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Results of water-resources investigations through 1968 in Yellowstone National Park, Wyoming

by

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Abstract

Water-resources investigations are being made in Yellowstone National Park by the U.S. Geological Survey in cooperation with the U.S. National Park Service. The investigations, begun in September 1966, include the study of water problems at selected sites and an overall appraisal of water resources in the Park.

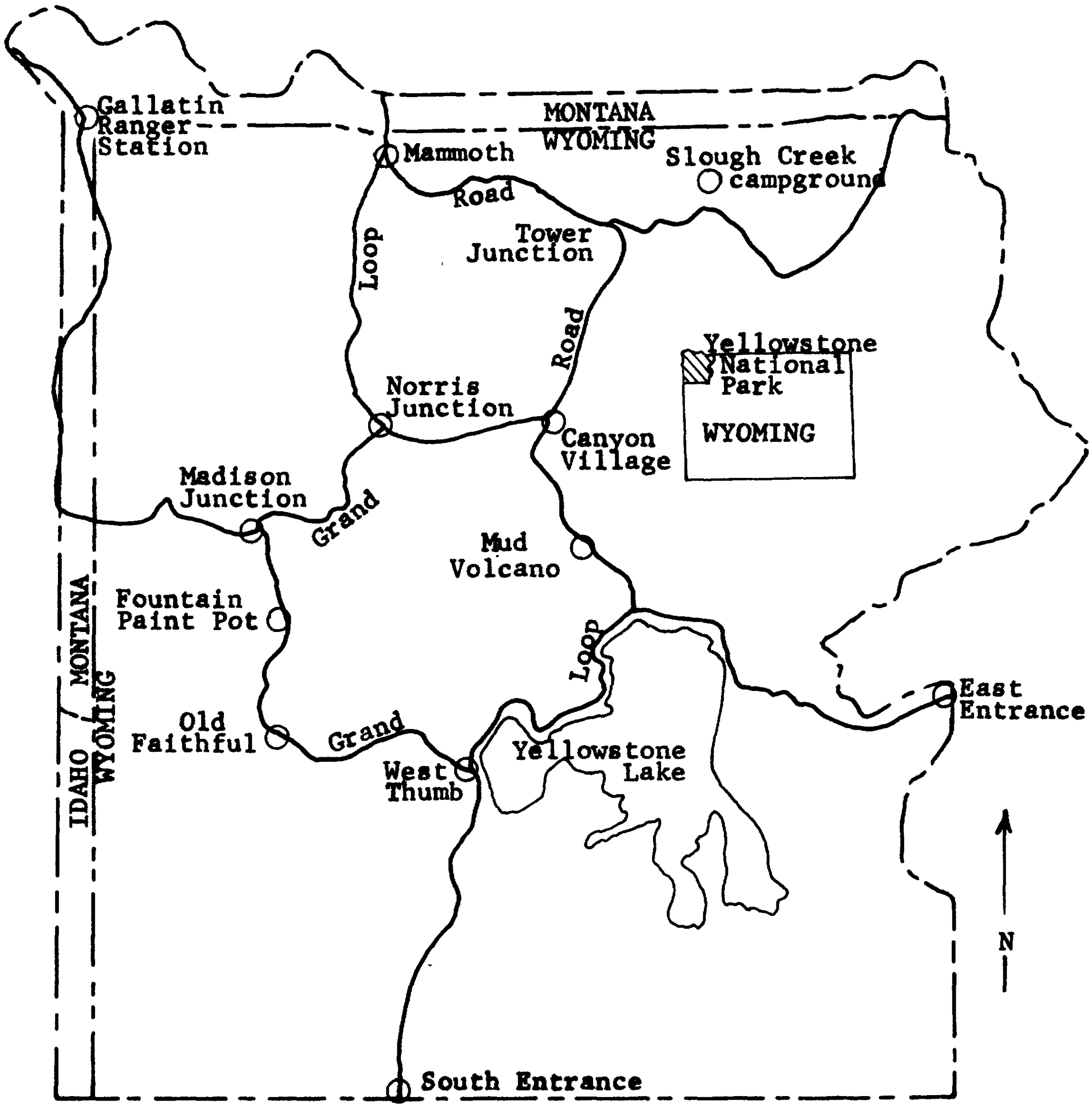
Reconnaissance studies were made near selected sites. Test holes were augered; wells were constructed and their yield characteristics determined by pumping tests. Information obtained indicates potential sources of ground water for public use at the following sites: Fountain Paint Pot, Tower Junction, Slough Creek campground, South Entrance, Mud Volcano, and Norris Junction. It seems doubtful that ground water can be obtained to replace surface-water supplies now in use at Canyon Village and Mammoth. Data collected to date indicate that the overall quality of water for use at Mammoth would not be improved by changing the point of diversion from Glen Creek to Lava Creek.

Most water sampled to date is potable. Fluoride concentrations of ground water and surface water at places, however, exceed the recommended limit established by the U.S. Public Health Service.

Introduction

This report is a summary of the results of work through 1968 at Yellowstone National Park by the Water Resources Division, U.S. Geological Survey, in cooperation with the U.S. National Park Service. Investigations, begun in September 1966, include the study of water problems at selected sites and an overall appraisal of water resources in Yellowstone National Park (fig. 1). The guidelines of the investigations are given in a memorandum of October 31, 1966 from the Supervisory Hydraulic Engineer, Office of Land and Water Rights, National Park Service, San Francisco, Calif., to the District Geologist, Water Resources Division (Ground Water Branch), Geological Survey, Cheyenne, Wyo.

A report on results of work in FY (Fiscal Year) 1967 was prepared and transmitted to the National Park Service. Some data and interpretations presented in that report are included in this report because they are helpful in understanding some of the new data given in this report.



Base from U.S. Geological Survey
Wyoming State base map, 1967

0 5 10 15 Miles

Figure 1.--Index map of Yellowstone National Park, Wyoming.

Reconnaissance studies were made near the sites selected for investigation in FY 1968 and in other areas of Yellowstone National Park, including those sites investigated in FY 1967 that needed additional study. Reconnaissance studies consisted of inspections of surface geology, topography, and hydrologic features. Locations were selected for test holes to be augered near the sites to study subsurface features. Observations were made and hydrologic data were collected in other areas for use in the overall appraisal of water resources in the Park. Effort, however, was concentrated on studies near the sites selected for investigation in FY 1968 and those investigated in FY 1967 that required additional study.

Test holes were constructed with a power-driven auger in FY 1967 and 1968 to study the occurrence of ground water and the nature of the water-bearing materials. Test holes were also constructed with a cable-tool drilling machine in FY 1967. Some holes were completed as wells by installing casing and screens or slotted casing. Pumping tests were made in selected wells to determine their yield characteristics.

Abbreviations are used in the text, illustrations, and tables of this report to identify the test holes and wells. The first letter indicates the method of construction--C, cable-tool drilling machine; and A, power-driven auger. The succeeding letters are abbreviations of place names near the sites studied--M, Mammoth; EE, East Entrance; NJ, Norris Junction; OF, Old Faithful; MV, Mud Volcano; SE, South Entrance; CV, Canyon Village; TJ, Tower Junction; FPP, Fountain Paint Pot; SC, Slough Creek; and SCS, Stephens Creek. The number gives the order of construction of a particular type of test hole. For example, CM 1 was the first hole drilled by a cable-tool machine near Mammoth, and ANJ 4 was the fourth hole constructed by a power-driven auger near Norris Junction.

Water levels measured to date in selected observation wells are shown in table 1. Logs of the holes augered in FY 1968 are shown in tables 2 and 3.

The location coordinates (latitude and longitude) given in the tables in this report were determined from U.S. Geological Survey 15-minute topographic maps.

Discharge measurements made on selected streams and springs during this investigation are listed in table 4.

Water samples were collected from holes, wells, streams, and springs to determine the general chemical quality of water. The chemical analyses of water samples collected from holes and wells are listed in table 5, and those collected from streams and springs are listed in table 6. Water samples for more complete analyses (including trace elements and radiochemical) were collected from selected wells at sites where ground-water supplies might be developed for public use. Detailed analyses of water collected from three wells in August 1967 are shown in table 7. Spectrographic and radiochemical analyses of water collected from four wells in July and August 1968 are shown in table 8. Water samples for bacteriological analysis were collected from four wells in July and August 1968. Two of the samples, however, did not arrive at the laboratory within 48 hours of collection, and they were discarded because the results of analysis would not have been reliable. Results of bacteriological samples from wells ASE 9 and ANJ 14 that were analyzed are mentioned under sites studied, South Entrance and Norris Junction. Values given in tables 5, 6, 7, and 8 are total concentrations of each element, and concentrations of each isotope (such as Sr-90 and Cr^{+6}) are less than the totals.

Most chemical constituents are expressed in milligrams per liter in this report. Trace elements determined by spectrographic analysis and gross alpha activity and uranium content determined by radiochemical analysis are expressed in micrograms per liter. A microgram equals 1 thousandth of a milligram. Radioactivity due to radium and gross beta activity are expressed in picocuries per liter. A picocurie is 1 million-millionth of a curie (a standard unit of radioactivity).

The Geological Survey reported concentrations of chemical constituents in parts per million prior to October 1, 1968. For practical purposes, concentrations less than 7,000 ppm (parts per million) are equal to those in milligrams per liter.

The drinking water standards published by the U.S. Public Health Service (1962) can be used in evaluating the quality of the water obtained at the sites studied. The following explanations and tables are from pages 7 and 8 of the above-mentioned report:

"The following chemical substances should not be present in a water supply in excess of the listed concentrations where...other more suitable supplies are or can be made available."

Substance	Concentration (milligrams per liter)
Arsenic (As)	0.01
Chloride (Cl)	250
Copper (Cu)	1
Fluoride (F)	1.7*
Iron (Fe)	.3
Manganese (Mn)	.05
Nitrate (NO_3)	45
Sulfate (SO_4)	250
Total dissolved solids	500
Zinc (Zn)	5

"The presence of the following substances in excess of the concentrations listed shall constitute grounds for rejection of the supply."

Substance	Concentration (milligrams per liter)
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	.01
Chromium (Hexavalent) (Cr^{+6})	.05
Fluoride (F)	2.4*
Lead (Pb)	.05
Silver (Ag)	.05

* Limits of fluoride vary according to annual average of maximum daily air temperature. At Yellowstone National Park, the upper limit is probably 1.7 mg/l (milligrams per liter) and the optimum concentration is probably 1.2 mg/l. The U.S. Public Health Service (1962, p. 8) states, "Presence of fluoride in average concentrations greater than two times the optimum values...shall constitute grounds for rejection of the supply."

Recommended limits for all radioactive materials in water have not been established. Approval of water supplies containing radioactive materials depends on the amount of radiation from all sources, so that total exposure does not exceed that recommended by the Federal Radiation Council. The U.S. Public Health Service (1962, p. 9) states that water supplies can be approved without further consideration of other sources of radioactivity when Radium-226 and Strontium-90 do not exceed 3 and 10 picocuries per liter, respectively. In the known absence of alpha emitters and Strontium-90, the water supply is acceptable if the gross beta concentrations do not exceed 1,000 picocuries per liter.

The Geological Survey, in order to have a uniform policy in classifying water hardness in the United States, uses the following classification:

Hardness range (milligrams per liter)	Adjective rating
0 - 60	soft
61 - 120	moderately hard
121 - 180	hard
>180	very hard

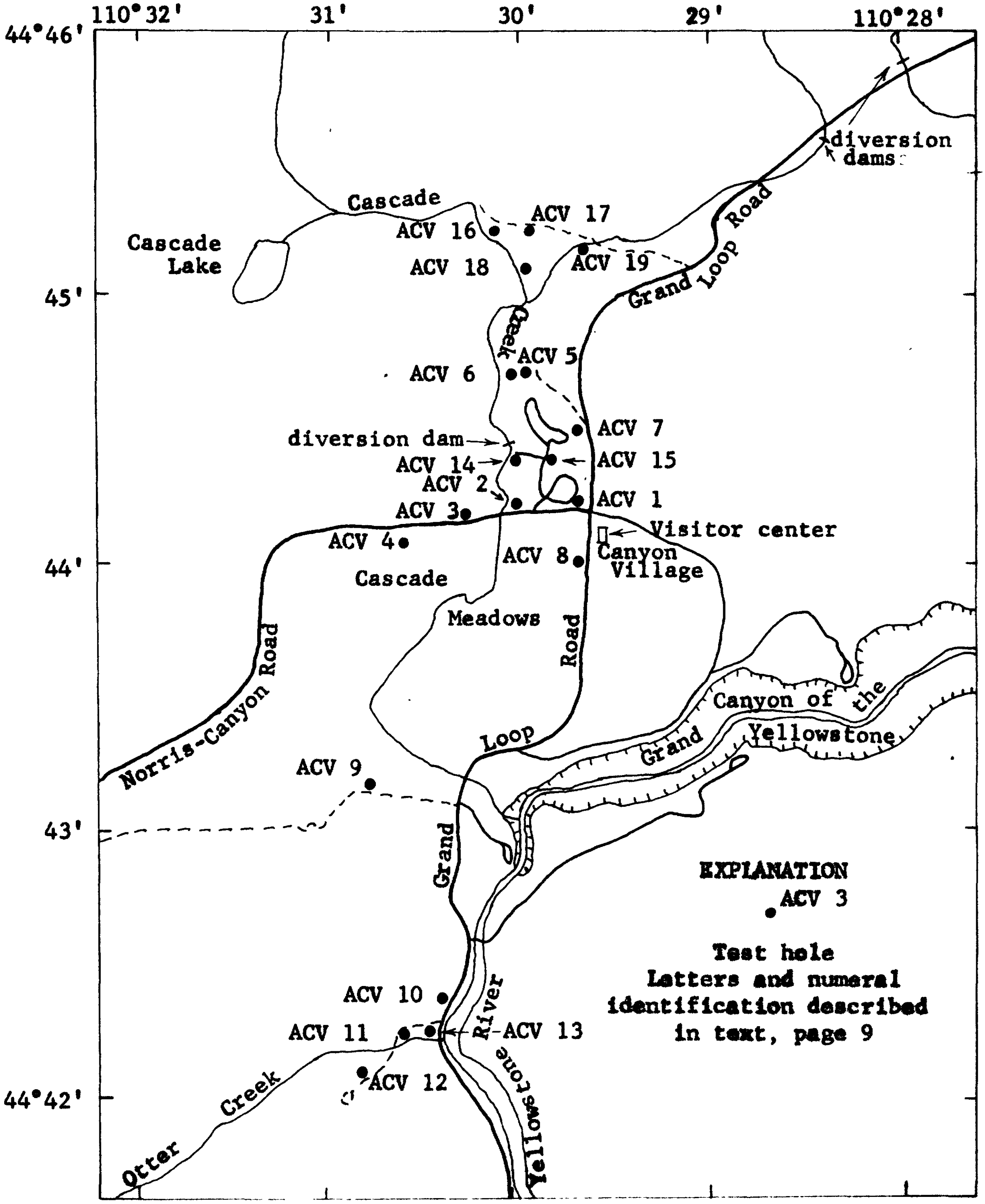
Sites studied

Canyon Village

About 1,000,000 gpd (gallons per day), or about 700 gpm (gallons per minute), is needed for the water supply for facilities at Canyon Village. Presently, water is diverted by gravity flow from unnamed tributaries of Cascade Creek and Sulphur Creek 2.0 and 2.5 miles, respectively, northeast of Canyon Village. An auxiliary pump is located on a water line from a diversion dam on Cascade Creek about 0.5 mile northwest of Canyon Village. Flow in these creeks declines during the summer and may become too small during dry years to supply the needs at Canyon Village. No water shortages occurred, however, during 1967 or 1968.

Nineteen holes were augered in the Canyon Village area in September 1968. These holes were augered in Cascade Meadows, other clearings along Cascade Creek, and along the lower reach of Otter Creek (fig. 2). Augering was limited to these sites because other nearby areas are inaccessible with the truck-mounted auger or bedrock is at or near land surface.

None of the augered holes penetrated water-bearing material from which water can be developed by wells at the rate of 700 gpm. Much of the material augered was clay or clayey sand and gravel. The material may be of lacustrine origin and related to known lake deposits in Hayden Valley, from 4 miles to 9 miles south of Canyon Village. Some of the sandy lenses penetrated by the auger holes may be beach deposits. These beach deposits may yield water to wells but not 700 gpm required for Canyon Village. A properly screened well near ACV 8, the most promising site augered, would probably yield 5 to 10 gpm and could supply water for Canyon Village when the streams are frozen. To date no other sites in the unconsolidated rock seem to be more promising for wells near Canyon Village than the sites augered.



Base from U.S. Geological Survey quadrangle maps, Mammoth 1958, Norris Junction 1958, Canyon Village 1959, Tower Junction 1959

0 1 2 Miles

Figure 2.--Location of test holes near Canyon Village.

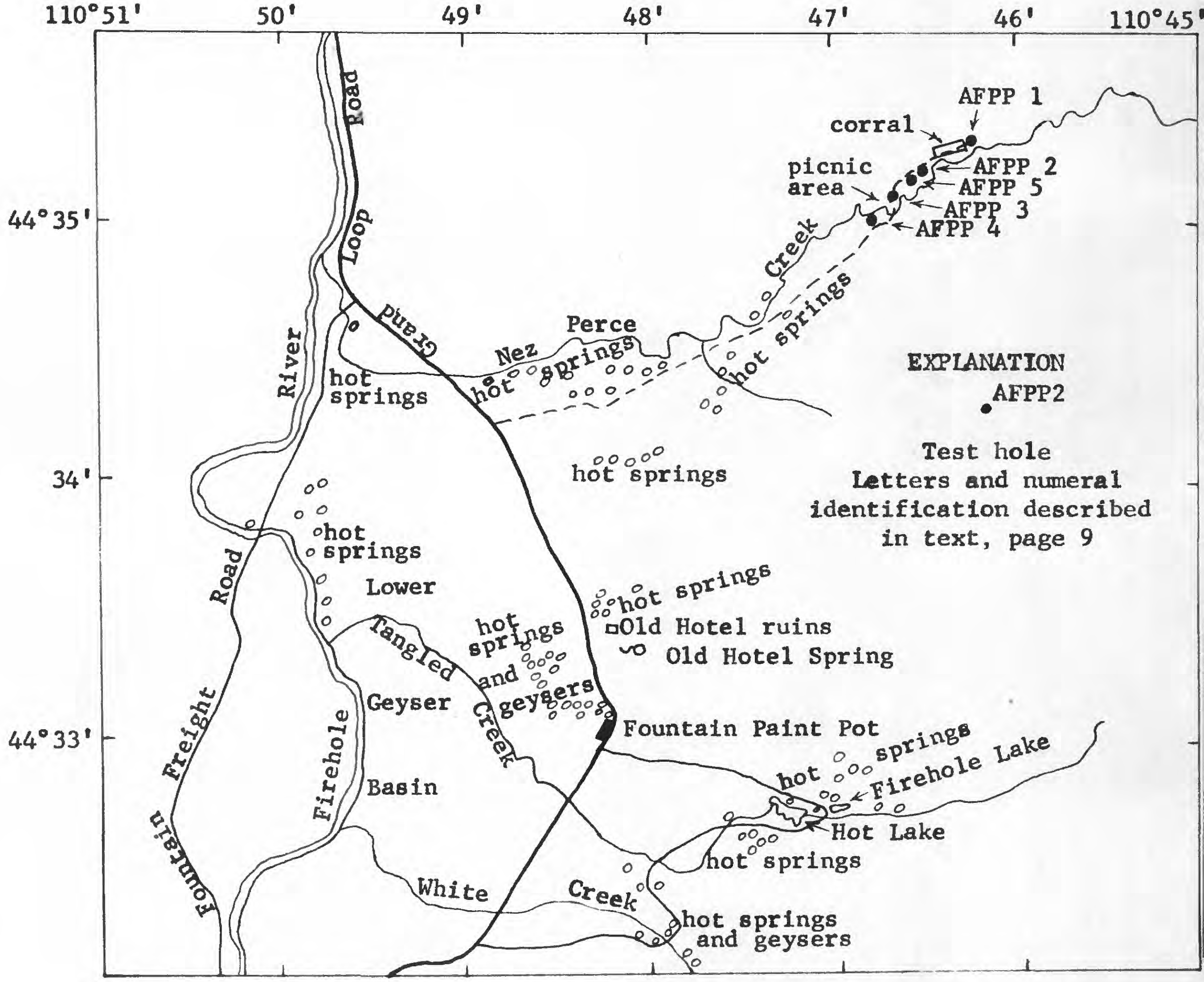
Exploration for a ground-water supply for Canyon Village has been limited to unconsolidated rock because the auger bit cannot penetrate hard rock. Some of the holes, however, penetrated relatively soft, probably weathered, bedrock. Little was learned from the augering about the occurrence of water in the bedrock.

Bedrock in the Canyon Village area is mostly rhyolite and volcanic breccia. The rhyolite has very low permeability, except possibly in fractured zones. Rhyolite probably does not contain enough water to supply Canyon Village, even in fractured zones. Fractures in the walls of the nearby Grand Canyon of the Yellowstone are dry or discharge water as small seeps. Aquifers in rhyolite within about 500 feet of land surface at Canyon Village would probably discharge into the Yellowstone River in Grand Canyon. The river is about 750 feet below the canyon rim. Numerous hot springs, gas vents, and much hydrothermally altered rhyolite within a 5-mile radius of Canyon Village may be evidence that any water in deep aquifers in rhyolite would probably be warm, possibly highly mineralized, and not suitable for a water supply for Canyon Village. Volcanic breccia crops out in Washburn Range about 3 miles north of Canyon Village and underlies rhyolite at great depth at Canyon Village. The breccia is well cemented and dense and, like rhyolite, would probably yield water only in fractured zones. Volcanic breccia probably cannot be considered a potential aquifer in the Canyon Village area unless water occurs in fractures at relatively shallow depth between Canyon Village and outcrops in Washburn Range.

Surface water could be used to supply additional water for Canyon Village. Water could be pumped from Yellowstone River above Grand Canyon, treated, and distributed to Canyon Village facilities. Treatment of water from Yellowstone River would probably have to include filtering. During this study, Yellowstone River has not been sampled for chemical analysis, but the water probably does not contain any chemical constituents in excess of the recommended limits.

Fountain Paint Pot

About 20,000 gpd (14 gpm) of water is needed for a proposed comfort station at the parking area near Fountain Paint Pot. This popular roadside attraction and nature trail is in the eastern part of the Lower Geyser Basin (fig. 3). Ground water in the Lower Geyser Basin is undoubtedly hot and probably too highly mineralized to use for the comfort station. An effort to locate a ground-water source for the comfort station was made in the valley along Nez Perce Creek, the area nearest Fountain Paint Pot where cool ground water might occur. Another possible source of water for the comfort station is a spring 0.4 mile north-northeast of Fountain Paint Pot. This spring, called Old Hotel Spring in this report, was formerly used as a water supply for a hotel, now destroyed (fig. 3). A flow of 16 gpm was measured from this spring in October 1968.



Base from U.S. Geological Survey
quadrangle map, Madison Junction 1958

0 1 2 Miles

Figure 3.--Location of test holes and thermal features near Fountain Paint Pot.

Four holes were augered in October 1967 in the general vicinity of the picnic area and the corral in Nez Perce Creek valley about 3 miles northeast of Fountain Paint Pot (fig. 3). Holes AFPP 1 and 2 penetrated 87 and 100 feet, respectively, of sand and gravel, composed mostly of angular fragments of obsidian. Hole AFPP 2 was completed as an observation well by installing 1-inch diameter pipe. Warm sand was penetrated below 11 feet at holes AFPP 3 and 4.

A test hole, AFPP 5, was augered in June 1968 near well AFPP 2, and 42 feet of 4-inch diameter casing and a 3-inch diameter screen 6 feet long were installed in the hole. Well AFPP 5 was pumped 4 hours at a rate of 35 gpm and the drawdown was 0.64 foot. The specific capacity was 55 gpm per foot of drawdown. The water level in the well was 8.1 feet below land surface before pumping began. Test well AFPP 5 would yield sufficient quantities of water for a comfort station at Fountain Paint Pot.

Yields of as much as 500 gpm could probably be obtained from properly constructed wells in the Nez Perce Creek valley near the sites of AFPP 1, 2, and 5. Production wells should not be drilled down the valley from well AFPP 5 because hot ground water might be penetrated. The valley upstream from hole AFPP 1 was not tested because it was inaccessible with the truck-mounted auger.

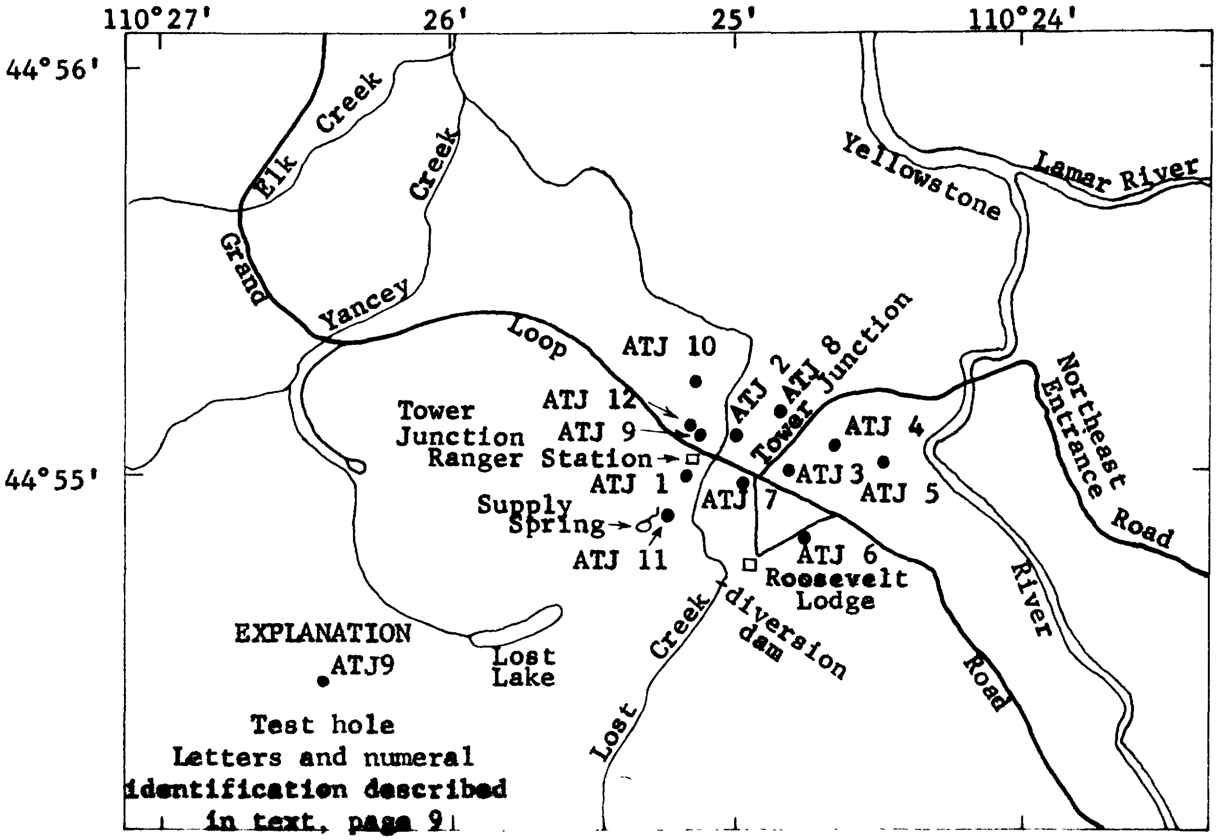
The aquifer in sand and gravel in Nez Perce Creek valley is recharged by infiltration from Nez Perce Creek. The flow of Nez Perce Creek is continuous and was measured as 77.4 cfs (cubic feet per second) on August 14, 1968. If ground water were pumped from sand and gravel in the vicinity of AFPP 1, 2, and 5, virtually all the dewatered part of the aquifer would be recharged by infiltration from Nez Perce Creek.

The chemical constituents of water from wells AFPP 2 and 5, Nez Perce Creek, and Old Hotel Spring are within recommended limits except for a fluoride content of about 5 mg/l from the wells and Nez Perce Creek and about 8 mg/l from the spring. Water from any of these sources would have to be defluorinated to meet the drinking water standard of the Public Health Service.

Tower Junction

Eleven test holes, ATJ 1-11, were augered near Tower Junction in September 1967 in order to locate the best site to obtain 200,000 gpd (140 gpm) of ground water for Tower Junction Ranger Station and Roosevelt Lodge to replace supplies from Lost Creek and a spring. Most of the holes were augered in the flat north of the Grand Loop Road, on both sides of the Northeast Entrance Road (fig. 4). Holes ATJ 1, 9, and 10 were cased and completed as observation wells. The area west of the Northeast Entrance Road showed more promise for establishing wells than that east of the Northeast Entrance Road where boulders or bedrock occur at shallow depths. In addition, the material above the bedrock east of the Northeast Entrance Road is glacial drift and does not contain enough water to warrant further exploration.

The flat north of Grand Loop Road and west of Northeast Entrance Road is bounded on the west by a ridge between Yancey Creek and Lost Creek and is approximately bisected by Lost Creek. Test augering indicated that the west half of this area, containing wells ATJ 9 and 10, is the most promising area to develop a ground-water supply for facilities near Tower Junction.



Base from U.S. Geological Survey
quadrangle map, Tower Junction 1959

0 1 2 Miles

Figure 4.--Location of test holes near Tower Junction.

Test hole ATJ 12 was augered near well ATJ 9 in June 1968. A well was established at ATJ 12 with 4-inch diameter casing and a 3-inch diameter well point. The well point was broken from the casing during construction of well ATJ 12, and a capacity test could not be made. In September 1968, the casing was pulled, equipped with a new well point, and installed in a new hole. The well has 19 feet of 4-inch diameter casing and a 3-inch diameter well point 5 feet long. A capacity test was not made, but the well was developed by pumping at a rate of 24 gpm for about 2 hours with the pump mounted on the auger rig. Well ATJ 12 probably has a sustained yield of about 25 gpm.

Water-supply wells could be drilled in the flat near wells ATJ 9, 10, and 12. The supply wells should be as shallow as possible because sand and gravel penetrated in the test holes became finer grained with increased depth. Logs of wells ATJ 9 and 10 indicate that wells should not be drilled deeper than 36 feet to avoid clay and silt.

More than one well would probably be necessary to obtain the 140 gpm needed at Tower Junction facilities. Three screened wells, properly spaced, might yield 140 gpm. One or two wells could be used to supplement the present supplies when springflow and streamflow are low or when Lost Creek contains much suspended sediment.

Chemical constituents in the water from wells ATJ 1, 9, 10, and 12, Lost Creek, and the presently used supply spring are below the recommended limits for all chemical constituents except iron in water from well ATJ 10. The source of the high iron content (1.88 mg/l) in water from well ATJ 10 is not known and it may be from the well casing and not from the aquifer. Well ATJ 10 is partly plugged, and it yielded only about 0.1 gpm when sampled.

Lost Creek is a source of intermittent recharge to aquifers in the alluvium and glacial deposits in the flat west of the Northeast Entrance Road. Most of the recharge occurs during spring runoff. A storm in May 1967 resulted in excessive runoff that flooded almost the entire flat and damaged the Grand Loop and Northeast Entrance Roads. Flow in Lost Creek declines during the summer, and the creek was dry at the Grand Loop Road bridge in September 1968.

Slough Creek campground

A test hole was augered at the Slough Creek campground, 6.0 miles northeast of Tower Junction (fig. 1), to determine if a ground-water supply could be obtained for the campground. At present, no water supply is provided at the campground. The test hole was augered with great difficulty through sand, gravel, cobbles, and boulders. A 1-inch diameter well, ASC 1, was established at the site and developed with a hand-operated pitcher pump. Well ASC 1 yields about 6 gpm of water of quality suitable for use at Slough Creek campground (table 5). Larger yielding wells could be drilled near well ASC 1, but 6 gpm is probably adequate to supply the campground.

South Entrance

Study was begun in September 1966 at South Entrance when eight holes, ASE 1-8, were augered. ASE 4 was completed as an observation well with 1-inch diameter pipe. In June and July 1967, a test hole, CSE 1, was drilled with a cable-tool drilling machine and finished as an observation well in the north end of the campground near South Entrance (fig. 5). The study to locate 20,000 gpd (14 gpm) of ground water for use at South Entrance facilities in place of a spring continued in FY 1968. Two holes, ASE 9 and 10, were augered near well ASE 4 on a terrace near the confluence of Lewis and Snake Rivers in June 1968. Wells were established at ASE 9 and 10. Well ASE 9 has 16 feet of 4-inch diameter casing and 6 feet of 3-inch diameter well screen. Well ASE 10 has 21 feet of $1\frac{1}{2}$-inch diameter pipe and 2 feet of $1\frac{1}{2}$-inch diameter well screen. During development, well ASE 9 was pumped at 30 gpm and well ASE 10 was pumped at 25 gpm. Drawdown could not be measured during pumping for development.

Well ASE 9 was pumped at a rate of about 38 gpm for 4 hours and the drawdown was about 1.6 feet. The specific capacity of the well was about 24 gpm per foot of drawdown. The water level was 9.4 feet below land surface before pumping began. Test well ASE 9 would yield sufficient water to satisfy the requirements at South Entrance.

A properly screened well about 50 feet in depth on the terrace near wells ASE 4, 9, and 10 would probably yield at least 100 gpm. The aquifer in sand and gravel under this terrace is recharged by seepage from Lewis and Snake Rivers. Wells should not be drilled deeper than necessary to obtain the desired yield because thermal water, such as discharges in hot springs 1,500 feet east of the confluence of Lewis and Snake Rivers, might underlie the terrace west of Snake River. Well ASE 4 was augered to a depth of 62 feet without penetrating thermal water.

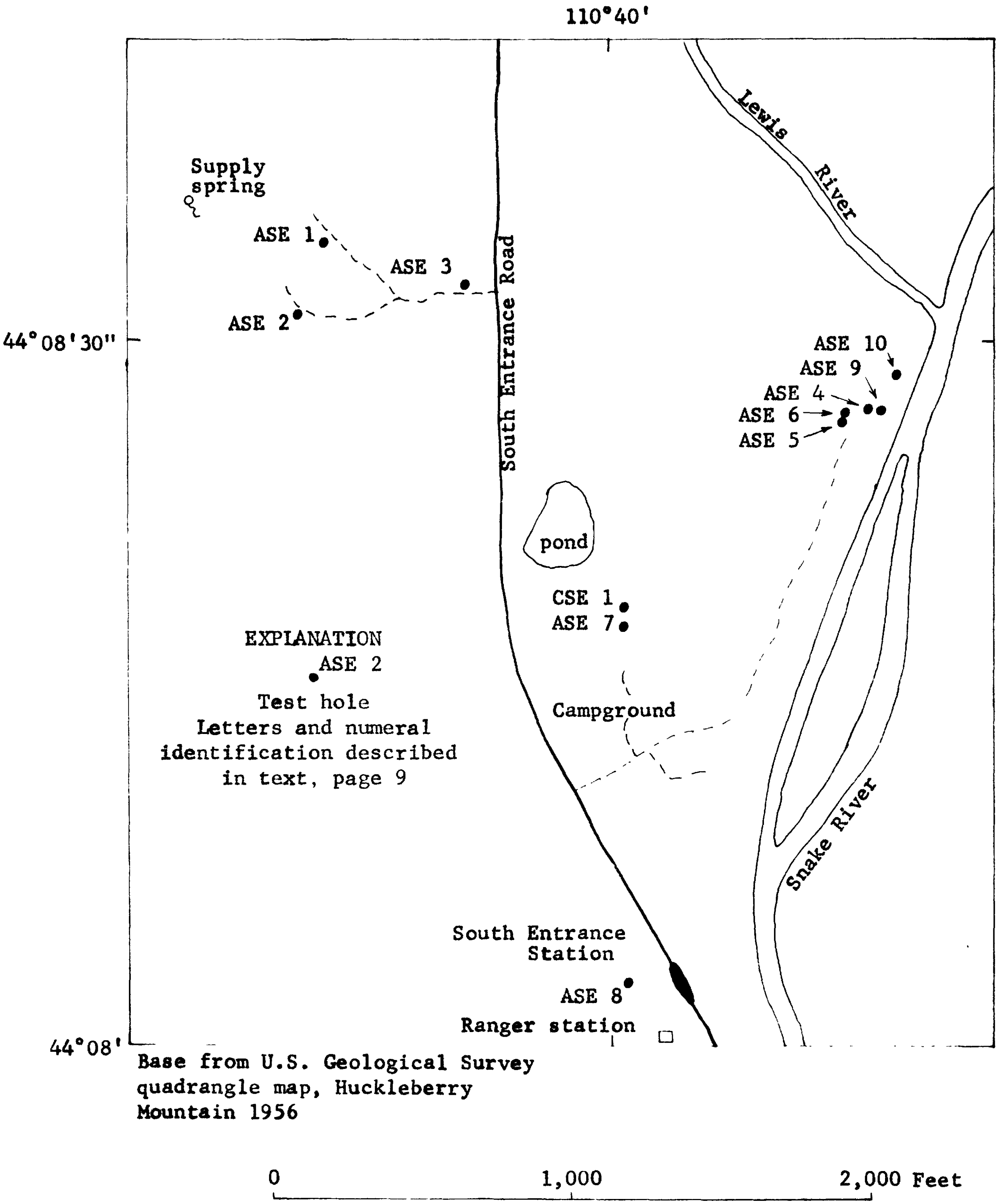


Figure 5.--Location of test holes near the South Entrance.

All chemical constituents, except fluoride, in the water from wells ASE 4, 9, and 10 are below the recommended limits. Water from well ASE 9 is at the limit for fluoride part of the year, and probably exceeds the limit part of the year. The fluoride content of water from wells ASE 4, 9, and 10, however, is less than that from well CSE 1 and the presently used supply spring (tables 5 and 6). Test well ASE 9, therefore, might be a better source of water for South Entrance than the supply spring because of less fluoride content.

A water sample from well ASE 9 was submitted to the Wyoming Department of Public Health for bacteriological analysis. The sample indicated the water from this well to be unsafe. Before well ASE 9 could be used for a water supply, it should be sterilized and resampled to determine if the contamination is from the pump, the well, or the aquifer. If the contamination is from the aquifer, bacteriological treatment of the water from any well drilled in the vicinity of well ASE 9 will be necessary before it can be used in the water supply at South Entrance.

Mammoth

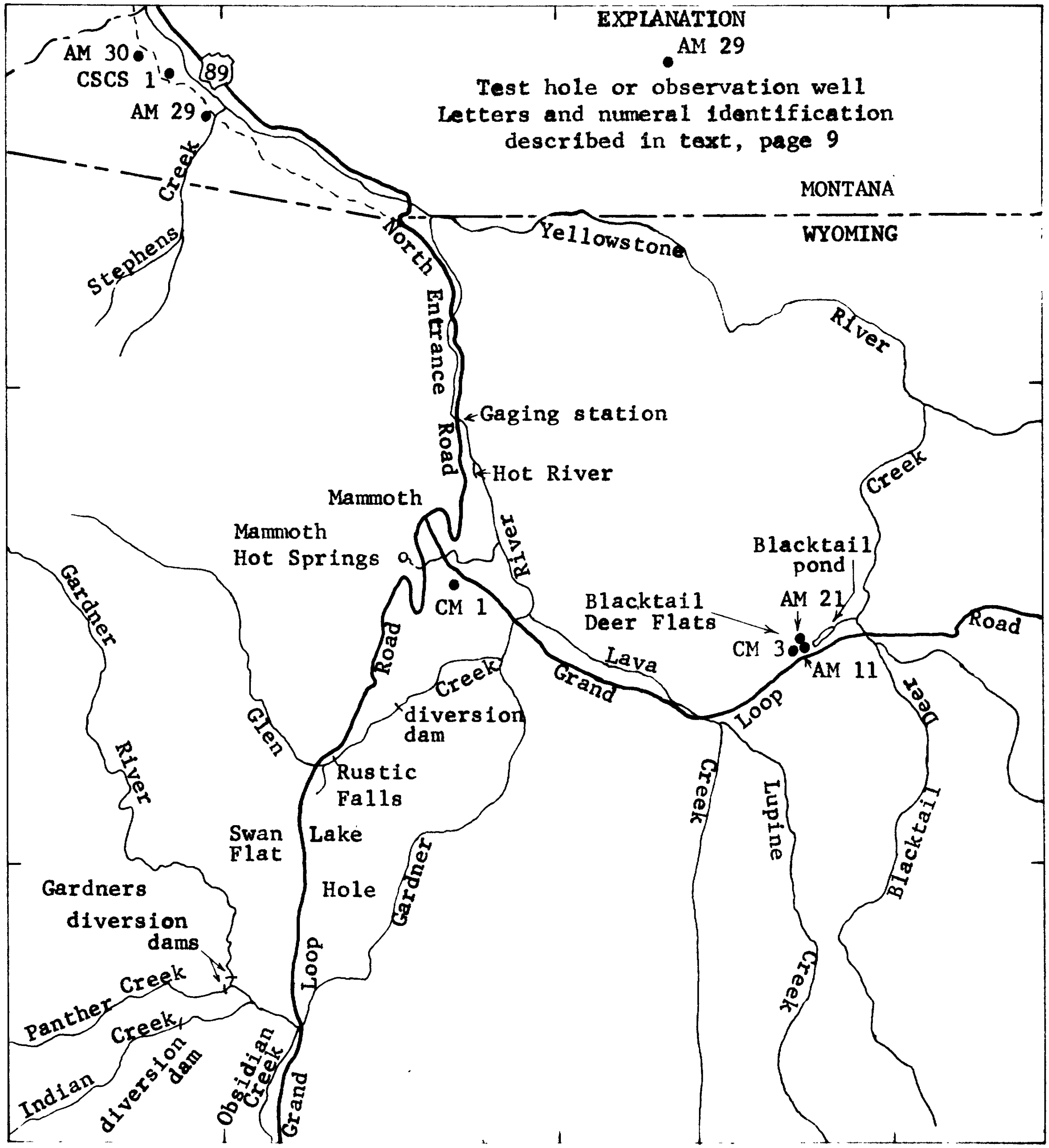
Study continued in FY 1968 in the Mammoth area in an effort to locate a ground-water supply of about 1,000,000 gpd (700 gpm) or a surface-water source that would be more satisfactory than the present source from Glen Creek. In FY 1967, 28 test holes were augered and three cable-tool test holes were drilled in the vicinity of Mammoth without locating a potential ground-water supply for Mammoth. Streamflow measurements were made of the Gardner River and tributaries, and water samples were collected for analysis of chemical quality and suspended-sediment load in FY 1967. These measurements and analyses are given in tables 4, 5, 6, and 9.

Two test holes, AM 29 and 30, were augered in October 1967 near the Yellowstone River 5.5 and 6.6 miles, respectively, northwest of Mammoth (fig. 6). Augering in these holes was stopped before reaching the water table, because the auger could not penetrate beds of cobbles and boulders in AM 29 and dry, tough clay in AM 30.

A test hole was drilled in October 1964 with a cable-tool drilling machine and completed as well CSCS 1 by a contractor hired by the National Park Service. The well was drilled to locate a water supply for a proposed Job Corps campsite, called the Stephens Creek site in this report. Well CSCS 1 was drilled near the Yellowstone River 6.2 miles northwest of Mammoth; it is on a line between test holes AM 29 and 30 (fig. 6). According to the completion report, the well was drilled to a depth of 85 feet. Water-bearing zones were penetrated at depths of 57 to 60 feet and 70 to 85 feet; the lower aquifer extends to an unknown depth below 85 feet. These aquifers are probably in glacial outwash deposits.

The well was equipped with a screen 15 feet long, opposite the lower aquifer, and 70 feet of 6-inch diameter casing. The well was pumped for 13.5 hours on November 19, 1964 at a rate of 92 gpm and the drawdown was 4.4 feet. The specific capacity was 21 gpm per foot of drawdown. The water level was about 44 feet below land surface before pumping began.

A water sample from the test well, collected during the pumping test, was analyzed by the Wyoming Department of Agriculture laboratory. The total dissolved solids content was 326 mg/l, and the concentration of each chemical constituent analyzed was below the recommended limit. Temperature of the water was 8°C. The Job Corps campsite was not built, and the well has been capped and unused since the pumping test.



Base from U.S. Geological Survey quadrangle maps, Gardiner 1955 and Mammoth 1958

0 1 2 3 4 5 Miles

Figure 6.--Location of test holes near Yellowstone River northwest of Mammoth and observation wells near Mammoth.

Developing a water supply for Mammoth might be possible from aquifers in glacial outwash deposits in the vicinity of well CSCS 1. Yields of as much as 200 gpm might be expected from single wells. The areal extent and thickness of the principal aquifer penetrated in well CSCS 1 (70-85 feet) is unknown, and additional test wells should be drilled before consideration is given to developing a ground-water supply for Mammoth in this area.

Augering and drilling of test holes in Blacktail Deer Flats west of Blacktail pond in FY 1967 did not indicate a potential source of ground water for Mammoth. No augering or drilling, however, has been done in Blacktail Deer Flats east of Blacktail pond. The area east of the pond is accessible by truck-mounted augering or drilling equipment only with great difficulty. The glacial drift in this part of Blacktail Deer Flats contains many cobbles and boulders that would make augering difficult and, in places, impossible.

Water from an aquifer in glacial drift or underlying bedrock (probably basalt) in Blacktail Deer Flats discharges into Blacktail pond. This is evident by the constant discharge of water through a narrow outlet from Blacktail pond to Blacktail Deer Creek while the level of the pond apparently remains relatively steady. Streamflow measurements show a gain in flow of Blacktail Deer Creek of 0.34 and 1.0 cfs in September 1967 and August 1968, respectively, in a half-mile reach of the creek east of Blacktail pond (table 4). This gain in streamflow indicates discharge from an aquifer in Blacktail Deer Flats.

Development of ground water for use at Mammoth might be possible in Blacktail Deer Flats if the aquifer discharging to Blacktail pond and Blacktail Deer Creek could be tapped. Cable-tool drilling would be required to establish test wells in glacial drift and bedrock in the eastern part of Blacktail Deer Flats. A study should be made of the relationship between the aquifer and the pond. The natural discharge of the aquifer includes evaporation and transpiration in the flats and flow into Blacktail Deer Creek. Pumping from the aquifer in amounts exceeding that part of the natural discharge of the aquifer flowing to Blacktail Deer Creek would probably affect the level of the pond. It is doubtful that a ground-water supply could be developed in Blacktail Deer Flats to satisfy completely the 1,000,000 gpd required for Mammoth. Ground water,however, might be developed in Blacktail Deer Flats as an alternate supply to be used during that part of the year when streams contain much suspended sediment.

Studies were made in 1967 and 1968 of quantity and quality of surface water in Gardner River and its tributaries near Mammoth to determine the most desirable source of a surface-water supply for Mammoth. It will be necessary to continue to use surface water at Mammoth for the public supply if a suitable ground-water source cannot be found. Suspended-sediment load is large enough to make the streams undesirable sources at times, particularly during spring runoff. Samples were collected from Gardner River and Glen Creek (the present public supply for Mammoth) and Lava Creek above Lupine Creek to compare the quality of water in these streams. Determinations of suspended sediment in streams near Mammoth are given in table 9. Determinations of color are given in table 10. Chemical analyses of water in streams are given in table 6.

Rating curves that show the stage and discharge relation were made for sampling sites on Lava Creek above Lupine Creek and Glen Creek above Rustic Falls. The rating curves are based on measurements listed in table 4. Discharge values for Glen Creek at Mammoth diversion are based on values from rating curves for Glen Creek above Rustic Falls. Discharge values listed in table 10 were determined from the rating curves using readings of stage and do not necessarily represent a discharge measurement made at the time the samples were collected.

Data collected in 1967 and 1968 show that during spring runoff the suspended-sediment concentration is greater in the Gardner River than in either Glen Creek or Lava Creek, and is greater in Lava Creek than in Glen Creek. Moreover, the relatively high suspended-sediment concentration from spring runoff seemingly continues longer in Gardner River than in Glen Creek and Lava Creek. No samples were collected in 1967 and 1968 from Panther Creek and Indian Creek, tributaries of Gardner River in Gardners Hole and sources of water for Mammoth, because the streams were inaccessible during spring runoff. They appeared, however, to have approximately the same suspended-sediment concentration at their mouths as Gardner River. Data collected in 1967 indicated that less suspended sediment would be added to the Mammoth water supply if no water was diverted to the system from Gardner River during spring runoff. No water was diverted to the Mammoth supply system from Gardner River, Panther Creek, or Indian Creek in May and June 1968.

Data collected to date indicate that the overall quality of water for use at Mammoth would not be improved by changing the point of diversion from Glen Creek to Lava Creek. Each water source, however, has advantages and disadvantages. Water in Glen Creek has more color but less suspended sediment than that in Lava Creek during spring runoff. In 1967 and 1968, both streams had sufficient flow to satisfy the water needs at Mammoth during spring runoff. Lava Creek had sufficient flow the entire year, and Glen Creek had sufficient flow until Gardner River cleared and became suitable for use in the public supply.

The chemical quality of water from both Glen Creek and Lava Creek is apparently suitable for public use at Mammoth. Lava Creek, at times, may have fluoride content above recommended limits, judging by a sample collected in August 1967 that had 3.4 mg/l of fluoride. Other samples collected to date from Lava Creek had fluoride contents ranging from 0.9 to 1.5 mg/l. Water from Lava Creek has lower total dissolved solids content than that from Glen Creek. Water from Lava Creek is soft; whereas, water from Glen Creek is moderately hard.

The drainage area of Lava Creek upstream from Lupine Creek is remote and not subject to heavy use by visitors. The drainage areas of Gardner River and its tributaries in Gardners Hole (including Glen Creek) are accessible to Park visitors. A water supply from Lava Creek, therefore, would be less subject to contamination by humans than the supply from Gardner River and its tributaries in Gardners Hole.

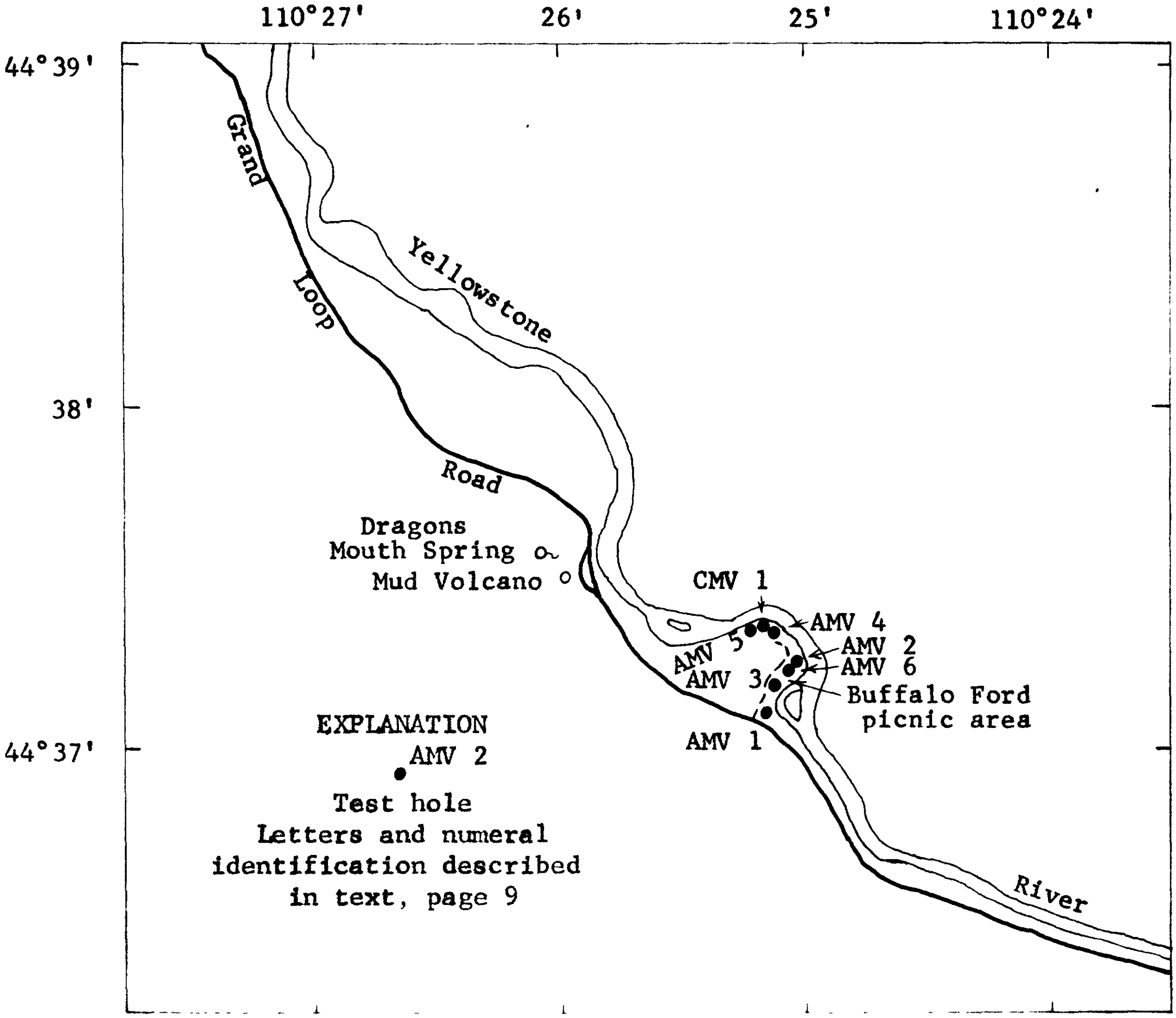
Mud Volcano

The effort to locate a ground-water supply of 20,000 gpd (14 gpm) for a proposed comfort station near Mud Volcano continued in FY 1968. Five holes, AMV 1-5, were augered and cable-tool test hole CMV 1 was drilled in FY 1967 in the vicinity of Buffalo Ford picnic area about 1 mile southeast of Mud Volcano (fig. 7). Water-bearing sand and gravel were penetrated in AMV 2, AMV 4, and CMV 1. Wells were established at AMV 4 and CMV 1. Water from wells AMV 4 and CMV 1, however, is probably not potable owing to dissolved carbon dioxide that gives the water a bad taste. Water from wells AMV 4 and CMV 1 is acidic, pH 5.6 and 5.5, respectively. Hole AMV 2 was reaugered in October 1967 and finished as a well by installing 22 feet of 1-inch diameter pipe and 2 feet of $1\frac{1}{4}$-inch well screen. Water from well AMV 2 does not have a bad taste, is only slightly acidic (pH 6.7), and is considered potable.

Test hole AMV 6, augered near well AMV 2 in June 1968, was completed as a well by installation of 18 feet of 4-inch casing and 6 feet of 3-inch well screen. During development, well AMV 6 was pumped at 40 gpm and well AMV 2 at 20 gpm. Drawdown could not be measured during pumping for development.

Well AMV 6 was pumped at 37 gpm for 4 hours, and the drawdown was 2.2 feet. Specific capacity of the well is about 17 gpm per foot of drawdown. The water level was 6.0 feet below land surface before pumping began. Test well AMV 6 would yield sufficient water to satisfy the requirements for a comfort station near Mud Volcano.

The aquifer in sand and gravel at Buffalo Ford picnic area, tapped by well AMV 6, is recharged by seepage from Yellowstone River.



Base from U.S. Geological Survey
quadrangle map, Canyon Village 1959

0 1 2 Miles

Figure 7.--Location of test holes near Mud Volcano.

The concentration of each chemical constituent in water from well AMV 6 is within the recommended limit. Fluoride is near and, at times, may exceed its limit. The fluoride content was 2.4 mg/l in June 1968 and 2.2 mg/l in August 1968.

A possible source of contamination of the aquifer tapped by well AMV 6 is the dug toilets in the Buffalo Ford picnic area. The low nitrate content (0.2 and 0.6 mg/l in June and August 1968) of the water in well AMV 6 indicates that the aquifer at the well has not been contaminated by the dug toilets in the picnic area. These toilets, however, should be abandoned if a ground-water supply for Mud Volcano is to be developed near well AMV 6.

Norris Junction

Two holes, ANJ 1 and 2, were augered in September 1966 and 8 holes, ANJ 3-10, were augered in June and July 1967 in an effort to locate a ground-water supply of 50,000 gpd (35 gpm) for facilities near Norris Junction to replace the surface-water supply diverted from Castle Creek (fig. 8). An observation well was established at ANJ 3 by installation of 1-inch diameter pipe and a well point. In addition, a cable-tool test hole, CNJ 1, was drilled in July 1967. This augering and drilling indicated a potential aquifer in sand and gravel near the Norris picnic area. The aquifer is shallow, thin, and not widespread. It is underlain by tight gray clay and clayey sand to an unknown depth.

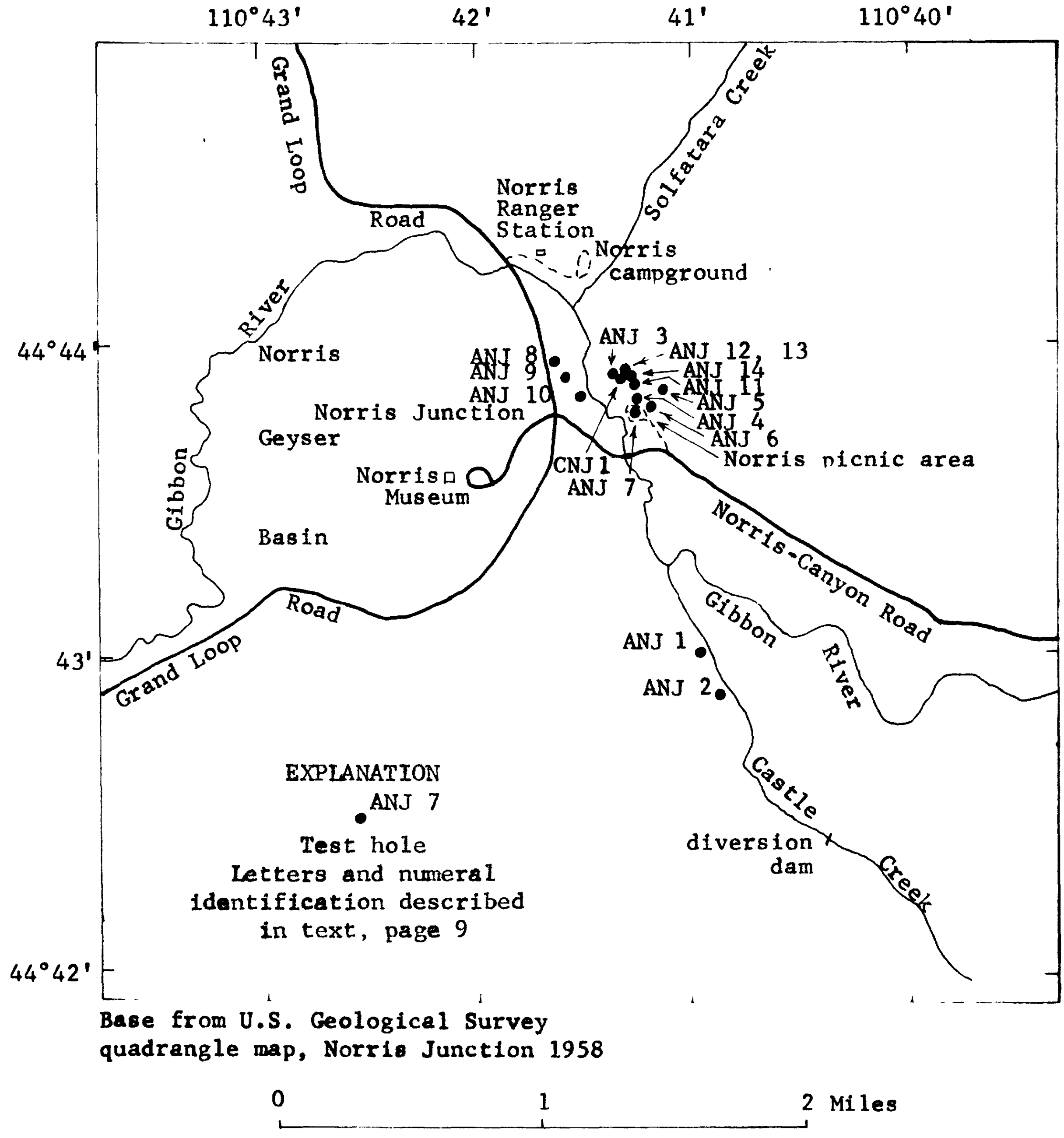


Figure 8.--Location of test holes near Norris Junction.

Holes ANJ 11-14 were augered in June 1968 to establish a screened test well in order to make capacity tests. These holes were augered within about 50 feet of hole CNJ 1 and well ANJ 3. Tight gray clay was penetrated at 18 feet in ANJ 11, 20.4 feet in ANJ 12, 18.5 feet in ANJ 13, and 20.3 feet in ANJ 14. One-inch diameter pipe and a 1-inch screen 1 foot long were installed in ANJ 11 to establish an observation well. Four-inch diameter casing and a 3-inch screen 5 feet long were installed in ANJ 12. The well screen became plugged during well development. The casing and screen were pulled from ANJ 12 and installed in ANJ 14. Well ANJ 14 was pumped at a rate of 40 gpm after being developed with compressed air. Drawdown measurements could not be measured during this pumping.

Well ANJ 14 was pumped at a rate of 35 gpm for 4 hours, and the drawdown was 9.3 feet. The specific capacity is about 3.8 gpm per foot of drawdown. The water level was 3.7 feet below land surface before pumping began. The top of the screen is about 15 feet below land surface; therefore, the water inside the well was lowered to a level about 2 feet above the top of the screen during the 4-hour test. The sustained yield from well ANJ 14 is probably less than 35 gpm.

Although well ANJ 14 probably will not yield the 35 gpm required for a water supply at Norris Junction, a larger diameter well with a longer screen might yield 35 gpm. Two or more wells, constructed like ANJ 14 and properly spaced, also would yield the required 35 gpm. If production wells are drilled for a water supply at Norris Junction, they should be located between well ANJ 14 and hole ANJ 4 in the area within a quarter of a mile of Norris picnic area. Ground water could be used to supplement, or replace during part of the year, the surface-water supply from Castle Creek that is presently used at Norris Junction.

All chemical constituents that were determined in water from well ANJ 14 are below recommended limits. The water is apparently suitable for domestic use, but it is moderately hard. A bacteriological analysis of water from well ANJ 14 by the Wyoming Department of Public Health showed it to be free from coliforms.

The area between well ANJ 14 and Solfatara Creek within a quarter of a mile of Gibbon River may be a potential site for wells. No augering has been done there, however, because the area is not readily accessible to a truck-mounted auger. Before test drilling or augering could be done in that area, a crossing would have to be constructed over either a small creek near well ANJ 14 or Solfatara Creek near Norris campground.

Future work

Although only Gallatin Ranger Station is listed for study in FY 1969 in the guidelines given in the memorandum of October 31, 1966, reconnaissance studies will be made near Madison Junction and West Thumb. Additional reconnaissance will also be made in FY 1969 near Mammoth and Old Faithful, where large supplies of ground water suitable for public use have not been found. Reconnaissance studies will be made in areas of Yellowstone National Park that are not near specific sites to aid in the overall appraisal of water resources in the Park.

Collection of basic data--including water-level and streamflow measurements, and samples from wells, springs, and streams--will continue in FY 1969.

Conclusions

Studies made in Yellowstone National Park in 1968 indicate potential sources of ground water for public use at Fountain Paint Pot, Tower Junction, Slough Creek campground, South Entrance, Mud Volcano, and Norris Junction. The possibility of obtaining ground water to replace surface-water supplies at Canyon Village and Mammoth seems doubtful. Ground water, however, might be developed to replace the surface-water supply at Mammoth during that part of the year when streams contain much suspended sediment.

Data collected to date indicate that the overall quality of water for use at Mammoth would not be improved by changing the point of diversion from Glen Creek to Lava Creek. A water supply from Lava Creek, however, would be less subject to contamination by humans than the supply from Gardner River and its tributaries in Gardners Hole, including Glen Creek.

Most water sampled to date in the Park is potable. All chemical constituents that were determined in water being considered as sources of public supply are below recommended limits established by the U.S. Public Health Service with notable exceptions. Fluoride concentrations in water at Fountain Paint Pot, South Entrance, Mud Volcano, and, at times, Lava Creek near Mammoth exceed the recommended limit. Water from one well near Tower Junction has an iron content that exceeds the recommended limit.

Although recommended limits for all radioactive materials in water have not been established, all of the water sampled to date seems to be below those limits that have been established.

The State of Wyoming Department of Public Health reports that bacteriological analyses indicate water from a well near Norris Junction to be safe and water from a well near South Entrance to be unsafe.

Reference cited

U.S. Public Health Service, 1962, Drinking water standards: U.S. Public Health Service Pub. 956, 61 p.

Table 1.--Water levels in selected observation wells in Yellowstone National Park.

Well	Total depth (feet)	Depth cased (feet)	Producing interval (feet)	Depth to water, in feet below land surface										
				Sept.1966	June 1967	July 1967	Sept.1967	Oct.1967	May 1968	June 1968	July 1968	Aug.1968	Sept.1968	Oct.1968
CM 1	75	51	27-33	----------	18.77	23.31	25.17	----------	21.76	22.17	23.50	----------	24.59	23.49
CM 3	34	31	31-34	----------	----------	8.93	8.93	----------	6.87	6.95	7.10	7.35	7.42	7.42
AM 11	25	15	15-17	----------	8.74	8.38	----------	----------	6.87	6.72	7.13	7.43	7.27	7.13
AM 21	45	20	20-22	----------	4.14	5.50	4.85	----------	5.88	5.87	6.65	7.26	6.79	6.35
CSCS1	85	70	70-85	----------	----------	----------	----------	42.18	42.94	39.09	38.53	39.86	40.94	41.73
ANJ 3	38	20	20-22	----------	----------	2.28	4.09	----------	1.94	2.79	3.57	----------	3.88	3.74
ANJ 11	19	16	16-17	----------	----------	----------	----------	----------	----------	2.66	3.20	----------	3.60	3.48
ANJ 14	20	15	15-20	----------	----------	----------	----------	----------	----------	3.66	3.43	----------	3.72	3.58
COF 1	50	45	32-35	----------	2.28	3.56	6.80	----------	----------	2.00	3.92	4.62	4.85	5.00
AOF 8	74	17	9-17	9.4	5.40	6.18	7.09	----------	----------	5.48	6.29	6.80	7.10	7.38
AOF 10	35	26	18-26	9.2	5.91	7.05	8.66	----------	----------	6.16	7.46	8.28	8.45	8.58
AOF 12	41	17	9-17	11.78	5.36	7.32	9.67	----------	----------	7.25	7.21	8.52	9.32	10.27
ASE 4	62	17	17-19	8.8	----------	7.94	8.93	8.87	----------	5.75	8.35	8.63	8.66	8.63
CSE 1	100	100	38-77	----------	----------	28.44	29.82	29.85	----------	25.24	29.04	29.45	29.64	29.68
ASE 9	29	16	16-22	----------	----------	----------	----------	----------	----------	6.27	9.20	9.49	9.52	9.52
ASE 10	23	21	21-23	----------	----------	----------	----------	----------	----------	5.65	8.73	9.03	9.05	9.06
CEE 1	98	98	28-89	----------	3.83	5.43	6.60	----------	4.75	----------	5.41	5.22	6.74	----------
AMV 4	68	20	20-22	----------	----------	4.41	----------	6.90	7.11	----------	4.59	5.28	6.31	6.77
CMV 1	65	64	58-65	----------	----------	4.44	----------	6.91	----------	----------	4.61	5.30	6.34	6.79
AMV 2	85	22	22-24	----------	----------	----------	----------	5.92	5.90	4.15	4.16	4.68	5.38	5.69
AMV 6	35	18	18-24	----------	----------	----------	----------	----------	----------	5.50	5.51	6.03	6.74	7.04
ATJ 1	23	4	4- 6	----------	----------	----------	----------	5.02	2.76	----------	3.83	4.20	4.58	4.53
ATJ 9	38	18	18-20	----------	----------	----------	----------	10.39	2.58	3.00	4.60	6.18	7.53	6.93

Table 1.--Water levels in selected observation wells--continued

Well	Total depth (feet)	Depth cased (feet)	Producing interval (feet)	Depth to water, in feet below land surface										
				Sept.1966	June 1967	July 1967	Sept.1967	Oct.1967	May 1968	June 1968	July 1968	Aug.1968	Sept.1968	Oct.1968
ATJ 10	61	18	18-20	----------	----------	----------	----------	7.14	2.33	----------	2.79	4.64	5.77	5.10
ATJ 12	28	19	19-24	----------	----------	----------	----------	----------	----------	----------	5.30	6.80	8.16	7.62
ASC 1	31	26	26-28	----------	----------	----------	----------	9.57	8.03	----------	7.40	8.88	8.91	8.83
AFPP 2	100	24	24-26	----------	----------	----------	----------	10.36	10.05	4.83	7.64	8.44	9.22	9.72
AFPP 5	49	42	42-48	----------	----------	----------	----------	----------	----------	4.56	7.35	8.16	8.94	9.42
ACV 2	64	44	44-46	----------	----------	----------	----------	----------	5.79	2.51	3.80	4.72	5.25	5.85
ACV 8	52	13	13-15	----------	----------	----------	----------	.77	----------	.45	2.55	2.80	2.47	2.14
ACV 14	50	33	33-35	----------	----------	----------	----------	----------	----------	1.44	.12	.37	----------	.10
ACV 16	27	12	12-14	----------	----------	----------	----------	3.31	----------	----------	.05	2.87	----------	2.66
ACV 18	72	26	26-28	----------	----------	----------	----------	2.28	----------	----------	1.95	2.43	----------	2.34

Table 2.--Logs of holes augered in Yellowstone National Park, September-October 1967.

Lithology and hydrology	Thickness (feet)	Depth (feet)
ACV 1		
lat 44°44'11" N.; long 110°29'36" W.		
Sand, very fine grained to very coarse grained, subangular, poorly sorted; damp; consists of obsidian and quartz grains; contains fine to coarse, angular obsidian and rhyolite gravel	5	5
Sand, clayey, fine-grained to very coarse grained, subangular to well-rounded; consists mostly of quartz and obsidian grains; contains gravel lense 7 to 8½ feet and several gravel lenses 11 to 21 feet; wet below 11 feet	17	22
Clay, very sandy and gravelly, grayish-brown; no sample below 31 feet	24	46
Rhyolite(?), gray and pink; augers very hard; sample collected from bit; could not auger past 55 feet	9	55
Water level 8.7 feet below land surface.		
ACV 2		
lat 44°44'10" N.; long 110°29'57" W.		
Silt and gravel, brown; loose	4	4
Clay, silty, sandy, brown; damp	4	8
Sand, slightly clayey, fine-grained and medium-grained, subangular to subrounded, well-sorted; consists mainly of quartz grains; contains some coarse-grained and very coarse grained obsidian fragments; wet below 15 feet	27	35
Sand and gravel; contains lenses of clay; sand is coarse grained; gravel consists of obsidian fragments; no sample collected; cuttings mixed with material above	21	56
Bedrock(?); augers hard; no sample	8	64
Water level 9.0 feet below land surface.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ACV 3		
lat 44°44'11" N.; long 110°29'58" W.		
Silt, sand, and gravel, brown; loose; dry	2	2
Sand, mostly fine-grained and medium-grained, subangular to well-rounded; consists mainly of quartz and obsidian fragments; gravelly 13 to 15 feet	15	17
Sand, clayey, mostly very fine grained and fine-grained; soupy; gravelly 30 to 32 feet; no sample below 27 feet	16	33
Sandstone(?); augers hard; consists mainly of medium-grained, subrounded, quartz grains; has much brown staining; no sample 33 to 42 feet	24	57
Water level 4.8 feet below land surface.		
ACV 4		
lat 44°44'05" N.; long 110°30'33" W.		
Silt and gravel, brown; loose; dry	4	4
Clay, gravelly, brown; moderately soft; damp	4	8
Sand, gravel, and clay; sand is mostly medium grained and coarse ~~grain~~ grained and probably quite clean; gravel is mostly fine, angular fragments of obsidian; clay occurs in lenses about 6 inches thick; no sample 21 to 38 feet	30	38
Clay, silty, gray; tough	32	70
Sandstone(?), gray; moderately hard; consists of fine-grained and medium-grained, subangular to subrounded; fragments of quartz and obsidian; cuttings contain fragments of pink rhyolite and poorly indurated pieces of sandstone	39	109
Sandstone(?), clayey, silty, gray; consists mostly of very fine grained fragments of quartz and obsidian; very poorly cemented; could not auger past 117 feet	8	117

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ACV 5		
lat 44°44'43" N.; long 110°29'54" W.		
Silt, sand, and gravel, brown; loose; dry	4	4
Sand, fine-grained and medium-grained, subangular to well-rounded, well-sorted, brown and grayish-brown; consists mostly of quartz and obsidian grains; moist; contains gravel below 15 feet	32	36
Bedrock(?); no return of cuttings; no sample available; augers hard; water struck at unknown depth below 41 feet; very hard below 46 feet	15	51
Water level 16.4 feet below land surface.		
ACV 6		
lat 44°44'36" N.; long 110°29'59" W.		
Clay, silt, sand, and gravel, brown and black; fragments are as much as 2 inches in diameter; moist below 4 feet	6	6
Sand, clayey, mostly medium-grained, subangular to well-rounded; contains fine gravel; wet below 11 feet	11	17
Bedrock(?); augers hard; cuttings contain more gravel fragments; probably sandstone or conglomerate; no return of cuttings below 31 feet	19	36
Water level 6.0 feet below land surface.		
ACV 7		
lat 44°44'29" N.; long 110°29'36" W.		
Silt and sand, brown; loose	4	4
Sand and gravel, gray to black; mostly angular fragments of obsidian; dry	10	14
Sand and gravel, clayey, poorly sorted, brown and black; moist; no return of cuttings below 22 feet; water struck below 22 feet	19	33

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ACV 7--continued		
Bedrock(?); augers very hard; no return of cuttings; no sample available; a trace of finely ground rhyolite on bit	5	38
Water level 10.4 feet below land surface.		
ACV 8 lat 44°44'00" N.; long 110°29'35" W.		
Clay, silty, brown; soft; damp	4	4
Sand, fine-grained to very coarse grained, but mostly coarse-grained above 12 feet, angular to subrounded, poorly sorted; contains some fine gravel; consists mostly of quartz and obsidian fragments; consists mostly of very coarse grained sand and fine gravel below 12 feet; water struck at 6 feet	29	33
Clay, sandy, brown and gray; moderately tough; sand probably occurs in lenses; contains fine-gravel-sized fragments of obsidian	5	38
Clay, brownish-gray; very tough; damp; contains some sand and fine gravel; no reliable samples recovered below 42 feet; sample from bit contained obsidian, clear glass, and rhyolite; hole probably bottomed in bedrock	14	52
ACV 8A lat 44°44'00" N.; long 110°29'35" W.		
Clay, silty, brown; soft	6	6
Sand and fine gravel, poorly sorted; angular to subrounded; consists mostly of quartz and obsidian fragments; sand is mostly coarse grained and very coarse grained	6	12
Sand, clayey; contains fine gravel; contains more medium-grained sand than interval 6 to 12 feet, otherwise similar	8	20

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ACV 8A--continued		
Clay, grayish-brown; tough; contains sand-sized and fine-gravel-sized fragments of obsidian	2	22
Water level 4.4 feet below land surface.		
Note: Hole ACV 8A located 4 feet from hole ACV 8. Log of hole ACV 8A considered to be more accurate than that of hole ACV 8 because auger stem was pulled more often and samples were collected from the auger and bit rather than from cuttings returned to the surface.		
ACV 9		
lat 44°43'07" N.; long 110°30'42" W.		
Clay, silty, grayish-brown; tough; damp; contains some sand-sized and fine-gravel-sized fragments of quartz and obsidian	17	17
Clay, silty; contains sand-sized and fine-gravel-sized fragments of obsidian	3	20
Clay, silty, olive-gray, moderately soft; contains some sand-sized fragments of quartz and obsidian; damp	20	40
Weathered bedrock(?); augers hard; cuttings consist of sand-sized and gravel-sized fragments of glass and obsidian, probably ground up during augering; damp	17	57
No water-saturated material penetrated in this hole.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ACV 10		
lat 44°42'16" N.; long 110°30'16" W.		
Clay, sandy, brown; moderately soft; damp; contains gravel up to 2 inches in diameter	7	7
Clay, sandy, and gravel; wet; clay is yellowish brown; gravel is fine to coarse; clay is more sandy in interval 12 to 17 feet	10	17
Bedrock; cuttings are sand-sized fragments of mostly obsidian and clear glass; contains fine-gravel-sized fragments of obsidian; augers harder in interval 32 to 42 feet	25	42
Water level 4.8 feet below land surface.		
ACV 11		
lat 44°42'07" N.; long 110°30'31" W.		
Sand and gravel, poorly sorted; consists mostly of fragments of quartz and obsidian; sand ranges from fine grained to coarse grained; gravel is mostly fine, but contains some gravel up to 3/4 inch in diameter; wet; contains some clay to 11 feet; contains much clay in interval 11 to 16 feet	16	16
Clay, sandy, gray with brown streaks; tough; dry; sand occurs in lenses; augers harder below 27 feet	25	41
Water level 2.9 feet below land surface.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ACV 12		
lat 44°42'02" N.; long 110°30'37" W.		
Clay, sandy, brown and gray; moderately soft; damp; contains fine gravel	6	6
Clay, silty, gray; tough; contains a few lenses of sand and fine gravel; wet	53	59
Clay, greenish-gray; very tough; augers hard but smooth; contains some pinkish-gray cuttings that may be weathered rhyolite	7	66
Water level 4.8 feet below land surface.		
ACV 13		
lat 44°42'09" N.; long 110°30'21" W.		
Silt and gravel, brown; loose; damp; gravel is fine to coarse	5	5
Sandstone(?), mostly medium-grained and coarse-grained, subangular to subrounded, light-brownish-gray; cuttings consist of fragments of quartz and some obsidian; augers hard; water struck at 12 feet; increase in obsidian fragments below 27 feet	32	37
Water level 8.3 feet below land surface.		
ACV 14		
lat 44°44'23" N.; long 110°29'58" W.		
Silt, clayey, brown; soft; damp	5	5
Clay, silt, sand, and gravel, poorly sorted, mostly brown; much of gravel is black fragments of obsidian; wet	10	15
Gravel; return consists of mostly fine and medium, angular fragments of obsidian; contains brown silt and sand; has hard and soft streaks; return probably not representative of material augered; augers hard at 43 feet and very hard at 47 feet	35	50
Water level 5.6 feet below land surface.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ACV 14A lat 44°44'23" N.; long 110°29'58" W.		
Silt, clayey, brown	5	5
Boulder	1	6
Bedrock; cuttings consist of medium-grained and coarse-grained-sand-sized fragments of quartz with some obsidian and fine- and medium-gravel-sized fragments of obsidian; much of the finer cuttings were dry and probably were ground up; interval below 22 feet contains a few fragments of rhyolite and a trace of gray and pinkish-gray finely ground rhyolite	31	37
Note: Hole ACV 14A is located 2 feet from hole ACV 14. Log of hole ACV 14A is considered to be more accurate than that of hole ACV 14 because auger stem was pulled more often and samples were collected from the auger and bit rather than from cuttings returned to the surface.		
ACV 15 lat 44°44'23" N.; long 110°29'47" W.		
Sand and silt, clayey, brown; damp below 5 feet; gravelly below 4 feet	9	9
Clay, sandy, brown; tough; dry; contains fragments of obsidian	3	12
Bedrock(?); cuttings consist of sand-sized and fine-gravel-sized fragments of quartz, obsidian, and rhyolite; dry; part of return is finely ground; augers hard; very hard below 17 feet	8	20
Water level 4.8 feet below land surface.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thick-ness (feet)	Depth (feet)
ACV 16		
lat 44°45'15" N.; long 110°30'05" W.		
Clay, silty, sandy, brown and gray; moderately soft; moist; contains gravel below 4 feet; gravel is angular and ranges from fine to coarse----------------------------------	12	12
Gravel and sandy clay, grayish-brown; contains cobbles; wet; has streaks that auger alternately hard and soft-----------	8	20
Clay, sandy, brownish-gray; moderately soft; wet; no sample from interval 22 to 27 feet because auger sticks-----------	7	27
Water level 3.5 feet below land surface.		
ACV 17		
lat 44°45'17" N.; long 110°29'53" W.		
Silt and gravel, clayey, brown; dry; contains cobbles; gravel is fine to very coarse and mostly angular; augers very hard---	12	12
Clay and gravel, silty, brown; wet; contains cobbles; gravel is mostly medium and angular; augers very hard; boulder or bedrock at 14 feet; could not auger past 14 feet--------	2	14
ACV 18		
lat 44°45'07" N.; long 110°29'55" W.		
Clay, sandy, brown to gray; soft; wet below 3 feet--------------	5	5
Sand, clayey, mostly medium-grained and coarse-grained, mostly subangular, brown; contains lenses of gravel---------------	12	17
Sand, clayey, medium-grained to very coarse grained, mostly subangular, grayish-brown; contains lenses of gravel and lenses of clay; contains much clay in interval 47 to 52 feet---	35	52

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ACV 18--continued		
Clay, slightly silty, brownish-gray; moderately tough	10	62
Clay, silty, yellowish-brown to dark-brown; tough; augers hard; contains sand and gravel	6	68
Bedrock(?); augers very hard; recovered fragments of pinkish-gray rhyolite	4	72
Water level 3.2 feet below land surface.		
ACV 19		
lat 44°45'12" N.; long 110°29'36" W.		
Clay, silty, gray and brown; moist; contains sand; contains gravel below 3 feet	7	7
Sand and gravel, clayey, angular to subrounded, poorly sorted, brown; wet	6	13
Clay, sandy, brown; soft; wet; contains gravel; tough below 20 feet; augers hard below 34 feet	30	43
Bedrock; sample is mostly ground up pinkish-purple rhyolite and fragments of obsidian; very hard; could not auger past 45 feet	2	45
Water level 4.0 feet below land surface.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thick-ness (feet)	Depth (feet)
ATJ 1		
lat 44°54'59" N.; long 110°25'10" W.		
Clay, silty, brown; soft	3	3
Sand and gravel, clayey, mostly subangular, poorly sorted; consists of fine-grained and medium-grained sand and fine and medium gravel; wet below 6 feet; not as much clay in interval 11 to 15 feet; boulder at 15 feet	12	15
Clay, silty, sandy, tan; soft; wet	1	16
Sand and gravel, clayey; consists mostly of medium-grained to very coarse grained sand and fine and medium gravel; contains cobbles; augers very hard; could not auger past 23 feet because of cobbles	7	23
ATJ 2		
lat 44°55'05" N.; long 110°25'01" W.		
Silt and gravel, brown to dark-gray; loose; dry; sandy below 4 feet	6	6
Clay, very silty and sandy, light-brown; soft; wet	10	16
Clay, sand, and gravel, brown to dark-brown; contains very little water; contains much sand in interval 26 to 31 feet	15	31
Sand, very fine grained to very coarse grained, angular to rounded, poorly sorted; contains some fine and medium gravel	5	36
Sand, mostly medium-grained, subangular to subrounded, quite well sorted; consists of grains of quartz, obsidian, rhyolite, and other rocks; contains some fine gravel	20	56
Sand, fine-grained to very coarse grained, angular to subrounded, poorly sorted; contains fine gravel; probably contains coarse gravel	10	66
Clay, sandy, gray; tough; contains gravel; very hard at 72 feet (bedrock?); could not auger past 72 feet	6	72
Water level 5.8 feet below land surface.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thick-ness (feet)	Depth (feet)
ATJ 3		
lat 44°55'00" N.; long 110°24'49" W.		
Silt, gravel, and cobbles, subangular to angular; dry----------	6	6
Sand, gravel, and cobbles, poorly sorted; consists of subangular to angular fragments; returns mostly coarse-grained sand and fine and medium gravel; dry-------------------------------	15	21
Sand and gravel, clayey; sand is mostly subangular and angular, medium-grained and coarse-grained fragments of quartz and rhyolite; gravel is mostly fine and medium, angular pebbles of pinkish-gray rhyolite; wet but does not contain much water--	15	36
Clay, silty, gray and brown; tough; wet------------------------	5	41
Clay and gravel, sandy; clay is tough; gravel is mostly fine, angular fragments of pinkish-gray rhyolite; very hard at 49 feet (bedrock?); bit contained ground up purple rhyolite	8	49

Lithology and hydrology	Thick-ness (feet)	Depth (feet)
ATJ 4		
lat 44°55'03" N.; long 110°24'40" W.		
Silt, clayey, dark-brown to black; damp------------------------	4	4
Clay, sandy, gravelly, gray to dark-brown; moist; more sandy and gravelly below 9 feet; unable to determine where water was struck; very hard at 18 feet (bedrock or boulder); augered another hole about 20 feet north of ATJ 4 and struck hard surface at 19 feet--	14	18
Water level 6.4 feet below land surface.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ATJ 5		
lat 44°55'01" N.; long 110°24'30" W.		
Silt, sand, and gravel, mostly angular, poorly sorted; dry------	6	6
Sand and gravel, slightly clayey, angular to subrounded, poorly sorted; sand is mostly medium grained to very coarse grained; gravel is fine to coarse; wet; cobble at 13 feet; hard at 20 feet---	14	20
Bedrock(?); not sampled; could not auger past 22 feet-----------	2	22
ATJ 6		
lat 44°54'51" N.; long 110°24'47" W.		
Silt, sand, and gravel, mostly angular fragments, brown and gray; sand is mostly fine grained and medium grained; dry; augers rough; very hard at 9 feet; could not auger below 9 feet (boulder or bedrock); could not auger below 9 feet at two adjacent locations---	9	9
ATJ 7		
lat 44°54'57" N.; long 110°24'59" W.		
Silt, sand, and gravel, mostly angular fragments, brown; sand is mostly fine grained; dry; augers rough; contains boulders--	6	6
Sand and gravel, angular to subrounded, poorly sorted; dry; sand is fine grained to very coarse grained; gravel is mostly fine, but probably contains very coarse gravel that was not returned with the cuttings; interval 16 to 20 feet seemingly contains much gravel in proportion to sand; very hard at 20 feet (boulder or bedrock); hard surface at 22 feet in another hole about 10 feet from hole ATJ 7-------------	14	20

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ATJ 8		
lat 44°55'08" N.; long 110°24'51" W.		
Silt, sand, and gravel, clayey, mostly angular fragments, poorly sorted, brown and dark-brown; wet below 4 feet	7	7
Clay, silty, dark-brown to black; soft; contains gravel in interval 12 to 22 feet	15	22
Clay, slightly silty, brown; moderately soft	5	27
Clay, sandy, gravelly, brown; moderately firm	10	37
Clay, very sandy, gray; contains some fine gravel; firm; very hard at 39 feet; could not auger past 40 feet	3	40
Water level 3.1 feet below land surface.		
ATJ 9		
lat 44°55'04" N.; long 110°25'09" W.		
Silt, sand, and gravel, angular to subrounded, brown; loose; dry	6	6
Sand and gravel, slightly clayey, poorly sorted; mostly subangular fragments, mostly medium-grained to very coarse grained sand and fine to very coarse gravel (up to $1\frac{1}{2}$ inches in diameter); may contain cobbles in interval 6 to 11 feet	13	19
Sand, slightly clayey, mostly coarse-grained and very coarse grained, mostly subangular, poorly sorted; contains fine gravel; contains more clay in interval 26 to 36 feet	17	36
Clay, silty, gray; tough; contains a few pebbles; very hard at 38 feet (boulder or bedrock); could not auger past 38 feet; bit contained fragment of rhyolite from 38 feet	2	38

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thick-ness (feet)	Depth (feet)
ATJ 10		
lat 44°55'12" N.; long 110°25'09" W.		
Silt, sand, and gravel, brown; loose; dry; probably contains cobbles	6	6
Sand and gravel, slightly clayey, angular to subrounded, poorly sorted; sand is fine to very coarse grained, but is mostly coarse and very coarse grained, except fine grained in interval 26 to 36 feet; gravel is fine to coarse	30	36
Silt and sand, subangular to rounded, quite well sorted, brown; sand is very fine grained and fine grained; contains some clay; contains some fine gravel in interval 41 to 46 feet	10	46
Clay and sand, gray and brown; probably occurs in alternating lenses; contains some gravel; sand is poorly sorted	10	56
Clay, reddish-brown; very tough; contains a few pebbles	5	61
Water level 7.9 feet below land surface.		
ATJ 11		
lat 44°54'53" N.; long 110°25'15" W.		
Silt, sand, and gravel, brown; loose; dry; very hard at 11 feet	11	11
Weathered bedrock(?), gray to dark-brown; augers hard, but has some softer zones; cuttings are seemingly ground up rock; some pebbles and cobbles of harder rock are probably present throughout the entire interval; interval 38 to 39 feet is wet; very hard in interval 36 to 39 feet; could not auger past 39 feet	28	39

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
ASC 1		
lat 44°56'56" N.; long 110°18'21" W.		
Gravel, cobbles, and boulders; augers very hard; cuttings are ground up and samples are probably not representative; augers much easier below 7 feet (probably much sand and gravel)	11	11
Sand and gravel, slightly clayey, poorly sorted; sand is very fine grained to very coarse grained, but is mostly coarse grained; gravel is fine to coarse; probably contains cobbles; auger flights not pulled often enough to get representative samples	20	31
Water level 9.6 feet below land surface; temperature 4°C; specific conductance 240 micromhos.		
AFPP 1		
lat 44°35'17" N.; long 110°46'16" W.		
Silt, brown; loose; dry	1	1
Sand and gravel, slightly clayey, poorly sorted; sand is medium to very coarse grained, but is mostly coarse grained; gravel is fine to coarse; consists mostly of subangular to subrounded fragments of quartz, rhyolite, and obsidian	15	16
Sand, medium-grained to very coarse grained, but is mostly coarse grained and very coarse grained, angular to subrounded, poorly sorted; consists of much obsidian with minor amounts of quartz, chert, and rhyolite; very clean; contains much very fine and fine gravel and some medium and coarse gravel; the gravel may occur in lenses; very hard at 87 feet (bedrock)	71	87
Water level about 13 feet below land surface.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
AFPP 2		
lat 44°35'11" N.; long 110°46'32" W.		
Silt, brown; loose; dry	3	3
Clay, brown; soft; moist	2	5
Sand, very fine grained, very well sorted, gray; moist	1	6
Sand and gravel, slightly clayey, poorly sorted; sand is mostly medium grained and coarse grained; gravel is mostly fine and coarse; fragments mostly angular	5	11
Sand, fine-grained to very coarse grained but mostly coarse-grained and very coarse grained, angular to subrounded but mostly angular, poorly sorted; consists mostly of obsidian with minor amounts of quartz, rhyolite, and chert; contains very fine and fine gravel and lenses of coarse gravel; contains much water; very hard at 100 feet (bedrock)	89	100
Water level 10.4 feet below land surface; temperature 11°C; specific conductance 200 micromhos.		
AFPP 3		
lat 44°35'05" N.; long 110°46'40" W.		
Clay, silty, tan; soft; moist; sticky	5	5
Clay, sandy, gravelly, brown; wet; warm	1	6
Sand, fine-grained to very coarse grained, but is mostly coarse grained and very coarse grained, angular to subrounded, poorly sorted; consists mostly of obsidian fragments with minor amounts of quartz, chert, and rhyolite; stopped at 11 feet; bottom-hole temperature 42°C	5	11
Water level about 6½ feet below land surface.		

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
AFPP 4		
lat 44°35'01" N.; long 110°46'48" W.		
Sand, very fine grained to very coarse grained, angular to rounded, poorly sorted; consists mostly of obsidian and quartz fragments with some chert and rhyolite; contains some fine gravel; cuttings are warm below 11 feet; stopped at 26 feet; bottom-hole temperature greater than 43°C	26	26
Water level about 10½ feet below land surface.		
AM 29		
lat 45°02'50" N; long 110°45'15" W.		
Silt, light-brown; loose; dry	5	5
Sand and gravel, poorly sorted; sand is fine grained to very coarse grained, but is mostly medium grained; gravel is mostly fine to coarse, but contains very coarse gravel; contains cobbles; augers very hard in places	31	36
Cobbles and boulders; augers very hard; cuttings consist of ground up rock; could not auger past 45 feet (large boulder); did not penetrate water-bearing material	9	45
AM 30		
lat 45°03'33" N.; long 110°46'16" W.		
Silt and gravel, brown; loose; dry	5	5
Clay, sandy, brown; soft; damp; contains gravel	5	10
Clay, silty, brown; moderately tough; damp; contains many gravel lenses	21	31
Clay, sandy, gravelly, brown; tough; dry; contains many gravel lenses and gravel mixed with the clay	5	36
Clay, sandy, brownish-gray; very tough; dry; could not auger past 40 feet; did not penetrate water-bearing material	4	40

Table 2.--Logs of holes augered, September-October 1967--continued

Lithology and hydrology	Thickness (feet)	Depth (feet)
AMV 2A		
lat 44°37'19" N.; long 110°25'02" W.		
Clay, sandy, brown; moderately soft; damp	5	5
Sand and gravel; sand is medium grained to very coarse grained, but mostly very coarse grained; gravel is mostly very fine and fine, but contains some coarse and very coarse gravel; cuttings consist mostly of very coarse sand and gravel-sized subangular and angular fragments of black obsidian; contains a minor amount of quartz; contains much water; stopped at 26 feet	21	26
Water level 5.9 feet below land surface; temperature 8°C; specific conductance 145 micromhos.		

Table 3.--Logs of holes augered in Yellowstone National Park, June 1968.

Lithology and hydrology	Thick-ness (feet)	Depth (feet)
ATJ 12		
lat 44°55'05" N.; long 110°25'10" W.		
Sand and gravel, clayey, poorly sorted; sand is mostly coarse-grained and very coarse grained subangular fragments of quartz, obsidian, rhyolite, and andesite; gravel is as much as 1 inch in diameter, mostly andesite breccia; increase in gravel in interval 10 to 24 feet; boulder at 15 feet	24	24
Sand, slightly clayey, mostly coarse-grained and very coarse grained, angular to subrounded, poorly sorted, consists of fragments of quartz, obsidian, and andesite; contains very fine and fine gravel	4	28
Water level 5.3 feet below land surface		
ASE 9		
lat 44°08'28" N.; long 110°39'46" W.		
Sand and gravel, angular to subrounded, poorly sorted; sand is mostly coarse-grained and very coarse grained; gravel is mostly very fine to medium, but contains some gravel more than 1¼ inches in diameter; contains thin lense of tough reddish-brown clay at 5½ feet	7	7
Sand, medium-grained to very coarse grained, subangular to subrounded, poorly sorted; contains very fine to medium gravel; contains a slight amount of clay	7	14
Sand and gravel, subangular and angular, poorly sorted; sand is mostly coarse grained and very coarse grained; gravel is very fine to coarse; cobble(?) at 16 feet	15	29
Water level 6.3 feet below land surface; temperature 9°C.		

Table 3.--Logs of holes augered, June 1968--continued

Lithology and hydrology	Thick-ness (feet)	Depth (feet)
AFPP 5		
lat 44°35'10" N.; long 110°46'33" W.		
Sand, very fine grained and fine-grained, well sorted; brown; contains some gray clay----------------------------------	5	5
Sand and gravel, angular to subrounded, poorly sorted; sand is fine grained to very coarse grained, consists of obsidian, rhyolite, and quartz grains, contains a few grains of travertine; gravel is very fine to very coarse, consists mostly of purple rhyolite fragments containing black obsidian and clear quartz; contains cobbles(?) in interval 9 to 12 feet------	9	14
Sand, medium-grained to very coarse grained, angular to subrounded, poorly sorted, consists mostly of black obsidian fragments with minor amounts of gray rhyolite, clear quartz, and white chert and travertine; contains very fine and fine gravel and lenses of coarse gravel; contains much water--------------------------------------	35	49
Water level 4.6 feet below land surface; temperature 12°C.		
AMV 6		
lat 44°37'18" N.; long 110°25'02" W.		
Clay, sandy, gravely, light-brown; sand is medium grained to very coarse grained; gravel is very fine to medium--------	4	4
Sand and gravel, angular to subrounded, poorly sorted; consists of fragments of obsidian with minor amounts of rhyolite and quartz; sand is medium grained to very coarse grained, but mostly coarse grained and very coarse grained; gravel is very fine to medium, but mostly very fine and fine---	11	15
Sand, medium-grained to very coarse grained, but mostly coarse-grained, subangular to subrounded, poorly sorted, consists mostly of obsidian with minor amounts of rhyolite and quartz; contains some very fine and fine gravel; contains much water---	9	24

Table 3.--Logs of holes augered, June 1968--continued

Lithology and hydrology	Thick-ness (feet)	Depth (feet)
AMV 6--continued		
Sand, medium-grained and coarse-grained, more rounded and better sorted than that in interval 9 to 24 feet; contains slight amounts of clay and gravel, probably in lenses-----	11	35
Water level 5.5 feet below land surface; temperature 8°C.		
ANJ 11		
lat 44°43'53" N.; long 110°41'19" W.		
Sand, medium-grained to very coarse grained, subangular to subrounded, poorly sorted, consists mostly of quartz and obsidian fragments; contains some very fine and fine gravel	14	14
Sand, medium-grained and coarse-grained, subangular to subrounded, poorly sorted, consists mostly of quartz fragments, with minor amounts of obsidian, gray; contains some very fine gravel and clay--	4	18
Clay, sandy, gray; tough---------------------------------------	1	19
Water level 2.7 feet below land surface; temperature 7°C.		
ANJ 12		
lat 44°43'54" N.; long 110°41'19" W.		
Sand, medium-grained to very coarse grained, subangular to subrounded, poorly sorted, consists mostly of quartz and obsidian fragments; contains very fine and fine gravel----	14	14
Sand, medium-grained to very coarse grained, subangular to subrounded, poorly sorted, consists mostly of quartz and obsidian fragments, stained brown by iron; contains very fine to medium gravel------------------------------------	5	19

Table 3.--Logs of holes augered, June 1968--continued

Lithology and hydrology	Thick-ness (feet)	Depth (feet)
ANJ 12--continued		
Sand, medium-grained to very coarse grained, subangular to subrounded, poorly sorted, consists mostly of quartz fragments with minor amounts of obsidian, gray with some brown iron stains; contains very fine to medium gravel----	1.4	20.4
Clay, sandy, gray; tough--	.1	20.5
Water level 5.0 feet below land surface.		
ANJ 13		
lat 44°43'54" N.; long 110°41'19" W.		
Sand, medium-grained to very coarse grained, subangular to subrounded, poorly sorted, consists mostly of quartz and obsidian fragments; contains very fine and fine gravel----	14	14
Sand, medium-grained to very coarse grained, subangular to subrounded, poorly sorted, consists mostly of quartz fragments with minor amounts of obsidian, gray; contains some very fine to medium gravel; contains slight amount of clay--	4.5	18.5
Clay, sandy, gray; tough--	2	20.5
ANJ 14		
lat 44°43'54" N.; long 110°41'19" W.		
Sand, medium-grained to very coarse grained, subangular to subrounded, poorly sorted, consists mostly of quartz and obsidian fragments; contains very fine and fine gravel----	14	14
Sand, medium-grained to very coarse grained, subangular to subrounded, poorly sorted, consists mostly of quartz and obsidian fragments with minor amounts of rhyolite and travertine; contains slight amount of clay---------------	6.3	20.3
Clay, sandy, gray; tough--	.2	20.5
Water level 3.7 feet below land surface; temperature 7°C.		

Table 4.--Discharge measurements made at miscellaneous sites, Yellowstone National Park.

Station No.	Stream	Location (N. lat and W. long)	Date	Discharge (cubic feet per second)
6-0368.00	Firehole River above diversion dam, near Old Faithful.	44°26'33" 110°48'15"	5- 2-67	34.5
			5-24-67	155
			6-21-67	275
			6-26-67	177
			7-18-67	98.4
			9-19-67	60.0
			5-22-68	101
			6-12-68	207
			8-14-68	59.1
6-0368.50	Old Hotel Spring, near Fountain Paint Pot.	44°33'17" 110°48'03"	10-16-38	.04
6-0369.00	Nez Perce Creek above bridge at picnic area, near Fountain Paint Pot.	44°35'05" 110°46'41"	8-14-68	77.4
6-0369.25	Castle Creek below diversion dam, near Norris Junction.	44°42'23" 110°40'23"	9-19-67	1.96
6-0369.27	Castle Creek at turnaround in road, near Norris Junction.	44°42'49" 110°40'49"	9-19-67	3.96
6-0369.30	Gibbon River near Norris picnic area, near Norris Junction.	44°43'47" 110°41'20"	8-13-68	30.2
6-1870.35	Tributary to Cascade Creek above diversion dam, near Canyon Village	44°45'37" 110°28'18"	7-25-68	.27
6-1870.50	Cascade Creek above diversion dam, near Canyon Village.	44°44'25" 110°29'59"	7-25-68	4.64
6-1871.00	Tributary to Sulphur Creek above diversion dam, near Canyon Village.	44°45'57" 110°27'52"	7-25-68	.44
6-1890.10	Blacktail Deer Creek above Blacktail pond tributary, near Mammoth.	44°57'20" 110°35'28"	9-27-67	3.77
			8-13-68	8.11
6-1890.20	Blacktail pond tributary, near Mammoth.	44°57'31" 110°35'40"	9-27-67	.10
6-1890.30	Blacktail Deer Creek below Blacktail pond tributary, near Mammoth.	44°57'42" 110°35'26"	9-27-67	4.11
			8-13-68	9.12
6-1897.30	Gardner River above diversion dam, near Mammoth.	44°53'36" 110°44'56"	10-28-66	12.8
			7-26-67	64.4
			9-20-67	23.7
			8-13-68	33.5
6-1897.50	Panther Creek above diversion dam, near Mammoth.	44°53'36" 110°46'00"	10-28-66	3.44
			8-14-68	9.98
6-1898.10	Indian Creek above diversion dam, near Mammoth.	44°53'20" 110°45'44"	8-14-68	23.2
6-1898.20	Indian Creek diversion, near Mammoth.	44°53'20" 110°45'44"	10-28-66	7.45

Table 4.--Discharge measurements--continued

Station No.	Stream	Location (N.lat and W. long)	Date	Discharge (cubic feet per second)
6-1898.90	Glen Creek above Rustic Falls above tributary, near Mammoth.	44°55'58" 110°43'36"	10-28-66	1.85
			5-23-67	33.1
			5-24-67	49.7
			6- 4-67	27.8
			6-17-67	20.1
			7- 3-67	11.5
			7-17-67	9.43
			9-20-67	3.10
			5-29-68	12.8
			8-13-68	3.21
6-1899.00	Tributary to Glen Creek above Rustic Falls, near Mammoth.	44°55'58" 110°43'36"	5-23-67	46.6
			5-24-67	45.9
			6- 4-67	21.1
			6-17-67	16.8
			7- 3-67	10.2
			7-17-67	14.4
			9-20-67	13.0
			5-29-68	6.43
			8-13-68	15.4
6-1899.02	Glen Creek above Rustic Falls below tributary, near Mammoth.	44°55'59" 110°43'33"	5- 8-68	23.0
			5- 9-68	20.5
			5- 9-68	28.1
			5-14-68	22.2
			5-17-68	18.3
			5-27-68	19.9
			5-29-68	19.2
			6- 6-68	33.2
			6- 7-68	30.7
			6- 9-68	39.2
			8-13-68	17.8

Table 4.--Discharge measurements--continued

Station No.	Stream	Location (N. lat and W. long)	Date	Discharge (cubic feet per second)
6-1899.80	Lava Creek above Lupine Creek, near Mammoth.	44°56'22" 110°37'36"	5- 2-67	14.4
			5-23-67	95.3
			5-26-67	112
			6- 2-67	147
			7- 3-67	148
			7-17-67	84.9
			8-23-67	39.2
			9-20-67	27.3
			5- 8-68	24.6
			5-10-68	30.2
			5-13-68	38.5
			5-14-68	42.4
			5-21-68	34.4
			5-27-68	38.4
			5-29-68	57.0
			5-29-68	69.7
			5-30-68	83.8
			5-31-68	75.2
			6- 1-68	70.1
			6- 3-68	103
			6- 4-68	121
			6- 5-68	119
			6- 5-68	116
			6- 6-68	128
			6-10-68	143
			8-13-68	37.2
			10-10-68	30.6
6-1903.00	Gardner River below Lava Creek near Mammoth.	44°57'48" 110°40'29"	4- 4-67	57.6
6-1904.10	Mammoth Hot Springs tributary, near Mammoth.	44°58'08" 110°41'10"	4- 4-67	8.20
6-1905.40	Hot River, near Mammoth.	44°59'10" 110°41'15"	4- 4-67	19.0
6-1910.00	Gardner River at gaging station, near Mammoth.	44°59'35" 110°41'25"	4- 4-67	85.6
6-2798.50	Middle Creek at East Entrance.	44°29'19" 110°00'02"	8-16-68	49.4

Table 5.--Chemical analyses of water from holes and wells, Yellowstone National Park.

[Analytical results in milligrams per liter except as indicated]

Hole or well no.	Location (N. lat and W. long)	Date of collection	Depth (feet)	Producing interval (feet)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Sum	Hardness as $CaCO_3$: Calcium, magnesium	Specific conductance (micromhos at 25°C)	pH
AM 11	44°57'12" 110°36'15"	5-23-68	25	15-17	13	20	0.29	21	8.9	7.0	2.6	115	0	15	1.5	1.2	0.1	0.03	136	135	90	247	7.5
AM 15	44°57'06" 110°36'37"	6-27-67	36	open	12	28	------	57	25	32	9.3	339	0	17	8.5	3.4	.7	.04	456	348	246	552	7.7
AM 16	44°57'05" 110°36'43"	6-28-67	78	open	8	34	------	36	12	26	4.4	233	0	12	1.8	1.7	.4	.03	250	243	142	373	7.2
AM 21	44°57'17" 110°36'23"	7- 8-67	45	20-22	9	25	------	38	16	20	4.5	225	0	18	2.5	1.5	.3	.02	272	237	159	379	7.9
CM 1	44°57'[illegible]" 110°[illegible]'[illegible]"	5-26-67	75	27-33	4	31	------	133	62	58	29	333	0	393	60	2.2	.3	.87	998	933	587	1,320	8.0
CM 3	44°57'12" 110°36'17"	7-21-67	34	31-34	7	38	------	24	8.4	11	4.7	134	0	7.4	2.5	1.9	.3	0	168	164	95	242	7.1
ASE 4	44°08'29" 110°39'48"	9-17-66	62	17-19	----	42	------	21	1.8	25	4.1	109	0	5.0	12	2.5	.2	.16	184	168	60	237	7.9
		8-11-67			13	40	.16	10	1.9	25	4.2	77	0	7.0	12	2.3	.1	.15	138	141	33	183	7.5
ASE 9	44°08'28" 110°39'46"	6-19-68	29	16-22	9	35	.13	11	1.3	21	3.3	73	0	11	9.1	2.0	.2	0	158	130	33	171	7.0
		8- 6-68			11	38	.10	12	1.0	24	3.5	80	0	5.0	9.7	2.4	.2	.12	144	135	34	184	8.1
ASE 10	44°08'29" 110°39'46"	6-19-68	23	21-23	12	44	.06	8.2	.7	27	4.2	67	0	2.5	12	2.8	0	0	156	134	24	177	6.8
CSE 1	44°08'21" 110°39'57"	7- 7-67	100	75-77	15	47	------	14	3.2	40	5.3	120	0	6.7	21	3.2	.7	.05	248	200	47	247	7.7
AMV 2	44°37'19" 110°25'02"	10- 4-67	85	22-24	8	54	.11	13	2.2	7.4	3.9	53	0	9.1	2.4	2.4	2.5	.03	186	123	40	129	6.7
AMV 4	44°37'23" 110°25'05"	7- 8-67	68	20-22	12	78	.16	15	4.7	12	6.0	93	0	37	0	2.9	1.0	.02	-----	-----	57	179	5.6
AMV 6	44°37'18" 110°25'02"	6-25-68	35	18-24	8	55	.23	12	2.9	6.9	5.3	58	0	7.9	2.2	2.4	.2	.05	132	124	42	126	7.5
		8- 2-68			8	60	.10	15	3.3	8.0	6.0	78	0	7.3	1.4	2.2	.6	.01	148	142	51	159	7.4
CMV 1	44°37'23" 110°25'05"	7-17-67	65	58-65	14	90	------	17	6.8	13	6.3	113	0	3.8	1.8	2.9	.2	0	210	198	70	213	5.5
AMJ 3	44°43'54" 110°41'21"	7- 8-67	38	20-22	7	38	.20	34	11	74	11	329	0	14	18	.9	.5	.35	400	364	128	559	6.9
		8-10-67			8	40	.43	32	10	77	10	334	0	3.8	21	1.0	.1	.17	357	362	121	563	7.4

Table 5.--Chemical analyses--continued

Hole or well no.	Location (N. lat and W. long)	Date of collection	Depth (feet)	Producing interval (feet)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids		Hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH
																			Residue on evaporation at 180°C	Sum	Calcium, magnesium		
ANJ 7	44°43'49" 110°41'18"	7-1-67	45	open	12	36	------	6.2	1.2	12	7.2	63	0	26	2.8	0.5	0.7	0	-----	-----	20	103	7.2
ANJ 11	44°43'53" 110°41'19"	6-26-68	18	16-17	7	41	0.12	28	8.8	77	8.4	299	0	2.7	18	1.4	0	.37	324	333	106	514	7.4
ANJ 14	44°43'54" 110°41'19"	6-26-68	20	15-20	7	42	.13	30	6.2	78	8.6	303	8	1.0	17	1.7	0	.37	340	342	100	523	8.4
		7-30-68			7	41	.06	29	6.0	77	8.2	303	0	3.5	18	1.6	0	.35	336	334	97	510	8.2
CNJ 1	44°43'55" 110°41'24"	7-18-67	30	20	11	41	.14	27	8.1	74	10	287	0	3.8	18	1.8	.1	.23	324	325	100	521	7.7
AFPP 2	44°35'11" 110°46'32"	10-3-67	100	24-26	11	74	.41	4.2	.9	31	5.9	56	0	11	10	5.1	.2	.03	230	171	14	181	6.6
AFPP 5	44°35'10" 110°46'33"	6-24-68	49	42-48	12	77	.22	4.1	.2	31	6.1	58	0	14	13	5.0	0	.26	180	180	11	196	7.2
		8-1-68			13	82	.29	4.5	.2	30	5.6	54	0	13	10	5.4	.3	.08	180	178	12	176	7.3
ATJ 1	44°54'59" 110°25'10"	5-21-68	23	4-6	4	26	.05	8.2	3.6	11	1.7	60	0	7.4	.6	.8	0	.03	102	89	36	117	7.1
ATJ 9	44°55'04" 110°25'09"	5-21-68	38	18-20	4	26	.02	12	3.4	11	1.9	73	0	9.0	1.2	.5	.2	.03	122	101	45	141	7.0
ATJ 10	44°55'12" 110°25'09"	5-20-68	61	18-20	19	18	1.88	21	7.1	19	2.8	132	0	17	1.6	.7	.2	.08	158	154	81	237	7.4
ATJ 12	44°55'05" 110°25'10"	9-19-68	28	19-24	7	31	.09	14	4.6	15	1.4	92	0	7.3	1.2	.8	.1	.03	110	121	54	160	7.2
ASC 1	44°56'56" 110°18'21"	10-5-67	31	26-28	4	17	.05	30	6.9	4.6	1.5	130	0	1.6	1.1	.1	.2	.03	168	127	103	227	7.8
ACV 8	44°44'00" 110°29'35"	6-10-68	52	13-15	7	33	.17	5.8	2.4	2.6	3.7	30	0	9.1	1.1	.1	.2	.01	90	73	25	77	6.5
ACV 16	44°45'15" 110°30'05"	7-16-68	27	12-14	28	30	.16	9.8	1.3	5.3	1.8	53	0	1.9	.5	.2	.3	.01	100	77	30	87	7.4
ACV 18	44°45'07" 110°29'55"	7-16-68	72	26-28	12	37	.09	11	4.5	4.9	1.6	66	0	1.9	.4	.1	..1	0	100	94	46	108	7.6
CEE 1	44°29'20" 110°00'10"	6-16-67	98	29-89	8	32	.03	9.8	2.2	18	1.0	83	0	82	0	.4	.2	.02	120	113	30	150	7.4
		8-14-67			7	32	.04	8.7	2.6	19	1.0	79	0	7.2	.7	.3	0	.05	118	111	32	146	7.6
COF 1	44°26'12" 110°48'17"	6-27-67	50	32-45	16	102	.85	2.8	1.0	86	20	0	0	20	139	3.4	.7	.54	420	376	11	563	4.4

Table 6.--Chemical analyses of water from streams and springs, Yellowstone National Park.

[Analytical results in milligrams per liter except as indicated.]

Station No.	Stream or spring	Location (N. lat and W. long)	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: [illegible]	Hardness as $CaCO_3$: Calcium, magnesium	Specific conductance (micromhos at 25°C)	pH
6-0368.00	Firehole River above diversion dam, near Old Faithful	44°26'33" 110°48'15"	6-22-67	11	20	0.12	2.4	0	4.2	2.3	10	0	0	4.6	0.9	0.3	0.01	50	40	6	39	6.5
			8-18-67	13	43	.11	4.8	.4	9.7	3.9	24	0	3.2	7.4	2.0	0	.01	84	87	14	81	6.5
			9-19-67	6	46	-----	2.0	1.2	11	3.3	18	0	.8	9.4	2.0	0	.04	96	85	10	86	7.1
			5-22-68	7	30	.19	2.4	1.3	12	3.2	17	0	4.8	10	2.0	.1	.09	82	74	12	84	6.4
			8-14-68	13	41	.20	3.0	1.1	13	.7	21	0	4.4	12	2.2	.2	.14	98	87	12	96	6.9
			10-13-68	6	42	.13	2.4	1.0	17	3.3	23	0	5.6	17	2.2	.4	.16	110	102	10	114	7.1
6-0368.50	Old Hotel Spring, near Fountain Paint Pot	44°37'17" 118°48'03"	8-22-67	17	111	.12	10	0	38	6.9	99	0	10	5.7	7.8	0	0	232	239	26	228	6.6
6-0369.00	Nez Perce Creek above bridge at picnic area, near Fountain Paint Pot	44°35'05" 110°46'41"	8-18-67	23	84	.11	6.2	1.5	51	8.6	74	0	28	27	4.8	.1	.14	252	248	22	305	7.6
			8-14-68	17	69	.30	7.7	1.5	50	7.1	72	0	35	29	2.6	.5	.42	248	238	25	311	7.0
6-0369.25	Castle Creek below diversion dam, near Norris Junction	44°42'23" 110°40'23"	9-19-67	15	79	.13	6.3	.2	18	7.1	57	0	1.6	1.5	4.2	.4	0	154	146	17	127	7.3
6-0369.27	Castle Creek at turnaround in road, near Norris Junction	44°42'49" 110°40'49"	9-19-67	21	------	-----	7.1	.4	42	11	90	0	13	11	6.7	.4	.02	250	246	19	251	7.5
6-0369.30	Gibbon River near Norris picnic area, near Norris Junction	44°43'47" 110°41'20"	8-22-67	18	57	.16	6.8	.7	13	5.3	41	0	10	3.9	2.9	0	0	118	120	20	117	6.9
			8-13-68	16	50	.20	5.3	1.0	12	4.3	38	0	10	2.8	2.2	.2	.06	114	107	17	103	7.1
6-1870.25	Tributary to Cascade Creek above [illegible] dam, near Canyon Village	44°45'37" 110°28'18"	7-29-68	8	21	.05	8.0	1.9	4.2	.6	47	0	.4	.2	0	.1	.02	60	59	[illegible]	76	7.6
6-1870.50	Cascade Creek above diversion dam, near Canyon Village	44°44'25" 110°29'59"	8-22-67	9	31	.09	16	2.4	5.8	1.8	68	0	2.6	.4	.7	.2	0	102	95	50	121	7.7
6-1871.00	Tributary to Sulphur Creek above diversion dam, near Canyon Village	44°45'57" 110°27'52"	7-29-68	8	19	.04	8.4	2.7	3.4	.8	51	0	.6	.1	0	0	.02	62	60	32	84	7.6
6-1881.20	Supply Spring near Tower Junction Ranger Station	44°54'52" 110°25'19"	8- 7-68	13	28	.11	16	4.4	7.3	1.5	82	0	1.2	1.0	.4	1.4	.03	122	101	58	156	7.2
6-1881.30	Lost Creek near Tower Junction Ranger Station	44°54'59" 110°25'08"	5-21-68	4	21	.19	9.4	1.9	4.3	1.3	43	0	8.2	1.0	.4	.2	.04	86	69	32	90	7.5

Table 6.--Chemical analyses--continued

Station No.	Stream or spring	Location (N. lat and W. long)	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Sum	Hardness as $CaCO_3$: Calcium, magnesium	Specific conductance (micromhos at 25°C)	pH
6-1897.30	Gardner River above diversion dam, near Mammoth	44°53'36" 110°44'56"	6- 8-68	4	6.0	0.10	27	9.1	2.0	0.3	112	0	16	1.1	0.2	0.3	0.01	132	117	105	212	8.2
6-1897.30	Gardner River above diversion dam, near Mammoth	44°53'36" 110°44'56"	8-13-68	15	5.2	.09	45	15	3.2	.8	148	0	55	.4	.2	.1	0	204	198	173	334	7.5
6-1897.50	Panther Creek above diversion dam, near Mammoth	44°53'36" 110°46'00"	8-14-68	8	5.6	.06	41	10	1.4	2.9	177	0	3.6	.4	.1	.1	0	148	152	145	267	7.3
6-1898.10	Indian Creek above diversion dam, near Mammoth	44°53'20" 110°45'44"	8-14-68	9	7.8	.05	26	4.6	2.0	.7	102	0	2.7	.8	.1	.1	0	98	95	84	164	7.7
6-1898.90	Glen Creek above Rustic Falls above tributary, near Mammoth	44°55'58" 110°43'36"	6-17-67	8	19	.09	31	6.6	2.6	1.4	128	0	.6	.4	.3	.2	0	140	125	106	210	7.5
			9-20-67	9	28	-----	25	7.7	4.9	2.0	120	0	.8	1.5	.2	.1	.03	144	129	94	202	7.3
			8-13-68	9	26	.05	30	7.5	4.4	1.4	136	0	4.4	.7	.2	.1	.01	144	142	106	216	7.9
6-1899.00	Tributary to Glen Creek above Rustic Falls, near Mammoth	44°55'58" 110°43'36"	9-20-67	9	8.2	-----	34	6.2	2.1	.9	135	0	4.9	1.2	0	0	.02	146	125	109	225	7.3
			8-13-68	10	7.2	.25	32	7.5	1.8	.7	135	0	4.0	.4	.1	0	0	120	120	111	213	7.6
6-1899.02	Glen Creek above Rustic Falls below tributary, near Mammoth	44°55'59" 110°43'33"	8-13-68	11	11	.03	31	7.7	2.3	.8	135	0	4.0	.4	.1	.1	0	124	123	109	213	7.7
6-1899.10	Glen Creek at Mammoth Diversion	44°56'40" 110°42'18"	5-17-68	6	19	.12	34	6.7	3.7	1.9	136	0	4.9	.3	.2	.2	.01	140	138	112	236	7.2
			6- 8-68	6	20	.01	31	5.4	3.6	1.3	126	0	5.8	2.1	.3	.2	.02	136	132	100	211	7.9
			6-21-68	12	21	.12	37	5.7	3.9	1.2	139	2	4.2	.5	.3	0	.01	148	144	116	225	8.3
6-1899.80	Lava Creek above Lupine Creek, near Mammoth	44°56'22" 110°37'36"	5-26-67	8	23	-----	5.8	.6	3.6	1.1	24	0	2.9	0	.9	.4	0	68	50	17	57	7.0
			8-23-67	13	35	.07	6.8	1.7	5.2	1.8	35	0	1.4	.7	3.4	0	0	72	73	24	70	7.1
			9-20-67	8	34	.04	6.3	2.2	5.4	1.4	38	0	1.6	.7	1.3	0	.01	88	72	25	76	7.1
			5-17-68	7	30	.08	6.2	3.2	4.3	1.4	41	0	4.9	.3	1.2	.2	0	70	72	29	80	6.8
			6- 6-68	6	23	.23	4.2	1.3	3.4	1.3	24	0	3.4	1.4	1.0	.2	.03	50	51	16	49	7.4
			6-21-68	9	23	.10	3.8	1.1	3.2	1.2	21	0	.6	.6	1.0	0	.01	48	44	14	70	7.6
			8-13-68	9	32	.10	7.2	1.0	4.7	1.5	38	0	1.9	.3	1.5	.1	0	76	68	22	72	7.3
			10-10-68	7	32	.03	6.5	2.7	6.0	1.1	39	0	2.5	.5	1.5	.1	0	76	72	27	74	7.1

Table 6.--Chemical analyses--continued

Station No.	Stream or spring	Location (N. lat and W. long)	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Sum	Hardness as $CaCO_3$: Calcium, magnesium	Specific conductance (micromhos at 25°C)	pH
6-1904.00	Discharge from Jupiter Terrace, Mammoth Hot Springs	44°58'06" 110°42'02"	5-23-68	20	40	0.04	139	48	82	34	243	0	411	107	1.8	0.3	2.1	1,030	985	545	1,430	7.8
6-1905.40	Hot River, near Mammoth	44°59'08" 110°41'16"	5-11-67	52	48	-----	156	59	117	51	208	0	547	149	2.4	.2	3.2	1,280	1,240	629	1,740	7.7
6-2798.50	Middle Creek at East Entrance	44°29'19" 110°00'02"	8-16-68	6	18	.11	6.8	1.5	5.9	.5	37	0	7.5	.3	.1	.1	.01	70	59	50	79	7.2
13-0100.50	Supply Spring, near South Entrance	44°08'34" 110°40'23"	10-26-67	18	43	.06	5.6	[illegible].6	33	37	74	0	1.6	16	3.6	.2	.05	154	143	17	187	7.1

Table 7.--Detailed chemical analyses and radiochemical analyses of water from three wells, Yellowstone National Park.

[Analytical results in milligrams per liter except as indicated]

Well No.	ANJ 3	ASE 4	CEE 1
Date	8-10-67	8-11-67	8-14-67
Temperature (°C)	8	13	7
Silica (SiO_2)	40	40	32
Aluminum (Al)	.5	.3	.2
Iron (Fe)	.43	.16	.04
Manganese (Mn)	.04	.02	.00
Chromium (Cr)	.00	.00	.00
Copper (Cu)	.06	.02	.07
Lead (Pb)	.15	.00	.00
Zinc (Zn)	1.8	.00	.00
Arsenic (As)	.00	.02	.00
Cadmium (Cd)	.00	.00	.00
Calcium (Ca)	32	10	8.7
Magnesium (Mg)	10	1.9	2.6
Strontium (Sr)	.00	.00	.00
Barium (Ba)	.00	.00	.00
Sodium (Na)	77	25	19
Potassium (K)	10	4.2	1.0
Lithium (Li)	.11	.04	.00
Bicarbonate (HCO_3)	334	77	79
Carbonate (CO_3)	0	0	0
Sulfate (SO_4)	3.8	7.0	7.2
Chloride (Cl)	21	12	.7
Fluoride (F)	1.0	2.3	.3
Nitrate (NO_3)	.1	.1	0
Boron (B)	.17	.15	.05
Dissolved solids - Determined	357	138	118
" " - Calculated	362	141	111
Hardness as $CaCO_3$ - Ca,Mg	121	33	32
" " " - Non CO_3	0	0	0
Alkalinity	274	63	65
Sodium-adsorption ratio	3.0	1.9	1.4
Specific conductance (micromhos at 25°C)	563	183	146
pH (pH units)	7.4	7.5	7.6
Color (standard color units)	25	1	5
Gross alpha activity (micrograms per liter)	9.8	1.5	3.8
Gross beta activity (picocuries per liter)	8.0	3.6	1.9
Radium (Ra) (picocuries per liter)	.2	< .1	< .1
Uranium (U) (micrograms per liter)	3.1	< .4	< .4

< Less than figure shown.

Table 8.--Spectrographic and radiochemical analyses of water from four wells, Yellowstone National Park.

[Analytical results in micrograms per liter except as indicated]

Well No.	ANJ 14	AFPP 5	AMV 6	ASE 9
Date	7-30-68	8- 1-68	8- 2-68	8- 6-68
Aluminum (Al)	20	100	32	23
Barium (Ba)	17	3	24	18
Beryllium (Be)	<2	4	2	<.7
Bismuth (Bi)	ND	ND	ND	ND
Boron (B)	290	100	25	110
Cadmium (Cd)	ND	ND	ND	ND
Cesium (Cs)	7	20	2	7
Chromium (Cr)	<8	<4	<3	<4
Cobalt (Co)	<16	<7	<6	<7
Copper (Cu)	.9	.9	3	.8
Germanium (Ge)	ND	ND	ND	ND
Iron (Fe)	33	75	20	15
Lead (Pb)	<8	<4	<3	<4
Lithium (Li)	180	75	27	85
Manganese (Mn)	<4	5	<2	<2
Molybdenum (Mo)	4	5	2	4
Nickel (Ni)	<8	<4	2	<3
Rubidium (Rb)	35	20	20	12
Silver (Ag)	<.8	<.4	<.3	<.3
Strontium (Sr)	80	5	60	35
Tin (Sn)	<16	<7	<6	<7
Titanium (Ti)	<4	<2	<2	<2
Vanadium (V)	<8	<4	<3	<4
Zinc (Zn)	<340	<150	<120	<130
Gross alpha activity	1.4	2.3	1.3	1.6
Gross beta activity (picocuries per liter)	8.0	5.5	5.7	3.8
Radium (Ra) (picocuries per liter)	<.1	<.1	<.1	<.1
Uranium (U)	2.1	<.4	<.4	<.4

< Less than figure shown.

ND Specifically sought, not detected.

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams, Yellowstone National Park.

6-0368.00 Firehole River above diversion dam, near Old Faithful
lat 44°26'33" N.; long 110°48'15" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1967					
May 2	1300	7	34.5	2	0.19
May 24	1430	10	155	25	10
June 21	1130	7	275	5	3.7
June 26	1355	11	177	5	2.4
July 18	0910	9	98.4	6	1.6
Sept.19	1000	6	60.0	--	---
1968					
May 22	1325	7	---	5	---
June 12	1235	8	207	10	5.6

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

6-1897.30 Gardner River above diversion dam, near Mammoth
lat 44°53'36" N.; long 110°44'56" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1966					
Oct. 28	1030	2	12.8	3	0.10
1967					
May 23	0815	--	280	88	66
	1520	1	420	325	370
	1945	1	410	205	230
May 24	0745	1	300	91	74
	1715	3	540	312	450
May 25	1830	5	430	141	160
May 26	1720	7	290	103	81
May 27	1845	8	310	136	110
May 28	1745	8	300	134	110
May 29	1830	5	320	98	85
May 30	1810	7	280	68	51
May 31	1825	7	280	44	33
June 4	1630	7	270	51	37
June 12	1845	8	220	16	9.5
June 17	1325	7	280	65	49
July 3	1325	8	210	57	32
July 17	1640	9	140	72	27
July 26	1000	8	66.4	---	------
Sept. 20	1600	12	23.7	2	.13
1968					
May 29	1325	6	-----	40	------
June 3	1425	7	-----	201	------
June 5	1120	3	-----	92	------
June 8	1135	4	-----	58	------
June 10	1810	9	-----	46	------
Aug. 13	1535	15	33.5	4	.36

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)

6-1897.50 Panther Creek above diversion dam, near Mammoth
lat 44°53'36" N.; long 110°46'00" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1966					
Oct. 28	1145	1	3.44	3	0.03

6-1898.20 Indian Creek diversion, near Mammoth
lat 44°53'20" N.; long 110°45'44" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1966					
Oct. 28	1225	3	7.45	2	0.04

6-1898.90 Glen Creek above Rustic Falls, above tributary, near Mammoth
lat 44°55'58" N.; long 110°43'36" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1966					
Oct. 28	0920		1.85	2	0.01
1967					
May 2	1435	--	E 2.5	8	.05
May 23	1400	7	33.1	34	3.0
May 24	0730	3	E 25	2	.14
May 24	1910	9	49.7	23	3.0
May 25	1855	11	E 35	2	.19
May 27	1905	12	E 30	3	.24
June 4	1610	12	27.8	9	.68
June 12	1900	10	E 25	3	.20
June 17	0930	8	20.1	3	.16
July 3	0830	7	11.5	4	.12
July 17	1620	9	9.43	E 3	.07
Sept. 20	1425	9	3.10	10	.08
1968					
May 29	1450	11	12.8	6	.21
Aug. 13	1325	9	3.21	36	.31

E Estimated

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

6-1899.00 Tributary to Glen Creek above Rustic Falls, near Mammoth
lat 44°55'58" N.; long 110°43'36" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1967					
May 23	1405	8	46.6	49	6.1
May 24	0730	4	E 40	3	.32
May 24	1935	9	45.9	60	7.4
May 25	1850	11	E 40	23	2.5
May 27	1910	12	E 30	10	.81
June 4	1615	11	21.1	2	.11
June 12	1905	10	E 20	3	.16
June 17	0910	8	16.8	3	.14
July 3	0825	8	10.2	3	.08
July 17	1605	9	14.4	E 3	.12
Sept. 20	1355	9	13.0	3	.11
1968					
May 29	1425	16	6.43	1	.02
Aug. 13	1320	10	15.4	4	.17

E Estimated

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

6-1899.02 Glen Creek above Rustic Falls below tributary, near Mammoth
lat 44°55'59" N.; long 110°43'33" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1968					
May 8	1220	2	23	5	0.31
	2035	3	24	6	.39
May 9	1010	2	20	3	.16
	1945	5	28	8	.60
May 10	1010	2	22	5	.30
	1825	6	26	10	.70
May 11	1105	4	22	2	.12
	1940	6	27	8	.58
May 12	1125	5	23	3	.19
	2010	6	27	6	.44
May 13	1055	4	22	4	.24
	1940	7	23	4	.25
May 14	1140	5	22	3	.18
	1940	6	22	3	.18
May 15	1020	3	21	2	.11
May 16	1125	3	19	3	.15
May 17	1110	3	19	2	.10
May 18	1245	7	18	5	.24
May 19	1320	8	18	3	.15
May 20	0955	4	18	2	.10
May 21	1155	6	18	6	.29
May 22	1020	4	20	3	.16
May 23	1030	5	19	2	.10
May 24	1015	4	19	3	.15
May 25	1950	8	20	6	.32
May 27	1045	6	19	4	.21
May 28	1325	10	19	4	.21
May 29	0950	8	19	4	.21
May 30	1125	8	19	4	.21
May 31	1125	4	18	5	.24
June 1	1030	7	18	5	.24
June 2	1130	9	18	5	.24
June 3	1045	8	18	4	.19
June 4	1010	7	19	6	.31
	1800	8	21	8	.45
June 5	0745	6	22	9	.53
June 6	1000	7	23	6	.37
	1440	7	29	11	.86
	1840	8	34	53	4.9
June 7	0950	6	30	15	1.2
	1815	11	31	5	.42

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

6-1899.02 Glen Creek above Rustic Falls below tributary, near Mammoth--continued

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1968					
June 9	1150	6	31	8	0.67
	2015	9	40	6	.65
June 10	1100	8	36	4	.39
	1830	11	37	5	.50
June 11	0840	6	34	11	1.0
	1905	13	33	5	.45
June 12	1020	8	33	4	.36
	1935	13	31	5	.42
June 13	1455	8	36	3	.29
June 21	1740	14	19	5	.26
Aug. 13	1430	11	19	3	.15

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

6-1899.10 Glen Creek at Mammoth Diversion, near Mammoth
lat 44°56'40" N.; long 110°42'18" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1967					
June 12	1945	9	E 45	3	0.36
1968					
May 7	2025	1	33	13	1.2
May 8	1245	2	23	5	.31
	2100	3	24	5	.32
May 9	1025	2	20	4	.22
	2000	5	28	7	.53
May 10	1025	3	22	3	.18
	1845	9	26	8	.56
May 11	1120	4	22	5	.30
	1955	6	27	4	.29
May 12	1145	5	23	3	.19
	2025	6	27	6	.44
May 13	1110	5	22	3	.18
	2000	7	23	5	.31
May 14	1155	5	22	3	.18
	1955	6	22	3	.18
May 15	1035	3	21	6	.34
May 16	1030	3	19	3	.15
May 17	1125	4	19	3	.15
May 18	1300	7	18	2	.10
May 19	1335	8	18	3	.15
May 20	1020	4	18	2	.10
May 21	1110	6	18	3	.15
May 22	0915	5	20	4	.22
May 23	1050	6	19	4	.21
May 24	0925	4	19	4	.21
May 25	2035	7	20	32	1.7
May 26	1300	6	19	4	.21
May 27	1100	6	19	5	.26
May 28	1345	11	19	5	.26
May 29	1010	8	19	5	.26
May 30	1155	8	19	4	.21
May 31	1155	7	18	5	.24
June 1	1050	7	18	5	.24
June 2	1145	9	18	5	.24
June 3	1105	8	18	5	.24
June 4	1025	7	19	11	.56
	1815	8	21	8	.45
June 5	0805	6	22	10	.59
June 6	1015	7	23	7	.43
	1505	7	29	25	2.0
	1900	8	34	32	2.9

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

6-1899.10 Glen Creek at Mammoth Diversion, near Mammoth--continued

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1968					
June 7	1010	7	30	8	0.65
	1750	9	31	10	.84
June 8	1355	7	29	11	.86
June 9	1205	6	31	21	1.8
	2030	8	40	16	1.7
June 10	1115	8	36	11	1.1
	1850	10	37	16	1.6
June 11	0855	6	34	11	1.0
	1845	12	33	6	.53
June 12	0955	6	33	5	.45
	1955	13	31	5	.42
June 13	1435	8	36	9	.87
June 21	1705	12	19	2	.10
June 27	1755	12	14	16	.60
July 15	1105	9	22	5	.30

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

6-1899.80 Lava Creek above Lupine Creek, near Mammoth
lat 44°56'22" N.; long 110°37'36" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1967					
May 2	1620	4	14.4	3	0.12
May 23	1100	--	95.3	33	8.5
May 25	0625	3	E 105	87	25
May 26	1345	8	112	18	5.4
May 28	0735	3	E 125	19	6.4
June 2	1250	8	147	15	6.0
June 12	1925	7	E 150	11	4.5
June 17	1015	7	E 155	34	14
July 3	1010	8	148	17	6.8
July 17	1450	9	84.9	16	3.7
Aug. 23	1400	13	39.2	---	------
Sept. 20	1035	8	27.3	2	.15
1968					
May 8	1035	3	26	1	.07
	2000	7	27	10	.73
May 9	0845	2	25	4	.27
	1800	7	27	5	.36
May 10	0935	4	29	2	.16
	1800	9	31	6	.50
May 11	1035	4	31	5	.42
	1910	7	36	10	.97
May 12	1055	5	34	4	.37
May 13	1010	4	39	6	.63
	2025	7	45	6	.73
May 14	1035	6	43	10	1.2
	2030	6	43	14	1.6
May 15	0950	4	40	10	1.1
May 16	1010	3	32	4	.35
May 17	1000	4	31	3	.25
May 18	1210	6	30	4	.32
May 19	1245	7	30	4	.32
May 20	0920	3	32	3	.26
May 21	0945	5	36	4	.39
May 22	0835	5	42	10	1.1
May 23	0950	4	43	7	.81
May 24	0900	4	43	8	.93
May 25	2015	7	43	6	.70
May 26	1215	6	40	4	.43
May 27	0930	4	40	5	.54
May 28	1255	9	43	6	.70
May 29	0915	5	58	46	7.2
	1935	10	67	68	12

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

6-1899.80 Lava Creek above Lupine Creek, near Mammoth--continued

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1968					
May 30	1010	6	87	61	14
	1835	9	87	36	8.5
May 31	0940	4	83	23	5.2
	1915	8	80	17	3.7
June 1	0955	4	73	---	------
June 2	1045	6	83	18	4.0
June 3	1015	6	105	66	19
	1800	9	103	49	14
June 4	0940	6	114	56	17
	1720	3	116	51	16
June 5	0710	5	120	53	17
	1800	8	114	28	8.6
June 6	0905	6	109	23	6.8
	1410	6	129	76	26
June 7	0845	7	129	33	11
	1725	7	131	38	13
June 8	1100	5	125	18	6.1
June 9	1110	7	139	43	16
	1910	7	146	42	17
June 10	1020	6	141	29	11
	1735	8	143	29	11
June 11	0810	5	134	18	6.5
	1820	10	129	16	5.6
June 12	0905	6	129	17	5.9
	1910	8	134	18	6.5
June 13	1400	6	143	29	11
June 21	1410	9	166	30	13
June 27	1720	12	125	13	4.4
July 15	1415	13	63	5	.85
Aug. 13	1125	9	36	2	.19

E Estimated

Table 9.--Periodic determinations of temperature, discharge, and suspended sediment in streams--continued

6-1900.05 Lupine Creek at mouth, near Mammoth
lat 49°56'25" N.; long 110°37'38" W.

Date	Time (24 hour)	Temperature (°C)	Discharge (cubic feet per second)	Sediment concentration (milligrams per liter)	Sediment discharge (tons per day)
1968					
June 3	1810	8	E 20	149	8.0
June 4	1925	4	E 20	73	3.9

E Estimated

Table 10.--Periodic determinations of discharge and color of water in Lava Creek and Glenn Creek near Mammoth, Yellowstone National Park.

6-1899.80 Lava Creek above Lupine Creek lat 44°56'22" N.; long 110°37'36" W.				6-1899.10 Glen Creek at Mammoth Diversion lat 44°56'40" N.; long 110°42'18" W.			
Date 1968	Time (24 hour)	Discharge (cubic feet per second)	Color (standard units)	Date 1968	Time (24 hour)	Discharge (cubic feet per second)	Color (standard units)
May				May			
27	0930	40	10	27	1100	19	5
29	0925	58	10	29	1010	19	10
29	1935	67	10				
30	1020	87	15	30	1155	19	15
30	1835	87	10				
31	0940	83	10	31	1155	18	20
31	1915	80	10				
June				June			
1	0955	73	10	1	1050	18	20
2	1105	83	10	2	1145	18	20
3	1015	105	10	3	1105	18	20
3	1800	103	10				
4	0940	114	10	4	1025	19	30
4	1720	116	10	4	1815	21	30
5	0710	120	10	5	0805	22	30
5	1800	114	10				
6	0905	109	10	6	1015	23	30
				6	1505	29	30
				6	1900	34	30
7	0845	129	10	7	1010	30	30
7	1725	131	10	7	1750	31	30
8	1100	125	10	8	1355	29	20
9	1110	139	10	9	1205	31	25
9	1710	146	20	9	2030	40	30
10	1020	141	10	10	1115	36	20
10	1735	143	10	10	1850	37	25
11	0810	134	10	11	0900	34	20
11	1820	129	10	11	1845	33	20
12	0905	129	10	12	0955	33	20
12	1915	134	10	12	1955	31	20
13	1400	143	10	13	1435	36	20