HYDROGEOLOGIC ASPECTS OF POTENTIAL WASTEWATER REUSE AREAS NEAR IDAHO FALLS-BLACKFOOT, IDAHO

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AUTHORIZATION TO PROCEED WITH THE FINAL DRAFT

This thesis of Omar Shakir Abdu Samara Shadid for the Master of Science degree with major in Geological Engineering and titled "Hydrogeologic Aspects of Potential Wastewater Reuse Areas Near Idaho Falls-Blackfoot, Idaho" was reviewed in rough draft form by each Committee member as indicated by the signatures and dates given below and permission was granted to prepare the final copy incorporating suggestions of the Committee; permission was also given to schedule the final examination upon submission of two final copies to the Graduate School Office:

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BIOGRAPHICAL SKETCH OF THE AUTHOR

Omar S. Shadid was born in Illar, Palestine, January 1, 1941. He attended elementary school in Illar and secondary school in Tulkarm. He enrolled in the University of Istanbul, Turkey, in September, 1959, and completed the requirements for the Bachelor of Science degree in Geology and Geophysics in February, 1964.

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ABSTRACT

The Idaho Falls-Blackfoot area of southeastern Idaho is one of the more densely populated and rapidly growing regions of the State. Situated on the edge of the Snake River plain along routes of easy access, this area is well located for irrigation projects and industrial development. The resulting residential, agricultural and industrial expansion is putting a growing demand on available groundwater and is contributing to a growing supply of wastewater. This paper reviews the current groundwater conditions in the semi-arid Idaho Falls-Blackfoot area and recommends the use of wastewater in selected areas for irrigation and fertilization and concomitant recharge of groundwater.

Tertiary rocks in the area, from oldest to youngest, consist of the predominantly rhyolitic Starlight Formation, the Neeley Formation and the Walcott Tuff Formation. The Quaternary units consist of Ash Flow Tuff, Raft Formation, Big Hole Basalt, Loess, Older Alluvium, Younger Alluvium, and sand dunes. The Older Alluvium is subdivided into Gibson Terrace and Snake River Pinedale Alluvial Terrace.

The rock units in the area have been grouped into three major hydrostratigraphic units: the Starlight-Neeley-Walcott-Ash Flow Tuff, the Big Hole Basalt, and the Alluvium. Loess and soil are minor hydrostratigraphic units.

Wastewater reuse sites have been evaluated and sub-

divided into First Class and Second Class sites. The evidence indicates that there are 11 First Class sites and 5 Second Class sites. The most favorable areas are the terraces on the Snake River Pinedale Alluvial Terrace north and south of the cities of Idaho Falls, Iona, and Ammon, northwest and southeast of the city of Shelley, and northeast of the city of Wapello. On the Gibson Terrace, conditions are favorable south of the city of Blackfoot. West of the Snake River, wastewater recharge conditions are favorable near the cities of Moreland and Groveland and in small areas south near the river in older alluvial material.

Most of the terrace alluvial deposits beneath these localities grade upward from coarse sand and gravel near the bottom of buried channels to silt and clay at the top. The thickness of the unconsolidated, unsaturated zone ranges from 70 feet west of the river to 120 feet east of the Snake River near Idaho Falls.

The groundwater beneath the Snake River plain in the study area flows southwestward parallel to the Snake River. Locally, along the Snake River, the water table intersects the ground surface so that springs issue onto the alluvial plain. The best aquifers are near the ground surface and are typically used for domestic purposes.

Most irrigation water comes from the Snake and Blackfoot Rivers; small amounts are obtained from Willow Creek, Lincoln Creek and Ross Fork in addition to that which is obtained from groundwater.

The major factors which determine the practical use of wastewater and surplus runoff for irrigation and fertilization in the area of study are distribution and availability. The hydrogeologic conditions of thick sections of unsaturated, unconsolidated detritus which are desirable for recharge underlie broad areas of the Snake River plain. Loess overlies some of the older alluvial material and improves recharge filtering capabilities. Where the water table is in the basalt, west of the river, the unsaturated zone ranges from 10 feet to 70 feet in thickness, however basalt crops out in a large portion of this area and limits its potential for renovating wastewater.

INTRODUCTION

Population growth, industrial expansion and irrigation development in southeastern Idaho are making increased demands on the available water of the area. Many wells have been drilled to tap groundwater and many canals have been built to distribute surface water to tillable land. Most of the wells are shallow and draw water from gravel alluvial terraces and flood plains along the Snake River. A few wells have been drilled in the basalt flows exposed beyond the limit of alluvial material and in the older sedimentary rocks in the foothills of mountain ranges along the eastern border of the study area.

A natural effect of the growth in population, industry and irrigation water demands is the dumping of more and more wastewater directly or indirectly into the Snake River. The area then has two water problems: first, an increasing demand for groundwater, and second, an increasing supply of wastewater. One solution is to turn wastewater into useable groundwater.

Purpose and Scope

Wastewater is best renovated by thick sections of unsaturated, unconsolidated detritus (Williams, Wallace and Eier, 1969). This project was designed to investigate shallow hydrogeologic characteristics of the Snake Plain area and to determine whether the plain is underlain by material suitable for irrigation wastewater reuse and groundwater recharge.

Specifically the study evaluated the hydrogeologic conditions of the soil and underlying rock in the Idaho Falls-Blackfoot area and determined where the near-surface unconsolidated materials can act as a renovating medium for the wastewater.

Field work began in August, 1970, and was completed by December, 1970. Aerial photographs of 1:62,500, 1:27,200, and 1:18,000 scales were available for use during the field study; data were compiled on 7½ and 15 minute topographic U.S. Geological Survey quadrangle maps.

Field work included collecting data on wells, (Appendix I), collecting water samples from wells, measuring temperature and water levels in wells, and testing geohydrological features related to groundwater supply. Water samples from representative wells were analyzed for total dissolved solid (TDS) (Figure 18). The study findings reported herein are based on these field observations and on data available from drillers' logs. The results illustrated include: a detailed geologic map (Plate 1), an isopach map showing the thickness of unconsolidated materials (Plate 5), a water-table contour map which defines the groundwater flow system (Plate 6), and a map showing the thickness of the unsaturated zones in the unconsolidated materials above the water table (Plates 7 and 12). The sub-surface stratigraphy as developed from field observations and the lithologic records available is illustrated by columnar sections (Plate 11).

The information collected during the study and the interpretation and conclusion drawn from it are discussed in this report in the following order. First the general physiographic setting and the economic needs for wastewater reuse are reviewed. Next the geologic conditions and rock types which will determine if reuse is practical are discussed. This section is followed by a hydrogeologic presentation which reviews the characteristics of subsurface materials and locates those which are suitable for reuse of wastewater. The report is terminated by conclusions and recommendations.

Location

The Idaho Falls-Blackfoot area covers approximately 1,000 square miles on the southeastern edge of the Snake River plain in southeastern Idaho. The area studied is approximately 24 miles wide east-west and 44 miles long north-south, and includes parts of Bonneville, Bingham and Bannock Counties. The area is transected by the Boise base line and includes parts of Tps. 1N., 2N., 3N., 1S., 2S., 3S., 4S., 5S., Rs. 33E., 34E., 35E., 36E., 37E., 38E. Boise Meridian (Figure 1).

Previous Investigations

Many geological reports have touched on portions of the Idaho Falls-Blackfoot area, but none describes the area in

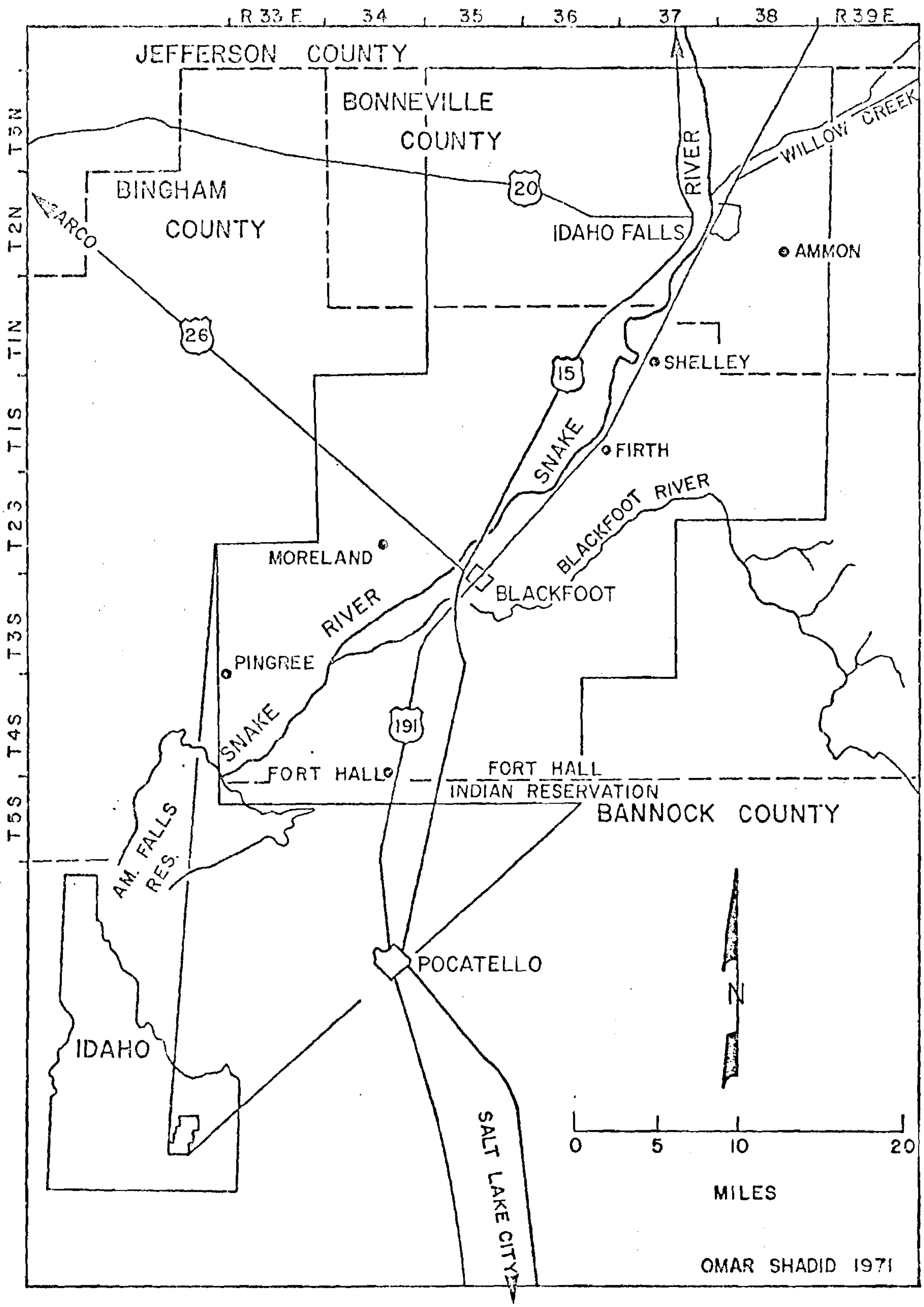

FIGURE 1- INDEX MAP OF IDAHO SHOWING AREA COVERED BY THIS THESIS

detail. As early as 1871, the Hayden Surveys made geological observations in eastern Idaho (Fifth Annual Report of the U.S. Geological and Geographical Survey in 1872). The first observations on groundwater, other than incidental mention of wells and springs, were made by Russell (1902). Piper and Kirkham (1925) prepared a report on groundwater in the Idaho Falls area. Other publications include studies by Mansfield (1920, 1927, 1952) and Stearns and others (1936, 1938). Kirkham (1924) studied the geology and oil possibilities in Bonneville and Bingham Counties. More recently Savage (1961) studied a portion of the area; Williams, Eier and Wallace (1969) described the feasibility of reuse of treated waste-water for irrigation, fertilization and groundwater recharge in Idaho with specific examples, discussed for the cities of Idaho Falls, Blackfoot and Shelley.

During the past decade, the U.S. Geological Survey, with the cooperation of the U.S. Bureau of Reclamation, the U.S. Atomic Energy Commission, and other government agencies has been studying more intensely the groundwater problems in the Snake River Basin. Many geological and groundwater resources reports of the Snake River Basin have been published by them or released to open file. These reports are cited in the References.

PHYSICAL SETTING

Land Forms and Drainage

The Idaho Falls-Blackfoot area includes portions of three physiographic provinces: the Eastern Snake River plain, the Middle Rocky Mountain province and the Basin and Range province (Fenneman, 1931, p. 183).

One portion of the study area, the Eastern Snake River plain, is a subdivision of the larger Columbia River intermountain province. In Idaho, this province is essentially flat. The surface of the plain rises from 3,000 feet above sea level in the west near Boise to about 6,000 feet in the east near Yellowstone Park. The Eastern Snake River plain in the Idaho Falls-Blackfoot area lies between the Snake River and Northern Rocky Mountain province of central Idaho. It occupies about 40 percent of the study area or approximately 400 square miles north and west of the Snake River. About two thirds of the surface, chiefly northwest of Idaho Falls and Blackfoot, consists of loess ranging from 5 to 40 feet in thickness. The remainder is waste land of rifted and fractured, aa, and pahoehoe Recent basalt flows (Figure 3a and 3b). Several low buttes, probably associated with former lava vents, produce relief varying from 200 to 700 feet (Savage, 1958, p. 8).

A second portion of the Idaho Falls-Blackfoot area east of the Snake River forms part of the western margin of

Figure 3a. Pahoehoe basalt flow southwest of Idaho Falls.

Figure 3b. Aa basalt on Highway 15 between Shelley and Blackfoot.

the Middle Rocky Mountain province. The Willow Creek Hills in the study area lie in this province. The rhyolites, welded tuff, and ash flows in the Willow Creek Hills form ridges that generally have a north-northwest trending strike. The valleys generally are formed in relatively softer units and drain westward to the Snake River. The altitude ranges from 4,750 to 5,000 feet.

The third portion of the area lies in the Basin and Range province. The Willow Creek Hills are foothills to the Blackfoot Mountains which touch the study area and mark the northern edge of the Basin and Range physiographic province. The ridges generally have a north or northwest trending strike. The broad valleys and basins are formed on relatively softer rock between the narrow ridges. Buckskin Basin and the valleys of Ross Fork and Lincoln Creek are characterized by gently-rounded slopes (Plate 1). Locally Ross Fork and Lincoln Creek have formed small flood plains (West and Kilburn, 1963, p. 6). The elevation in this area is from about 4,355 feet to more than 7,414 feet. Most of the drainage is northward to the Snake River. Many of these streams are intermittent and flow only during or after storms (Ross and Savage, 1967, p. 150).

The Snake River is the master stream in the area and serves a dominant role on the groundwater regime. From the point where it enters the northeast corner of the area, it flows approximately 60 miles in the Snake River alluvial plain to a point three miles northeast of American Falls where it enters the American Falls Reservoir. The river has an average gradient of 10 feet per mile throughout the area.

Locally the Idaho Falls-Blackfoot area is drained by four tributaries of the Snake River (Plate 1). From north to south, they are Willow Creek, Blackfoot River, Lincoln Creek, a tributary of the Blackfoot, and Ross Fork, a tributary of the Portneuf River. Such intermittent streams as Rock Hollow, Henry Creek, Taylor Creek, Wolverine Creek, Cedar Creek, and Garden Creek carry runoff for a few months in the spring of the year. Cold Creek receives water from groundwater seepages of local flow systems and is less intermittent. However, this water either infiltrates to groundwater downstream or is diverted for irrigation and generally does not reach the Snake River.

Large volumes of water from the Snake River, Blackfoot River, and Lincoln Creek are diverted into canals for irrigation. Most of these canals are unlined, and some of the water recharges groundwater.

Climate

The climate of the Idaho Falls-Blackfoot area is variable because of the wide range in physical setting. The estimated average monthly and annual temperature and total monthly and annual precipitation in the Idaho Falls-Blackfoot area are summarized in Table 1. The Idaho Falls-Blackfoot vicinity has a dry, semi-arid continental climate. The moun-

Table 1

Average monthly and annual temperature and total monthly and annual precipitation in the Idaho Falls-Blackfoot area - 1970 (U.S.Weather Bureau)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average Annual
					Temperature, in degrees Fahrenheit								
Aberdeen Exp. Station	26.7	33.8	34.1	37.2	51.5	60.8	66.9m	67.7	51.3	41.0	35.2	24.1	44.2
Fort Hall Indian Agency	29.9m	36.3m	35.7m	39.0		63.2m	67.6m	70.9m	54.5	43.5	37.9	26.2	43.1
Idaho Falls 2 ESE *	26.7	35.2	34.8	38.2	54.0	62.5	69.9	70.7	53.2	42.1	36.3	24.1m	46.0
Idaho Falls FAA AP **	25.8	35.1	36.6	35.4	52.7	62.2	68.9	70.0	52.1	41.4	35.9	21.3	45.0
Idaho Falls 46 WR ***	21.9	30.5	31.1		49.8	60.2	67.7	68.2	49.7	38.5	31.8	14.7	51.3
Idaho Falls 16 SE *	23.8	29.5	28.1	33.0	48.3	57.3	64.5	64.7	48.4	37.8	32.5	21.3	48.0
Blackfoot Dam					m	55.5	61.9	63.0	47.4	38.9m			53.3
Blackfoot 2 SSW ****	28.6	35.5	35.4	39.2	54.1	61.6	67.6	67.8	51.5	43.1	36.8		46.5
					Precipitation in Inches								
													Normal Annual
Aberdeen Exp. Station	1.81	.14	.93	1.05	1.97	.79	.74	.08	.28	.56	1.00	.08	9.43
Fort Hall Indian Agency	1.75	.16	1.58	1.86	1.92	.96	.95	-.37	.74	.64	1.58	1.13	12.90
Idaho Falls 2 ESE *	---	.15	1.25	1.63	---	1.70	1.01	.18	1.19	.29	1.84	.92	10.16
Idaho Falls FAA AP **	1.55	.07	1.16	1.26	.45	1.41	.32	.38	.73	.30	1.68	1.09	10.30
Idaho Falls 46 WR ***	.62	.05	.83	---	1.28	.97	.51	.50	.53	.35	1.53	.97	8.13
Idaho Falls 16 SE *	2.61	.62	1.50	1.89	1.77	2.24	0.00	.60	1.74	1.28	2.82	2.08	24.96
Blackfoot Dam	---	---	---	---	---	1.35	1.44	.32	---	---	---	---	3.11
Blackfoot 2 SSW ****	2.35	.38	.78	1.50	2.05	1.48	.90	.00	.60	.32	---	---	10.36

m - One or more days of recording missing.
* - Miles and direction from Idaho Falls Post Office.
** - Federal Aviation Administration at the Air Port.
*** - Miles west from recording station.
**** - Miles and direction from Blackfoot Post Office.

tain uplands to the east and south are more humid with a high percentage of clear days. The mean annual temperature is 46.5^{o}F at Blackfoot, but the mountainous parts of the Fort Hall Indian Reservation have a lower mean annual temperature. Daily temperature changes average 20^{o}F during winter months and 38^{o}F in summer months in the plain's area. Winds are generally strong and persistent and the humidity is typically low; heavy dust storms are common in the northern part of the area during spring and summer.

Overall, on the Snake River plain where groundwater use is most common, annual precipitation average is 10 inches. According to the Fort Hall Indian Agency, annual precipitation is about 13 inches. Precipitation in the mountains in the southeastern plain of the area is considerably higher than on the Snake River plain and ranges up to 24 inches per year. July and August are the driest months. December's precipitation on the plain is the highest of any month of the year, an average of 1.4 inches. In summer and during the growing season, precipitation on the plain is primarily from thunder storms.

The altitude and configuration of the land surface influence both the amount and nature of precipitation as well as the runoff characteristics of drainage basins. This strongly affects groundwater recharge. Several feet of snow accumulates in the winter on the higher mountains in the area. Melting of this snow is commonly slow, and because the mountain slopes are steep, much of the melt water runs off. However, some melt water percolates to the water table and moves down valley by underflow.

The large amount of water lost by evaporation (Figure 4) from reservoirs, canals, and irrigated land (Stearns and others, 1938, p. 19) is not necessarily a total loss of water to the area. This water loss is based on measured evaporation from the lake pans at Milner and American Falls, multiplied by a coefficient of 90 percent to give reservoir evaporation losses. The prevailing west and southwest winds carry a part of the moisture evaporated from the Snake River plain to the mountainous headwaters' area to the east. There, because of the higher elevation, the moisture of the ascending winds is in part precipitated and may reappear as stream flow, creating a small weakly-closed hydrologic cycle.

Vegetation

Irrigated lands in the area produce a diversified crop. The staple crop is alfalfa and other hay grasses. Grown in lesser amounts are wheat, oats, barley, potatoes, sugar beets, onions, beans, peas, and head lettuce. Buckbrush, bunchgrass, juniper, rabbit brush, wild rye, and squirrel tail grow wild throughout the area (Stearns and others, 1938, p. 7). Douglas fir and Lodgepole pine (Savage, 1961, p. 12) grow where the precipitation is heaviest in the higher elevations in the eastern portion of the area.

Figure 4. Shallow reservoir illustrating consequence of evaporation.

Status of Economic Development

The Idaho Falls-Blackfoot region is one of the more prosperous farming and industrial areas in Idaho. Irrigation, farming and industry allied with agriculture are the basis of the economy of the Snake River Basin. On non-irrigated Fort Hall Indian reservation lands, processing sugar beets, potatoes, and dairy products, storing potatoes and seed, and grazing stock are the principal agricultural enterprises.

The demand on surface water and groundwater is expected to grow as the area continues to develop. The related increasing rate of production of wastewaters can be seen and can be expected to continue and create new problems. This study proposes to reduce this impact by renovating wastewater in a natural environment and to offer an alternative to disposal in surface water bodies. Reuse of effluent for irrigation, fertilization, and groundwater recharge is among the techniques which offer promise in the coming years.

GEOLOGIC SETTING

Rhyolitic tuff, welded tuff, vitrophyre, basalt, and basaltic tuffs of late Tertiary age, and basalt, loess and sandstones and alluvium of Quaternary age are exposed in the area (Plate 1).

The disposition of groundwater in the Idaho Falls-Blackfoot area is closely related to the geology and is as varied as the geologic features. The water-bearing materials range from highly permeable unconsolidated gravel to nearly impermeable silicic volcanics.

The distribution of geologic formations and their physical and water-bearing characteristics are summarized in Appendix II.

Tertiary System

Tertiary rocks in the area are, from oldest to youngest, the Starlight Formation, the Neeley Formation, and the Walcott Tuff Formation (Wilfred and Trimble, 1963, p. 5). These rocks are predominantly rhyolitic. The Starlight Formation is mainly bedded, friable tuff and welded tuff with minor amounts of marl, sandstone, and conglomerate. The Neeley Formation is a poorly bedded, friable tuff, and the Walcott Formation is a bedded friable tuff and obsidian welded tuff (Wilfred and Trimble, 1963, p. 65) (Plate 2). A detailed description of these formations starts on page 18 of this report. In general, the hydrologic properties of the Tertiary rocks are unsatisfactory for massive recharge attempts. These units commonly have been tilted toward the Snake River and are in poor structured attitudes for reuse programs. These conditions are discussed in detail under Hydrostratigraphic Units.

The Tertiary Starlight-Neeley-Walcott Tuff stratigraphic classification is a subdivision of rock assigned to parts of the Payette-Salt Lake Formations by earlier workers in the region. The name "Salt Lake Formation" was mainly applied to fluvial sediments in the Salt Lake Valley and as originally described contained no volcanic material. Subsequently the term was applied by Peale (1879, p. 510) to similar rocks in southeasternmost Idaho. Later Mansfield (1920, p. 54; 1927, p. 110) attached the name "Salt Lake Formation" to the middle and upper Tertiary rocks in southeastern Idaho. For example, Tertiary volcanic rocks are mapped as Salt Lake Formation, Pliocene(?) in the Fort Hall Indian Reservation by Mansfield (1920, pl. 3). Two miles southeast of Blackfoot, in this same area, Mansfield also mapped a unit which he called "deposits of volcanic ash, hill wash, etc." of Tertiary and Quaternary age (1920, pl. 3). Much of what he assigned to the latter unit is Pleistocene loess and alluvium, but it does contain some Pliocene rhyolitic tuff.

The Salt Lake Formation was mapped in the American Falls area by Ross and Forrester (1947) as separate units.

They were the Snake River basalt, the Tertiary silicic volcanic deposits, and the Payette Formation. A detailed study of these rocks indicates that all are interbedded with rocks which Ross and Forrester mapped elsewhere as Salt Lake Formation. The Payette Formation probably has no equivalent in this area.

The Tertiary rocks along the Snake River in the American Falls area include two formations, the Neeley Lake Beds and the Eagle Rock Tuff, as defined by Stearns and others (1938, p. 43). The Eagle Rock Tuff has been renamed the Walcott Tuff by Wilfred and Trimble (1963, p. 7).

As just described, most workers in the Snake River Basin have assigned some beds of Tertiary age to the Salt Lake Formation. Much confusion exists in the relationship of these rocks to rocks of other areas, and it is not difficult to see that the term Salt Lake Formation has been used to include many rocks whose age and lithologic character are different from those in the original description of the formation.

Recent work in the Idaho Falls-Blackfoot area has shown the need for subdivision and redefinition of the Salt Lake Formation. The Starlight Formation, the Neeley Lake Beds and the Walcott Tuff, as defined by Stearns and others (1938, p. 43) or modified by Wilfred and Trimble (1963, p. 15) are retained in this report.

One section containing examples of the three Tertiary units exposed in Henry Creek is presented in Appendix III.

Starlight Formation

The oldest rock exposed in Idaho Falls-Blackfoot area is the Starlight Formation. This unit was named by Wilfred and Trimble (1963, p. 7), for exposures in Starlight Creek about 10 miles southeast of American Falls. The Starlight Formation is subdivided into upper and lower members separated by a vitric-crystal tuff middle member.

The lower member of the Starlight Formation is that part of the unit that lies below the vitric-crystal tuff member. The only outcrop of this member in the study area is located in the Blackfoot River Canyon, 2S-37E-7NW¼ NW¼ (Figure 5)(Plates 1 and 2). It consists of moderate yellowish green (10 GY 6/4) bedded, rhyolitic, friable tuff with interstratified basalt flows. The thickness of the exposure is about 10 feet.

The vitric-crystal tuff member is a light-colored, partly welded, rhyolitic tuff. It contains about 30 percent broken and embayed but normally conspicuous crystals composed of euhedral quartz with minor biotite and pumice fragments in a fine, mostly devitrified, dense, ashy matrix. The rocks may show a distinct, pyroclastic texture. The lack of pyroclastic texture is probably more common toward the top of the unit where the rock, locally, is a rhyolite.

Microscopic examination shows that sanidine composes about 11 percent of the vitric-crystal tuff, and that plagio-

Figure 5. Blackfoot River Canyon Basalt overlying Starlight Formation.

clase and quartz make up about 9 and 7 percent, respectively. The remainder of the crystals are biotite 2 percent, and hypersthene, augite, and opaque minerals 1 percent. Devitrified glass with a faint pyroclastic texture forms the matrix of the rock (Wilfred and Trimble, 1963, p. 9).

The vitric-crystal tuff is as much as 35 feet in thickness in the area (Figure 6). It is exposed in a series of small outcrops east of Goshen in Cedar Creek, east of Taylor in Taylor Creek, north of Wolverine Creek in the Fort Hall Indian Reservation, west of Eastern Idaho Slough Reservoir, east of Buckskin Basin on the Cosgrove Road, in scattered exposures three miles east of Stevens Peak, and in the Blackfoot Mountains (Plate 1). The widely separated exposures are believed to represent a single continuous unit, and it is probable that with further work in the region, additional outcrops will be discovered.

The upper member consists of very white (N8) parallel-bedded, friable, rhyolitic tuff with minor massive pumiceous tuff and grayish yellow (5 Y 8/4) marl. In the well-bedded tuff along Taylor Creek south of Ammon, the layers range from less than 1 to more than 14 inches in thickness. The thickness of the exposed part is about 120 feet. Also massive pumiceous tuff and marl are along Henry Creek south of Ammon in the SE¼ SE¼, sec. 26T., 1N., R. 38E (Figure 7).

Mollusca are abundant in both upper and lower members of the Starlight Formation, particularly in the marl beds.

Figure 6. Vitric-Crystal Tuff, Starlight Formation.

Figure 7. Water laid pumice beds of upper Starlight Formation capped by Neeley and Walcott Formations.

They are identified by Taylor (Wilfred and Trimble, 1963, p. 12) as mollusca of middle Pleiocene age.

Neeley Formation

The Neeley Formation was named the Neeley Lake Beds by Stearns and others (1938, p. 43) for exposures near Neeley, five miles southwest of American Falls. The name was changed by Wilfred and Trimble (1963, p. 15) to the Neeley Formation. The Neeley Formation crops out in the study area in southeast Iona and Henry Creeks. The lower contact with the Starlight Formation is an angular unconformity of less than five degrees. The upper contact is conformable with the overlying Walcott Tuff. The Neeley Formation consists of dark reddish brown (10 R 3/4), non-bedded, rhyolitic tuff, tuffaceous, clay-like sandstone and tuff.

In the study area, the Neeley Formation thins northward from 49 feet at American Falls to 10 feet near Idaho Falls in Henry Creek (Figure 8).

Walcott Tuff Formation

The Walcott Tuff was named by Stearns and Isotoff (1956, p. 23) for exposure near Lake Walcott 40 miles southwest of the study area. Stearns and others (1938, p. 44) and Wilfred and Trimble (1963, p. 17) originally named these obsidian welded tuffs and bedded tuffs "the Eagle Rock Tuff" (Figure 9).

The Walcott Tuff conformably overlies the Neeley For-

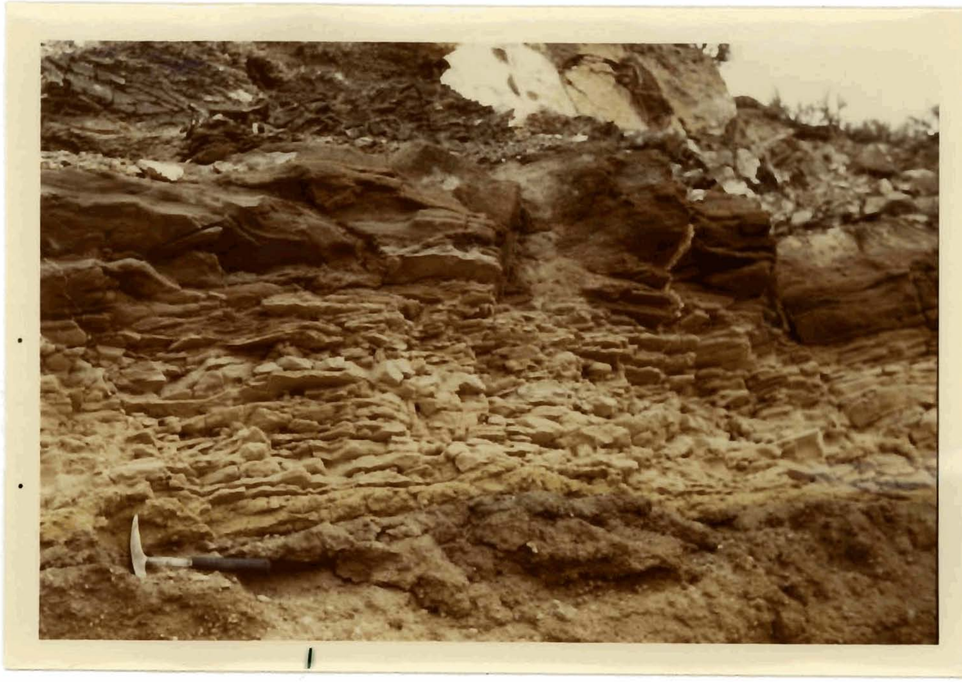

Figure 8. Neeley Rhyolitic Tuff (above hammer) capped by Walcott Tuff.

Figure 9. Walcott Rhyolitic Tuff, Ferry Hollow on American Falls Quadrangle.

mation and contains two distinctive rhyolitic members (not mapped separately). These are a lower white (N9), or light gray (N7), parallel bedded, friable tuff member and an upper dark pink (5 R 5/4), obsidian, massive, welded tuff and a black (N1) dense, obsidian, welded tuff member. The total thickness of this formation in the American Falls quadrangle ranges from 30 feet near the American Falls Dam to 16 feet in the Upper Ferry Hollow area three miles south of American Falls (Wilfred and Trimble, 1963, p. 17). The thickness of the Walcott Tuff in the Idaho Falls-Blackfoot area ranges from 10 to 25 feet.

The Walcott Tuff is exposed east and south of Ammon in the northeastern part of the study area (Plate 2). The unit may be missing locally in the southeastern part of the study area.

Quaternary System

Quaternary units in the study area are, from oldest to youngest, Ash Flow Tuff, Raft Formation, Big Hole Basalt, Loess, Older Alluvium, Younger Alluvium and Sand Dunes. One of the units, Older Alluvium, is subdivided on physiographic expression into Gibson Terrace and Snake River Pinedale Alluvial Terrace on the southeastern side of the Snake River valley.

Ash Flow Tuff

The oldest Quaternary rock in the Idaho Falls-Blackfoot area is the Pleistocene Ash Flow Tuff. This ash flow occurs as a thick flow and blanket of welded tuff. It overlies the Walcott Tuff and it underlies the Big Hole Basalt and the loess in the area.

The Ash Flow Tuff contains volcanic dust, pumice, scoria, and blocks, in addition to ash. The Ash Flow Tuff consists of units that are poorly sorted and massive, dense reddish-brown (10 R 4/6), gray (N7), and black (N1); jointing ranges from platy to columnar. Fine- to coarse-grained ash and pumice beds (commonly reworked by running water) are associated (Figure 10).

In the Idaho Falls-Blackfoot area, the Ash Flow Tuff crops out discontinuously where exposed; it forms a persistent cap on the long-smooth slopes along the northeastern side of the mountainous area, from southwest of Lincoln Creek northeastward to Taylorville and Stevens Peak (Plates 1 and 2).

Raft Formation

Stearns and others (1938, p. 48) named the unit the Raft Lake Bed from exposures along the Raft River south of American Falls. Trimble and Carr (1961, p. 1743) changed the name to Raft Formation because most of the unit is fluvial, not lacustrine, in origin. The Raft Formation predominately is a yellowish gray (5 Y 8/1) and light brown (5 YR 5/6) clay and silt with brown (5 Y 6/4), fine- to very fine-grained sand cemented by calcium carbonate. The Raft Formation contains interstratified and capping basalt layers (see Big Hole Basalt below).

Figure 10. Ash Flow Tuff, Stevens Peak.

In the Idaho Falls-Blackfoot area, the Raft Formation unconformably overlies the Walcott Formation; it is interbedded with the Big Hole Basalt. The only exposure in the study area is in Lincoln Creek Valley, in E½, SE¼, sec. 10, T3S., R36E. The exposed thickness near American Falls southwest of the study area is about 75 feet (Wilfred and Trimble, 1963, p. 22); it is about eight feet thick in the study area (Plate 1).

Stearns and Isotoff (1956, p. 27) tentatively assigned an age of late Pliocene to the Raft Formation; no fossils were found. Wilfred and Trimble (1963, p. 24) report that mollusca have been obtained from two stratigraphic levels of the Raft Formation. Fresh water clams, Sphaerium Striatinum (Lamarck), fresh water snails, Valvata Humeralis (Say), were identified by D. W. Taylor (Wilfred and Trimble, 1963, p. 24) who considered them to be middle to late Pleistocene.

Big Hole Basalt

The Big Hole Basalt was named by Wilfred and Trimble (1963, p. 25) at the basalt-rimmed inlet at Big Hole on the western side of American Falls Reservoir about three miles east of Aberdeen. This basalt is a part of the Snake River Basalt.

The Big Hole Basalt in adjacent areas has been assigned to the Pleistocene by Anderson (1931, p. 21) and Stearns and others (1938, p. 56), but it is thought by some authors to be Pliocene to Recent in age (Stearns and others, 1938, p. 80).

The basalt rock is composed primarily of calcic plagioclase that generally ranges in composition from bytownite to labradorite and pyroxene. It commonly contains minor olivine crystals which have been unaffected by weathering. The basalt characteristically is dense, bluish gray (5 B 5/1) to medium dark gray (N4).

The Big Hole Basalt encompasses a series of overlapping flows which erupted from several centers. In the Idaho Falls-Blackfoot area, this basalt crops out south and southwest of the Snake River. Thicknesses ranging from 150 to 250 feet were determined from the well logs. The thickness of flows are variable in part because flows include layers of basaltic cinders, rubbly basalt, and interflow deposits (Figure 11). Well logs and excavations at some places show that beds of clastic sediments a few feet or a few tens of feet in thickness are intercalated with the basalt. These sediments may be called Raft Formation. The upper crust of any single basalt layer generally has a vesicular structure caused by steam and other gases entrapped in the molten lava (Figure 12). Its upper surface may be pahoehoe and is generally rough and broken with pressure ridges due to contemporaneous crusting, flowing and draining of the lava (Figure 13). Consequently, many openings, some of which are extensive, occur between the successive flows and, as discussed in hydrostratigraphy, are capable of holding great quantities of water. The interior of a basalt layer, formed from a lava extrusion

Figure 11. Basalt intercalated with clay, National Reactor Testing Station (not in study area).

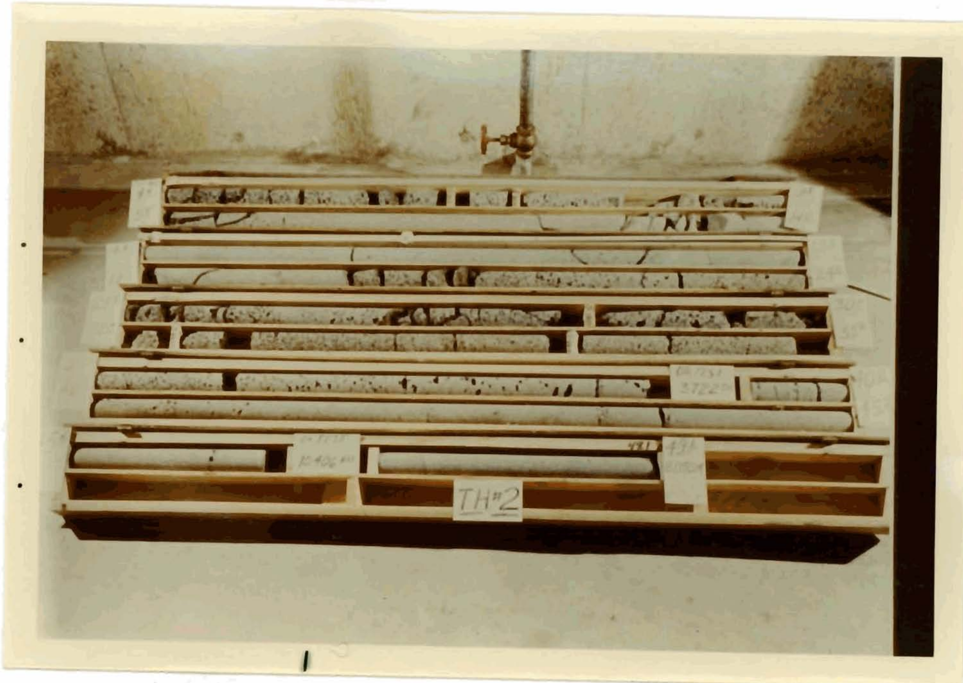

Figure 12. Vesicular structure in upper part of basalt, National Reactor Testing Station (not in study area).

Figure 13. Rugged upper surface of basalt with pressure ridges.

that ceased movement and cooled gradually, is generally fine-grained and compact. In the process of cooling, contraction created joints and fissures, which provide for poor storage but good circulation of water (Figure 12).

Loess Deposits

Loess in the Idaho Falls-Blackfoot area forms an extensive mantle on the basalt west and southwest of the Snake River. It has been deposited in the valleys and on the flanks of the adjoining mountain ranges up to an altitude of 6,000 feet. The loess in the area overlies the Pleistocene Basalt and Ash Flow Tuff rocks. The loess is Pleistocene in age and may have been derived largely from the Raft Formation. The thickness of the loess in the hill front in the southeastern part of the study area is unknown; it may be at least 150 feet. In some places, west and southwest of the study area, the average thickness is 25 feet.

The loess is a light brown (5 YR 6/4), poorly indurated, very well-sorted silt and contains about 20 percent calcium carbonate. The grain diameter ranges from 0.009 mm to 0.07 mm (Davis and DeWiest, 1966, p. 406). Loess constitutes a good wastewater renovation medium where it is unsaturated.

A coarse eolian quartz sand with unknown thickness has been identified in outcrops in the northwestern part of the Lincoln Creek Valley near the Raft Formation. The coarse sand overlies silicic volcanic rocks of Tertiary age and contains several cross-bedded, pebbly sand lenses, small fragments of Walcott Tuff Formation, and quartzite. The coarse sand is light-gray (N6) to light brown (5 YR 6/4), coarse-grained, and cemented by films of calcium carbonate. This coarse sand is different in grain size and color from the normal pinkish dune sands described further on.

This sand probably has been largely derived from the Raft Formation. This unit was included in the deposits mapped as loess in this paper and are Late Pleistocene in age (Plate 1).

Older Alluvium

The alluvial deposits in the study area are separated into an Older and Younger Alluvium. The Older Alluvium deposits differ from the Younger Alluvium stratigraphically only in that the older deposits are now expressed as terraces above the level of the present day Snake River flood plain.

The Older Alluvium was deposited late in the Pleistocene when the Snake River and its tributaries were flowing above the current river levels. During this part of the Pleistocene, streams like the Snake River carried a much greater load than they do now. To accomodate this load, stream gradients were increased by depositing alluvium until a dynamic equilibrium was reached. This elevated gradient and the alluvial material deposited is now recorded by remnant terraces above the level of the modern Snake River and tributary flood plains. Locally, on the east side of the Snake River, these remnants have been named the Gibson Terrace in the southeastern part of the area of study and the Snake River Pinedale Alluvial Terrace to the north. A lower terrace of Older Alluvium persists west of the Snake River flood plain but is unnamed in this report.

Gibson Terrace--The Gibson Terrace rests on an irregular surface of basalt and silicic volcanic and sedimentary rock in the southeastern part of the study area (Plate 1). As noted above, Gibson Terrace is a remnant of Older Alluvium which was deposited over much of the areas during Pleistocene channel and flood plain alluviation. Subsequently the Snake River eroded part of the flood plain leaving the Gibson Terrace bordered by the Fort Hall Bottoms.

The detritus of the Gibson Terrace alluvium range from gravel to clay size. A well-sorted sand is common in the upper 50 to 110 feet. The composition of the lithic fragments in the Gibson Terrace reflects as much the deposition of the tributary Ross Fork as it does the main stream Snake River. The more locally derived volcanic detritus and the weak fan-shaped distribution around the mouth of the tributary make the Gibson Terrace a mappable unit.

The Gibson Terrace is one of the most important aquifers in the study area and its internal makeup is described in more detail in the section on HYDROGEOLOGY which follows as is the makeup of other Older Alluvium deposits.

Snake River Pinedale Alluvial Terrace--North of the Gibson Terrace is another Older Alluvium terrace herein named the Snake River Pinedale Alluvial Terrace. This terrace presently stands from 25 to 35 feet above the Snake River and extends northeastward from the Blackfoot area to Rigby beyond the study area.

The Older Alluvium in this terrace is mainly lithic gravel which is composed of all rock types across which the upstream Snake River has flowed. The rock types include Precambrian, Paleozoic, and Mesozoic chert, quartzite, and coarse- and fine-grained highly indurated sandstone. Tertiary and Pleistocene silt, clay, tuff and volcanic detritus also are present.

Across the Snake River northwestward from the Snake River Pinedale Alluvial and Gibson Terraces is another Older Alluvium terrace of similar composition and internal makeup. This unit is mapped (Plate 1) as Older Alluvium but is left unnamed. The surface of this terrace, which persists along the northwest side of the modern Snake River flood plain, extends northeastward from the American Falls Reservoir to beyond the study area. In general, this terrace is 30 to 35 feet lower than the Older Alluvial terraces on the east side of the Snake River. This lower elevation may represent a truncated surface which was created as the Snake River began to cut down in Recent time and to migrate into its present position.

No evidence could be found that the Pleistocene Sterling Terrace described by Poulson and others (1943, p. 5) which was adjusted to a higher stand of the Snake River near the American Falls Reservoir to the southeast extends northward above the lower Older Alluvium terrace west of the Snake River. It is possible that the two terraces grade together but the nearly horizontal Sterling Terrace appears to die out where the Snake River empties into American Falls Reservoir.

Younger Alluvium

Recent alluvium is mainly gravel, sand and silt. It consists, to a large extent, of cobbles of older silicic volcanic units and resistant rocks from the mountains bordering the area. Recent alluvial deposits occur in the bottoms of small valleys of such streams as Blackfoot River and Lincoln Creek and form islands and bars in and along the Snake River. The Snake River from southwest of Ferry Butte to the American Falls Reservoir, in particular, has left many islands and bars in the meanders.

Several springs flowing from beneath Gibson Terrace form a Yazoo stream which meanders on the Recent alluvium for some distance parallel to the main channel because natural levees prevent the stream from entering the Snake River.

Dune Sand

A long narrow belt of Recent sand dunes extending from Blackfoot Reservoir northeastward to near Ammon rests on the Snake River Pinedale Alluvial Terrace gravels (Plate 1). The dune sand is probably as much as 30 feet thick in some places; the average thickness is about 10 feet (Figure 14). The dune sand has been supplied by sediment from the Blackfoot River and Lincoln Creek, and is composed of minor volcanic constituents derived from the various tuffaceous volcanic units exposed upstream.

Soil

Soil has developed over almost all of the area of study with the exception of a few basalt flows and Recent dune and alluvial surfaces. The distribution of soils is shown on Plate 3. Appendix IV gives a breakdown of the units as they are recognized by Chugg and others (1968, p. 52).

The consideration of soil is an important factor in the reuse of wastewater. Its effect on infiltration rate and filtration effectiveness is discussed in the section of Selected Sites.

Figure 14. A dune sand in a long narrow belt extending from Blackfoot Reservoir to near Ammon.

GEOLOGIC HISTORY

Three major structural episodes have affected the geology of the area and, in part, the hydrologic properties of the late Tertiary sediments and volcanic units which occupy near-surface positions on or about the Snake River plain. These structural events are the Laramide orogeny, Basin and Range faulting and Snake River plain subsidence.

The Cordilleran geosyncline which occupied the area of most of the western states from pre-Paleozoic times to the end of the Mesozoic was terminated by the Laramide orogeny in southern Idaho in Cretaceous and early Tertiary time. The marine rocks were thrust faulted by compressional forces and intruded by plutonic bodies. The resulting induration and rock types are reflected in the many hard, resistant lithic sands and gravels of the present Snake River alluvial deposits. These materials are being derived by the Snake River from the Middle and Northern Rocky Mountain provinces where Paleozoic and Mesozoic rock is exposed.

After the Laramide orogeny had fairly well spent itself and degradational processes became dominant, a post-orogenic Basin and Range normal-fault deformation developed. The thrust sheets and deformed indurated rock associated with the Laramide orogeny were broken by this post-orogenic phase in southeastern Idaho into northwest trending ranges and valleys starting in Miocene time. The drainages which supply water and sediments to the Snake River plain from the mountains nearby reflect the structural pattern. This influence results, in part, from the fact that Basin and Range fault movement continues to a small degree to the present and controls the physiography.

Subsidence of the Snake River plain area appears to have started in Pliocene time. This northeast oriented depression cut across Basin and Range features and became the site of accumulation for sediments and locally sourced volcanic rocks which now underlie most of the area of study. This structural depression, which persists across southern Idaho (Plate 4), may be a simple downwarp as suggested by Kirkham (1931, p. 457), or may have boundary faults as indicated by Trimble (oral communication). This paper follows Trimble and shows the Snake River plain to be bounded by a fault (Plate 1). Nevertheless, tilting associated with subsidence of the Snake River plain is apparent in late Tertiary and early Quaternary sedimentary and pyroclastic rocks. Northwestward-dipping units are common among the southeastern margin of the study area.

The basalt flows and sediments beneath the Snake River plain represent a geologic episode of lava extrusion and solidification, stream deflection and ponding and sediment accumulation. Buried channels and sediments are common beneath the basalt plain. In late Pleistocene, alluviation occurred from climatic influences; the remnant terraces represent the only preserved record of stream erosion on the plains of the study area.

To summarize, the near surface geologic setting within the study area is rather simple because only late Tertiary and Quaternary rocks are present. Nevertheless, surrounding areas have rocks of very complex histories exposed and are contributing the detritus which makes up the unconsolidated formations making up aquifers and potential wastewater recharge units. As observed above, the dominant structural feature of Tertiary rocks is a gentle regional dip toward the Snake River. The Starlight Formation dips generally between 10° to 30° NW; but the Walcott Tuff and Neeley Formation dip 1° to 5° NW. Rocks younger than the Raft Formation, with the possible exception of the Big Hole Basalt, are not faulted and are flatlying or have initial dips. Basalt flows and fluvial sediments are the dominant rock at shallow depths beneath the Snake River plain.

HYDROSTRATIGRAPHIC UNITS

The preceding section discussed the general Tertiary and Quaternary rock types found in the Idaho Falls-Blackfoot area, their outcrop distribution, and geologic history. In this section, the shallow, subsurface natural hydrogeologic properties of these rock units are reviewed to determine what groundwater conditions and responses can be anticipated if recharge consequent to wastewater reuse occurs in the area.

The rock units in the area subdivide into three major hydrostratigraphic units because of their common physical properties and effect on groundwater. From oldest to youngest, these hydrostratigraphic units are (1) the Tertiary Starlight Formation, Neeley Formation and Walcott Tuff and the Quaternary Ash Flow Tuff; (2) the Quaternary Big Hole Basalt; and (3) the unconsolidated Quaternary Older and Younger Alluvium. Minor hydrostratigraphic units include the loess veneer and soil cover. Each hydrostratigraphic unit represents a "body of rock with considerable lateral extent that comprises a geologic framework for a reasonably distinct geohyrologic system" (Maxey, 1962, p. 203).

Within the following discussion of each hydrostratigraphic unit, groundwater properties are first reviewed. Then the potential of the unit for future groundwater development and wastewater renovation and recharge is evaluated.

Starlight-Neeley-Walcott-Ash Flow Tuff Hydrostratigraphic Unit

The Starlight-Neeley-Walcott-Ash Flow Tuff unit is the poorest of the hydrostratigraphic units in the area. The more silicic varieties of volcanic rock which typify this unit differ considerably with respect to groundwater from the basalt and alluvium hydrostratigraphic units. As a rule, they yield much smaller supplies and are good for domestic purposes only. They contain fewer large openings and do not have definite water horizons between successive deposits. Tuffs may supply many shallow dug wells by slow seepage from the upper parts that are weathered. Deeper wells that penetrate faults or shear zones where the rock is broken and weathered to intermediate depths produce minor amounts of water. Experience has shown that little is accomplished by deep drilling in these rocks, but where necessary, supplies can be developed by sinking numerous shallow holes or by excavating below the water table (Meinzer, 1923, p. 142).

Groundwater seeping from the Starlight-Neeley-Walcott-Ash Flow Tuff units as springs exemplify its weak aquifer properties. The Cold Creek, Whiterock, Cowboy, Dixey and Buckskin Springs that issue from these compact silicic rocks yield small and less regular flows than the basalt or alluvial units. The small and irregular flows also reflect the shallow sources which result from the elevated, tilted portions of these units along the flanks of the Snake River plain.

The low permeability of this hydrostratigraphic unit makes it a poor prospect for reuse of wastewater. Although the unit generally has an adequate unsaturated zone where exposed and would tend to filter wastewater well, it can not absorb large enough volumes of water to make efficient use of a surface-water supply. Its general outcrops are away from the population and farming centers which would add large transportation costs to any disposal project.

Big Hole Basalt Hydrostratigraphic Unit

The Big Hole Basalt ranks as the second most important water-bearing rock in the Idaho Falls-Blackfoot area. The total yield capacity normally is large. Basalt layers are in discontinuous sheets over extensive areas and form the only economically feasible shallow groundwater supply throughout some of the area northwest of the Snake River. This unit is covered by one to 50 feet of loess and minor wind-blown sand. It also lies at depths near the river and may be a secondary, deeper aquifer.

As described in the geology section, basalt is extremely vesicular, fractured and jointed (Figure 12); therefore, it takes in surface water very readily unless a soil or loess veneer is acting as a blotter.

Groundwater is stored in large openings and other cavities (Figure 15). Not all of the basalt, however, will store or yield water. The interior dense parts of large lava flows are likely to be very unproductive except where they are jointed; drilling to deep flow contacts will generally yield adequate water for most purposes (Figure 16).

Alluvial Hydrostratigraphic Unit

The Older Alluvial of the Gibson Terrace, the Snake River Pinedale Alluvium Terrace and related terrace feature plus the Younger Alluvium of the flood plain make up the best hydrostratigraphic unit in the area. It is the only hydrostratigraphic unit which regionally can be considered a good aquifer. As noted in the Geology section, the various aged alluvial deposits are similar in composition and depositional feature; they simply represent different levels of Snake River deposition.

This hydrostratigraphic unit consists of washed boulder to granule gravel, sand, silt and clay, locally cemented by hardpan which precipitated from upward migrating groundwater as it evaporated. The porosity and permeability of these alluvial sediments are generally high. Well yield varies from medium to high because of variations in sorting and thickness of the deposits from place to place.

Gravel beds in the alluvium are the best aquifers. They supply most of the better wells and furnish more water to wells than all other units within the alluvial deposits combined. The coarse, clean gravels have a high porosity, high permeability, and high specific yield. They absorb water readily, store it in large quantities, and yield it freely to wells. The clean gravels were deposited chiefly by large,

Figure 15. Large openings in the basalt permit groundwater storage.

Figure 16. Interior dense block basalt intercalated with clay, National Reactor Testing Station (not in study area).

swift streams whose velocity decreased because of channel shape, course shifting or general gradient change. It should be noted, however, that there can be a great range in the water-bearing properties in gravels, because of the varying admixture of fine sediment and cementation.

The water in gravel beds normally is of a good quality. When it entered the gravel, it contained little contamination. The groundwater also receives relatively little mineral matter from stable rock types forming the gravel. There is little opportunity for the water to react in the interstices of the gravel where the specific surface area is small (Meinzer, 1923, p. 118).

The gravel deposits of this hydrostratigraphic unit form a continuous flat-topped mass from Roberts to American Falls and are especially conspicuous on the eastern sides of the river. In some places, the gravel overlies basalt, and may also be interbedded with it. In a few places, the gravel rests on older rocks.

Some tests of the rate of shallow groundwater movement near Firth, in coarse, clean gravel, give velocities averaging 5 feet an hour. Similar tests in material of the same kind on the north bank of the Snake River, opposite the mouth of Blackfoot River, give results of about 4 feet an hour (Stearns and others, 1938, p. 91).

Sand beds generally are excellent as water-bearing units. The water-bearing character of a sand unit is affected, however, by the size of the grains, the degree of sorting, the degree of cementation, and the amount of jointing. The size of the grains is very important because a coarse sand, if well-sorted, yields freely; whereas an equally well-sorted, fine-grained sand bed holds a large part of its water and surrenders the remainder slowly. A fine, loose sand is unsatisfactory as a source of water. It also may seriously hinder the completion of a well by pressing so hard upon the outside of the casing as it is being set that it becomes impossible to drive the casing further down. Loose sand may also run into a well and fill much of it. By running into a well, fine sand may damage the pump, erode the casing, and frequently it will clog the aquifer.

A sand bed is, as a rule, more continuous and widespread than a coarse bed of gravel. Deposits of sand generally are better sorted than deposits of gravel because their depositional environment was less turbulent and erratic.

In the area east of Idaho Falls, south of Ammon, east of Firth, and on the Gibson Terrace, many of the sand deposits are clean. In the area northwest and west of Idaho Falls and north of Pingree, many of the sand deposits contain a clay matrix which spoils their water transmission capacity.

The units of the alluvium that consist of silt and clay are light brown (5 YR 6/4) in color, soft and poorly consolidated. These deposits have high porosities but very low permeabilities and yield very little water to wells. Commonly, the fine-grained units may act as barriers to the movement of water.

Most of these deposits are above the water table. Where wells penetrate fine sediments below the water table, the water may come into wells from relatively sandy or gravelly lenses or may trickle in from small crevices.

The low permeability of silt and clay units make them desirable for filtration and they will be beneficial when part of a wastewater reuse cycle, however expanding clay should be avoided.

Loess Hydrostratigraphic Unit

Loess, one of the minor hydrostratigraphic units in the area, is a porous material that has such a size that it has a high water-returning capacity, but permits only slow percolation. It, therefore, has the hydrologic properties for making an excellent soil and a good renovater of wastewater but a poor transmitter of groundwater. In most places west and southwest of Idaho Falls, the loess forms a veneer of a few feet in thickness. However, in the eastern and southeastern elevated parts of the cities of Idaho Falls and Blackfoot, it attains a thickness of 50 to 150 feet. In the elevated parts, the loess is some distance above the water table. The water in loess is likely to be hard but otherwise of good quality.

Soil Hydrostratigraphic Unit

Soil is the other minor unit and it is discussed in the Soil section. Like the loess, soil normally is in thin units above the water table. The principal effect in the study area is that of holding and filtrating rather than transmission.

Distribution of Unconsolidated Sediments

Unconsolidated materials are expected to offer maximum potential for renovation of wastewater. The thickness and distribution of unconsolidated materials above the bedrock in the study area are shown on Plate 5.

The Snake River Valley has been partially filled by up to 600 feet of fine to coarse alluvial materials. With respect to the reuse of wastewater, the most promising locations of thick unconsolidated sediments are between the hill fronts and the Snake River southeast of the river. The locations are in Tps. 1, 2, and 3N., Rs. 37 and 38E., Tps. 1 and 2S., R. 35 and portions of Rs. 36 and 37E., Tps. 3 and 4S. and a portion of T.5S., Rs. 34 and 35E., and T.4S. and a portion of T.5S., R.33E. In the Moreland-Groveland area northwest of the Snake River, reuse potential is good because unconsolidated material is moderately thick and has only a small percentage of gravel.

Distribution of Unsaturated, Unconsolidated Sediments

The areas which have more than 50 feet of unsaturated, unconsolidated sediments have very good reuse potential; areas having 10 to 50 feet of unsaturated, unconsolidated sediments have a good potential for wastewater reuse. Poor areas with less than 10 feet of unsaturated, unconsolidated sediments are shown in Figures 17, 19 and 20. The thickness of unsaturated, unconsolidated sediments above the water table in the study area is presented on Plates 7 and 12. Plate 7 shows a considerable portion of the area to be underlain by more than 10 feet of unsaturated, unconsolidated sediments. Unsaturated, unconsolidated sediments are less than 10 feet in thickness only where noted by the blank areas on Plate 7.

Plate 12 is a contour map of the elevation of the bottom of the unconsolidated, unsaturated materials above the water table; the datum is mean sea level. From this map it is feasible to accurately estimate the thickness of unsaturated material in areas of irregular surface topography.

Additional information will be discussed on these areas of thick unsaturated zones subsequently in this report.

Figure 17. View north from Stevens Peak toward Blackfoot showing near surface groundwater illustrated as less than ten feet deep in Plate 7.

Figure 19. View to the southwest from Ferry Butte showing area mapped as less than 10 feet above water table in Plate 7.

Figure 20. Panoramic view N.E., N., N.W. from Ferry Butte showing area mapping as less than 10 and 10 to 50 feet above water table in Plate 7.

HYDROLOGY

Groundwater

Preceding chapters have discussed the physiographic, meteorologic, geologic and hydrostratigraphic conditions which strongly influence the groundwater regime in the Idaho Falls-Blackfoot area. These conditions, when combined with field data of water well observations and effluent groundwater locations lead to interpretations about the present water table, the disposition of recharge and discharge areas, the types of groundwater flow systems in operation, and the distribution of unsaturated materials which could act as desirable sites for artificial recharge and storage of wastewater.

The following terms are used frequently throughout the remainder of the text and are defined here for ready reference.

The water table as used herein will refer to a water surface beneath the ground surface below which the rock pores are saturated and above which the rock is unsaturated. In general the groundwater table is marked by the level at which water stands in shallow wells. Freeze (1969, p. 2) defines natural groundwater recharge as "the water which percolates down through the unsaturated zone to the water table and actually enters the dynamic groundwater flow system". He also defines discharge as "that water which is discharged from the dynamic groundwater flow system by stream base flow, springs, seepage".

Toth (1963, p. 4806) defines a groundwater flow system as "a set of flow lines in which any two flow lines adjacent at one point of the flow region remain adjacent through the whole region, and that can be intersected anywhere by an uninterrupted surface across which flow takes place in one direction only" (Plate 6). A local flow system has its recharge area at a topographic high and its discharge area at an adjoining topographic low. A regional flow system is one whose recharge area occupies the basin's major water divide and whose discharge area lies at the bottom of the basin.

A discharge area is an area where the direction of groundwater flow is upward toward the water table (Freeze, 1969, p. 2). In the discharge area, the vertical component of groundwater potential increases with depth (Toth, 1963, p. 4810). A recharge area is an area where the direction of groundwater flow is downward away from the water table, and the groundwater potential decreases with depth (Freeze, 1969, p. 2). A hinge line is a line on the surface of the water table that separates a recharge area from a discharge area (Toth, 1963, p. 4800).

Water Table

The water table in the Idaho Falls-Blackfoot area is depicted on the water table map (Plate 6). This map shows at what elevation the rock is saturated. The water table in this area more or less coincides with the topography and slopes toward the southwest and west.

The water table contour interval on Plate 6 is 50 feet for much of the area. Where more detailed data were available in the southwestern part of the study area, an auxiliary 10-foot contour interval is added. The relatively closely-spaced equipotential contour lines east of Idaho Falls indicate steep slopes on the water table and high gradients which are about 25 feet to the mile. At a lower elevation, in the flat areas between Idaho Falls and American Falls, the equipotential lines are widespread and the water table has low slopes and a low gradient. In this area, the gradient of the water table is less than 4½ feet to the mile.

The meager data gathered from deep wells indicate that many of the basement rocks below the unconsolidated material on the plain are probably composed of low permeability siliceous volcanics. The gradient of the water table in the area then is somewhat determined by the sub-basalt floor of the ancestral Snake River Valley.

In most of the main perennial stream valleys tributary to the Snake River, however, the depth to the water table is less than 50 feet.

In some areas away from the major drainage, the groundwater table is not less than 250 feet below the surface west and northwest of Idaho Falls except in the vicinity of irrigation (Plate 8).

Ground water moves from places of recharge to places of discharge down the hydraulic gradient at approximately right angles to the contours on the water table or pressure surface. The approximate direction of groundwater flow in the Idaho Falls-Blackfoot area in the fall of 1970 is shown by the flow-net map on the water table (Plate 6) and by records of representative wells (Appendix V).

Stearns and others (1938, p. 109) have described the water table and concluded that the contour lines show a groundwater "cascade" from between Idaho Falls and Roberts northwest to Market Lake out of the study area. The cascade may start as far northwest as Mud Lake and Medicine Lodge Creek.

The delineation and significance of the hydrologic boundaries of the Snake Plain aquifer are described in some detail by Mundorff and others (1964, p. 193), and their mapping of the boundaries are shown in Plate 9 of this study.

Groundwater Recharge

Groundwater recharge commonly is by infiltration of precipitation and by percolation of river channels, water from irrigation canals, and irrigated fields. In the Idaho Falls-Blackfoot area, precipitation is rainfall (up to 10 inches) and snowfall (up to 50 inches in the adjacent mountain ranges).

The Snake River and its tributaries contribute water by percolation into the ground surface along some reaches. Both the Snake and Blackfoot Rivers are above the water table in the vicinity of Blackfoot and are influent streams contributing water to the water table in this area. Locally Willow Creek, Lincoln Creek, Ross Fork and the Blackfoot River contribute water by seepage.

The amount of recharge from irrigation grossly depends on the amount of water supplied to the land in excess of crop needs and on the permeability and moisture-retention capacity of the sub-surface materials. The importance of irrigation water to groundwater recharge is shown by the pronounced rise in the water table, generally 15 to 30 feet, each spring after irrigation begins (Mundorff and others, 1964, p. 36). The final proportional disposition of irrigation water as soil moisture, surface waste, and groundwater recharge in the study area, however, is not known.

Groundwater Discharge

Groundwater discharge generally is most obvious in the form of springs. Groundwater may also be lost to surface water bodies along stream and lake bottoms. The Idaho Falls-Blackfoot area contains many springs. They extend from the mouth of the Blackfoot River southward to the Portneuf River beyond the study area. Many flow from beneath the Gibson Terrace and are grouped along the margins of the Fort Hall bottoms, now partly flooded by the American Falls Reservoir. Most of these springs flow on the valley floor at elevations of 10 to 15 feet above the river and have a fairly steady discharge.

Springs account for about 28 percent of the water that enters the American Falls Reservoir, or about 1.8 million acre-feet per year (1954-65 average). Much of the water from these springs flows into the Snake River above American Falls Dam and is captured in that reservoir (Norvitch and others, 1969, p. 20). Most of the springs issue from basalt which underlies the alluvium in the area. Many of the minor springs and seeps along this section of the river have come into existence since irrigation began and derive their water largely from percolation losses from nearby fields. There are some minor discharge points which appear as seepages in Lincoln Creek and in the higher adjoining ranges. These seepages discharge several cubic feet per second and supply a large part of the groundwater in Lincoln Creek and in Buckskin Basin (West and Kilburn, 1963, p. 21).

Groundwater Flow Systems

An analysis of the flow systems in the study area indicates that generally groundwater is moving westward beneath most of the areas of recharge. Evidence indicates that the groundwater turns to the southwest and discharges into the reach of the Snake River between Blackfoot and American Falls.

Local influences are apparent in the groundwater system (Plate 6) east of the Snake River where a high in the water table exists. This results from a local flow system with recharge from precipitation in the foothills, from irrigation, and from nearby streams. The discharge points of this flow system are seepages in the Fort Hall Bottoms and probably in the bottom of American Falls Reservoir.

The regional flow system probably underlies this local flow systems east of Snake River. West of the Snake River, the flow appears to be mostly regional where the main recharge comes from the uplands to the north and northeast. No discharge from this flow system has been found in the study area.

To summarize, it is believed that the percolating water from rainfall, the water lost from the Snake River and other streams, and the water percolating away from irrigated areas sinks rapidly until it reaches the water table. It then flows toward the south and southwest until it is discharged into American Falls Reservoir. A portion of the seep water probably moves to the southwest at much greater depths under the Snake River plain.

Mundorff and others (1964, p. 196) constructed an approximate flow net, which is reproduced as Plate 9 in this study. Areas and amounts of recharge and discharge, direction, and amount of underflow, are shown by flow lines representing underflow of 200 c.f.s. each. Because of lateral and vertical variations in permeability, these lines do not everywhere cross the contour lines at right angles as they theoretically would if the aquifer were completely isotropic. Furthermore, the flow net is intended to be only an approximation to the prototype.

Groundwater Characteristics

According to the U. S. Salinity Laboratory staff (1954, p. 75), "The characteristics of an irrigation water that appear to be most important in determining its quality are: (1) total concentration of soluble salts; (2) relative proportion of sodium to other cations; (3) concentration of boron or other elements that may be toxic, and (4) under some conditions, the bicarbonate concentration as related to the concentration of calcium plus magnesium".

The concentration of soluble salts can be estimated for approximate classification of water for irrigation by electrical conductivity expressed as specific conductance. The four salinity-hazard classes based on specific conductance are as follows:

C1, less than 250 micromhos, low salinity hazard;

Cl_2, 250 to 750 micromhos, medium salinity hazard;

Cl_3, 750 to 2250 micromhos, high salinity hazard;

Dl_4, more than 2250 micromhos, very high salinity hazard.

In the study area, water samples were collected from wells and analyzed for electrical conductivity expressed as specific conductance (micromhos). Total Dissolved Solids (TDS) include all the dissolved cations and anions. In this report, TDS was obtained by multiplying the specific electrical conductance by a factor of 0.64. The general areal distribution of the Total Dissolved Solids is given in Figure 18. High concentrations are found in deep water and in shallow water in areas where human activities have affected the groundwater. Increased human activities may be the cause for the high values of TDS in wells Nos. 2N-38E-(1dc1, 26cd1), near Ammon, which are shallow (Figure 18). (APPENDIX I for Well Numbering System).

The chemical quality of groundwaters in the study area is suitable for most purposes for which they are now used.

Chemical analyses, in parts per million, of water in the Idaho Falls-Blackfoot area are given in Table 2.

The maximum value of the Total Dissolved Solids is 476.7 ppm (parts per million), and the minimum is 195.2 ppm, whereas, the values for surface waters range from 249 to 315 ppm.

Evapotranspiration and the use of fertilizers and soil conditioners increase the concentration of T.D.S. in water infiltrating to the water table. Artificial recharge with surface water and wastewater could improve the chemical quality in some areas by diluting the dissolved solids content of the groundwater.

pH

The groundwater pH range is from 7.3 to 8.3 with an average of 7.4 in the municipal wells.

Groundwater Temperature

Groundwater temperatures in the study area range from 6°C in well no. 3S-36E-2cb1 to 18.8°C in well no. 4S-34E-36add1, and the average temperature is 11.8°C (Appendix V). Below the irrigation canals, considerable contribution to groundwater takes place from the colder irrigation water and

Table 2

Summary of Chemical Analyses of Water in Idaho Falls-Blackfoot area in parts per million
Analytical agencies: IDPH, Idaho Department of Public Health

Well Location	Date of Analysis	Agency Making Analysis	Temperature (centigrade)	pH	Total Dissolved Solids	Bicarbonate (HCO_3)	Hardness ($CaCO_3$)	Calcium (Ca)	Magnesium (Mg)	Iron (Fe)	Manganese (Mn)	Fluoride (F)	Sodium (Na)	Chloride (Cl)	Sulphate (SO_4)	nitrate (NO_3)	Phosphate (PO_4)	Color	Turb.	Per cent Sodium	Alkal Carbonate
City of Idaho Falls																					
2N-38E-19db1	19-8-69	IDPH	11.5	7.7	390	140	288	74	25	<0.01	0.03	1.31	40	106	39	9.7	0.04	<5TU	<25JTu		136
2N-37E-13da2	"	IDPH	12	7.7	300	132	272	70	23	0.13	0.01	1.22	26	82	40	6.4	2.01	<5TU	<25JTU		
24aad3	"	IDPH	11	7.7		128	300	72	29	0.07	<0.01			95	43	9.8	0.41	<5TU	<25JTU	5%	
2N-38E-17cb4	"	IDPH	11	7.8	340	112	248	54	28	1.10	0.02	1.34	32	70	40	7.0	0.06	<5TU	<25JTU		
2N-37E-30ba5	"	IDPH	11	7.7	380	268	64	26	.05	0.02		1.37	68	39	--	8.26	---	<5 U	<25JTU		120
43ca6	"	IDPH	11	7.8		97	268	51	34	0.05	0.03	1.37	72	40	40	5.5	0.08	<5TU	<25JTU		
2N-38E-16cd7	"	IDPH	13	7.8	380	120	256	56	28	0.08	0.05	1.31	40	93	40	8.7	0.04	<5TU	<25JTU		
2N-38E-20dc8	"	IDPH	11	7.8		116	288	48	40	0.04	0.03	1.31	46	91	42	8.0	0.03	<25TU	<25JTU		
20cd9	"	IDPH	11	7.7		120	264	48	25	0.11	0.02	1.44	37	85	40	9.7	0.01	<5TU	<25JTU		
20dc10	"	IDPH	11	7.8	380	136	240	64	19	0.10	0.02	1.41	32	85	39	8.9	0.03	<5TU	<25JTU		
2N-37E-23ca11	"	IDPH	11	7.7	335	136	256	48	33	0.08	0.01	1.25	26	87	43	9.2	0.01	<5TU	<25JTU		
Shelley Municipal 1N-37E-37bd1	4/14/65	IDPH	--	7.9	300	190	260	91	8	0.09	0.00	0.32	--	47	62	0.5	---	---	---		190
Firth Municipal 1S-36E-25db1	5/26/46	IDPH	12.7	7.3	312	210	277	63	17	0.05	---	0.60	--	11	32	---	---	---	---		210
Blackfoot Municipal 3S-35E-4dbc	6/30/59	IDPH	--	7.5	400	104	176	48	4	0.60	0.00	0.64	42	27	42	---	0.04	---	---		
Fort Hall Municipal 4S-31E-dd1	7-8-64	IDPH		8.2	310	163	116	25	10	0.02	0.02	0.33	28	15	17	0.1	---	---	---		
Iona Municipal 2N-38E-1dd1	6/11-45	IDPH		8.0	470	136	310	83	25	2.80	---	0.00	--	18	42	---	---	---	---		136
Ucon Municipal 3N-38E-14bb1	18-6-45	IDPH	13.3	7.4	376	250	282	73	24	0.20	---	0.20	--	12	45	---	---	---	---		250

and canal seepage which decreases the shallow groundwater temperature.

REUSE OF WASTEWATER

Expansion of industry and population in the Idaho Falls-Blackfoot area continually increases the demand for water resources. Concomitantly, if not consequently, the increased problems of waste disposal and water pollution indicate that lakes and streams can no longer dilute the quantities of effluent discharged into these bodies to levels acceptable for all users. The Department of the Interior's Federal Water Quality Administration (FWQA) has documented water quality problems of a very serious nature along the Snake River. Serious fish kills from dissolved oxygen depletion occur on an annual basis in some reservoirs. Communities have abandoned the domestic use of surface water because of problems with taste, odor, and bacterial contamination. Irrigators have suffered inconvenience when masses of aquatic vegetation have interferred with water transmission. Thick blooms of algae make the waters of the upper and central Snake River Basin a characteristic opaque green. Floating rafts of algae on the surface of the Snake form clinging slimes that adhere to rocks and banks.

The main causes of oxygen depletion problems are the low flows caused by irrigation withdrawals, by untreated or inadequately treated organic wastes, by the operation of storage reservoirs, and by resultant growth and decay of aquatic vegetation. Decomposition of organic wastes consumes oxygen, and under low flow conditions caused by irrigation withdrawals, the quantity of oxygen available is rapidly depleted. The principal source of organic wastes is industrial effluent from food processing industries along the river, but domestic and agricultural wastewater also is a significant source of organic material.

Another factor compounding the problem is the system of storage reservoirs on the Snake River. When a free-flowing stream is changed into a series of pools, the aquatic environment becomes more susceptible to algae and other plant productivity. Temperature stratification and detention time serve to increase biological productivity.

Excessive aquatic growths are related to the high concentrations of the basic nutrients, nitrogen and phosphorous, in the Snake River system. Phosphate concentrations rise steadily through the upper basin, and increase abruptly at the head of the American Falls Reservoir, where the Portneuf River enters the Snake. In addition, irrigation return flows, municipal wastes, animal wastes and the decay of aquatic biota all contribute to the nutrient balance which stimulates aquatic growth.

There are two principal sources which are the cause of bacterial contamination in the Snake River Basin: industrial and agricultural wastes. Both of these contaminants are carried by runoff into the tributary streams feeding the main Snake River.

Associated turbidity and sedimentation resulting from runoff and from irrigation returns during the summer are additional problems that occur along the Snake River.

The FWQA has documented the discharge of industrial wastes into the Snake system and reported that the load in 1967 was equivalent to the input of a population of 6.4 million people. It is recognized that agricultural effluent is probably significant.

Domestic effluent must be subjected to secondary treatment or its equivalent by 1972. But because of the volumes of effluent involved, it is questionable whether secondary treatment will ever be sufficient to reduce nutrient content of the industrial and domestic effluents to a satisfactory level. The State of Idaho is concerned with determining means of achieving this control, and the concern has resulted in the inauguration of a statewide effort to define alternatives for further renovation. This study is a part of this concern. Several communities and industries in the state are now reusing wastewater, and several others, Idaho Falls and Blackfoot among them, are looking further into the economics of wastewater reuse. For this purpose, thickness of unconsolidated sediments (Plate 5) and the thickness of the unsaturated zone of unconsolidated sediments (Plate 7) are presented in this report. In general, unsaturated portion of the unconsolidated sediments is thicker in the northeastern part of the area and thinner in the southwestern part of the area.

Wastewater is available from and near the cities of Idaho Falls, Shelley and Blackfoot. The type of irrigation system used for each crop is different. Near Idaho Falls, flood irrigation and corrugate irrigation predominate, with minor sprinkling or spray irrigation. Near Shelley, the type of irrigation systems used are flood irrigation adjacent to the treatment plant along with limited sprinkler irrigation. In the past, many food-processing companies have dumped wastewater which might be terrestrially disposed, directly into the Snake River (Williams, Eier, Wallace, 1969). An increase in the supply of water available for agricultural irrigation, and renovation of the wastewater by lowering nutrient content and removal of some of the dissolved solids from industrial wastewater, Biochemical Oxygen Demand (BOD) in the wastewater is reduced, and removal of bacteria from the wastewater occurs. In addition, such irrigation or surface spreading onto a soil system often will result in recharge to the groundwater of a portion of the effluent, with minimum threat to the continued quality of that resource.

Under proper hydrogeologic conditions, irrigation or surface application of wastewater to crops, pasture, or woodland can provide an economical method of renovation. This application is less costly than extensive advanced treatment of domestic and industrial wastewater. Where hydrogeologic conditions permit, surface application of wastewater can yield a level of treatment or renovation equivalent to that obtainable with the tertiary treatment processes currently available. Also irrigation with wastewater will generally result in increased crop production.

The major factors affecting the feasibility of wastewater reuse and limiting the selection of suitable reuse sites are: availability of wastewater for reuse, availability of appropriate topography and the occurrence of appropriate hydrogeologic conditions, particularly the occurrence of near surface unconsolidated, unsaturated materials with a low content of expanding clay minerals. The water table should be at least 10 feet and preferably more below the ground surface.

Availability of Wastewater

Considerable wastewater is available from the expansion of industry and population in the Idaho Falls-Blackfoot area. The Federal Water Pollution Central Administration (now it is Federal Water Quality Administration) noted that in 1967 the Idaho Falls and the Blackfoot area combined contributed 10.0 percent (in population equivalent) of the waste load for the Snake River (U.S.D.I., 1968). Some of this wastewater can be considered available for reuse in crop irrigation, especially near Idaho Falls.

Topography

The topography in the Idaho Falls-Blackfoot area ranges from smooth and nearly level to gently sloping and undulating, which should be adaptable to the distribution of wastewater.

Erosion is at a minimum in most places. If the wastewater to be used for irrigation or recharging is to be transported by gravity with minimum pumping, then the areas suitable for irrigation are limited to lands lower in elevation than the elevation of the wastewater sources. The central part of the study area is slightly higher at the east end which should aid in the transportation of wastewater toward the southwest. The arable lands in the study area are confined chiefly to an irregular belt adjacent to the Snake River. The flat or gentle sloping lands which have the greatest topographic potential lie in this area.

Hydrogeologic and Soil Characteristics

The hydrogeologic conditions cited herein are compatible with the reuse of wastewater in some parts of the study area. West of the Snake River locally overlying the basalt is a mantle of windblown sand and silt 10 to 70 feet in thickness. In the east and southeast overlying the basalt, thick unconsolidated deposits reach 600 feet and consist of gravel, sand, silt and clay.

The water table in most of the study area is more than 10 feet below the ground surface. On the valley floor of the Snake River, however, from southwest of Ferry Butte to American Falls Reservoir, the water table ranges from zero to 5 feet below the ground surface. The areas that have a thin unsaturated zone receive water from the Snake and Blackfoot Rivers. In general, the thickness of the unsaturated zone above the water table varies up to 120 feet.

Some of the principal factors governing the capacity of a soil to renovate wastewater are the character of the soil, stratification of the soil profile, and initial moisture content of the soil. A reconnaissance study of the soil in the Idaho Falls-Blackfoot area has been classified according to hydrologic groups by Chugg and others (1968a, 1968b) and are given in Appendix IV. Certain portions of the soil classification systems described by Morgan and others (1950) are also applicable to this study. Their classification will be referenced where it is utilized.

Selected Sites for Wastewater Reuse with Details about the Soil in Each Site

The sites recommended here for wastewater use were selected on the basis of the data presented in this report and on data provided by Poulson and others (1943, p. 14) and by Morgan and Poulson (1950,p. 18). These data are primarily hydrogeological in nature. Other factors, such as the presence of dispersible clays may need to be evaluated prior to use. Soils and selected sites are shown in Plate 10. Sites selected are divided into two categories: first class sites and second class sites.

First Class Sites

One suitable site for wastewater reuse is the Bannock gravelly, silty, clay loam which occurs in small widely scattered bodies throughout the area. The distribution of this soil is shown in Plate 10. These soils are located 1½ miles southwest of Coltman School in the northern part of the study area, in the area 1½ miles northeast and east of Idaho Falls Municipal Power Plant, to the south of the city of Idaho Falls near the river, 1 mile southwest of the city of Ammon, and 1 mile southeast of New Sweden (Plate 10). The soil surface consists of medium to heavy textured undulating terraces. The surface is slightly hard, non-calcareous, gravelly, silty clay loam. The percent slope is 0 to 2. The soil lies over beds of gravel and sand. The soil has a moderate to moderately high permeability. The water-holding capacity is moderate; natural fertility is medium; and it has only a slight erosional hazard. Generally the cropland is not ideal, but alfalfa, potatoes, wheat, peas, clover and sugar beets are grown. The thickness of the unconsolidated, unsaturated zone is, in general, less than 25 feet except for a few areas near the city of Idaho Falls (Plate 10). All areas of this site are under cultivation.

The second suitable site for wastewater reuse is the area covered by the Bannock loam. The Bannock loam soil occurs chiefly west of the Snake River in T.1N., R.37E., two miles south of the city of Idaho Falls to the north and northeast of Coltman School (Plate 10). The soil also occurs in an irregular-shaped area east of Ucon. The surface of the soil is medium to heavy textured, smooth and nearly level. The soil is a light brownish-gray loose to slightly hard, non-calcareous, loamy, fine sand. Percent slope is 0 to 2. The soil rests on loess sand and gravel. The permeability of the soil is moderate to high; the water-holding capacity is moderate; the natural fertility is medium, and the erosional hazard is slight. The crops suitable are: alfalfa, hay, and red clover.

The thickness of the unconsolidated, unsaturated zone in the vicinity of the city of Ucon is about 110 feet thick. West of the Snake River and northwest of the city of Idaho Falls the soils rest on 50 feet of unconsolidated, unsaturated loess. Southwest of the city of Ammon, the soils rest on an unconsolidated, unsaturated zone about 70 feet in thickness.

A third suitable site for wastewater reuse consists of the area covered by the Bannock very fine sandy loam. The largest single area covered by this soil occurs southeast of the city of Idaho Falls. This soil also occurs in widely scattered places throughout the valley floor (Plate 10). The soil generally is non-uniform in texture. The surface of the soil is nearly smooth to gently undulating. The slope of the soil is 0 to 2 percent. The soil is underlain by beds of gravel, sand and clay. The soil has a moderate permeability and the water-holding capacity is medium. The natural fertility is medium; the erosion hazard is slight, and the general crop suitability is alfalfa, sugar beets, small grains, and beets. The thickness of the unconsolidated, unsaturated zones is about 70 feet.

The fourth site which is suitable for wastewater reuse is the area covered by the Paul gravelly silty clay. This soil occurs in some areas in association with other types of soil near the city of Ammon and Lincoln, northeast of the city of Idaho Falls and south of the city of Ucon. Each area is less than one mile square (Plate 10). The soil has a fine-texture on the nearly level terraces. The soil surface is pale brown, mildly calcareous, hard, gravelly silt and clay. The slope of the soil is 0 to 2 percent. The soil rests on beds of gravel and sand. The soil has a medium permeability; the water-holding capacity is medium; the natural fertility is medium; the erosion hazard is negligible, and the general crop suitability is alfalfa, small grains, sugar beets, and potatoes.

The thickness of the unconsolidated, unsaturated zone is about 19 feet near the city of Ammon, 30 feet northeast of the city of Idaho Falls, 45 feet at Lincoln, and about 70 feet south of the city of Ucon.

A fifth area which is suitable for wastewater reuse is the Paul gravelly silty clay loam. It occurs mainly in the vicinity of Ammon, Iona and in small widely scattered patches throughout the area (Plate 10). The soil has a fine-texture on the nearly level gently sloping terraces. The soil is a pale-brown, mildly calcareous, slightly hard, gravelly, silty clay loam. The slope of the soil is 0 to 2 percent. The soil rests on thick beds of gravel and sand ranging from 50 to 300 feet. The permeability of the soil is moderate to low; the water-holding capacity is medium; the natural fertility is medium. The erosion hazard is slight and the general crops suitability is alfalfa, potatoes and small grains. The thickness of unconsolidated, unsaturated sediments range from 30 to 60 feet.

A sixth site for wastewater reuse is the area covered by the Paul sandy loam. It occupies nearly smooth to gently sloping easily irrigated areas on the valley floor. The soil occurs in close association with wind-worked sandy soils and along present and abandoned stream channels. The largest exposures occur north of the city of Taylor and west of Washington School and along either side of the Snake River north of the city of Idaho Falls. Small areas are located in the vicinity of Lincoln (Plate 10).

The soil readily absorbs water so that larger heads on shorter runs are necessary for an even distribution of irrigation water. The surface is nearly level to gently sloping, pale to brown, slightly hard, granular, mildly calcareous, silty clay loam. The slope is 0 to 2 percent. The soil is underlain by thick stratified gravel and sand. The permeability of the soil is moderate; the water-holding capacity and natural fertility is medium, and the erosion hazard is low. The generally suitable crops are: alfalfa, potatoes, and small grains. The thickness of the unconsolidated, unsaturated sediments north of the city of Taylor is about 55 feet, 65 feet west of the Washington School, and about 45 feet west of the river north of the Idaho Falls Airport, and about 12 feet across the river from the airport.

A seventh site suitable for wastewater reuse is the area covered by the Bannock fine sandy loam. It occurs in the city of Idaho Falls and is widely scattered over the valley floor and northeast and southeast of York School 2½ miles south of the city of Idaho Falls (Plate 10). The soil is sandy textured and occupies the smooth, level to gently undulating terraces. The soil consists of light brownish-gray to pale-brown, non-calcareous, soft, fine sand loam. The slope of the soil is 0 to 2 percent. The soil is overlain by loess, sand and gravel. The permeability of the soil is high and the water-holding capacity is medium to low. The natural fertility is medium; the erosion hazard is slight. The general crops suitable for use are alfalfa, potatoes, sugar beets, small grains, clover seed, and peas. The thickness of the unconsolidated, unsaturated sediments is about 5 to 70 feet in the city of Idaho Falls. South of the city of Idaho Falls near York School the unconsolidated, unsaturated zone is approximately 70 feet in thickness.

An eighth suitable site for wastewater reuse in the area is covered by Portneuf fine sandy loam. This soil occurs only in a few small areas, mainly west of Idaho Falls, 1 mile south of Cotton Siding, and northwest of Lincoln (Plate 10).

The soil is a very pale to pale brown, noncalcareous, soft, light-textured fine sandy loam. The soil surface is nearly level to undulating with hummocky surfaces. The percent of slope is 0 to 2. The underlying materials are gravel and sand. The soil has a moderate to high permeability. The water-holding capacity and natural fertility is moderate; and it has only a slight to moderate erosional hazard, and the general crop suitability is alfalfa, small grains, potatoes, and sugar beets. The thickness of the unconsolidated, unsaturated zone is generally 30 feet, west of Idaho Falls, 60 feet, south of Cotton Siding, and 40 feet, northwest of Lincoln.

A ninth site suitable for the reuse of wastewater is in the area covered by the Bannock Loam. The Bannock Loam is widely scattered south and west of the city of Shelley, north and west of the city of Kimball, near the Lava Side School west of the Snake River, east and south of the city of Groveland, north of the city of Blackfoot, and near Gibson (Plate 10). The soil is dense and has a high lime content. The surface is smooth and level to slightly undulating and drainage is good. The soil is light brown or light grayish brown, friable loam containing scattered quartzite gravels. The slope is 0 to 2 percent. It is underlain by coarse gravel with some sand on the east bank of the Snake River and by loess and gravel on the west bank of the river. The permeability is moderate, the natural fertility is medium, and the erosion hazard is slight. The crops generally suitable for use are alfalfa, sugar beets, beans and clover. The thickness of the unconsolidated, unsaturated sediments varies from place to place. In the vicinity of Shelley, the thickness is 85 to 90 feet thick. In the vicinity north of Blackfoot, it is 15 to 60 feet thick, and in the vicinity of Moreland, it is 30 to 40 feet thick.

A tenth site suitable for the reuse of wastewater consists of the Bannock very fine sandy loam. This soil is widely scattered in small patches throughout the Snake River plain. The soil occurs south of the city of Shelley, west of Lava Side School, and west of the city of Blackfoot (Plate 10). The soil has a fine to light wind-borne loess texture. The surface is nearly level to slightly undulating. The soil is a light grayish-brown moderately calcareous, very fine, sandy loam. The slope of the soil is 0 to 2 percent. It is underlain by coarse gravel with some sand. The permeability is moderate; water-holding capacity moderate; natural fertility medium; and the erosional hazard is slight to moderate. The crops generally suitable for use are alfalfa and potatoes. The thickness of the unconsolidated, unsaturated sediments is about 80 feet thick in the vicinity of Shelley, about 20 to 40 feet in the vicinity of Blackfoot, and 35 to 40 feet in the vicinity of Moreland.

An eleventh suitable site for wastewater reuse is the Bannock fine sandy loam in the Blackfoot area. This soil is widely distributed over the Gibson Terrace and northwest of Blackfoot River (Plate 10). It covers about 15 square miles. The soil is a noncalcareous, light brown to light grayish-brown, fine sandy loam. The surface is smooth and nearly level to slightly undulating. The percent of slope is 0 to 2. The underlying materials are gravel, sand, and clay. The soil has a moderate permeability; and water-holding capacity and natural fertility is medium; and the crop suitability is alfalfa, potatoes, sugar beets, clover seed, peas and beans. The thickness of unconsolidated, unsaturated sediment is 30 to 40 feet.

Second Class Sites

A twelfth site suitable for wastewater reuse is the Ammon silt loam. This soil extends along the base of the upland from the Bingham County line south of Taylor to just southeast of Dewey School. It also occurs in a small area 1 mile east of Ammon and 2 miles north of Iona (Plate 10). The soil is developed from fine textured, light-colored material, and is situated on alluvial fans. The soil surface is nearly level to gently sloping, pale-brown, calcareous, soft, silt loam. The slope is 0 to 2 percent. The underlying materials are silt over sand and gravel. The permeability is moderate to high; water-holding capacity is medium to high; natural fertility is medium to high; with slight erosional hazard. The crops generally suitable for use are alfalfa and potatoes. The thickness of the unconsolidated, unsaturated materials is 50 to 65 feet thick.

A thirteenth site suitable for wastewater reuse is the Bannock silt clay loam. This soil occurs east of the Snake River between Idaho Falls and Cotton Siding (Plate 10). Some small patches are scattered on the western side of the

Snake River plain. The soil has medium to heavy texture. The surface is nearly level to gently undulating. The soil is pale-brown, slightly hard, noncalcareous, silty, clay loam. The slope of the soil ranges from 0 to 2 percent. The soil rests on a coarse gravel with some sand. The permeability is moderate to low; the water-holding capacity is medium to high; the natural fertility is medium and the erosion hazard is slight. The crops generally grown are alfalfa, sugar beets, potatoes, small grains, peas, and clover. The thickness of unconsolidated, unsaturated zone is 120 to 140 feet.

A fourteenth site suitable for wastewater reuse is the Redrock silt clay loam. This soil occurs in sections 7 and 16 of T.2N., R.38E (Plate 10). This soil has a dark surface color and consists of fine texture. The surface of the soil is nearly level with an uneven surface and the slope is 0 to 2 percent. The soil rests on a sand containing some gravel beds. The soil has a moderate permeability; the water-holding capacity is medium to high with a high natural fertility and slight erosional hazard. Crops generally grown are alfalfa, potatoes, sugar beets, small grains, and irrigated pasture. The thickness of the unsaturated, unconsolidated zone is 50 to 70 feet.

A fifteenth site suitable for wastewater reuse is the Bannock gravelly loam. This soil is widely distributed south of the city of Shelley, west of the city of Wapello and east and south of Ferry Butte (Plate 10). The soil has a fine texture. The surface is nearly level to gently sloping. The soil has a thin caliche layer above the porous gravelly subsoil. The slope of the soil is 0 to 2 percent. The soil overlies gravel, sand, and some clay beds. The permeability of the soil is medium to high; water-holding capacity is low to medium; natural fertility is low, and erosional hazard slight. The thickness of unconsolidated, unsaturated sediments is about 10 to 20 feet in the vicinity of Wapello and 20 to 30 feet at Gibson Terrace.

A sixteenth site suitable for wastewater reuse is the Ammon silt loam, bottom-land phase. This phase is found in the alluvial bottom land along a drainageway that passes through T.2 and 3N., R.37E west of the Snake River, and deposits its runoff waters and on the valley floor below (Plate 10). The soil has a fine texture. The surface is nearly level to undulating. The soil is very light yellowish brown, calcareous, slightly hard, silt loam. The slope of the surface is 0 to 2 percent. The soil is underlain by loess, sand, and gravel. The soil has a moderate to high permeability, medium to high water-holding capacity, and slight erosion hazard. The crops suitable are: alfalfa, potatoes, sugar beets and small grains. The thickness of unconsolidated, unsaturated soil is about 50 to 60 feet.

CONCLUSIONS AND RECOMMENDATIONS

The following observations can be drawn from this study:

1. The drainage pattern and landforms are controlled mostly by block faulting and Snake River plain subsidence.

2. Older and Younger Alluvium making up Gibson Terrace, Snake River Pinedale Alluvial Terrace, and Snake River gravels form one hydrostratigraphic unit and can be considered a good aquifer. This hydrostratigraphic unit is the result of the Snake River valley having been filled by up to 600 feet of fine and coarse sediments. Groundwater in the alluvium occurs under confined and water-table conditions.

3. The Big Hole Basalt, a member of the Snake River Basalts, is the second important hydrostratigraphic unit. Groundwater in the basalt occurs under confined and water-table conditions.

4. The Starlight Formation, the Neeley Formation, the Walcott Tuff, and the Ash Flow Tuff make up the third hydrostratigraphic unit of the area and supplies many shallow-dug wells. In these rocks, shallow groundwater occurs under water-table conditions.

5. Loess makes up the fourth hydrostratigraphic unit in the area. The loess forms an extensive mantle on much of the basalt and silicic rock. It has hydrologic properties of soil, the fifth hydrostratigraphic unit, and both make a poor aquifer.

6. The area has considerable groundwater of good quality.

7. Specific capacities of wells in the area decrease with depth, and the water table aquifer is more productive than the artesian aquifer.

8. The regional groundwater flow system does not have natural discharge along much of the Snake River. This means it discharges into the American Falls Reservoir or it discharges some distance further to the southwest along the Snake River.

9. The direction of local groundwater movement is to the west beneath most of the study area of recharge, but it turns to the southwest a few miles from the Snake River.

Equipotential lines indicate that the local groundwater is moving to the west beneath most of the study area, which is a recharge area, but it turns to the southwest a few miles west of the Snake River and much of this water discharges into the reach of the Snake River between Blackfoot and American Falls as a local flow system.

10. The depth to water table under much of the study area lies more than 150 feet below the surface. In general, it is not less than 250 feet below the surface to the northwest and west of the cities of Idaho Falls, Shelley, and northwest of Moreland. In most of the main perennial stream valleys and tributaries of the Snake River, the depth to the water table is less than 50 feet.

11. The water table fluctuates with the irrigation

season. It is lowest during April and May and is highest in September and October.

12. Groundwater recharge is by infiltration of precipitation and percolation of irrigation water from canals and irrigated fields. In some reaches, the Snake River and its tributaries contribute water by percolation into the ground surface.

13. The hydrogeologic data presented and the studies discussed and cited herein suggest that the reuse of wastewater is feasible with safe proper management in several parts of the Idaho Falls-Blackfoot area. In general, reuse looks feasible along the Snake River extending from northeast of Idaho Falls to south and southwest of Blackfoot.

Additional problems which became apparent during this study and which should receive further study are:

1. The regional groundwater flow should be studied particularly in the Idaho Falls-Blackfoot area to determine its relation to local flow systems.

2. A survey of groundwater quality should be undertaken to provide a basis for evaluating changes in groundwater quality caused by Snake River recharge, irrigation, canal seepages and wastewater reuse. Water quality data could be utilized in a quantitative study to determine how much recharge the various sources contribute to the groundwater in the area. Limited water quality data obtained during this study suggest that nitrate concentrations may be unusually high at present.

3. A study should be undertaken to determine the total thickness of the aquifer for further artificial recharge in the study area.

4. Data should be gathered to evaluate the aquifer as a storage reservoir which might be artificially recharged. Such a procedure might be more efficient than surface water reservoir maintenance.

5. The hydraulic relations between the main water-table aquifer and the perched-table bodies which overlie the main aquifer in some areas should be studied to show the vertical flow between the different aquifer units which might cause water logging of some nearby farmlands during irrigation with wastewater.

6. Prior to reuse of wastewater in a given area, a laboratory study of interaction of wastewater in the soil environment should be made since the interaction of soil and wastewater are the sum of the characteristics of both phases.

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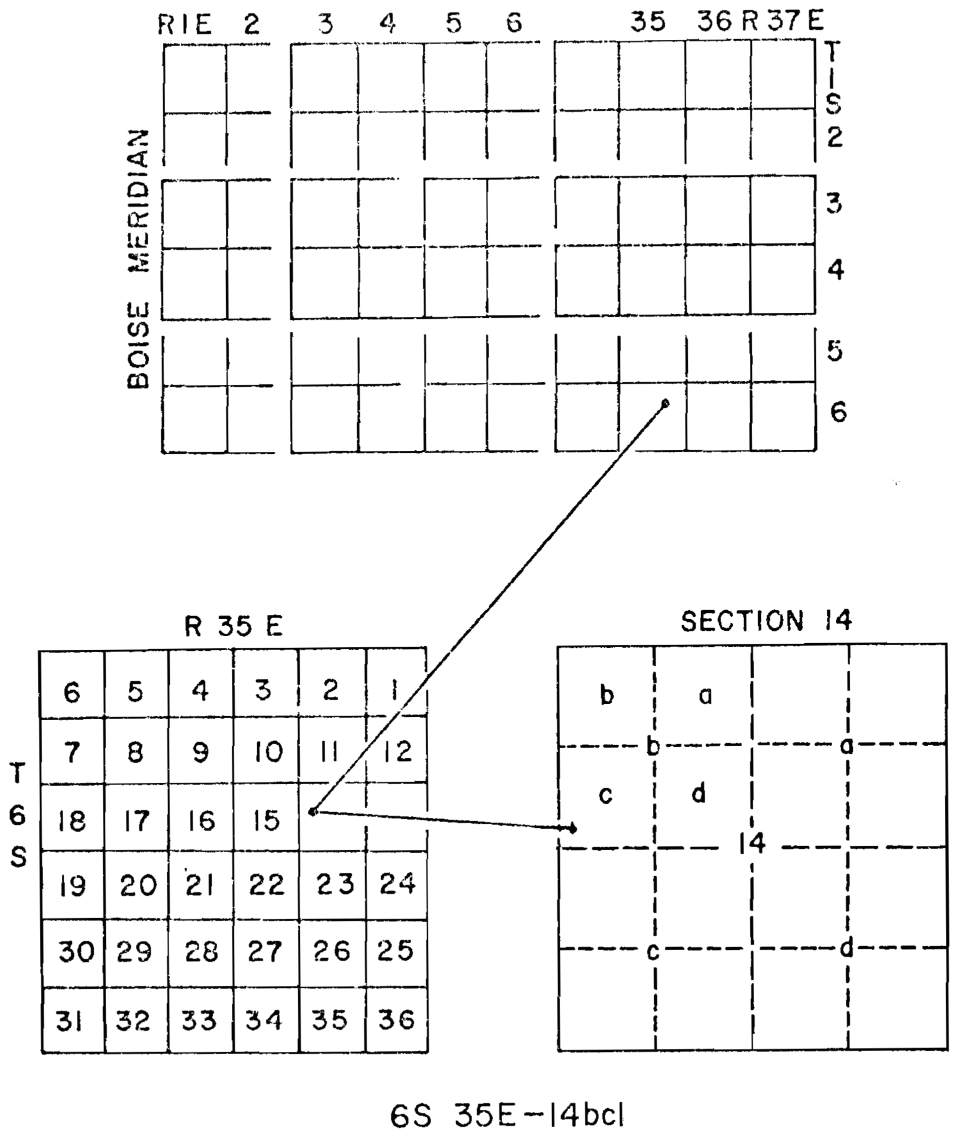
APPENDIX I

APPENDIX I

WELL NUMBERING SYSTEM

The well numbering system used in Idaho by the U.S. Geological Survey (and in this study) indicates the location of wells or springs within the official rectangular subdivisions of the public lands with reference to the Boise base line and meridian. The first two segments of a number designate the township and range. The third segment gives the section number followed by two letters and a numeral, which indicate the quarter section, the 40-acre tract, and the serial number of the well or spring within the tract. Quarter sections are lettered a, b, c, and d in counterclockwise order starting from the northeast quarter of each section. Within the quarter sections, 40-acre tracts are lettered in the same manner. Thus, Well 6S-35E-14bc1 is the well first visited in the tract and is in the SW¼ NW¼ sec. 14, R. 35E., T. 6S. The method of numbering is illustrated in Figure 2.

FIGURE 2



SKETCH OF WELL NUMBERING SYSTEM

APPENDIX II

APPENDIX II-1

Summary of stratigraphic units in the Idaho Falls-Blackfoot area

Period	Epoch	Stratigraphic Unit	Thickness (feet)	Physical Characteristics and Areal Distribution	Water-Bearing Characteristics
Quaternary	Recent to Pleistocene	Dunes	0-30	Well-sorted, fine-grained, quartz detritus with a few volcanic fragments, forms a longitudinal dune veneer a few feet to a few tens of feet in thickness on alluvial terrace between Blackfoot and Ammon.	Normally occurs above the water table in discontinuous masses. Would be a good aquifer, but not an ideal unit for wastewater disposal because of high permeability and probable low ion exchange capacity.
	Recent	Younger Alluvium	0-35	Predominantly unconsolidated gravel and sands; contains moderate amounts of silt and clay where poorly sorted. Underlies the flood plains of the Snake and Blackfoot Rivers and Lincoln Creek and Ross Fork.	Generally an important aquifer in the area and contains unconfined ground water. Sand and gravel yield moderate-to-large quantities of groundwater to wells along the Snake River. Good unit for wastewater disposal where unsaturated zone is thick and where covered by soil of a moderate water-holding capacity.
	Upper Pleistocene	Older Alluvium (including	0-600	Mainly lithic gravel and sand derived from the headwaters of the Snake River	Beds of coarse-grained material below the water table may yield

		Snake River Pinedale and Gibson Terraces)		Locally contains abundant angular fragments of basalt, welded tuff and ashflow transported by tributaries from nearby Tertiary and Quaternary units. Commonly poorly sorted and poorly bedded, may have near-surface caliche layer. Commonly persists as alluvial terraces along the Snake River.	moderate amounts of ground water to wells. Locally contains confined aquifer. Will probably yield adequate supplies for domestic and livestock and irrigation use. Should prove to be a very good wastewater disposal unit where a thick unsaturated zone is present.
Quaternary	Upper Pleistocene	Loess	0-100	Fine-grained, windblown silt and clay mantle on older basalt and pyroclastic units. Commonly preserved northwest of Snake River.	Generally lies above water table. Retains water well and makes poor aquifer. Could make fair wastewater disposal unit if water application is properly managed.
	Unconformity				
	Middle to Upper Pleistocene	Big Hole Basalt (Snake River Basalt)	25±	Exhibits a wide range of characteristics such as light to dark gray color, dense to vesicular structure, aphanitic to porphyritic texture, and irregular to columnar jointing. Thickness of flows is variable resulting from included beds of basaltic cinders, rubbly basalt, and interflow deposits. Intercalated at depth with sediments in the Ross Fork	One of the most important aquifers in the area. Yields large amounts of unconfined and confined groundwater to wells where water table is penetrated. Permeability highly variable because of jointing and rubbly contacts between flows. Permeability of dense flow is low. Interbedded sedi-

				district and the buckskin Basin. Underlies or is intercalated with alluvium beneath the Blackfoot River flood plain. Crops out over extensive areas west and southwest of Idaho Falls, Shelley, and Blackfoot, east of Gibson, and at Ferry Butte.	ments yield little or no water to wells. Receives and transmits recharge readily but not a good unit for wastewater disposal unless water is uncontaminated.
	Unconformity				
Quaternary	Middle	Raft Formation	4-8	Yellow and light brown clay, silt and sand with high calcium carbonate content. Contains a few Mollusks. Exposed only west of Lincoln Creek in Section 10.	Generally not a good aquifer in the study area. Permeability is low, and the fine-grained texture makes well development difficult. Too thin and poorly located to be of much value for wastewater filtration. May make good wastewater reuse unit where thick and unsaturated in the Raft Valley out of the study area.
	Unconformity				
	Pleistocene	Ash Flow Tuff		Forms a consolidated pyroclastic deposit resulting from ashflow. Ordinarily includes ash, pumice, scoria, and blocks. Exposed at Stevens Peak, Cedar Creek and east of Taylorville.	Will probably yield little groundwater to wells. Lies predominantly above the water table. Not a good unit for wastewater
	Unconformity				

Tertiary	Middle Pliocene	Walcott Formation	20±	Welded, well-bedded, white or light gray friable rhyolitic tuff. Medium- to fine-grained, and composed almost entirely of clear shards. Crops out discontinuously along Garden Creek and on the Fort Hall Indian Reservation.	Water-bearing properties not know. Yield very small quantities of water to wells from joint and fault zones. Probably not an important aquifer nor a potential wastewater reuse unit.
		Neeley Formation	10±	Composed of partly reworked rhyolitic tuff beds. May contain latite flow rocks, welded tuff, fine- to coarse-grained ash, and light brown to orange tuffaceous claylike sandstone. Bedded, sorting and consolidation are poor throughout the formation. Exposed at Henry Creek and southeast of Iona.	Will probably yield little groundwater to wells. Thinness and hydrogeologic properties not desirable for wastewater reuse.
	Unconformity				
Tertiary	Middle Pliocene	Starlight Formation	165±	Subdivided into upper and lower members separated by a 30-foot vitric-crystal middle member. Upper member mainly bedded friable rhyolitic tuff about 20 feet thick. The lower member about 8 feet thick contains much rhyolitic tuff, but has many local beds of marl and basalt. Crops out in the Blackfoot River Canyon.	Water-bearing properties not know; probably will yield adequate water for livestock supplies. Probably could handle large volume of wastewater but is poorly located for a readily available supply.

APPRENDIX III

APPENDIX III -1

Stratigraphic section of Starlight, Neeley, and Walcott Tuff Formations exposed at the north wall of Henry Creek, SE½, SE¼, Sec. 26T. 1N, R38E (Figure 7)

Formation	Thickness (feet)	Description from top to bottom
Raft Formation		Not exposed
Unconformity		
Walcott Tuff	4½	Obsidian tuff, massive of black (N1), dense, perlitic spherulitic, obsidian welded tuff, about 10 percent white, rectangular feldspar crystals-1 mm long.
	3	Obsidian tuff, massive of gray, dense, perlitic, spherulite, obsidian welded tuff.
	3½	Welded tuff, light brownish gray (5 YR 6/1), contains white feldspar crystals.
	3	Welded tuff, brownish gray (5 YR 4/1), contains scattered small, white feldspar crystals.
	2	Welded tuff, olive black (5 Y 2/1), friable and perlitic.
	2	Obsidian tuff, welded, black (N1), breaks with smooth conchoidal fracture, contains a few scattered white feldspar crystals.
	3	Tuff, white to light gray (N7), medium-grained, friable, uniformly well-bedded in layers six inches thick.
Neeley	3½	Clayey sand, contains small amount of volcanic material, shards, and some pumice fragments. Dark reddish brown (10 R 3/4).

Formation	Thickness (feet)	Description from top to bottom
	2½	Tuffaceous clay and scattered pebbles. Pale red (5 R 6/2).
	2½	Clayey sand, contains a small amount of volcanic material. Light olive gray (5 Y 6/1).
	½	Clayey sand, coarse-grained, contains more non-volcanic debris than the upper. Moderate yellowish brown (10 YR 5/4).
Unconformity		
Starlight	21	Rhyolitic, parallel-bedded and friable tuff. Very light gray (N8).
	2	Rhyolitic tuff, friable pale, yellowish brown (10 YR 6/2).
	1½	Marl, thin-bedded, grayish yellow (5 Y 8/4).
	29	Pumiceous tuff, massive pale yellowish brown (10 YR 6/2). Consists of obsidian welded tuff fragments. Black (N1).
	½	Marl, thin-bedded, grayish yellow (5 Y 8/4).
	28	Pumiceous tuff, massive pale, yellowish brown (10 YR 6/2).
	1	Marl, thin-bedded, grayish yellow (5 Y 8/4).
	35	Pumiceous tuff, massive pale yellowish brown (10 YR 6/2), with obsidian welded tuff fragments, black (N1).
	1	Marl, thin-bedded, grayish yellow (5 Y 8/4).
	6	Pumiceous tuff, massive pale yellowish brown (10 YR 6/2).

APPENDIX IV

APPENDIX IV-1

Classification of Soils

A classification of soils has been developed by Chugg and others (1968, p. 19) for Bonneville and Bingham Counties.

The distribution of Soil Mapping units under group A are identified by letters or a combination of letters and numbers (A_1, A_2, A_3, etc.). The mapping units pertinent to the Idaho Falls-Blackfoot area are portrayed in Plate 3 of this report. The Soil Mapping units describe the characteristics of the soil as follows:

A_1, A_5 Mapping Units-- Have a variation in thickness which ranges from deep, moderately deep, and shallow.

A_2 Mapping Unit-- An A_2 unit is located northwest of the city of Idaho Falls and covers more than 140 square miles (Plate 3). The western part of this A_2 area is covered with loess and a small amount of clay which ranges in thickness from 5 to 18 feet; the unsaturated zone is approximately the same thickness (Plates 3 and 12). The eastern part of this A_2 area contains, in addition to the loess at the top, a layer of gravel and sand on which the loess rests. The thickness of the unconsolidated sediments in the eastern portion ranges from 20 to 70 feet, and the unsaturated zone is approximately the same thickness. Morgan's Pasture (Plate 3) is a Basalt depression containing loess which is 10 to 35 feet thick. The thickness of the soil is moderately deep to deep. Well-drained soils overlie nearly smooth to very gently sloping loess-covered Basalt rocks. An A_1 unit is located in the northwest corner of the study area around Kettle Butte and ranges from 10 to 20 feet thick. This is also approximately the thickness of the unsaturated zone in this A_1 area.

The A_5 depression shown in Plate 3 about 10 miles west of Idaho Falls is filled with 50 feet of loess. The thickness of the unsaturated zone is about 50 feet.

A_3, A_4 Mapping Units-- The soil in these zones is deep, moderately deep, and shallow. The soil is well-drained on nearly-smooth to sloping loess, which rests on the basaltic rocks.

The A_3 Mapping Unit around Shattuck Butte is covered with loess. The area two miles west of the city of Shelley and north of the city of Firth is covered with clay, gravel and sand. The thickness of unconsolidated sediments ranges from 5 to 15 feet which is approximately the same as the thickness of the unsaturated zone.

An A_4 Mapping Unit covers an area three miles west of the city of Idaho Falls and three miles north of the city of Blackfoot. The thickness of the soils range from 10 to tt feet, which is approximately the thickness of the unsaturated sediments.

An A_4 Mapping Unit covers an area three miles west of the city of Idaho Falls. The thickness of the soil ranges from 4 to 40 inches, while the approximate thickness of the unconsolidated, unsaturated zone is 10 to 55 feet.

Also an A_4 Mapping Unit occurs three miles north of the city of Blackfoot. The thickness of the soil ranges from 4 to 40 inches, and the approximate thickness of the unconsolidated unsaturated sediment is 10 to 55 feet.

A_6 Mapping Unit-- The soil is deep, well-drained on nearly smooth to very gently sloping loess resting on the Basalt rocks. This unit covers a small area three miles north of the city of Moreland. The thickness of the unconsolidated, unsaturated zone is about eight feet.

A_7 Mapping Unit--This unit occurs only on Ferry Butte in the study area. The soil is moderately deep. Well-drained soils lie on nearly level to gently sloping loess-covered Basalt rocks. The thickness of unconsolidated, unsaturated zone is 18 feet.

A_{13} Mapping Unit--The soil beneath this unit is deep to moderately deep. Well-drained soils overlie nearly smooth to gently sloping loess-covered Basalt rocks and buttes. This unit lies north of Baldy Knoll. The thickness of the unconsolidated, unsaturated zone is less than three feet.

A_{17} Mapping Unit--One A_{17} unit lies west of Baldy Knoll. The soil in the area is deep to shallow. Well-drained soils on nearly smooth to very gently sloping loess lies on the Basalt rocks. The thickness of unconsolidated, unsaturated zone is less than five feet.

A_{30} Mapping Unit--The soil is deep, well-drained and overlies amooth to very gently sloping Basalt rocks. The A_{30} soil covers an area northwest and west of the city of Rockford and south of Baldy Knoll. The thickness of unconsolidated, unsaturated zone is about three feet in the northern part of the unit to about 5 to 40 feet, except for a small depression of 50 feet of loess and silt about 50 feet thick four miles west of the city of Thomas.

Soil Mapping Unit B--The soils in group B lie on a Recent irregular-shaped, jointed, fractured Basalt rock in the southwestern part of Bonneville County. The elevation ranges from 4,500 to 5,500 feet. The soil is less than 10 inches thick. The rock surface is unweathered and has no soil except where wind-borne material has lodged in crevices, cracks, and sheltered pockets. This type of surface has no agricultural or grazing value and it offers no potential for wastewater reuse.

Soil Mapping Unit C_1--This unit occurs on stream terraces deposited by the Snake River. This unit extends from Jefferson County north to the city of Idaho Falls and north of the city of Shelley. Elevation ranges from 4,700 to 4,725 feet. The soil is deep to moderately deep. The surface of the C_1 Unit is nearly smooth and level to very gently sloping. The soil is underlain by washed gravel and sand. The surface soil is a gravelly light brownish-gray. Some excessively gravelly areas occur in the vicinity of Ucon and northward, northwest of Coltman School. The thickness of the unsaturated zone of the unconsolidated sediments is not less than 20 feet north of the city of Idaho Falls; south of the city, it is not less than 40 feet thick.

Soil Mapping Unit D--This soil occurs in a large, fairly continuous, area east and north of the city of Idaho Falls, south of the city of Ucon to Willow Creek. It is about one mile in width near Taylorville. The unit is deep and nearly smooth and level to very gently sloping. This unit occupies the Snake River Pinedale Alluvium Terrace. This unit has been formed from mixed alluvial material transported from high elevations. The thickness of the soil is 36 to 60 inches. This unit is underlain by gravel and sand to an average depth of 80 feet. The thickness of the unsaturated zone ranges from 25 to 110 feet.

Soil Mapping Unit E--This soil occurs as a long belt one mile south of the city of Ammon to the city of Goshen. The belt is one to three miles in width. The thickness of the soil unit is deep to moderately deep. Excessively drained soils are in hummocky to rolling sand dunes on nearly smooth and level to very gently sloping stream terraces. The soil in this unit is fairly friable and easily penetrated by plant roots. Probably less than half of this soil is farmed. The thickness of the underlying gravel and sand is about 50 to 75 feet; the thickness of the unsaturated, unconsolidated sediments is 65 to 78 feet.

Soil Mapping Unit F--An inextensive F soil occurs southeast of the city of Blackfoot. It lies adjacent to very sandy and dunelike soils and is noticeably modified by sandy materials blown from these areas. The color of the surface soil is grayish-brown. The soil is deep, well-drained and lies on steep loess-covered alluvial deposits. The thickness of the unconsolidated sediment is about 300 to 400 feet.

Soil Mapping Unit G--This unit occurs in the vicinity of Blackfoot north of Moreland, southwest to Ferry Butte, south bordering the Blackfoot River. The soil is deep to moderately deep, well-drained, and lies on nearly smooth to very gently sloping, alluvial fans and colluvial slopes. The land has a slight slope toward the river. This unit occurs on nearly flat stream terraces deposited by the Snake River and the Blackfoot River. The thickness of unconsolidated sediment in the area is about 100 feet, but the thickness of the unsaturated zone ranges from two feet in well 2S-36E-ad1 to 40 feet.

Soil Mapping Unit H--This soil is deep to moderately deep. This soil mapping unit occurs on stream terraces of Sand Creek and the Blackfoot River. The area is about 35 miles long and varies in width from about two miles, east of Shelley, to about ten miles north of Fort Hall. Half of the area is covered by sand dunes, which are moderately steep. Some of the soil is well-drained, but some soils are poorly drained and display saline conditions. This soil is resting on gravel and sand in the vicinity of Fort Hall, but in the northeast portion of Soil Mapping Unit H, the soil is on loess or volcanic rocks. The thickness of the unconsolidated sediment is about 150 to 200 feet in the vicinity of Fort Hall, and the unsaturated zone thickness in the mountain ranges is in the order of 85 feet.

Soil Mapping Unit I--This unit is located east of Buckskin Basin and around Fort Ross; it continues northeast on the mountain slopes and along Blackfoot Mountain front. It ranges from one to two miles to about eight miles wide. The soil in this unit is deep, but minor areas are shallow. Slopes range from nearly smooth to steep. The soil of this unit is strongly calcareous. The soil is well-drained at the northern extremity and becomes more poorly drained as Soil Mapping Unit F is approached.

The soil lies on gently sloping to sloping land which occupies the less-complex mountain colluvium which crops out along the Blackfoot Mountain front. It has a moderate infiltration rate. Also the soil in the area east of Fort Hall which has a gentle slope consists of a moderately calcareous silt loam. The water-holding capacity in the 48 inches of soil is high. This area has a moderate infiltration rate. Morgan and Poulson (1950) describe the soils in the vicinity of Idaho Falls in much greater detail than do Chugg and others (1968a,b). A similar statement is applicable to the work of Poulson and others (1943) with respect to the Blackfoot area. Morgan and Poulson (1943) and Poulson and others (1950) studies were utilized along with the work in the selection of specific sites to be recommended for wastewater reuse.

Hydrologic Soil Groups

Soils were classified in hydrologic groups according to their effect on direct runoff. Major soil features determining hydrologic soil groupings are infiltration rate and water transmission. Classification was at the end of long-duration storms occurring after prior wetting and an opportunity for swelling, and without the protective effect of vegetation. Four groups were used for estimating runoff potential of soils and watersheds (Plate 3).

Hydrologic Group A: Soils that have high infiltration rates even when thoroughly wetted, consisting chiefly of thick well-drained sands and/or gravel. These soils have a high rate of water transmission and result in a low runoff potential when irrigated.

Hydrologic Group B: Soils that have moderate infiltration rates when thoroughly wetted, consisting chiefly of moderately thick to thick, moderately well- to well-drained soils with medium to coarse textures. These soils have a moderate rate of water transmission.

Hydrologic Group C: Soils that have slow infiltration rates when thoroughly wetted, consisting chiefly of (1) soils with a layer that impedes the downward movement of water, and (2) soils with very fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission.

Hydrologic Group D: Soils that have very slow infiltration rates when thoroughly wetted, consisting chiefly of (1) clay soils with a high swelling potential, (2) soils with a high permanent water table, (3) soils with clay pan or clay layer at or near the surface, and (4) shallow soils with nearly impervious materials. These soils have a very slow rate of water penetration.

Definitions pertinent to the classification by Chugg and others (1968a,b) and by Morgan and Poulson (1950, p. 16) are as follows (Fosberg, 1971, personal communication):

Soil Mapping Unit--A reoccurring pattern of geographically associated soils. Soil mapping units are not to be confused with hydrological soil groups.

Surface Soil--The part of the soil commonly moved by tillage or a soil 4 to 12 inches in thickness.

Shallow Soil--A soil 10 to 20 inches in thickness.

Moderately Deep Soil--A soil 20 to 36 inches in thickness.

Deep Soil (thick)--A soil 36 to 60 inches in thickness.

Permeability--Permeability refers to the relative freedom with which the soil is penetrated by plant roots, water and air.

Water-holding Capacity--A qualitative expression of the total quantity of water available to plants within a depth readily penetrated by roots when the soil is at field capacity; that is, after free water has had time to drain off.

Well-drained--Water is removed from the soil readily but not rapidly.

Somewhat excessively drained--Water is removed from the soil rapidly.

Natural Fertility--Refers to the natural ability of the soil to provide the proper nutrient compounds in the proper quantity and in the proper balance for the growth of the common crops when other factors, such as light, temperature, moisture, and physical conditions are favorable.

Erosion Hazard--Erosion hazard refers to probable susceptibility to erosion when the land is cultivated or heavily grazed.

APPENDIX V

APPENDIX V-1

Records of representative wells in the Idaho Falls-Blackfoot area. Use of wells: D, domestic; I, irrigation; S, stock; M, municipal; In, industrial; C, culinary; U, general. Principal aquifer: B, Basalt; g, gravel, S, sand; C, cinder. Remarks: Temp., temperature of ground water in C, centigrade, casing; P, perforation in feet.

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	Aquifer	Altitude of land surface datum above mean sea level (feet)	Depth to Water (feet)	Altitude of water surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
3N-38E1aa1	Nerman Alson	---	130	5	150	D	G,S	4847	65	4772	---	---	Aug.31,1970	Temp. 15°C
2cc1	Earl Spaulding	7/S star	202	14	189,50	I	G	4817	117	4700	2000	½	Sept.1,1970	Temp. 12°C
3db1	Henry Hill	---	130	6	130	C	G,S	4810	120	4690	22	---	"	
3ca2	Idaho Trav. Corp.	R	188	8,6	23,156	D	S,G	4807	130	4677	---	---	"	
13dd1	R.E.Hill	7/S star	148	6	143	D	S,G	4834	90	3738	---	---	"	Temp. 12°C
14ad2	City of Ucon	C	280	16,12, 10	142, 102,70	M	C	4820	142	4690	11000	38	"	Temp. 8.8°C
14bc1	" " "	---	229	30,20, 16	140	M	B	4803	122	4681	2242	11.4	"	Temp. 13.7°C
15cc1	Lowell Miller	---	163	8	64	C	B	4787	127	4660	---	---	"	Temp. 15°C
16ab1	Blair Wilkins	C	171	8	82	D	C	4787	128	4659	---	---	"	
17bc1	Joe Clifford	C	145	6	29.5	D	C	4770	113	4657	---	---	"	
17dd2	Reed Stanger	C	152	8	137	D	B	4772	105	4667	---	---	"	Temp. 12°C
18bb1	Richard L. Smith	R	140	8	26	D	C	4756	100	4656	---	---	"	
18cc2	Hal & Bud Taylor	C	155	8	34	D	B	4749	119	4630	---	---	"	
19aa1	Don Wilding	R	165	8	27	D	C	4758	124	4636	---	---	"	
20ad1	H.L.Jensen	---	193	---	---	D	B	4765	135	4630	---	---	Oct.10,1970	
20cc2	J.G.Hopkins	C	180	6	30	D	B	4752	127	4625	---	---	"	
22dd1	Ceicel Walker	---	166	6,4	145	D	S,G	4788	131	4658	---	---	"	

Continued

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	V-2 Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
3N-38E28ba1	E. Burgie	C	165	6	136	D	B	4770	126	4644	---	---	Oct.10,1980	Temp. 11.2°C
29dd1	G. McDougal	C	190	8,6	47,60	D	C	4764	140	4624	---	---	"	
30bd1	Richard Mills	---	182	10	94,10	D	B	4740	115	4625	---	---	"	
30bb2	N.G.Harris	C	193	8,6	64,88	D	S,G	4741	125	4616	---	---		Temp. 12°C
32dc1	William Bush	---	187	6	164	D	C	4755	150	4605	---	---	"	
32bb2	R. Casperson	C	160	8	9	D	B	4754	132	4622	---	---	"	
33ac1	S. Nelson	---	180	8,6	73,53	D	C	4778	141	4637	---	---	"	
35cc1	M. Rich	---	180	---	---	D	C	4785	117	4668	---	---	"	
35db2	Harvey Jeppson	71 star	227	8,6,4	47,114, 121	D	G,S	4797	118	4679	---	---	"	Temp. 12°C
35ab3	Chester Clark	---	166	---	---	D	B	4800	110	4690	---	---	"	
3N-37E-2aa1	H.A.Phillips	C	160	8	22	I	C	4757	109	4648	---	---	Aug.17,1970	Temp. 12.5°C
2bb2	D. Marshall	C	265	8	44	D	C	4810	202	4608	---	---	"	Temp. 12°C
6da1	E. Steinke	C	405	20	20	I	B	4879	322	4557	---	---	"	Temp. 12°C
8ba1	Leonard Steinke	---	420	20,18	40,42	I	C	4885	325	4560	---	---	"	
13cb1	A. Naegle	R	190	6	170	D	B	4745	136	4609	---	---	"	
15ad1	Robb Lowe	---	252	16	59	I	B	4812	213	4699	800	24	"	Temp. 12.5°C
17bd1	Mikami Brothers	C	350	20	27	I	B	4840	275	4570	---	---	"	
18ac1	" "	C	375	20	38	I	C	4875	302	4573	---	---	Oct.11,1970	
21bd1	Utah Id. Sugar Co.	C	263	6	21	D	B	4785	227	4562	---	---	"	Temp. 12°C
23da1	Sach Mikami	R	255	8	80	D	B	4820	218	4602	---	---	"	
27bb1	Osgood LDS Church	R	263	6	59	D	B	4788	220	4568	---	---	Aug.27,1970	Temp. 12.1°C
29bdb1	Howard Taylor	---	277	6	23	D	B,C	4780	210	4570	---	---	"	Temp. 8.8°C
31aa1	G.Lake & N.Sauers	---	311	20	28	I	C	4810	242	4068	---	---	"	

Continued

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	V-3 Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
3N-37E31db2	Neal W. Sauer	---	360	20	46	I	C	4840	278	4562	---	---	Aug.27,1970	
32cc1	L.D.S. Stake Farm	R	275	6	80	D	C	4780	226	4554	---	---	"	
34cd1	Utah Id. Sugar Co.	C	295	20	44	I	B	4760	192	4568	---	---	Aug.29,1970	
35bd1	R. Stacking	---	262	6	55	D	B	4775	210	4565	---	---	Aug.27,1970	Temp. 12.5°C
36cb1	Mikami Brothers	C	263	12	158	In	B,C	4725	156	4569	---	---	"	
3N-36E 1bd1	L. Steinke		550	22	48	I	B	5000	478	4532	---	---	"	
4ba1	Wilde Brothers		480	20	30	I	B	4930	410	4520			Aug.19,1970	
5cd1	Avon & Elmer Wilde		540	---	---	I	B	4900	365	4535	---	---	"	Temp. 11°C
6bd2	Dolly R. Holm	C	370	20	6½	I	C	4882	352	4530	---	---	"	Temp. 11°C
7da1	William A. Craft	C	475	20	9	I	C	4934	404	4530	---	---	"	
8bd1	Anton Brinkman		470	20	21½	I	B	4907	372	4535	---	---	Nov.12,1970	
10aa1	L.Gray & D.Gray	C	715	20	21	I	B	5070	539	4531	---	---	"	
12bd1	George Lake	---	470	---	---	I	B	4974	440	4534	---	---	"	
13dc1	G. Osterhant	---	418½	20	17.6	I	C	4880	349	4531	---	---	"	
14aa1	William H. Croft	---	472	20	15	I	C	4950	410	4540	---	---	"	
11db1	Ivan L. Ashment	---	547	20	14	I	B,C	5003	470	4533	---	---	"	
17db1	S. Wright, M.D.	---	493	20	17	I	B	4890	370	4520	---	---	"	
18ac1	Roy Torngren	C	500	20	9½	I	C,B	4930	409	4521	---	---	"	
23cc1	Jackson & Clements		555	20	28	I	C	5010	470	4540	---	---	"	
30cc1	Wintroath Pump Co.	Ch	500	---	---	I	B	4935	410	4525	---	---		
31dc1	David Croft		417	20	7	I	B,C	4870	350	4520	2000	---	"	
3N-35E 2bc1	Idaho Gem Frams	C	690	20	17	I	B,C	5033	510	4523	---	---		
4ac1										4500				

Continued

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	V-4 Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
3N-35E13dd1	Keith Jeppson	---	568	20,18	37,188	I	B,C	4985	460	4525	---	---	Nov.12,1970	
23ca1	Neal Sours	C	635	20	22	I	C,B	5085	535	4550	---	---	"	
26bc1	L.B.Holden Co.	---	745	20	12	I	C,B	5155	650	4505	---	---	"	
2N-38E 2da1	C.P.Tawzer	C	80	6	80	D	G	4790	50	4740	---	---	Sept.1,1970	Temp. 12°C
3dd1	Bonneville High School		182	110	---	D	G,C	4769	110	4659	---	---	"	Temp. 11°C
2dc2	Jay Longhurst		192	---	172	D	G,S	4772	42	4730	---	---	Aug.8,1970	Temp. 14°C
3bc2	Iran Hill	C	183	8,6	47	D	G	4768	125	4643	---	---	Nov.12,1970	
3aa3	Richard Larsen		180			D	C	4778	123	4655	20	---	"	
5da1	Kenneth Gray	---	200	6	4	D	C	4752	140	4612	---	---	"	Temp. 13°C
5cc2	Martin Partman	C	201	6 5/7	15	D	B	4739	160	4579	---	---	"	
7db1	Don Lortz	C	286	---	182	D	G	4728	160	4668	---	---	"	
8dc1	John M. Homer	C	181	10	162½	D	C	4730	152	4578	---	---	"	Temp. 12°C
8da2	Morley Campbell	C	409	---	---	D	B	4748	153	4595	---	---	"	Temp. 12°C
10ad1	Russell Rock	---	150	8	128	D	G,S,B	4762	97	4665			"	Temp. 12°C
10dc2	Lincoln School Dist.	A.R.	190	8	169	D	C	4754	110	4644			"	Temp. 12°C
13ad1	Williams Craft	---	120	6	29	D	B	4754	50	4704				Temp. 14°C
15bb1	Lincoln Cemetary	R	190	8	140	I	B	4743	115	4628	---	---	"	Temp. 14°C
15aa2	LaMoyne Webster	---	143	8	87½	D	B	4754	104	4650			"	
16ba1	Carlyle Chaffin	R	190	6	3	D	C,B	4737	131	4606			Aug.21, 1970	Temp. 13.5°C
17cb1	City of Idaho Falls#4	--	1630	22,15,14	955	M	B,S,C,	4725	155	4570	4550	3	"	Temp. 11°C
19db1	" " " " #1		13			M	B,C	4705	138	4567	3300	---	"	Temp. 11°C
20dc1	" " " " #8	C	775	18	663	M	B,G	4722	143	4579	3000	---	"	Temp. 11°C
20cd2	" " " " #9		400	18	186	M	B,C	4718	155	4563	3800		"	Temp. 11°C
22ad1	G. Peterson,N.Realty	R	120	8	85	D	B,G	4724	46	4678	---		"	

Continued

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
2N-38E22dc2	Gene inv. Sargent	---	120	8	10	D	C,G	4724	60	4664	---		"	
25cb1	Larry Nliting	C	78	6	76	D	G,S	4728	29	4690	---		"	
25da2	D. Robertson	C	84	6	84	D	G,S	4750	15	4735	---		"	
26ba1	F. Kvarfordt	C	220	16,12	109	M	G,C	4725	32	4693	1926	---	Oct.20,1970	Temp. 9.5°C
27ddb1	City of Ammon 1	---	---	---	---	M	---	4714	44	4670	---	---	"	Temp. 14.5°C
27bd2	City of Ammon 2		170	12,10,0	220	M	G,S	4719	45	4674	---	---	"	Temp. 14°C
28cd1	South Stake Farm	C	215	20,15,12	127	I	B,C	4714	102	4612	802	50	"	
29cc2	Arch M. Wackerti	C	192	8	66.5	D	B	4707	150	4557	---	---	"	Temp. 12°C
30bd1	City of Id. Falls#5					M	C,B	4705	138	4567	4450	---	Oct.20,1970	Temp.11°C
31cc1	James Leader		165	6,4	108	D	B	4595	120	4475	---	---	"	Temp. 12°C
34ca1	Grand Shipper		78	6	78	-	S,G	4704	39	4665	---	---	"	
36bb1	Robbert Wadsworth		108	8	108	D	S,G	4728	52	4676	---	---	"	
2N-37E11bb1	Ferrel Hansen	C	225	8	32	D	C,B	4745	185	4560	---	---	Aug.26,1970	
16dd1	E. Haynie		205	6	15	-	B	4721	160	4561	---	---	"	
18cc1	J. Cavanaugh	C	230	22,6	36	D	B,C	4721	182	4539	---	---	"	
18db2	W. Quinn	C	262	8	7	D	B	4750	208	4542	---	---	"	Temp. 12°C
19aa1	H. Peterson	C	202	8	18	D	C	4720	174	4546	---	---	"	
21da1	L. Hall	C	200	6	27	D	B	4702	138	4557	---	---	"	
22ad1	W. Gisin		220	6	197	D	C	4718	162	4553	---	---	"	
23aa1	J. Cropley		266	8,6	68	D	C	4739	163	4576	---	---	"	
25cb1	D. Allen	---	170	6	118	D	B	4682	114	4568	---	---	Aug.15,1970	Temp. 10°C
34ab1	George Lewis	---	175	6,4	110	D	B,G,S	4688	130	4558		0	"	Temp. 10°C
29aa1	A. Backer	---	158	8	6	D	B	4673	131	4542	---	---	"	
2N-36E 5bb1	J. Croft	C	422	20	15	I	B	4882	365	4517	---	---	"	
26ab1	L. Bingham	---	304	16	68.4	I	B	4729	219	4510	---	---	"	

Continued

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	V-6 Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
2N-35 12ac1	Brunt Form Inc	C	590	20	45	I	B,C	4902	450	4502			Aug.15,1970	
12dd2	" " "		537	22	30	I	B,C	4934	434	4500	---	---	"	
14dd1	W. Ray	C	468	6	32	C	B	4958	462	4492	---	---	"	
1N-38E 2ad1	Elmer Tawzer	---	96	6	92	D	G	4720	53	4667	---	---	Sept.2,1970	
4cd1	Clyde Hess	C	141	8	47	D	B	4695	79	4616	---	---	"	Temp. 12°C
8ad1	A. Pancheri	---	142	8	87	D	C	4689	110	4579	---	---	"	
11ad1	Clifford Judy	---	225	6	195	D	G	4790	140	4650	---	---	"	
15dc1	M. Curmitt	C	142	6	115	D	S	4740	95	4645	---	---	"	
19db1	I.Irrig. Dist.	71 star	141	6	137	D	G,S	4663	66	4597	---	---	"	Temp. 12°C
29ba1	C. Ried	22.w	105	6	100	D	G,S	4667	65	4602	---	--		Temp. 8.8°C
1N-37E 2ca1	B. Builders		145	8,6	130	D	G,S	4667	109	4558	---	---	"	
4bc1	J. Newman	R	135	6	84	D	B	4656	105	4551	---	---	"	
9dd1	O. Cox		139	8,6	65	D	G,S	4644	102	4542	---	---	"	
12dd1	J. Newman	C	192	8,6	75.5	D	B	4674	117	4557	---	---	"	Temp. 12°C
17cd1	Woodville Comm.Well	C	172	8	143	M	B	4635	110	4525	60	0	"	Temp. 12°C
21dc1	U.S.Steel Corp	R	125	6,4	115	In	C	4637	90	4558	---	---	"	
26cd1	D. Polik	C	132	8,6	108	C	B	4643	85	4558	---	---	"	
29dd1	R. Jamas		146	8	20	C	B	4626	86	4540	---	---	"	Temp. 10°C
32bad1	R. T. French Co	C	243	20,18,16	261	In	G,B	4625	63	4562	1500	28	"	Temp. 12°C
1N-36E 1aa1	Clyde Hawley	C	216	16	22.8	I	B,C	4658	153	4505	---	---	"	
21bdc1	L. Stalworthy	C	503	20,16,10	267	I	C,B	4720	210	4505	4600	---	"	
34ba1	E. Stolworthy & Sons		378	20,16	70	I	S,C	4685	181	4504	400	5	"	Temp. 11.2°C
1N-35E20zz1	M. Brothers,Inc.	C	555	24	15	I	C,B	5885	410	4475	---	---	"	Temp. 11.6°C
26ac1	L. Mardoch		330	16	10	I	B	4766	283	4483	---		"	

Continued

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
1N-35E32ad1	R. Macs	C	340	8	18	D	B,C	4720	270	4450	---	---	Sept.2,1970	
1S-37E 4bd1	W. Lyon		118			D	G,B	4616	80	4536	---	---	Sept.3,1970	
11cc1	Al Rennek	C	118	10	118	D	S,G	4622	55	4567	35		"	Temp. 18°C
12cgd1	M. Hansen	C	115	6	151	D	G,S	4630	65	4565	---	---	"	
17db1	R. Esplin	71 star	92	6	21	D	G,S	4595	58	4547	---		"	Temp. 8.8°C
18cd1	Pete Kondis		46	6	46	D	G,S	4573	8	4565	---	---	"	
19cc1	J. Griffen	22-w	54	6	54	D	G,S	4568	23	4545	---	---	Sept.5,1970	
21ad1	Sterling Cheekey		70	6	70	D	G,S	4568	23	4545	---	---	"	
24bd1	D. Cook	C	127	6	127	D	G	4622	62	4560	---	---	"	
26bc1	O.E.McInelly	C	110	6	110	D	G,S	4638	60	4578	---	---	"	
27cd1	J. Burch	C	65	6	65	D	G	4593	39	4554	---	---	"	
29cd1	J. Meek	C	67	6	67	D	G	4587	42	4545	---	---	"	
31cc1	Boyde Jolly	C	65	6	65	D	G	4577	30	4547	---	---	"	
31dd2	Gene Mecham	C	65	6	15	D	G,S	4580	10	4570	1800	3	"	
36dc1	W. Tew	C	356	6	356	D	G,S	4810	240	4570	---	---	"	Temp. 12°C
1S-36E25dc1	J. Chapman	C	62	6	50	C	G	4562	48	4514	---	---	"	
25cd2	C. Russel		51	6	51	D	G,S	4560	18	4542	15	0	"	Temp. 15°C
35aa1	O. Mecham	22-w	47	6	42	D	G,S	4556	15	4541	---	---	"	
1S-35E 2aa1	S. Johnston		325	18	15	I	B,C	4705	217	4488	---	---		Temp. 11.2°C
10dc1	Hulen #2		317			I	C	4667	180	4487	---	---	Sept.8,1970	
12ca1	J. Johnston	60L	292	18,16	73	I	C	4655	180	4475	1920	0	"	Temp. 8.8°C
15dc1	J. Johnston	60L	147	18	22	I	C	4610	123	4487	1920	½	"	Temp. 8.8°C
21da1	J. Johnston	60L	200	18	18	I	C	4577	120	4457	960	¼	"	Temp. 8.7°C
25dd1	C. Ashley		261	18	36	I	C	4565	90	4470	---	---	"	Temp. 10°C

Continued

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
1S-35E34ba1	T. Greiting		237	18	11	I	C,B	4549	82	4447	---	---	Sept.9,1970	Temp. 8.8°F
1S-34E10bd1	G. Leavitt	C	400	20	6	I	C,B	4782	358	4424	---	---	"	Temp. 7.2°F
26bb1	B. Williams		142	18	5	I	C	4548	100	4448	---	---	"	Temp. 10°F
2S-38E 8dd1	L.D. Cox	C	110	110	6 5/8	S	S	4925	60	4865	20	---	"	
2S-37E 2bb1	G. Stolworthy & Son	C	332	24,20	326	I	G,S	4665	80	4585	4600	9	"	
7cb1	A. Harres & Cook		135	6	52	I	S,G	4585	35	4545	---	---	"	
19aa1	G. Cook		109	20	109	I	S,G	4581	23	4558	4380	18½	"	
2S-36E 5cd1	J. Bridge	C	80	6	59	D	B,S	4525	20	4505	40	2	"	
11cd1	M. and B. Jolley	C	50	6	51	S	G	4562	18	4544	5000	6	Sept.10,1970	
18aa1	A. Williams	C	37	6	37	D	G	4520	6	4514	---	---	"	Temp. 13.7°C
25cd1	C. Russell	C	51	6	51	D	S,G	4555	18	4537	15	0	"	Temp. 15°C
29da1	J. Robinson	C	72	6	72	D	S,G	4534	2	4532	---	---	"	
31cb1	C. Turner	C	60	6	60	C	G	4521	13	4508	---	---	"	
2S-35E 2ca1	J. Burkman	C	195	16,12	110	I	C	4537	90	4447			"	
5da1	R. Caldwell		115	16	4	I	C	4510	70	4445	---	---	"	
14cc1	C. Price	C	100	6	26	C	C	4520	72	4448			"	
17bc1	J.D.Sanders		62	6	10	D	G	4490	12	4478				
18aa1	A. Williams		33	6	33	D	S	4490	15	4475	20		"	
25bc1	A. Swenson	C	70	6	70	D	G,S	4511	56	4455	15	0	"	
28cb1	S. Schuttgen	---	75	6	75	D	G	4486	38	4448	30	---	Sept.15,1970	
30dd1	R. Denney	---	60	6	57	D	G,S	4478	40	4438	---	---	"	
33cc1	Custom Body Works		76	6	47	D	G	4486	41	4445	---	---	"	
2S-34E 4da1	Eugene Ternus	5 72 sand star	180			I	B	4495	53	4442			"	
21bc1	L. Clement	72 speed star	113	16	18	I	B	4477	34	4443			"	Temp. 10°C

Continued

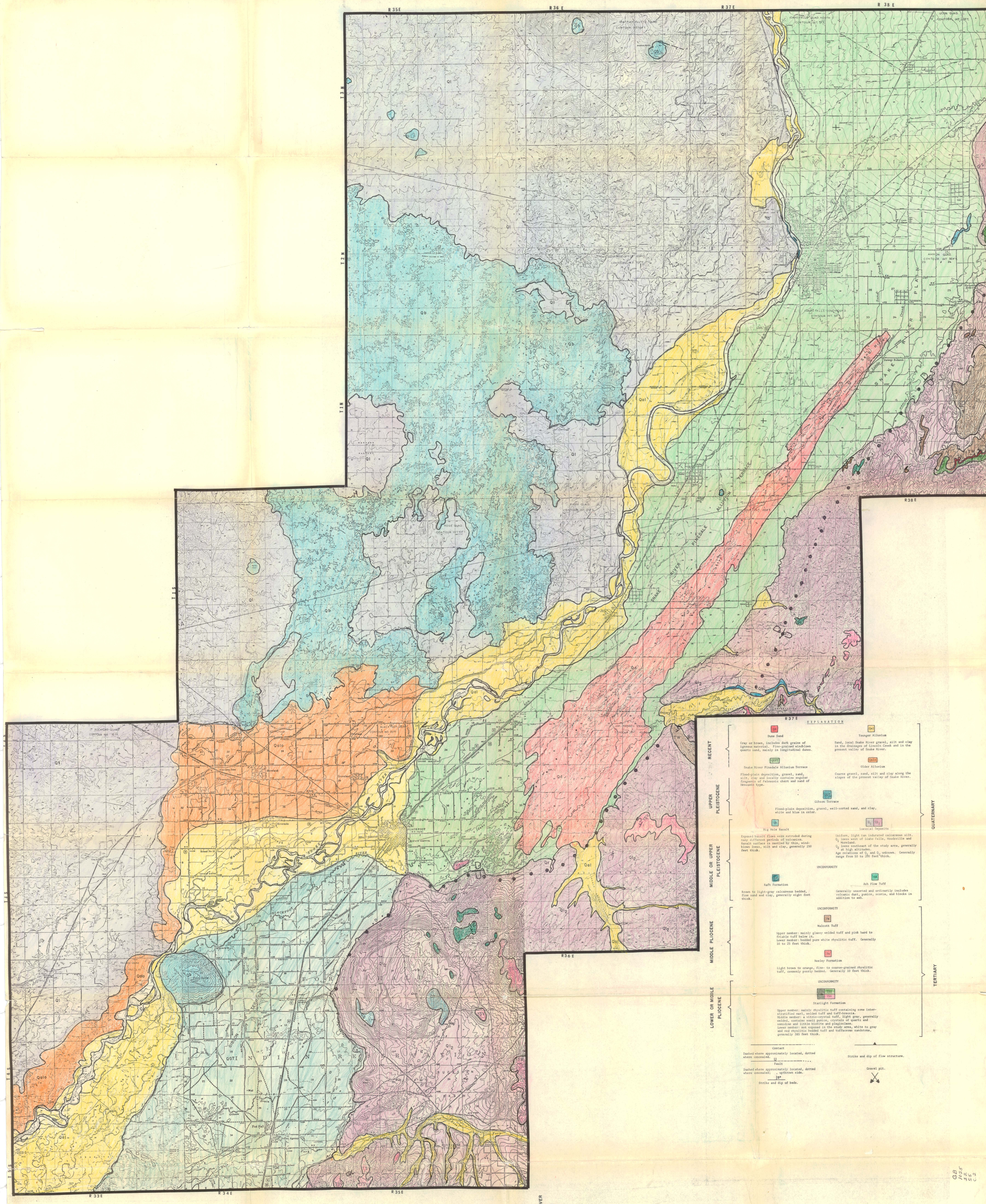
Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
2S-34E24da1	J. Verbera	C	62	8	62	D	G	4477	32	4495			Sept.15,1970	
26ad1	M. Page	C	65			C	B	4465	28	4437	45	0		
2S-33E21bc1	A. Merrill	---	154			D	G	4550	180	4440	---	---	Sept.25,1970	
25cc1	A. Higgenson	72 speed	136	18	5	I	C,B	4482	55	4427	---	---	"	Temp. 10°C
26b1	H. Katseanes #3	36L	206	16,14	42	I	C,B	4503	73	4430	---	---	"	Temp. 9.5°C
3S-36E 2db1	S. Marshall	C	65	6	65	D	G	4607	15	4582	---	---	"	Temp. 6°C
4ac1	B. Shoemaker	C	83	20	84	I	S,G	4540	11	4529	---	---	"	
3S-35E 2db1	Thompson	C	83	6	40	D	G,S	4504	12	4492	---		"	Temp. 13.3°C
4db1	Blackfoot City Well #6		793	18,16,12	357	M	B,C	4492	40	4452	1400	55	"	Temp. 15.5°C
6aa1	A. Sealey	C	68	6	62	D	G,S	4462	12	4450	---	---	Sept.25,1970	Temp. 10.5°C
11cd1	R. Mecham	C	50	6 5/8	50	D	S,G	4503	20	4483	---	---	Sept.26,1970	Temp. 13.3°C
17dd1	E. Appney	C	60	6	60	C	G	4481	28	4453	---	---	"	
18ba1	T. Toney	C	80	10	80	I	G,S	4471	19	4452	30	000	"	
19bb1	B. Elison	C	73	6	73	D	G.S	4464	25	4439	45	---	"	
21bb1	F. Cameron	C	60	6	60	C	S,G	4481	35	4446	----	---	"	
31dd1	S. Shrader		84	6 5/8	84	D	G,S	4405	2	4403	20	4	"	
3S-34E 1ba1	G. Parsons	C	63	6	63	D	S,G	4460	22	4438	---	---	Sept.27,1970	
6aa1	G. Parsons	C	63	6	63	D	S,G	4462	37	4435	---	---	"	
8bac1	N. Mecham	C	73	4½	65	D	B,C	4450	18	4432	---	---	"	Temp. 12.5°C
10ba1	O. Williams	C	39	6	40	C	G	4442	11	4431	---	---	"	Temp. 15°C
12ab1	L. Patrick	C	50	6 5/8	50	D	G	4456	9	4447	---	---	"	Temp. 12°C
16dc1	C. Neitzel		60	16	60	I	S,G	4428	10	4418	900	18	"	Temp. 9.9°C
20bb1	R. Jackson	C	52	5 5/8 4½	52	D	G,C	4446	28	4418	10	0	Sept.28,1970	

Continued

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
3S-34E26cc1	H. Reeder	C	69	6	69	D	G,S	4451	38	4413	25	0	Sept.28,1970	
30aa1	D. Carter		83	18,14	29	I	B,S	4458	45	4413	---	---	"	Temp. 11.2°C
31dd1	Rockford Sumner Co.	C	70	6	55	D	B,G	4405	3	4402	30	0	"	
36ba1	L. Nadda	C	74	6	74	D	G	4460	42	4418	---	---	"	
3S-33E12db1	L. Broadhead & Son	D	120	---	46	D	C	4485	60	4420	---	---	"	Temp. 11.2°C
4S-36E17dd1	S. Janston	C	87	16	49	D	C	5000	75	4925	48	---	Sept.30,1970	
17cd2	S. Janston	C	87	16	85	D	B	4780	17	4763	48	---	"	
32ad1	J. Truekat	22-w	145	6	43	D	B	4785	20	4765			"	
4S-35E 6bc1	B.I.A	C	84	8	61	I	B,G	4464	48	4416	500	0	"	Temp. 13.3°C
29dd1	D. Hernankes	C	108	6	58	D	C	4481	63	4418	---	---	"	
36ad1	H. Charlton	C	82	6	82	D	G,S	4680	48	4637	39		"	
4S-34E 2ad1	R. Philps	C	80				G	4455	43	4412			"	
9ab1	H. Sweets	C	75	6	75	D	G	4438	21	4417	30	0	"	
11bc1	W. Wada	C	270	16,12	230	I	C,B	4447	42	4405	4000	67	"	Temp. 13.3°C
21ab1	G. Shiozawa	C	380	16	225	I	B,C	4434	22	4412	5000	50	"	Temp. 8.3°C
25dd1	H. Batilett	22-w	75	6¼	48	D	S	4459	40	4419	---	---	Nov.1,1970	Temp.8.4°C
31dc1	Teck Farms, Inc.	C	62	6,20	62	I	S,G	4415	0	4410	---	---	"	
33aa1	Tech Farms, Inc.	C	115	16,12	115	I	G,S	4425	10	4415	3300	32	"	
34cc1	Teck Farms, Inc.	C	109	16,14	109	I	G,S	4440	20	4420	3000	55.5	"	
35bb1	W. Hayball	---	54	---	---	D	S	4434	20	4414	30	10	"	Temp. 8.3°C
36add1	M. Ackinson	C	80	6	80	C	G	4459	35	4424		2	"	Temp. 18.8°C
4S-33E 3da1	C. Higby		75	16	8	I	C	4495	31	4404	---	---	Nov.2,1970	
4ca1	L.D.S.Ward	---	70	12	16	D	C	4445	30	4415	---	---	"	
14da1	F. Sweigart	---	35	8	35	I	G	4382	9	4473	---	---	"	Temp. 13.3°C
15da1	F. Sweigart	---	90	16	90	I	S,G	4404	2	4402	1800	20	"	Temp. 13.3°C

Continued

Well	Owner	Type	Depth (feet)	Casing: Diameter of Casing (inches)	Casing: Depth (feet)	Use	Aquifer	Altitude of land surface datum above mean sea level	Depth to Water (feet)	Altitude of water Surface	Yield (gpm)	Draw-down (feet)	Date of Measurement	Remarks
4S-33E21cc1	C. Papas	C	39	20	21	I	G,B	4403	26	4373	---	---	Nov.2,1970	
22ab1	F. Sweigart	---	82	16	82	I	S,G	4402	20	4382	2500	22	"	Temp.13.3°C
5S-34E 2cbc1	R. Catton	C	127	6	127	C	G,S	4458	38	4420	8	---	"	
4cb1	Teck Farms, Inc.	C	112	16,14	112	I	G	4430	23	4407	3200	33	"	
6ba1	Teck Farms, Inc	C	44	6	49	C	G	4425	18	4407			"	
5S-35E 8ad1	F & F Farming Co	C	593	20	593	I	S,G	5050	250	4800	135	50	"	Temp. 15.5°C
5S-34E11cb1	C. Caffer	C	77	6	75	D	G	4450	35	4415	---	---	"	



EXPLANATION

RECENT

Qd — Dune Sand

Gray or brown, includes dark grains of igneous material. Fine-grained windblown quartz sand, mainly in longitudinal dunes.

Qal — Younger Alluvium

Sand, local Snake River gravel, silt and clay in the drainages of Lincoln Creek and in the present valley of Snake River.

QSPT — Snake River Pinedale Alluvium Terrace

Flood-plain deposition, gravel, sand, silt, clay and locally contains angular fragments of Paleozoic chert and sand of Mesozoic type.

Qalo — Older Alluvium

Coarse gravel, sand, silt and clay along the slopes of the present valley of Snake River.

UPPER PLEISTOCENE

QGT — Gibson Terrace

Flood-plain deposition, gravel, well-sorted sand, and clay, white and blue in color.

MIDDLE OR UPPER PLEISTOCENE

Qb — Big Hole Basalt

Exposed basalt flows were extruded during many different periods of volcanism. Basalt surface is mantled by thin, wind-blown loess, silt and clay, generally 250 feet thick.

Q_1 Ql_2 — Loessial Deposits

Uniform, light tan indurated calcareous silt.
Q_1 loess west of Idaho Falls, Woodsville and Moreland.
Q_2 loess southeast of the study area, generally at high altitudes.
Age relations of Q_1 and Q_2 unknown. Generally range from 50 to 200 feet thick.

UNCONFORMITY

Qr — Raft Formation

Brown to light-gray calcareous bedded, fine sand and clay, generally eight feet thick.

QA — Ash Flow Tuff

Generally unsorted and ordinarily includes volcanic dust, pumice, scoria, and blocks in addition to ash.

QUATERNARY

UNCONFORMITY

MIDDLE PLIOCENE

TW — Walcott Tuff

Upper member: mainly glassy welded tuff and pink hard to friable tuff below it.
Lower member: bedded pure white rhyolitic tuff. Generally 10 to 25 feet thick.

Tn — Neeley Formation

Light brown to orange, fine- to coarse-grained rhyolitic tuff, commonly poorly bedded. Generally 10 feet thick.

UNCONFORMITY

LOWER OR MIDDLE PLIOCENE

TSL TSU TSV — Starlight Formation

Upper member: mainly rhyolitic tuff containing some inter-stratified marl, welded tuff and tuff-breccia.
Middle member: a vitric-crystal tuff, light gray, generally welded, contains small pumice, crystals of quartz and sanidine and little biotite and plagioclase.
Lower member: not exposed in the study area, white to gray and red rhyolitic bedded tuff and tuffaceous sandstone, generally 385 feet thick.

TERTIARY

Contact

Dashed where approximately located, dotted where concealed.

Fault

Dashed where approximately located, dotted where concealed; U, upthrown side.

5° Strike and dip of beds.

Strike and dip of flow structure.

Gravel pit.

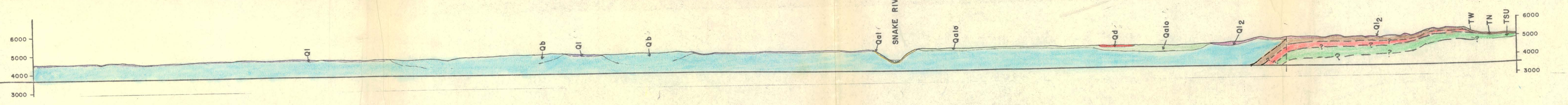


PLATE 1 - GEOLOGIC MAP AND SECTION OF THE IDAHO FALLS-BLACKFOOT AREA, IDAHO

0 1 2 3 4
MILES

CONTOUR INTERVALS 5, 10, 25, 40, AND 50 FEET

18° TRUE NORTH MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1955

OMAR SHADID

1971

BASE FROM U.S. GEOLOGICAL SURVEY TOPOGRAPHIC QUADRANGLES 7-1/2 AND 15 MINUTES

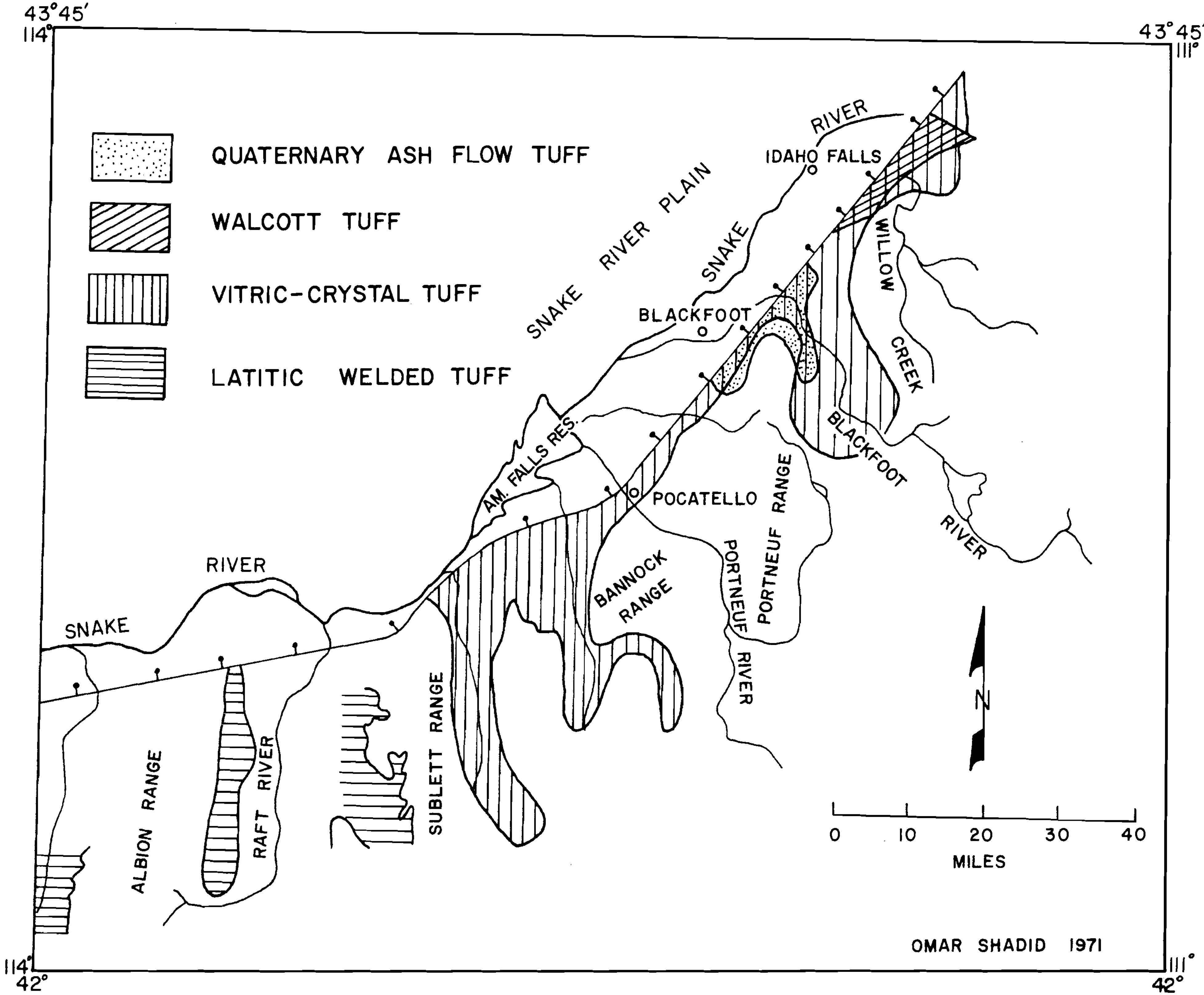


PLATE 2–DISTRIBUTION OF ASH FLOW TUFFS AT SOUTH EDGE OF EASTERN SNAKE RIVER PLAIN

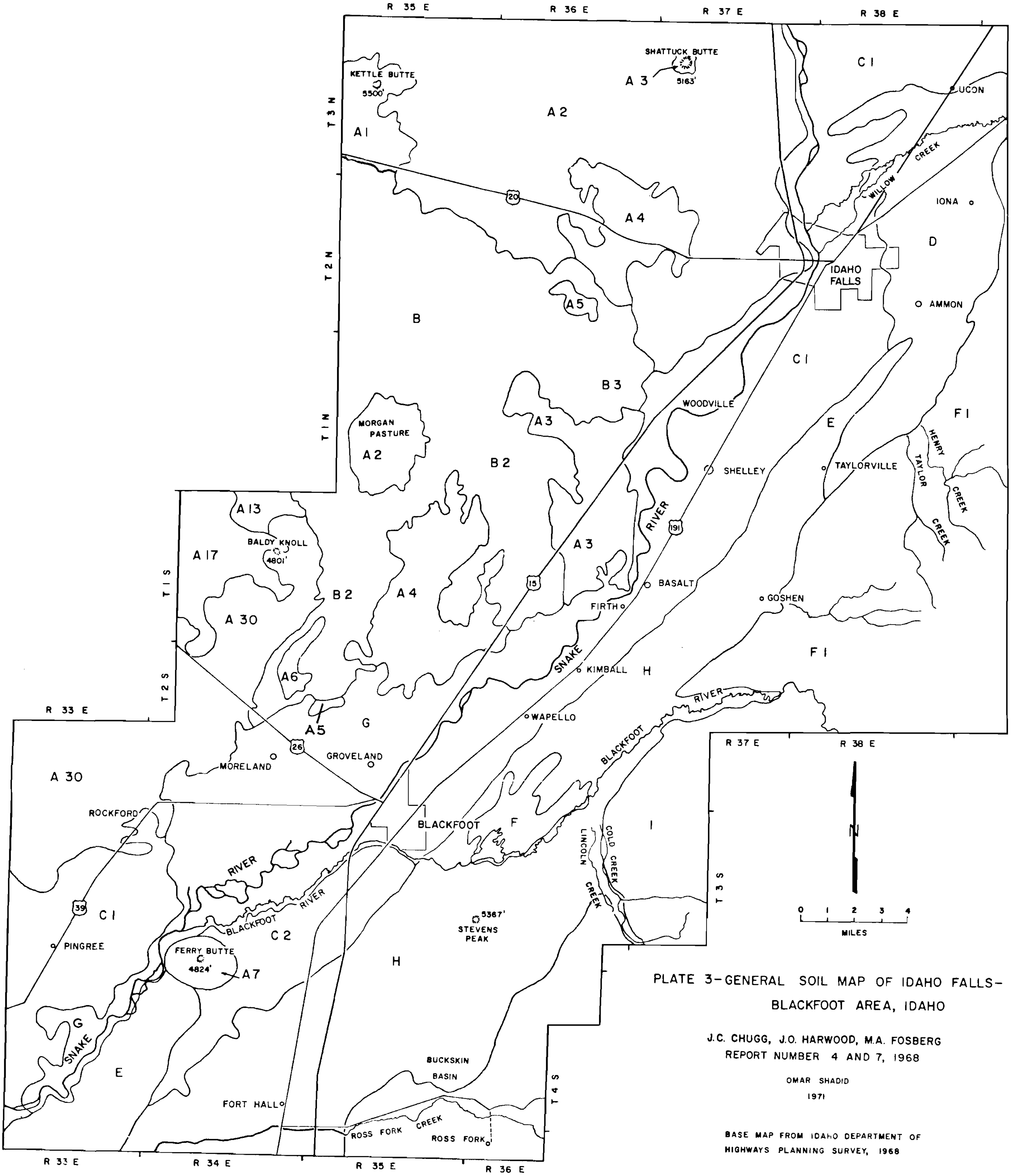


PLATE 3–GENERAL SOIL MAP OF IDAHO FALLS–BLACKFOOT AREA, IDAHO

J.C. CHUGG, J.O. HARWOOD, M.A. FOSBERG
REPORT NUMBER 4 AND 7, 1968

OMAR SHADID
1971

BASE MAP FROM IDAHO DEPARTMENT OF HIGHWAYS PLANNING SURVEY, 1968

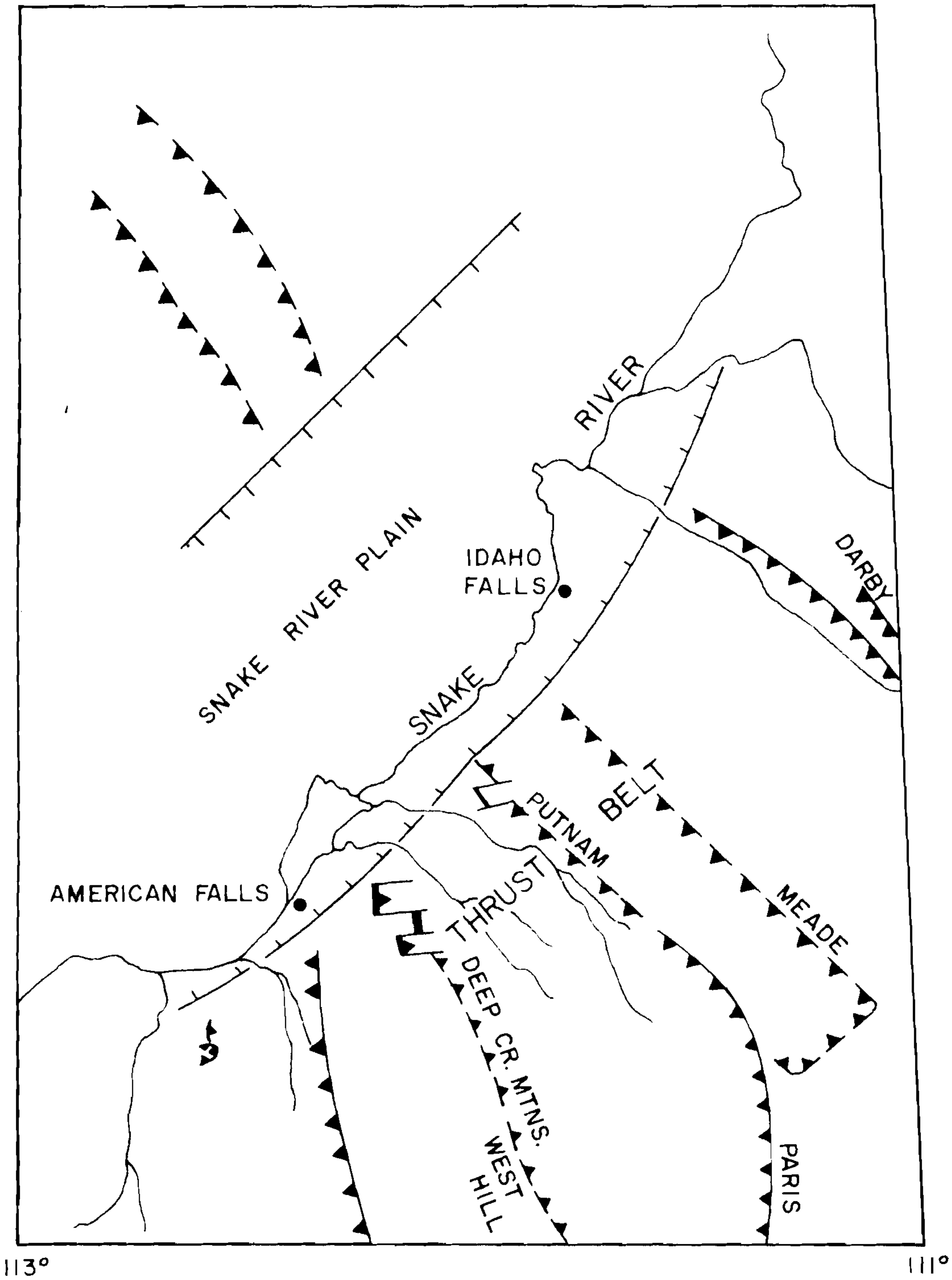


PLATE 4-TECTONIC SKETCH MAP

DOWNTHROWN

UPPER PLATE

N

0 10 20 30 40

MILES

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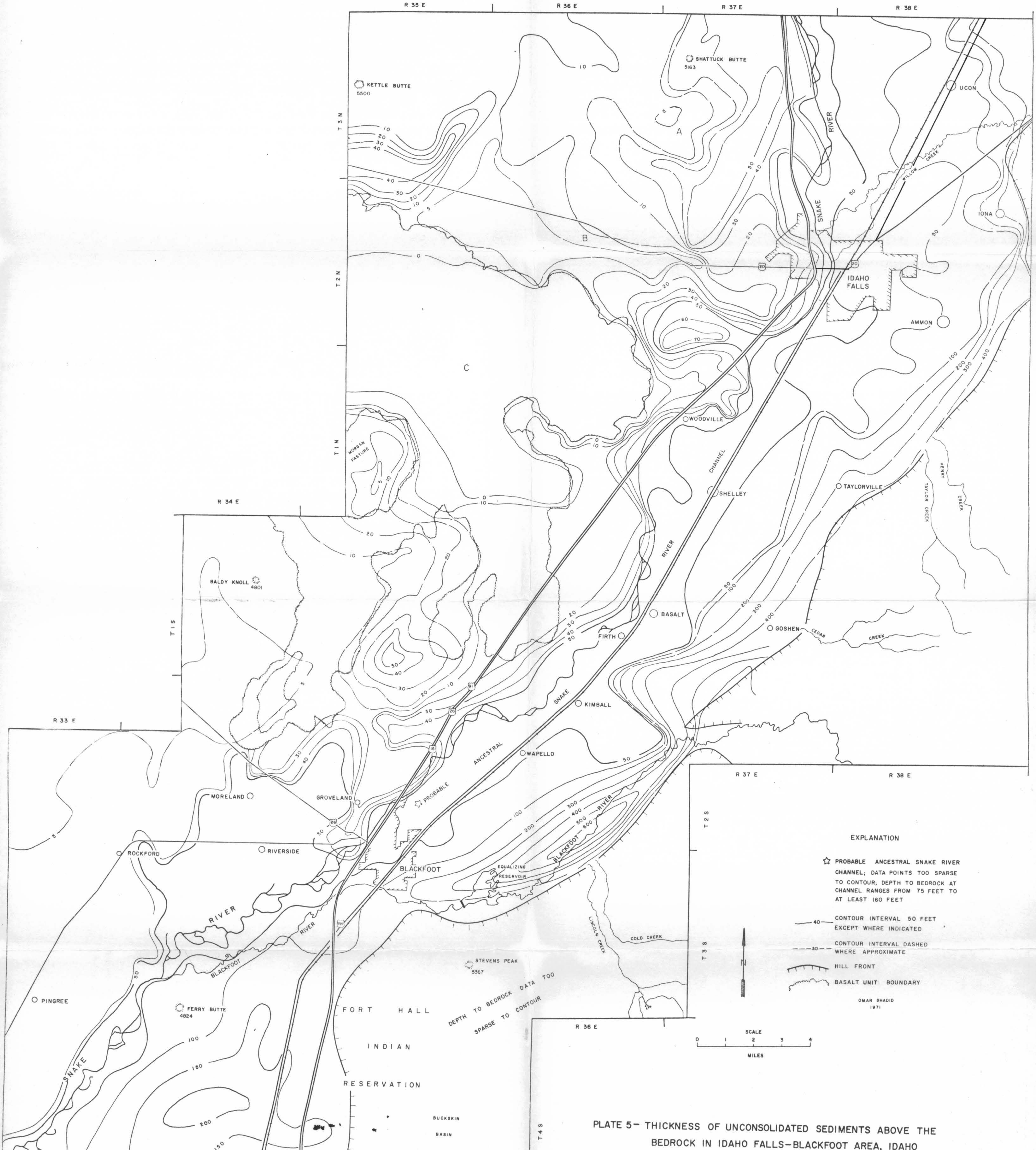

EXPLANATION

☆ PROBABLE ANCESTRAL SNAKE RIVER CHANNEL; DATA POINTS TOO SPARSE TO CONTOUR; DEPTH TO BEDROCK AT CHANNEL RANGES FROM 75 FEET TO AT LEAST 160 FEET

—40— CONTOUR INTERVAL 50 FEET EXCEPT WHERE INDICATED

--30-- CONTOUR INTERVAL DASHED WHERE APPROXIMATE

HILL FRONT

BASALT UNIT BOUNDARY

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SCALE
0 1 2 3 4
MILES

PLATE 5 – THICKNESS OF UNCONSOLIDATED SEDIMENTS ABOVE THE BEDROCK IN IDAHO FALLS–BLACKFOOT AREA, IDAHO

BASE FROM U.S. GEOLOGICAL SURVEY TOPOGRAPHIC QUADRANGLES 7-1/2 AND 15 MINUTES

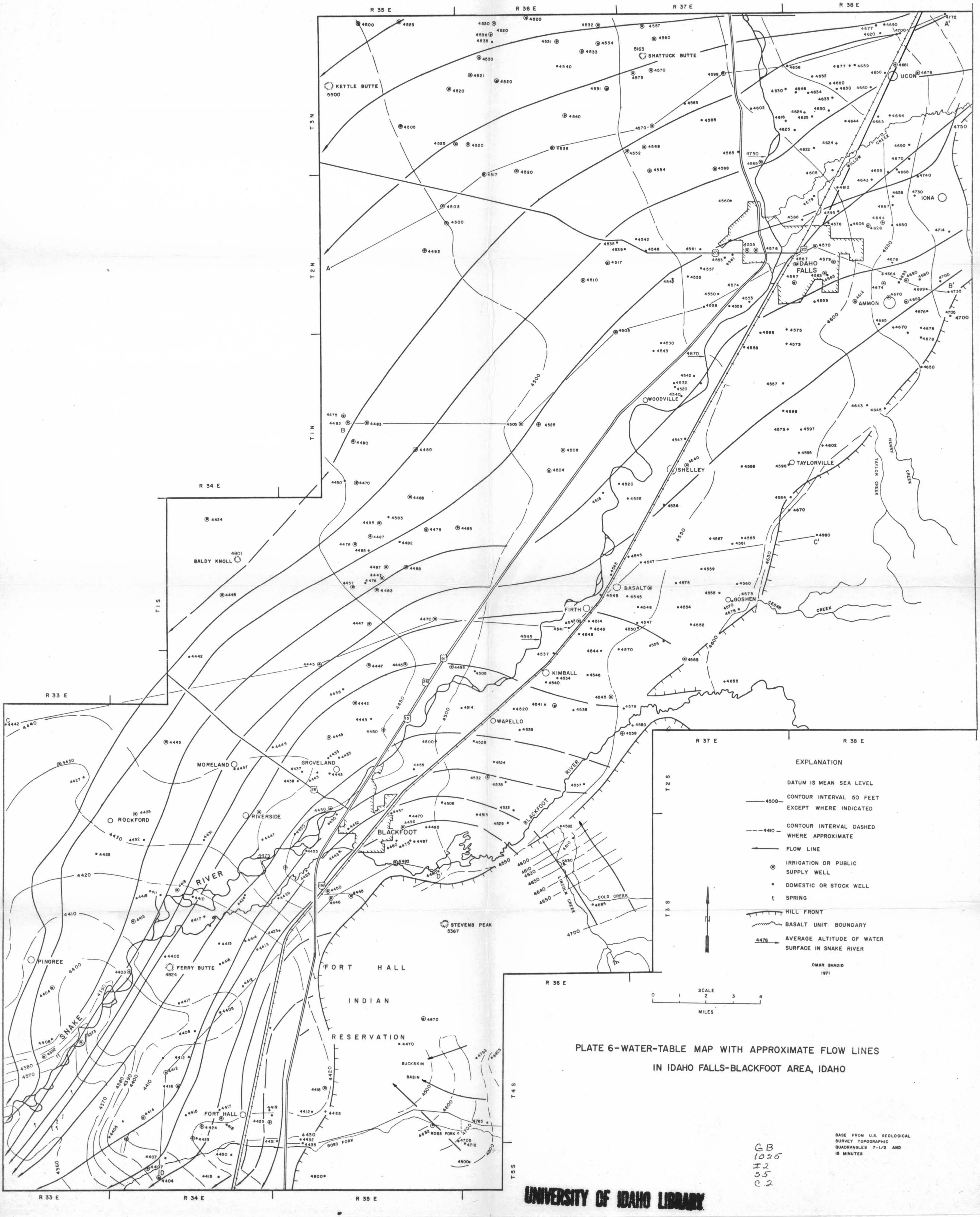

PLATE 6-WATER-TABLE MAP WITH APPROXIMATE FLOW LINES IN IDAHO FALLS-BLACKFOOT AREA, IDAHO

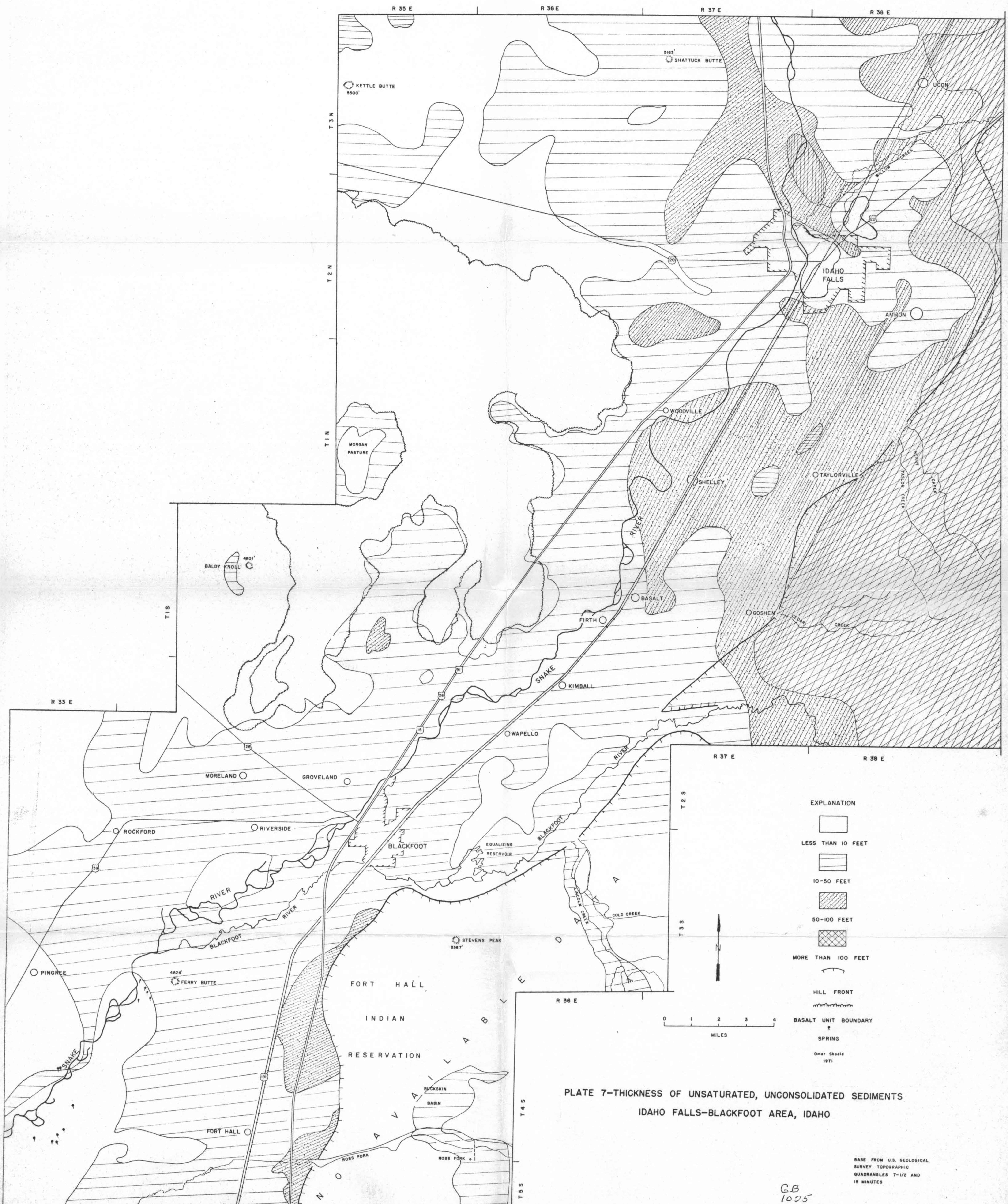

PLATE 7—THICKNESS OF UNSATURATED, UNCONSOLIDATED SEDIMENTS
IDAHO FALLS–BLACKFOOT AREA, IDAHO

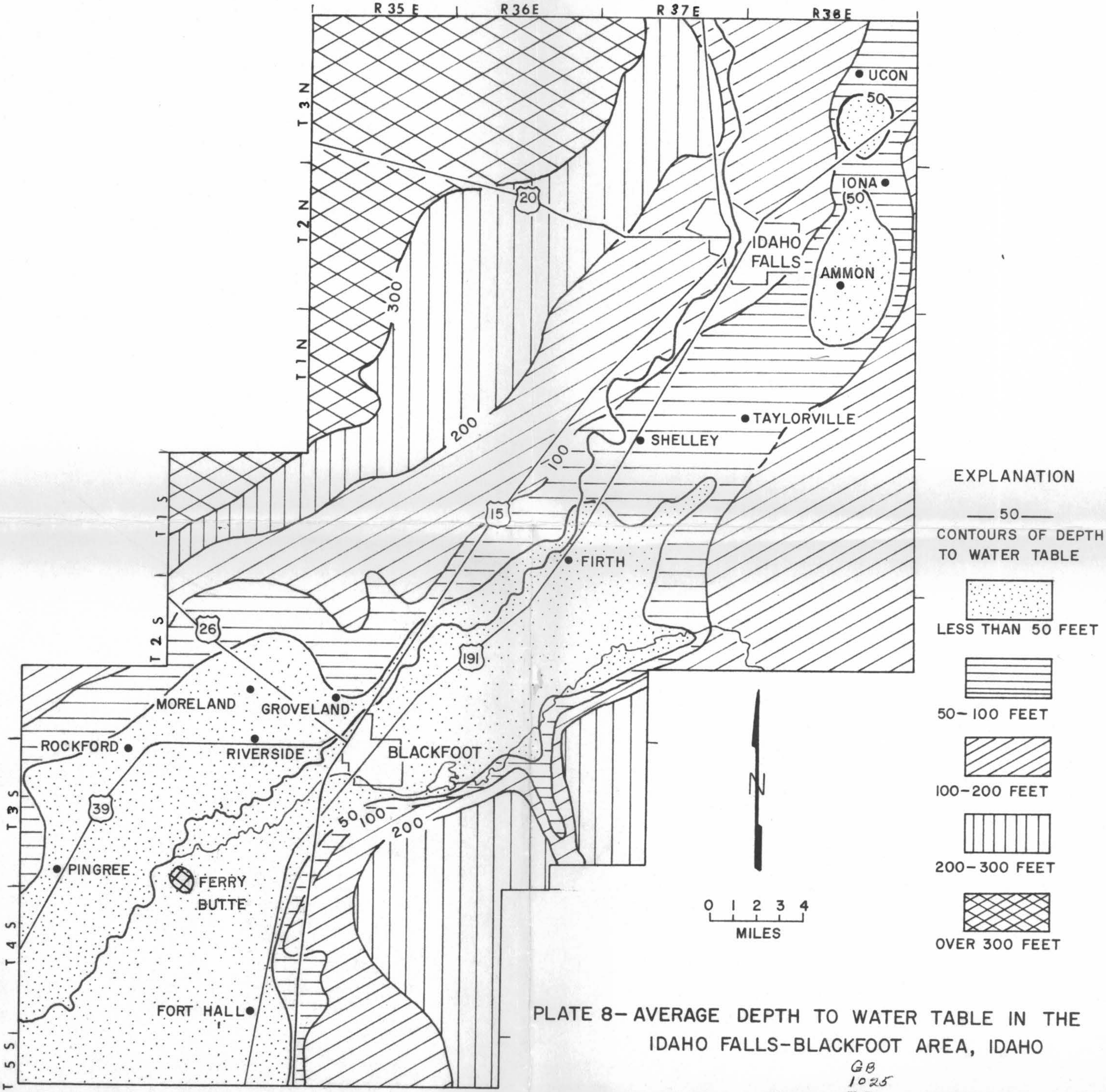

PLATE 8— AVERAGE DEPTH TO WATER TABLE IN THE IDAHO FALLS-BLACKFOOT AREA, IDAHO

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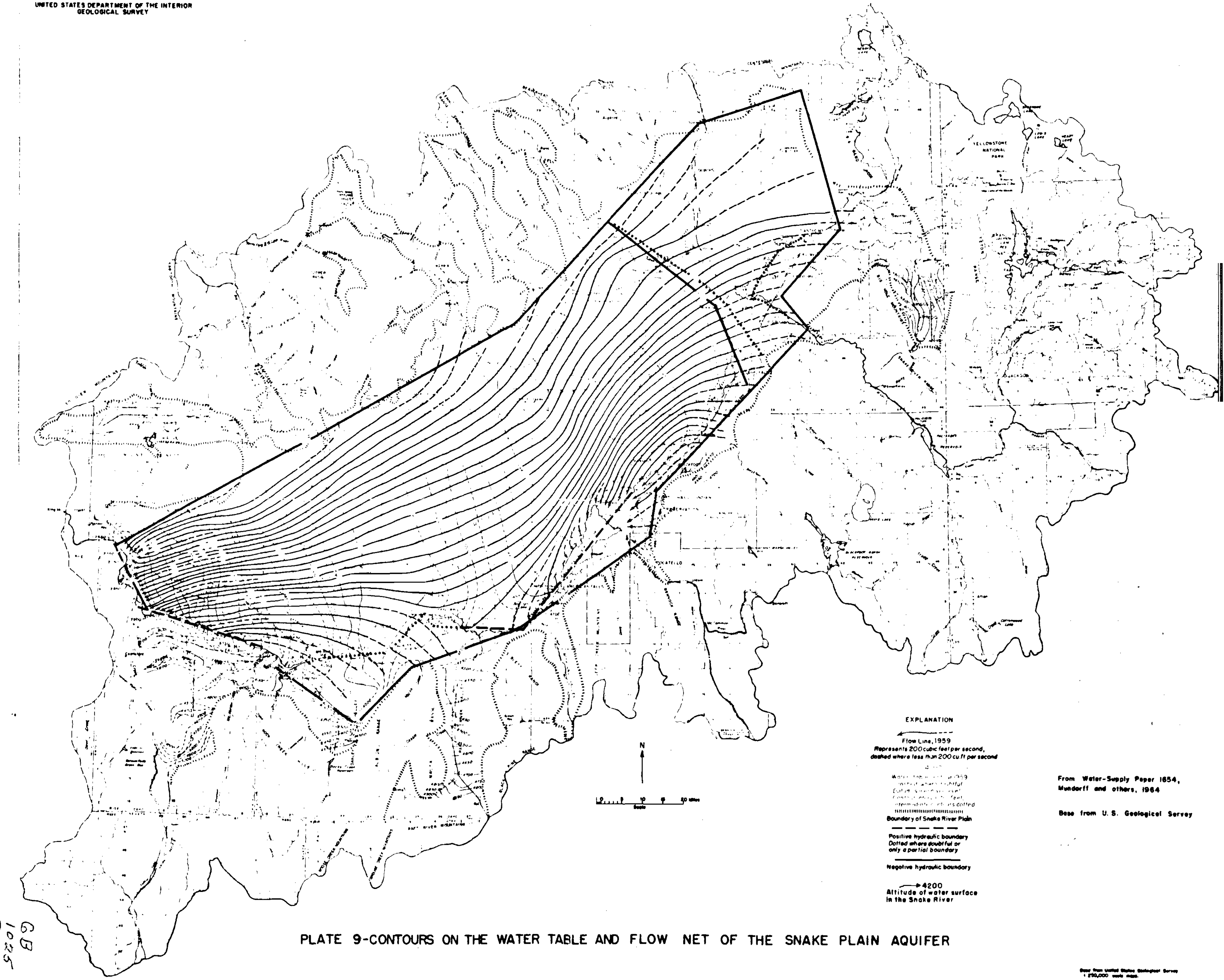
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



From Water-Supply Paper 1654, Mundorff and others, 1964

Base from U. S. Geological Survey

PLATE 9-CONTOURS ON THE WATER TABLE AND FLOW NET OF THE SNAKE PLAIN AQUIFER

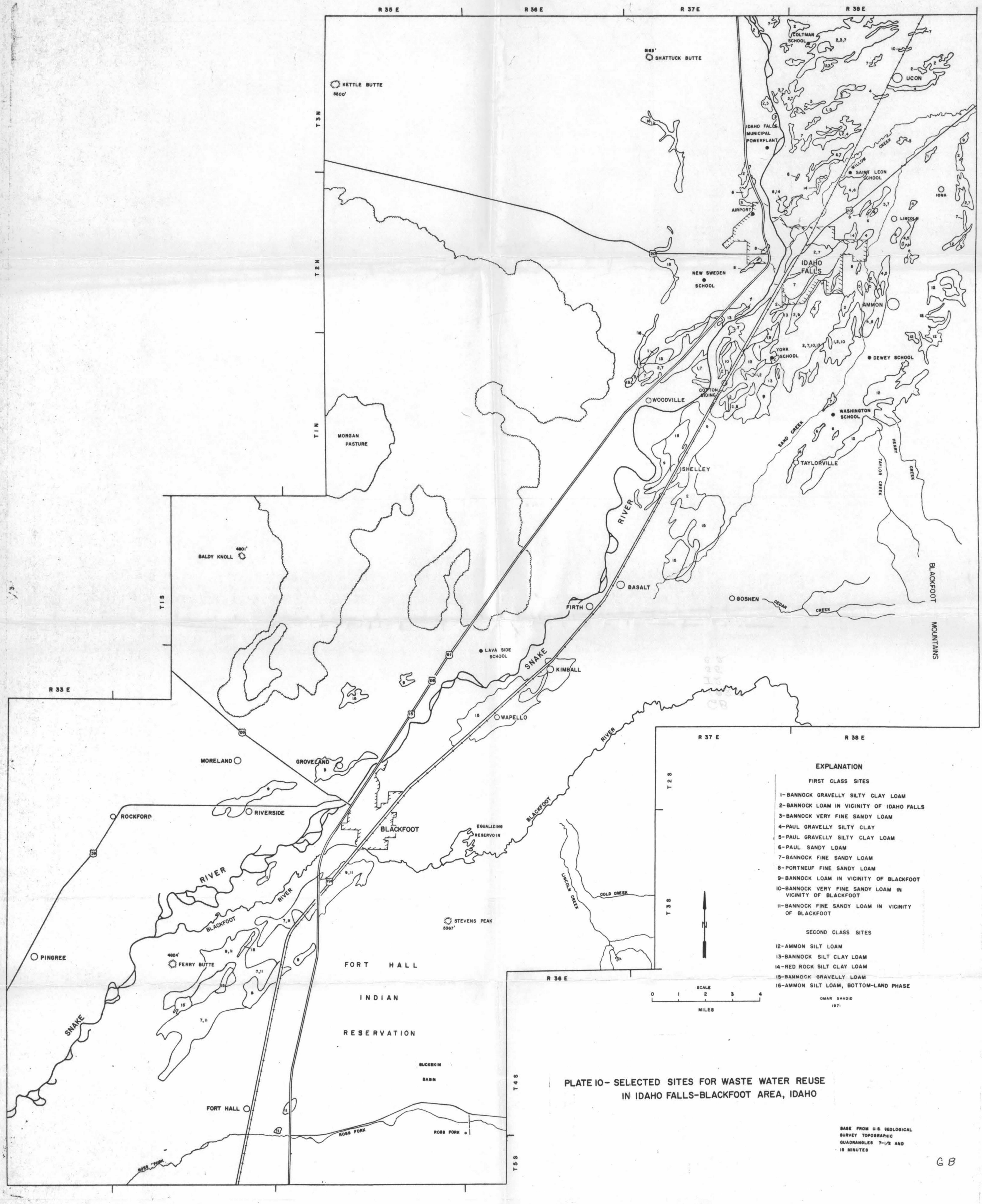
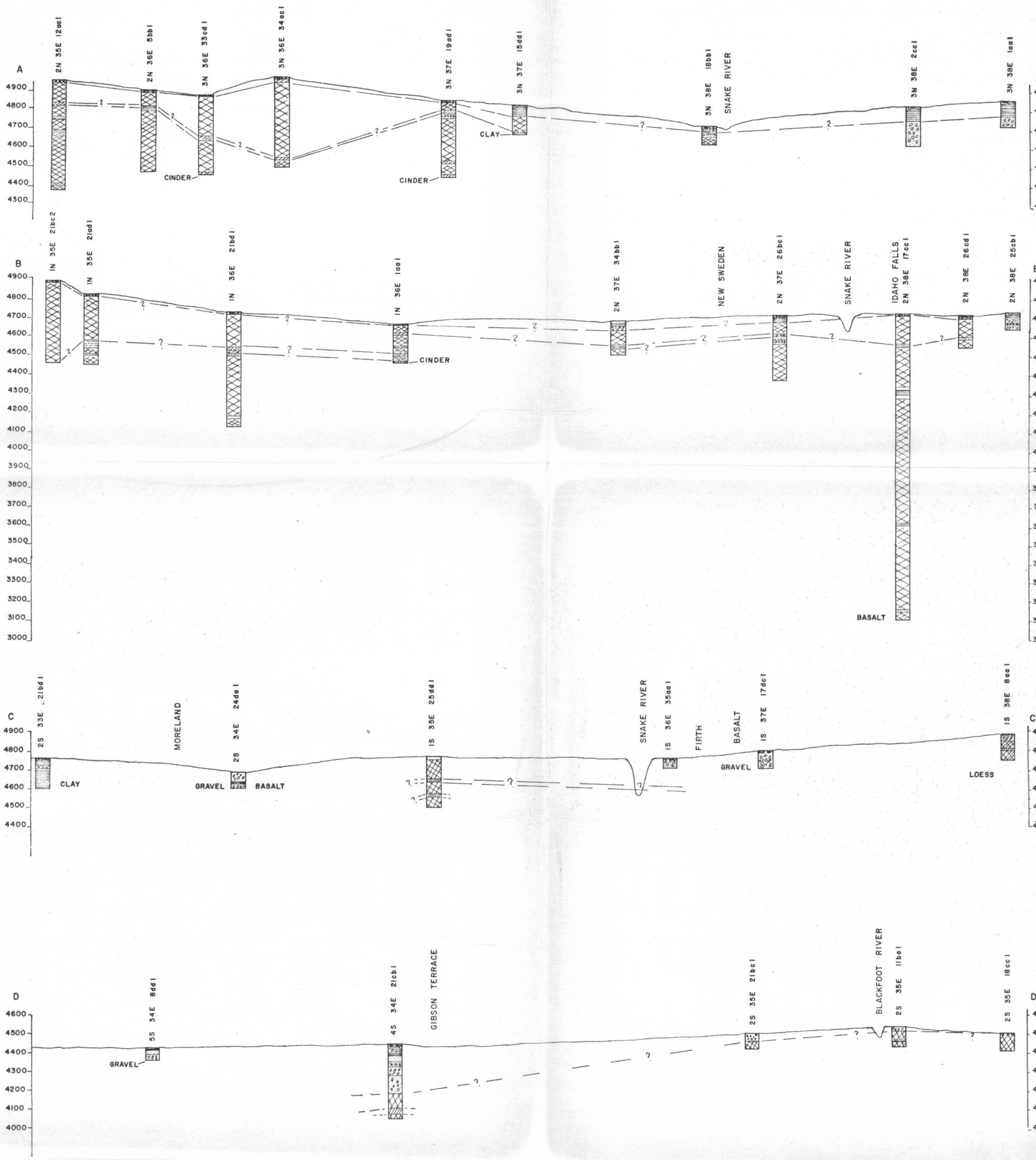


PLATE 10- SELECTED SITES FOR WASTE WATER REUSE IN IDAHO FALLS-BLACKFOOT AREA, IDAHO



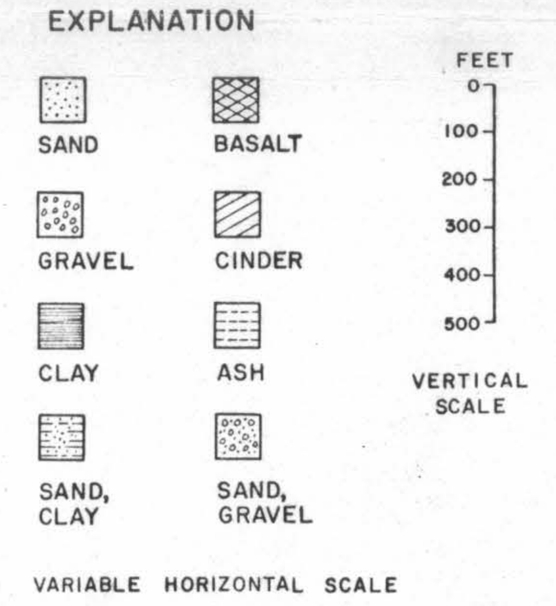


PLATE II–GEOLOGIC SECTIONS COMPILED FROM WELL LOGS A–A', B–B', C–C', AND D–D' IN THE IDAHO FALLS–BLACKFOOT AREA, IDAHO

LINES OF SECTION ON PLATE 6

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1971

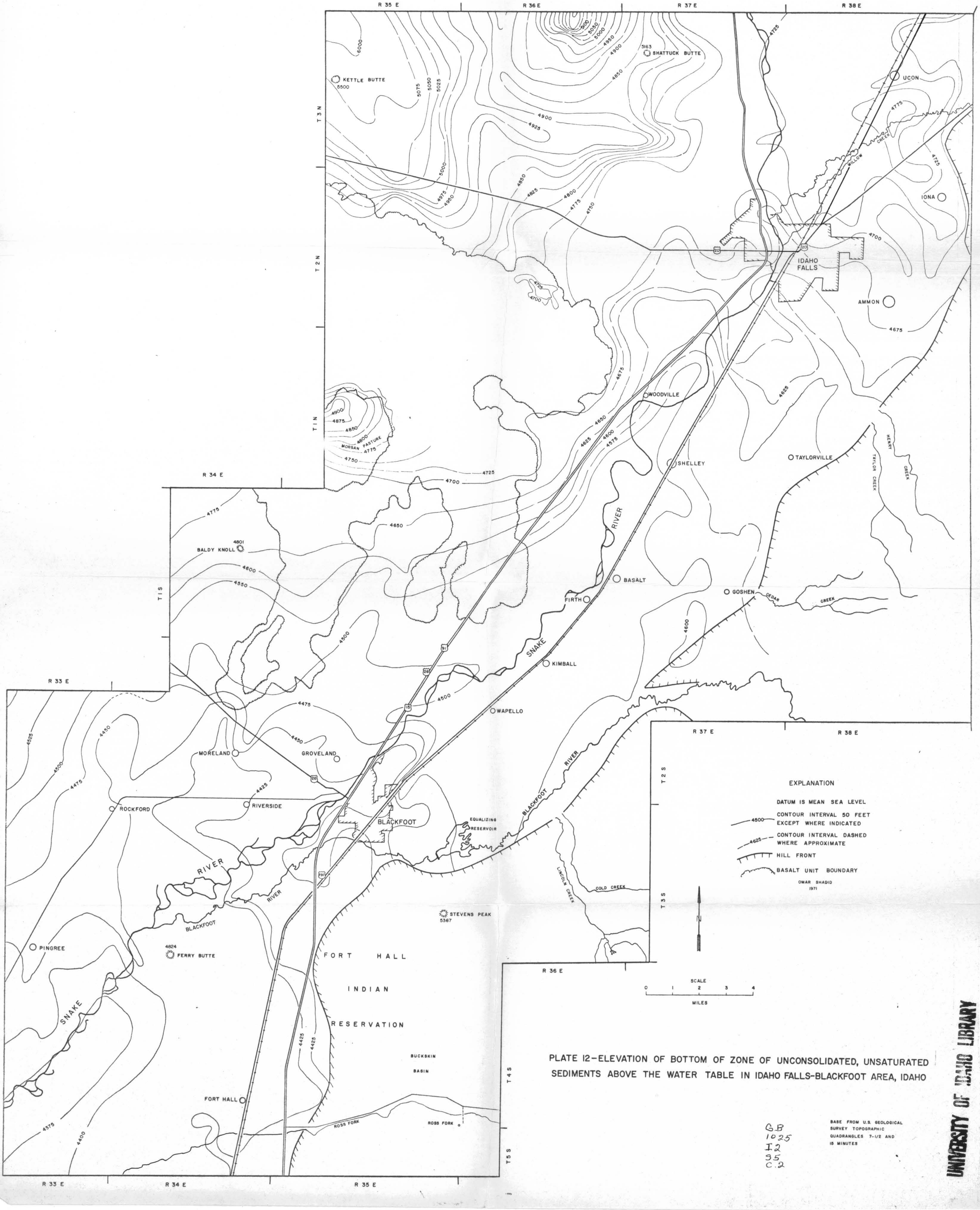

PLATE 12—ELEVATION OF BOTTOM OF ZONE OF UNCONSOLIDATED, UNSATURATED SEDIMENTS ABOVE THE WATER TABLE IN IDAHO FALLS-BLACKFOOT AREA, IDAHO

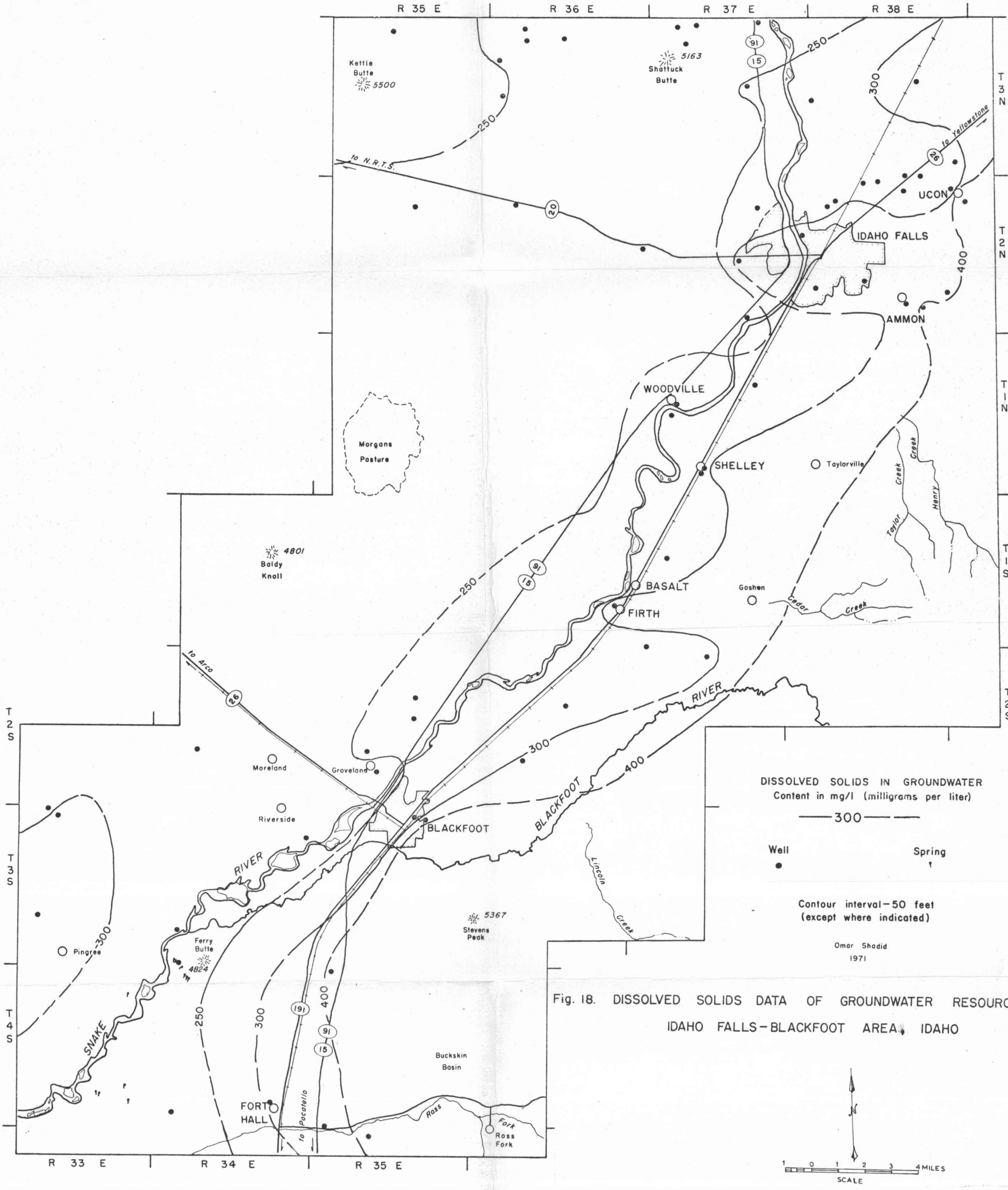

Fig. 18. DISSOLVED SOLIDS DATA OF GROUNDWATER RESOURCE IDAHO FALLS-BLACKFOOT AREA, IDAHO