum construction features of a typical well based on dimensions of 25 wells located as described hereafter are shown below.

Diameter -	hole for pump chamber	27 in.
	pump chamber casing	24 in.
	open hole in basalt	23-19 in.
Total depth -	average	400 feet
	maximum	450 feet
	minimum	325 feet
Pump chamber casing depth -	average	175 feet
	maximum	225 feet
	minimum	125 feet
Open hole in basalt		225 feet

A diagram of a typical well is included hereafter and cost estimate is given in Table 6. The cost estimate includes partial cost of the two completed test wells in the total for 27 wells.

DIAGRAM OF TYPICAL WELL

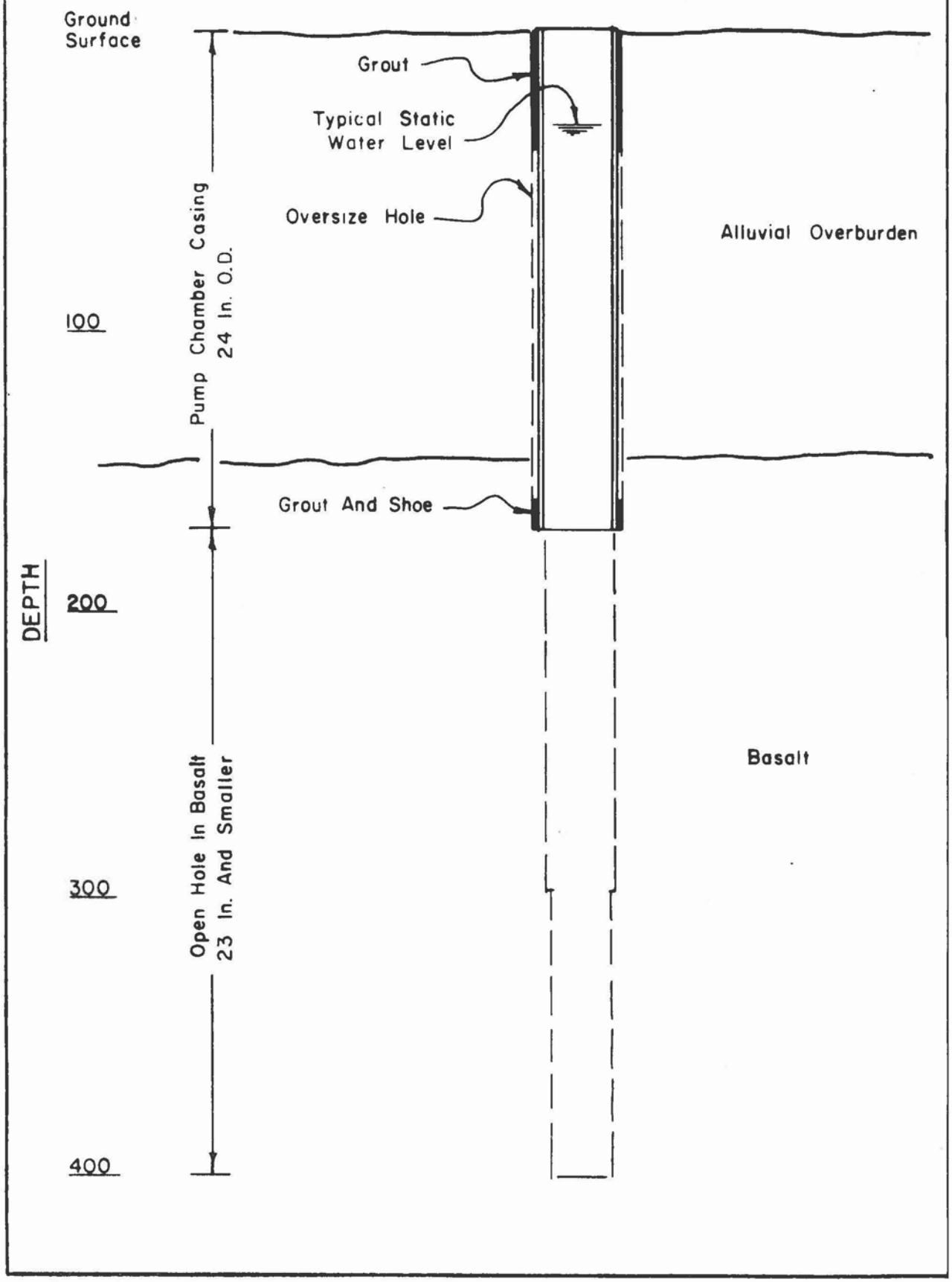


Table 6. Estimated unit prices and total cost of typical basic well

Item	Quantity and Unit	Unit Price	Amount
Moving in and removing equipment	one move	$ 250.00	$ 250.00
Drilling hole in overburden to accommodate 24-inch O.D. casing	150 lin. ft.	37.50	5,625.00
Drilling hole in basalt to accommodate 24-inch O.D. casing	25 lin. ft.	32.00	800.00
Drilling the following minimum diameter holes in basalt:			
23-inch	125 lin. ft.	24.00	3,000.00
19-inch	100 lin. ft.	20.00	2,000.00
Furnishing and installing 24-inch O.D. - .500-inch wall thickness casing	175 lin. ft.	20.00	3,500.00
Furnishing and installing 24-inch casing shoe	one shoe	210.00	210.00
Grouting around casing	6 c.y.	50.00	300.00
Sterilizing well with HTH	50 pounds	0.70	35.00
Furnishing, installing, and removing test pump	one pump	2,500.00	2,500.00
Surging and test pumping wells	32 hours	30.00	960.00
Disposal of water	one site	500.00	500.00
Standby time	24 hours	20.00	480.00
Total			$ 20,140.00
For 27 wells			$543,780.00

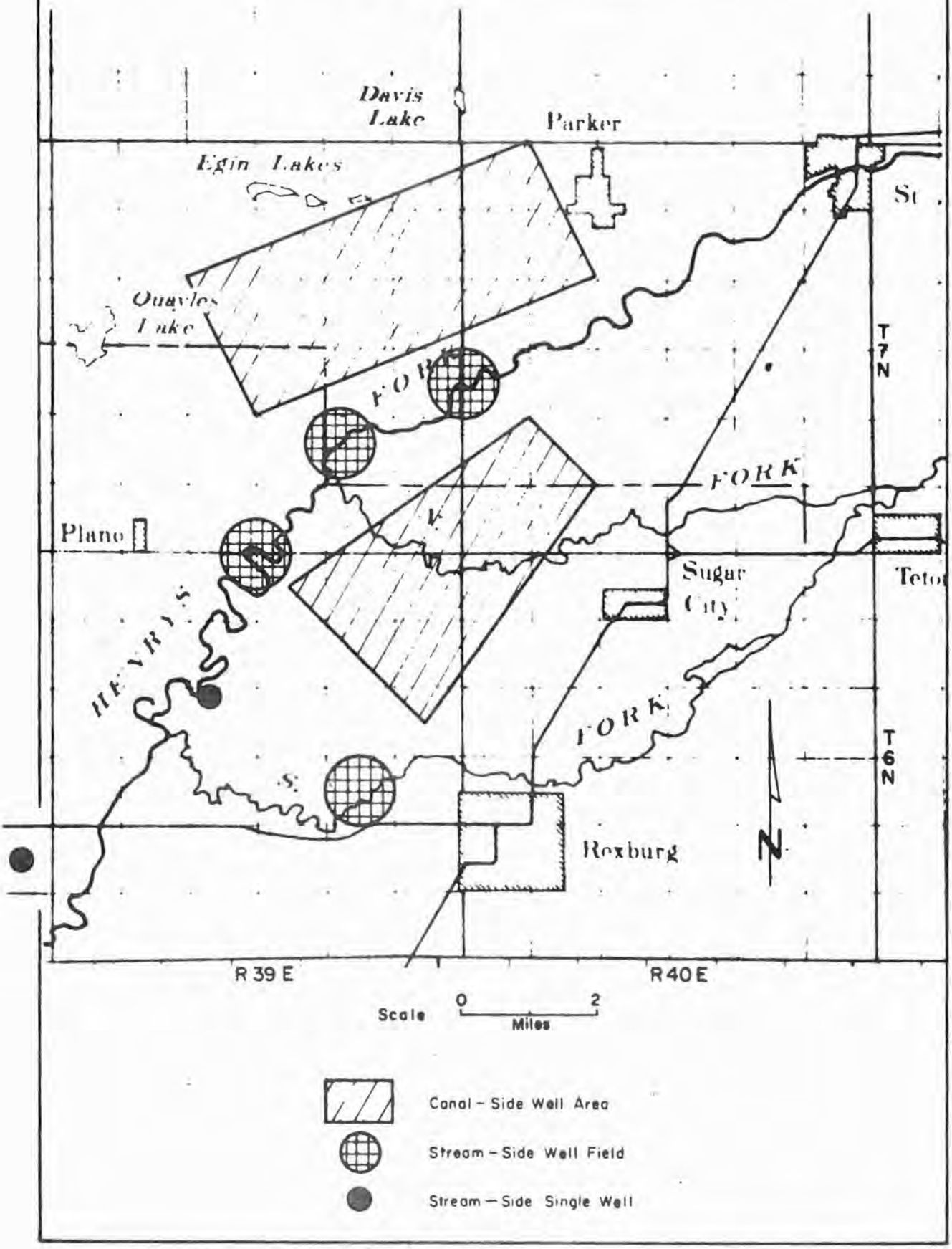
The aforementioned estimate covers the direct contract unit cost of a basic well as described. Not included are pumping or electrical equipment, discharge facilities, land or right-of-way, overhead, or contingencies. Unit prices are based principally on the three low bid prices received for drilling Test Wells 1 and 2 with modifications as justified by field experience.

Location of Facilities

Based on the requirement for 30 percent delivery of replacement ground water into existing irrigation facilities and the several advantages of location of wells along major streams, the following general distribution of facilities is proposed:

1. Eighteen streamside wells located in four well fields of four wells each and two single wells. (See location map of replacement wells.) Discharge would be directly into the Henrys Fork River or tributary thereof.

PROPOSED GENERAL LOCATION OF WATER REPLACEMENT WELLS



2. Nine canalside wells located within the general areas shown and with discharge into major canals.

These sites have been selected to meet the following criteria in addition to the requirement for 30 percent discharge into canals.

1. Presence of an adequate thickness of saturated basalt.

2. Maximum overburden depth of 200 feet.

3. Minimum static water levels consistent with other criteria.

4. Proximity to a stream or to a canal of adequate capacity.

Streamside wells would require the following sites and appurtenant facilities.

1. Two singly located wells - about 1,000 lin. ft. of discharge pipe each with related valves, meters and inlet facilities. Site - one acre each with right-of-way for discharge pipe and access.

2. Four fields of four wells each - about 660 lin. ft. of discharge pipe or open channel with inlet facilities. Each well within the field - about 75 lin. ft. of discharge pipe each with related valves and meters. Site - two acres each with right-of-way for discharge and access.

Canalside:

Nine individually located wells - about 25 lin. ft. of discharge pipe, each with related valves, meters, and inlet facilities. Site - one-quarter acre with right-of-way for discharge and access.

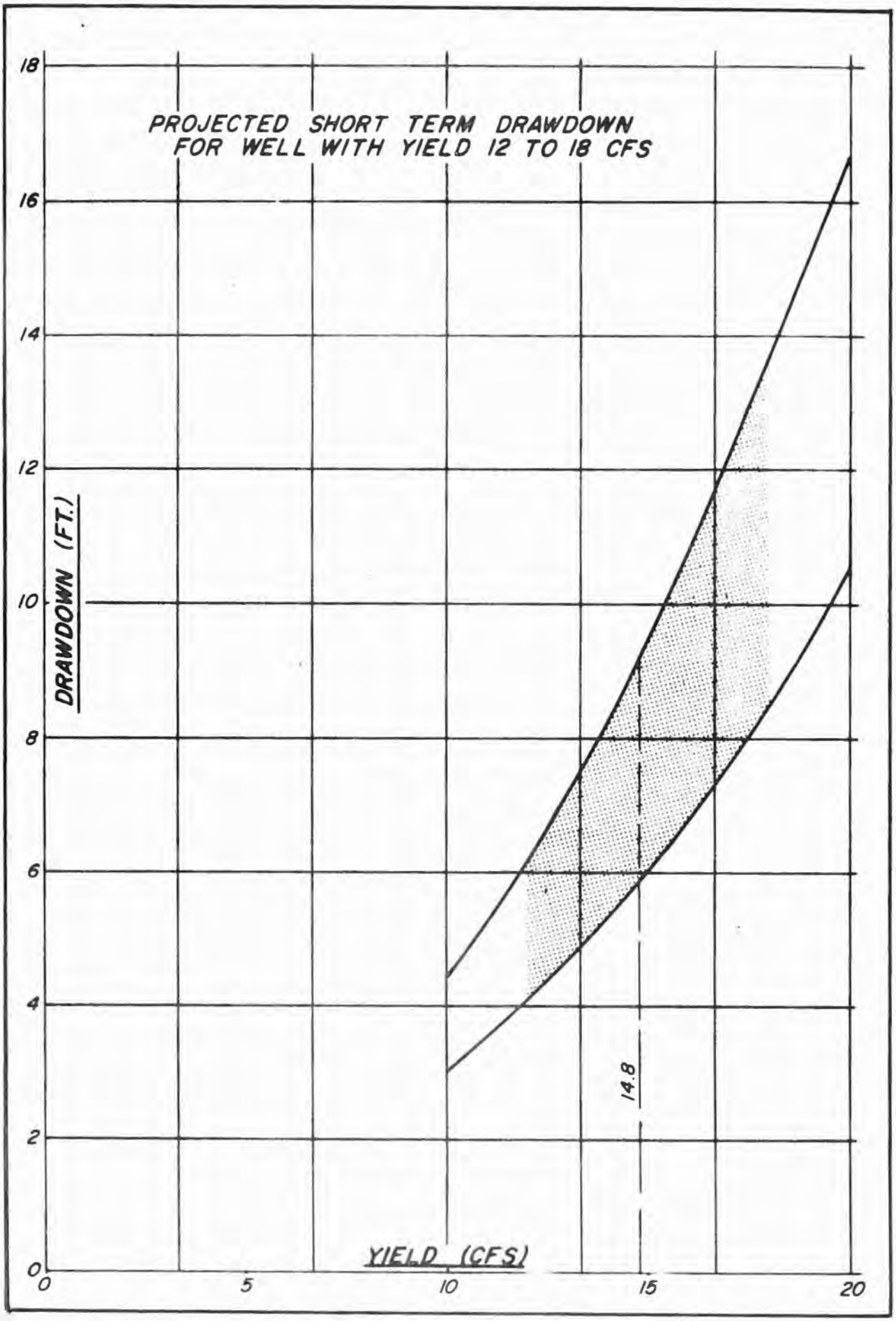
Well Performance

Under long-term operating conditions, pumping lifts of replacement wells will be the sum of a number of components, some of which are related to well characteristics, whereas others depend on aquifer characteristics and/or recharge conditions. These components are as follows:

1. Static water level - observed depth to static water taken from depth to water table map. Static water levels at each well field are weighted to obtain an average.

2. Short-term drawdown - based on projection of observed drawdown of Test Wells 1 and 2 up to an average yield of 14.8 c.f.s. (See graph of projected drawdown for wells with yields 12 to 18 c.f.s.) Includes weighted mutual interference within multiwell fields.

3. Seasonal drawdown - based on projection of observed drawdown in Test Wells 1 and 2 to 14.8 c.f.s. average yield and 270 days pumping time.


PROJECTED SHORT TERM DRAWDOWN
FOR WELL WITH YIELD 12 TO 18 CFS
DRAWDOWN (FT.)
YIELD (CFS)
14.8
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20

4. Seasonal decline in static water level - taken from observed seasonal fluctuations in the static water level as shown on hydrographs.

5. Long-term decline in static water level - an arbitrary estimate given in absence of data on long-term cyclic fluctuations of the static water level.

6. Long-term drawdown - based on estimates of the effect of mutual interference between wells and well fields and the resultant creation of an area-wide zone of influence. Taken principally from unpublished analog model studies support by results of independent calculations.

Pumping lift components and total for an average well of 14.8 c.f.s. capacity are summarized in Table 7. Maximums and minimums generally are observed or computed values. Averages are based on weighted values where practicable and on judgment elsewhere.

Table 7. Estimated pumping lift for 14.8 c.f.s. capacity well

	Maximum	Minimum	Average
	(feet)	(feet)	(feet)
1. Static water level	80	15	32
2. Short-term drawdown	12	6	10
3. Seasonal drawdown	1	0.3	0.6
4. Seasonal decline in static water level	6	1	3
5. Long-term decline in static water level	10	2	5
6. Long-term drawdown	12	8	10
Subtotal	121.0	32.3	60.6
TOTAL (+10% & rounded)	135	35	70

EFFECTS OF REPLACEMENT PUMPING

Barring existence of serious unforeseen conditions, it is evident that the Snake River basalt aquifer underlying the alluvial lowlands in the St. Anthony-Rexburg-Plano area is capable of yielding on a sustained basis the necessary volumes of replacement ground water with reasonable construction and operational costs. As stated previously, however, the consequences of replacement pumping on existing conditions and uses within the pumping area, and also regionally, should be considered.

Local

The effect on the basalt aquifer within the area will be limited to moderate cyclic declines in the static water level. This reaction could cause water level declines up to 10 feet in municipal wells in St. Anthony, Sugar City and Rexburg in addition to a limited number of domestic, irrigation, and industrial wells. Generally, these could be offset by lowering of pumps where well depths are adequate. Conceivably, where the thickness of saturated basalt is marginal, some wells could undergo serious reductions in yield. Wells of this type probably are very limited in number.

The basalt aquifer is not known to discharge ground water to streams within or in the immediate vicinity of the Division area. Local stream depletion, therefore, will not be a factor in replacement pumping in the Division area.

Generally, the data at hand indicate that significant local problems will not be encountered with respect to existing ground water conditions in the basalt aquifer or depletion of discharge therefrom caused by replacement pumping from the basalt in the Division area.

Locally, the potentially unfavorable influences on the perched aquifer from replacement pumping could include interference with subirrigation, water level decline in domestic wells, and depletion of return flows. The above would result from any significant decline in the perched water level caused by pumping from the basalt aquifer. The relationship of the perched and regional aquifers is imperfectly known. Thus, a quantitative estimate based on present data of the reaction of the water level in the former to withdrawals from the latter is not practicable. However, present relationships between the two aquifers and the previously described results of test pumping tend to indicate qualitatively that withdrawal from the basalt aquifer will influence the perched aquifer to only a minor extent. Principal among the relationships is the hydraulic separation between static water levels in the two aquifers which ranges from a few feet to more than 100 feet.

Throughout the lowland area the perched water level lies above the regional water level, thus indicating the existence of a zone of hydraulic discontinuity with accompanying disruption of vertical flow. Under such conditions the rate of percolation would depend principally on the vertical permeability of the material and would be relatively independent of the separation between the two water levels.

Regional

Withdrawal of replacement ground water from the alluvial lowlands of the Division area will affect ground water levels everywhere within the zone of influence of the pumping. The nature and magnitude of change will be dependent principally on the rate and duration of withdrawals, characteristics of the aquifer, and distances involved. In areas where discharge from the aquifer occurs, the influence from replacement pumping will cause a decline in discharge. Elsewhere the influence will be in the form of a decline in water level in the aquifer.

American Falls Reservoir

The principal areas of discharge reduction will be in the Twin Falls-Hagerman and Blackfoot-American Falls reaches of the Snake River. In the former reach, flows presently exceed needs and rights so it is not hereafter considered. In the latter, however, reduction of aquifer discharge will result in adverse depletion of inflows to American Falls Reservoir.

Mundorff (1962) in connection with artificial recharge studies estimates that increase in discharge from the Snake Plain aquifer resulting from an increase in recharge in the Roberts-Plano area would be divided about 60 percent to the Twin Falls-Hagerman reach of the Snake River and about 40 percent to the Blackfoot-American Falls reach. Since withdrawals of the same magnitude would have equal but opposite reaction on water levels, Crosthwaite and others (1967) suggest that similar percentages would hold true for depletion by pumping. They estimate that the reduction in inflow to the Blackfoot-American Falls reach after pumping 600 c.f.s. for 6 months annually for 5 consecutive years in the lower Henrys Fork valley would be about 60 c.f.s. or about 2.3 percent of average inflow. The Division First Phase requirements as previously shown vary somewhat in total volume and timing. Since the depletion would be generally in proportion to withdrawals, those due to First Phase pumping would certainly be somewhat less than 60 c.f.s.

Crosthwaite states, however, that the depletion would be much less than the computed amount because the average annual withdrawals would be less than the maximum. In addition, increased recharge due to Division operations would tend to offset aquifer depletion caused by pumping. Estimates made by others (Bureau of Reclamation, 1968, unpublished data) indicate that increased recharge to the basalt aquifer

due to Division operations would nearly offset depletion of American Falls inflow. The maximum annual depletion based on combined Phase 1 and 2 operations would be about 3,700 acre-feet or 10 c.f.s. flow for 6 months.

With present state of knowledge of ground water flow conditions in the Snake Plain aquifer, a precise, reliable estimate of the effects of Lower Teton Division replacement pumping on ground water inflows to American Falls Reservoir is not feasible. However, the data at hand indicate the effects will be minor if not negligible. Fortunately, because of unusually favorable ground water conditions in the St. Anthony-Rexburg-Plano area, flexibility can be built into the replacement facilities to permit the pumping of up to 10 percent more than the Division First Phase requirement at small additional construction and operational costs if such becomes necessary.

Mud Lake-Market Lake Basins

In addition to the two aforementioned reaches of the Snake River, natural discharge from the basalt aquifer also occurs as springs in the Mud Lake and Market Lake basins which lie 10 to 25 miles west of the Henrys Fork lowlands. According to Stearns and others (1939) the two basins were relatively dry prior to the beginning of irrigation in the lower Henrys Fork valley in about 1895. Following this irrigation, ground water levels rose over much of the two basins to near the ground surface and, in addition, numerous springs appeared.

The ground water conditions beneath the Mud Lake and Market Lake basins, which lie astride the Mud Lake ground water barrier, are relatively unknown. The basins presently support large irrigation developments based partially on ground water and, in addition, contain United States and State waterfowl management facilities.

Stearns and others (1939) attribute the barrier effect to the presence of a perched water table in the lacustrine beds of the Mud Lake basin and presumably the Market Lake basin. This perched water is said to lie 250 to 275 feet above the regional water level of the basalt aquifer south of the barrier. Mundorff and others (1964) presume that the barrier is related to the presence of extensive lacustrine interbeds which lie with the basalt in the area. Parallel fault traces have been found and these are also presumed to be related to the origin of the barrier.

Results of unpublished analog model studies indicate that ground water levels in the Mud Lake area above the barrier will decline as much as 6 feet as a result of replacement pumping in the St. Anthony-Rexburg-Plano area, which is at a distance of about 27 miles. This is about 60 percent of the decline that will be experienced at a distance of about 6 miles from the pumping area. However, inspection of well hydrographs in the pumping area and in the Mud Lake area indicates

that the wave resulting from annual recharge in the pumping area is greatly dampened by the time it reaches Mud Lake. Since a decline due to pumping would have a similar but opposite effect, it would appear that the magnitude of decline produced by the analog is not reliable. This probably is due to invalid duplication of aquifer conditions in the model resulting from inadequate data on subsurface geologic and hydrologic conditions in the area between the lower Henrys Fork valley and the Mud Lake-Market Lake basin. Until these conditions are determined, a precise estimate of the effects of replacement pumping on ground water conditions in the Mud Lake-Market Lake basins is not feasible.

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