Sedimentation in Brownell Creek Subwatershed No. 1 Nebraska

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1798-C

Prepared in cooperation with the
U.S. Department of Agriculture
Soil Conservation Service

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By JAMES C. MUNDORFF

SEDIMENTATION IN SMALL DRAINAGE BASINS

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GLOSSARY

Automatic suspended-sediment sampler. A bottle that is equipped with intake nozzle and exhaust tube, that is mounted in a fixed position, and that admits water-sediment mixture when the water rises to the level of the nozzle.

Drainage density. The ratio of the total length of all drainage channels to the drainage area.

Flocculation. The formation of a large sediment aggregate caused by the coalescence of small particles that are subjected to certain physicochemical conditions.

Instantaneous suspended-sediment discharge. The rate at which dry weight of suspended sediment passes a section of a stream or conduit at a given instant.

Particle-size classification. In this report the classification is, unless otherwise noted, as follows: Sand, 0.062–2.0 mm; silt, 0.004–0.062 mm; clay, less than 0.004 mm.

Percent sodium. The ratio, expressed in percentage, of sodium to the sum of the positively charged ions (calcium, magnesium, sodium, and potassium)—all ions in equivalents per million.

Relief ratio. The ratio of the maximum relief in a basin to the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956).

Sodium-adsorption-ratio. A ratio for soil extracts and irrigation waters, used to express the relative activity of sodium ions in exchange reactions with soil.

$$SAR=\frac{Na^{+}}{\sqrt{\frac{Ca^{+2}+Mg^{+2}}{2}}}$$

The ionic concentrations are expressed in equivalents per million.

Suspended-sediment concentration. The weight of dry sediment per unit weight of water-sediment mixture, expressed in parts per million.

Trap efficiency. The ratio, expressed as a percentage, of the weight of sediment retained in a reservoir to the weight of sediment entering the reservoir.

SEDIMENTATION IN BROWNELL CREEK SUBWATERSHED NO. 1, NEBRASKA

By James C. Mundorff

ABSTRACT

This report presents the results of a sedimentation investigation in Brownell Creek subwatershed No. 1 which was made as part of a nationwide investigation of the trap efficiency of detention reservoirs. The subwatershed is in southeastern Nebraska, has a drainage area of 495 acres, receives an average of 28.75 inches of precipitation annually, has a total relief of about 95 feet, and has a surface mantle composed mainly of loess and glacial till.

Average annual runoff, based on records of precipitation and reservoir discharge and on estimates of reservoir evaporation and seepage loss, was 3.3 inches during 1955–59. Precipitation ranged from significantly below normal in 1955 and 1956 to appreciably above normal in 1957–59.

Most of the sediment transported into reservoirs 1 and 1A is silt and clay; generally, less than 10 percent of the suspended sediment is sand. Of the total sediment that enters reservoir 1, all the sand and much of the silt and clay are trapped. Trap efficiency of this reservoir, computed from partly estimated data, was between 90 and 95 percent during 1955–59.

During 1955–59, total sediment discharge from reservoir 1 was about 400 tons, of which 135 tons was discharged during the period June 24–26, 1955. About 77 percent of the sediment from reservoir 1 was discharged during seven outflow periods, each of which was less than 5 days in duration.

INTRODUCTION

The Geological Survey, in cooperation with the Soil Conservation Service, began an investigation of sedimentation in Brownell Creek subwatershed No. 1 in 1955. This investigation is part of a nationwide investigation of the trap efficiency of detention reservoirs; it was conducted under the general supervision of P. C. Benedict, regional engineer, to 1957 and D. M. Culbertson, district engineer, after 1957.

Records of water discharge were furnished for 1955 and 1956 by D. D. Lewis, district engineer, and for 1957–60 by F. F. LeFever, district engineer. Records of precipitation were furnished by the U.S. Weather Bureau. Valuable information on land use, land treatment measures, and structures was furnished by Gene O'Donnell and R. R. Hraban, Work Unit Conservationists of the Soil Conservation Service. Information on reservoir stage-capacity relations and on bulk density and particle-size distribution of deposited sediment was furnished by H. G. Heinemann, hydraulic engineer, of the Agricultural Research Service.

CHARACTERISTICS OF THE SUBWATERSHED

Brownell Creek subwatershed No. 1, one of many subwatersheds that compose Brownell Creek watershed, is in the central part of Otoe County, Nebr. (fig. 1), and is part of the Dissected Till Plains of eastern Nebraska. The drainage area of the subwatershed is approximately 495 acres.

CLIMATE

The climate of Brownell Creek subwatershed and of southeastern Nebraska is continental and subhumid. At Syracuse, the long-term mean temperatures are about 25°F for January and about 79°F for July. Since about 1900, the range in temperature has been nearly 150°F; a maximum of 116°F and a minimum of −33°F have been recorded. The growing season is usually 160–170 days.

The long-term average annual precipitation at Syracuse is 28.75 inches. On the average, about 55 percent of the total annual precipitation occurs from May to August, and about 75 percent from April to September. During 1955–59 the annual precipitation averaged about 30.3 inches; in 1955 and 1956 it was significantly below normal, and in 1957–59 it was significantly above normal.

Precipitation in Brownell Creek subwatershed was measured at a recording gage near the south side of the subwatershed and at a nonrecording gage near the northeastern part of the subwatershed. (See fig. 1.) The available records for these gages extend back only to July 1956. For 1957, 1958, and 1959, the total annual precipitation reported in the subwatershed was significantly less than that reported at a recording gage and a nonrecording gage about 3 miles to the west at Syracuse. Differences in gage maintenance and reporting techniques may be responsible for some of the discrepancy. The discrepancy between the data for the recording gages was appreciably less than that between the data for the nonrecording gages.

Most of the rainfall and runoff are a result of warm-season thunderstorms. For any particular storm, rainfall variability is high even in small areas; therefore, data from the two precipitation gages in the subwatershed give only a general indication of the quantity and distribution of precipitation over the area.

At Syracuse, precipitation events exceeding 0.25 inch occur, on the average, about 31 times a year, and those exceeding 1.0 inch about 7 times.

GEOLOGY AND SOILS

Deposits of Pleistocene age mantle the subwatershed. Peorian Loess, of late Pleistocene age, forms a nearly continuous mantle over the eastern half of the area and is on divide areas and upper slopes

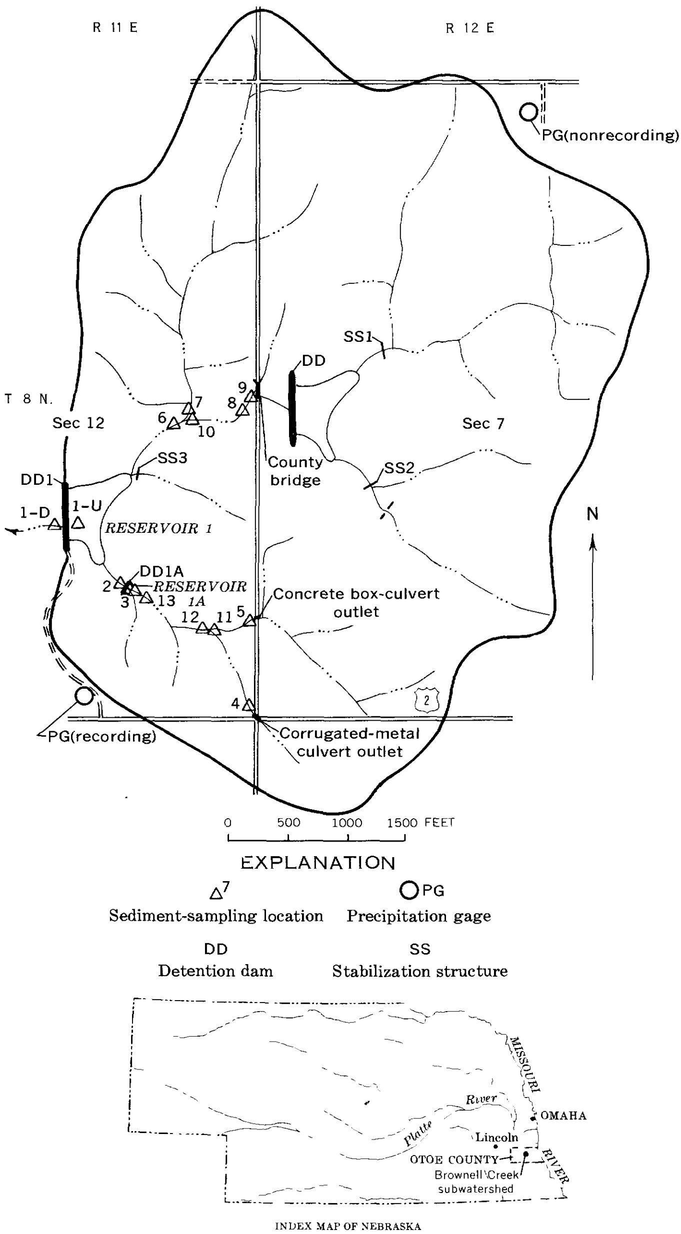

FIGURE 1.—Brownell Creek subwatershed.

in the western half of the area. Loveland Loess, which underlies the Peorian Loess in this southeastern Nebraska area, is not exposed to any significant extent. Kansan Drift, also of Pleistocene age, is generally exposed on moderate to steep slopes in the western part of the subwatershed. The Kansan Drift, which is stratigraphically lower than the Peorian and Loveland Loess, is also topographically lower in most places. Late Pleistocene to Recent alluvium mantles the small, narrow bottomland areas.

Soil development in the subwatershed varies mainly with parent material, physiographic position, and slope. Because climate and vegetation conditions under which soils developed in this small drainage basin were relatively homogeneous, they were unimportant determinants of profile differences. Soils developed on loess are predominant in the eastern half of the area and grade into mainly glacial-till soils in the western part of the subwatershed. Slope, infiltration rate, soil permeability, and parent material may vary within small areas. Severe erosion has exposed the B horizon in small areas of steeply sloping land.

A soil survey of Otoe County, Nebr. (Beesley and others, 1950), indicates that 61.6 percent, or 305 acres, of the subwatershed is occupied by soils of the Sharpsburg series, which are developed on Peorian Loess. Of the 305 acres, about 155 acres is Sharpsburg silty clay loam; 112 acres is Sharpsburg silty clay loam, rolling phase; and 38 acres is Sharpsburg silty clay loam, eroded rolling phase. About 29.3 percent, or 145 acres, of the subwatershed is occupied by soils of the Carrington series,[1] which are developed on glacial till. Of the 145 acres, about 5 acres is Carrington clay loam; 125 acres is Carrington clay loam, eroded rolling phase; and 15 acres is Carrington loam, eroded rolling phase. Soils of the Burchard-Carrington complex, developed on glacial till, occupy about 2.0 percent of the subwatershed. The Judson-Wabash complex, developed on colluvial-alluvial material, occupies about 7.1 percent of the subwatershed. Figure 2 shows the relation between soils, parent material, physiographic position, and slope.

Most of the drainage area is under cultivation; corn, sorghum, wheat, and oats are the main crops. Much of the steeply sloping land is in native grass or is seeded to grasses and legumes; small areas of native grass are along the major channels. Nearly all the minor drainageways have been seeded to grass to prevent gully formation. Plate 1 shows the general kinds of land use during 1955–59; these uses are indicative of the diversity of crops and of the rotation system commonly used in the subwatershed. The lack of quantitative data on

[1] In November 1959, the Carrington soil series was discontinued; the present (1962) equivalent of the Carrington in eastern Nebraska is generally the Shelby series (A. R. Aandahl, oral commun., 1962).

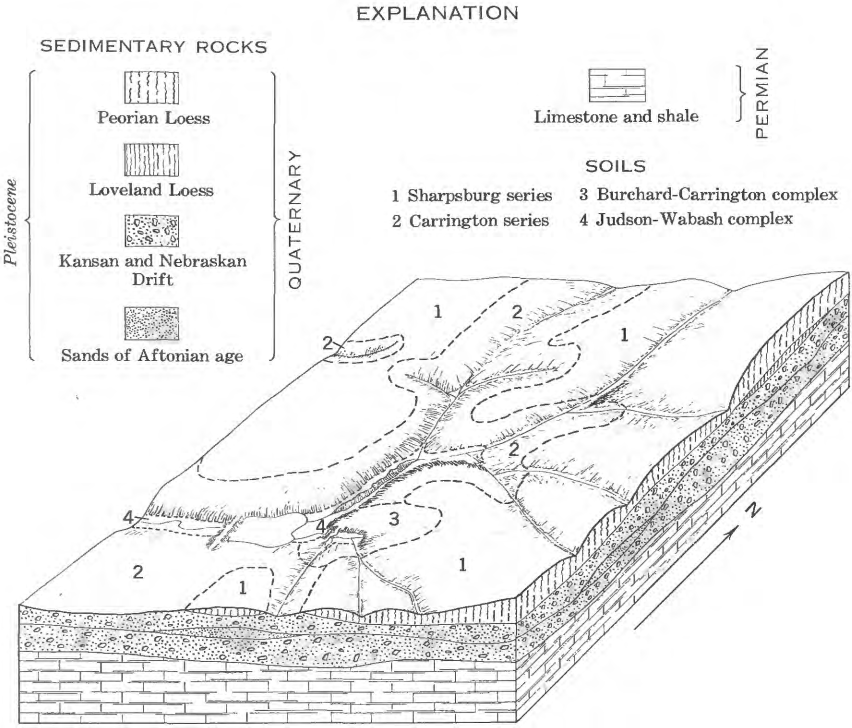

FIGURE 2.—Part of Brownell Creek subwatershed showing the relation of soils to geology and psysiographic position. Subsurface geology is inferred. Area shown is about 450 acres.

sediment yield from different parts of the subwatershed upstream from reservoirs 1 and 1A prevents the establishment of the relation of land use to sediment yield from any specific part of the subwatershed during any given year or any given storm. The establishment of this relation would require not only quantitative sediment data but also detailed analysis of the reason why certain crops are grown on a specific area, of the roadside erosion and the natural channel erosion in the subwatershed, of the earthmoving and construction operations in the subwatershed during the period of investigations, of the type of tillage practices, of the type and intensity of precipitation relative to the season and to the type and density of soil cover, of the presence or absence of soil frost during any given storm, and of the natural differences in erodibility of the surface materials that mantle the subwatershed.

DRAINAGE

Total relief within the drainage area is about 95 feet. Slopes generally are 4–12 percent and range from 100 to 800 feet in length.

The major natural channels of the dendritic drainage system have very steep or vertical banks. The main channel leading into the northeast corner of reservoir 1 is incised 4–8 feet below the flood plain. (See fig. 3.) Graded terraces that are constructed on most of the cultivated land and on some of the pastureland have modified the natural runoff pattern on most of the subwatershed. Figure 4 shows the general runoff pattern under both natural and terrace conditions on about 60 acres adjacent to reservoirs 1 and 1A. The terraces affect surface runoff in two ways: the runoff travels farther and at a lower gradient than the runoff would under natural conditions, and the runoff from any given point in a terraced area generally enters the main channels farther upstream than the runoff would under natural conditions. The drainage area of reservoir 1A is larger under terrace conditions than under natural conditions because runoff that would naturally flow directly into reservoir 1 is caused to enter the channel upstream from reservoir 1A.

Prior to the construction of reservoir 1, the channel that drains the north 370 acres of the subwatershed joined the channel that drains the south 125 acres near the center of the present reservoir site. (See fig. 5.) The present main north channel is a fourth-order stream, and

FIGURE 3.—Channel upstream from northeast corner of reservoir 1.

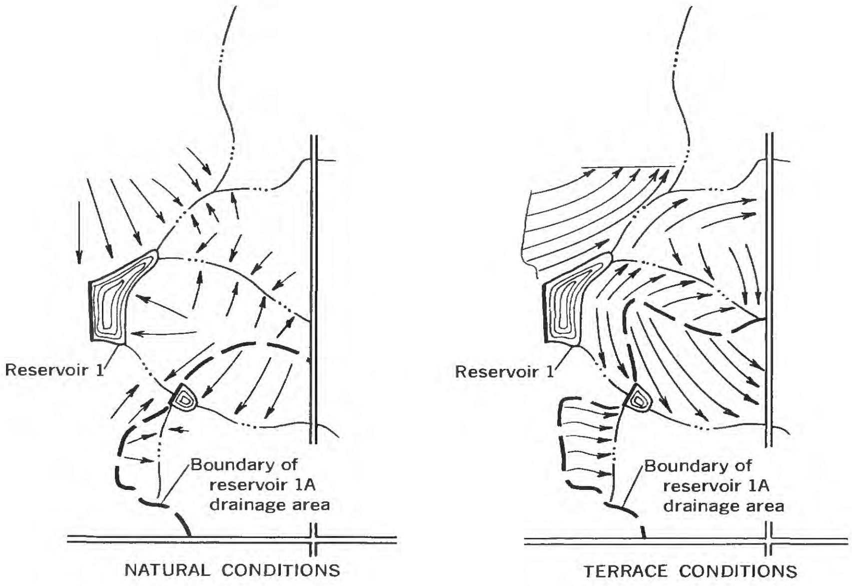

FIGURE 4.—Runoff pattern under natural conditions and under terrace conditions in part of the subwatershed.

FIGURE 5.—Looking north across preconstruction site of reservoir 1. Photograph by Soil Conservation Service.

the main south channel is a third-order stream. The method described by Strahler (1952) was used in determining stream order: the smallest, or "fingertip," channels are the first-order segments, the junction of any two first-order streams form a second-order segment, the junction of any two second-order streams form a third-order segment, and so on.

Relief ratio for the subwatershed is about 0.018. Natural drainage density was 7.3; present drainage density may be slightly different because of routing of runoff from terraced areas and because of the obliteration of some first-order channels during tillage operations and terrace construction. If each graded terrace is regarded as a channel, then the drainage density is probably increased at least fourfold—to 30 or more.

STRUCTURES AND RESERVOIRS

In 1955, reservoir 1 (fig. 6), which was completed in 1954, had a capacity of 125.6 acre-feet and a surface area of 16.0 acres at the crest of the emergency spillway (elevation 1,144 ft above mean sea level) and a capacity of 30.5 acre-feet and a surface area of 5.0 acres at the top of the drop inlet (elevation 1,134 ft). Table 1 gives the area and capacity at 1-foot increments of elevation for this reservoir.

In 1955, reservoir 1A (fig. 7), which was completed several years before reservoir 1, had a capacity of 4.25 acre-feet and a surface area of 1.29 acres at the crest of the emergency spillway (elevation 1.152 ft above mean sea level) and a capacity of 1.94 acre-feet and a surface area of 0.6 acres at the top of the drop inlet (elevation 1,149.34 ft). Table 2 gives the area and capacity for this reservoir.

Stabilization structures 1, 2, and 3 exert a minor control on runoff and sediment discharge from part of the subwatershed.

In May 1959, a large dam was completed about 300 feet upstream from the county bridge. (See figs. 1, 8.) This large upstream reservoir now detains or stores runoff from about 230 acres. It has a capacity of 14.3 acre-feet and a surface area of 3.5 acres at drawdown elevation of 1,167.5 feet above mean sea level. The capacity is 24.9 acre-feet and the surface area is 5.04 acres at the riser elevation of 1,170 feet; the capacity is 58.6 acre-feet and the surface area is 8.76 acres at the crest of the emergency spillway, elevation 1,175 feet. Outflow from this reservoir begins when the reservoir stage reaches a horizontal inlet, which is about 8 inches in diameter and which taps into the riser of a drop inlet of 24 inches in diameter. The top of the riser is about 2.5 feet higher than the top of the 8-inch drawdown tube. The discharge tube has a circular opening 18 inches in diameter.

FIGURE 6.—Reservoir 1 (June 24, 1955, reservoir elevation about 1,140 ft).

FIGURE 7.—Reservoir 1A (1960).

TABLE 1.—*Area and capacity of reservoir 1 from survey of March 1955*

Gage height (feet)	Elevation (feet above mean sea level)	Surface area (acres)	Capacity (acre-feet)
−11. 00	1, 122	------------	0. 5
−10. 00	1, 123	------------	1. 0
−9. 00	1, 124	------------	2. 0
−8. 00	1, 125	------------	3. 3
−7. 00	1, 126	------------	5. 0
−6. 00	1, 127	------------	7. 0
−5. 00	1, 128	------------	9. 0
−4. 00	1, 129	------------	12. 0
−3. 00	1, 130	------------	15. 0
−2. 00	1, 131	------------	18. 0
−1. 00	1, 132	3. 32	22. 0
0. 00	1, 133	4. 15	26. 0
1. 00	1, 134	5. 00	30. 5
2. 00	1, 135	5. 90	35. 5
3. 00	1, 136	6. 85	41. 5
4. 00	1, 137	7. 89	48. 1
5. 00	1, 138	8. 90	55. 6
6. 00	1, 139	9. 98	64. 0
7. 00	1, 140	11. 00	73. 6
8. 00	1, 141	12. 20	84. 4
9. 00	1, 142	13. 50	96. 7
10. 00	1, 143	14. 64	110. 3
11. 00	1, 144	16. 00	125. 6

TABLE 2.—*Area and capacity of reservoir 1A from survey of March 1955*

Gage height (feet)	Elevation (feet above mean sea level)	Surface area (acres)	Capacity (acre-feet)
8.20	1, 141. 2	0. 00	0. 00
9.00	1, 142	. 03	. 02
10.00	1, 143	. 10	. 09
11.00	1, 144	. 16	. 22
12.00	1, 145	. 22	. 41
13.00	1, 146	. 28	. 63
14.00	1, 147	. 34	. 92
15.00	1, 148	. 40	1. 29
16.00	1, 149	. 50	1. 74
17.00	1, 150	. 75	2. 33
18.00	1, 151	1. 03	3. 15
19.00	1, 152	1. 29	4. 25

FIGURE 8.—Large dam about 300 feet upstream from county bridge.

Runoff from about 125 acres is detained in reservoir 1A before entering reservoir 1; runoff from about 230 acres is detained in the large upstream reservoir; and runoff from about 10 acres is detained by a small stabilization structure near the northeast corner of reservoir 1. Therefore, runoff from only about 130 acres enters reservoir 1 without having first passed through an upstream structure.

Flow regulation through reservoir 1A is similar to that through reservoir 1 except for the time of detention, which is much shorter because of the small reservoir capacity and the larger discharge tube. The drop-inlet structure at reservoir 1 has a concrete riser which has a rectangular opening 30 by 24 inches, and the discharge tube has a circular opening 18 inches in diameter. The drop-inlet structure at reservoir 1A has a metal riser 48 inches in diameter, and the discharge tube is 36 inches in diameter. Stabilization structures 1 and 2 have earth spillways; stabilization structure 3 has a metal drop-inlet arrangement similar to that of reservoir 1A.

RUNOFF

Comprehensive analysis of runoff data on the subwatershed is not possible for several reasons: no storage nor discharge data were obtained at three small upstream reservoirs during 1955–59 nor at a large upstream reservoir that was completed in May 1959; complete data are available only for discharge from reservoirs 1 and 1A and are not available for changes in reservoir content throughout the range

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of reservoir stage during 1955–59. Although complete runoff data are not available, total runoff in the subwatershed can be approximated. Table 3 shows reservoir discharge and other pertinent hydrologic data for 1955–59. The data on evaporation and seepage were estimated; the data on direct precipitation on the reservoirs were based on data obtained at the precipitation gages in other parts of the subwatershed. Only 0.4 percent of the 125-acre drainage area of reservoir 1A was open water surface; for the remaining 370 acres of the subwatershed, 1.5 percent was open water surface during 1955–58 and 2.8 percent since 1959. Thus, estimated evaporation, seepage, and direct precipitation on reservoir surfaces were proportionately much lower for reservoir 1A than for the rest of the subwatershed.

The data in table 3 indicate that the average annual runoff for the entire Brownell Creek subwatershed was 3.3 inches during 1955–59 and that runoff was somewhat lower from the drainage area of reservoir 1A than from the rest of the subwatershed.

Brownell Creek subwatershed is in the Little Nemaha River basin. Discharge data show that the average annual runoff for the drainage area (218 sq miles) of Little Nemaha River near Syracuse was about 3.8 inches during 1955–59.

Between December 27, 1959, and about March 15, 1960, exceptionally heavy snowfalls occurred in southeastern Nebraska. On March 21, 1960, a detailed snow survey was made in Brownell Creek subwatershed. For this area of less than 1 square mile, over 500 observations of snow depth and about 20 moisture-content determinations were made. Random observations indicated that the ground was frozen in most of the watershed, but the depth of frost was not determined. Melting was insignificant between March 21 and March 26; a reconnaissance of the area on March 26 indicated no change in snow depth from that measured on March 21. The snow over the subwatershed averaged 1.03 feet in depth and was rather uniformly distributed. Moisture content of the snow averaged 3.49 inches of water in each foot of snow; this exceptionally high moisture content was caused by considerable melting and compaction between about February 25 and March 20. Moisture-content determinations of the snow cover in Lincoln, Nebr., on March 22 indicated 3.60 inches of water in each foot of snow.

On March 27, 1960, the snow began to melt very rapidly and by the evening of March 28, an estimated 95 percent or more of the snow cover in the subwatershed had melted. At the time the melting began, all reservoirs were at maximum dead-storage capacity; therefore, reservoir outflow was equal to inflow, and none of the runoff resulted in additional reservoir storage. Runoff, as indicated by the discharge from reservoir 1 during March 27–31, was the result of snowmelt.

TABLE 3.—*Reservoir discharge and other hydrologic data, reservoirs 1 and 1A*

	Reservoir 1A	Reservoir 1–1A	Reservoir 1
Area .... acres	125	370	495
Reservoir discharge, in acre-feet			
1955[1]	22	83	105
1956	11	38	49
1957	7.8	19	27
1958	57	146	203
1959	36	[2] 187	[2] 223
1955–59	[3] 134	473	607
Reservoir discharge, in percentage of total			
1955	21	79	100
1956	22	78	100
1957	29	71	100
1958	28	72	100
1959	16	84	100
1955–59	22	78	100
Precipitation, in inches			
1955	----------	----------	[4] 23.77
1956	----------	----------	[4] 22.59
1957	[5] 26.57	[6] 25.31	[7] 25.94
1958	[5] 39.23	[6] 37.96	[7] 38.65
1959	[5] 29.89	[6] 30.17	[7] 30.03
1955–59	----------	----------	[7] 28.20
Reservoir evaporation,[8] in acre-feet			
1955	2	19	21
1956	2	17	19
1957	1	14	15
1958	2	18	20
1959	2	37	39
1955–59	9	105	114
1955–59 Miscellaneous data			
Direct precipitation on surface of reservoir .... acre-feet	6	72	78
Estimated seepage loss .... do	5	35	40
Total runoff .... do	[9] 142	[10] 541	683
Average annual runoff .... inches	2.7	3.5	3.3

[1] Includes new storage in reservoir 1 and estimated discharge from reservoir 1A for October 1954 to March 1955.
[2] Includes 15 acre-feet of new storage.
[3] Total rounded.
[4] At Syracuse.
[5] 4 miles northeast of Syracuse.
[6] 3 miles north-northeast of Syracuse.
[7] Average.
[8] Based on pan-evaporation data at Lincoln and on information from Kohler, Nordenson, and Baker (1959).
[9] Total runoff=reservoir 1A inflow+direct precipitation on reservoir 1A=reservoir 1A outflow+evaporation+seepage.
[10] Total runoff=reservoir 1 inflow+direct precipitation on reservoir 1=reservoir 1 outflow+evaporation+seepage+storage−reservoir 1A outflow.

Computations based on average snow depth and average moisture content indicate that 148 acre-feet of water was contained in the accumulated snow. The discharge from reservoir 1 during March 27–31 was about 115 acre-feet and represents about 78 percent of the water incorporated in the snow cover in the subwatershed (see table 4); 33 acre-feet of the water in the snow apparently did not enter the reservoirs. Most of this unaccounted for water probably infiltrated the soil in areas where ground frost was absent or where the upper part of the soil profile was not frozen, or it infiltrated the soil after temporary terrace storage. Some of the melt water may have recharged the ground-water reservoir, and minor amounts may have been lost through sublimation from the snow surface and through evaporation from the reservoirs.

TABLE 4.—*Hydrologic data, Brownell Creek subwatershed No. 1 Mar. 27–31, 1960*

	Drainage area		Water in snow cover (acre-feet)	Discharge		Runoff, percentage from snowmelt
	Acres	Percentage of total		Acre-feet	Percentage of total	
Reservoir 1A	125	25	37	20	17	54
1–1A	370	75	111	95	83	86
1	495	100	148	115	100	78

METHOD OF INVESTIGATIONS

From April 1, 1955, to September 30, 1959, suspended sediment was sampled at 14 locations in Brownell Creek subwatershed. (See fig. 1.) Outflow from reservoirs 1 and 1A was sampled at locations 1–D, 1–U, and 2; upstream from these reservoirs, flow was sampled at locations 3–13. Locations 10–13 were not used before June 30, 1956.

Outflow was sampled from reservoir 1A at the discharge tube (fig. 9) and from reservoir 1 at the discharge tube (fig. 10) and at the trash rack that protects the inlet of the discharge tube. Samples were collected at the discharge tubes with a U.S. DH–48 sampler and at the trash rack with automatic suspended-sediment samplers in vertical stacks on the upstream corners of the rack (fig. 11). At reservoir 1, samples were also collected at the discharge tube by a continuous suspended-sediment sampler having the intake nozzle in a fixed position inside the discharge tube.

Inflow to the reservoirs was sampled with a U.S. DH–48 sampler or with a handline sampler at locations 4–13 and with automatic suspended-sediment samplers at locations 3, 6–8, 10, and 13. The automatic samplers were placed in the channels so that the initial samples were collected when the flow reached a depth of about 0.7 foot. Automatic samplers were arranged in vertical stacks so that successive samples were obtained as the stage increased. Manual sampling at locations 5 and 9 was done by a local resident, who was assisted by Geological Survey personnel during periods of major runoff.

Reservoir stage recorders are on the upstream side of the dams at reservoirs 1 and 1A. (See figs. 6, 7.) Water discharge measurements are made about 100 feet downstream from the discharge tubes of the reservoirs.

The suspended-sediment concentrations of all samples, in parts per million by weight, were determined in the laboratory. The particle-size distribution of the suspended sediment in selected samples was determined by standard methods based on the fall velocity of the particles. The particle-size distribution of the sand from samples of deposited sediment was determined by the sieve method; the particle-size distribution of the silt and clay was determined by sedimentation methods.

For days of significant discharge, the suspended-sediment concentrations were plotted on the gage-height chart, and a smooth curve was drawn through the plotted points; the mean daily concentration was determined from this curve. Daily suspended-sediment discharge, in tons, was computed by multiplying daily mean concentration by

FIGURE 9.—Discharge tube, reservoir 1A.

daily mean water discharge and by a constant. On days when both concentration and water discharge were changing rapidly, each day was divided; sediment discharge that had been computed separately for parts of the day were totaled for the daily discharge.

SUSPENDED SEDIMENT

SUSPENDED-SEDIMENT DISCHARGE

The periods of significant outflow from reservoir 1 between April 1955 and September 1959 are summarized in table 5. The sediment discharge and water discharge shown for these periods represent about 99 and 88 percent, respectively, of the total from April 1955 to September 1959; a few very small sediment discharges are not included. The weighted suspended-sediment concentrations are the concentrations that would result if all the water and all the sediment discharged during a given period were uniformly mixed. For the periods shown in this table (99 percent of the sediment discharge and 88 percent of the water discharge), the weighted concentration is 587 parts per million. If the remaining 12 percent of the water

FIGURE 10.—Outflow from discharge tube, reservoir 1 (June 24, 1955, water discharge about 32 cfs).

FIGURE 11.—Partly submerged vertical stack of automatic suspended-sediment samplers at trash rack, reservoir 1 (June 24, 1955, reservoir elevation about 1,140 ft).

discharge, which had a weighted concentration of only 24 ppm, is included, the weighted concentration for all the water discharged from the reservoir between April 1955 and September 1959 would be 525 ppm.

The periods of significant outflow from reservoir 1A during 1955–59 are summarized in table 6. Because the drainage area is small in size, has flash-type runoff characteristics and a short detention time, the data for reservoir 1A are probably much less reliable than those for reservoir 1.

Sediment discharge from reservoir 1 as a result of the storm of June 23–24, 1955, was greater than that during any other single period from 1955 to 1959, inclusive, and represents about one-third of the total sediment discharge from reservoir 1 during 1955–59. Hydrologic information for reservoirs 1 and 1A is shown in figures 12 and 13. Samples at location 3 indicate that the peak suspended-sediment concentration for inflow occurred during the initial sharp rise in stage. During a 12-hour period on June 23–24, 4.30 inches of rain fell at a maximum intensity of about 2.00 inches per hour. At reservoir 1, peak inflow, based on preliminary data, was about 700 cfs; peak out-

TABLE 5.—*Summary of outflow from reservoir 1, 1955–59*

Date	Discharge		Sediment discharge (tons)	Weighted suspended-sediment concentration (ppm)
	Cubic feet per second—days	Acre-feet		
1955				
Apr. 23–24	4. 54	9. 0	10. 0	818
Apr. 25–30	. 22	. 44	. 9	1, 520
June 24–26	29. 7	58. 9	135	1, 680
June 28–29	3. 32	6. 6	11	1, 230
1956				
July 2–4	6. 47	12. 8	11	630
July 31–Aug. 1	3. 23	6. 4	1. 0	115
Aug. 18–20	14. 7	29. 2	25	630
1957				
Apr. 3–5	3. 91	7. 8	3. 1	294
June 16–18	5. 02	10. 0	3. 1	229
July 1–2	4. 38	8. 7	3. 9	330
1958				
Mar. 5–6	2. 60	5. 2	. 6	85
July 10–12	15. 0	29. 8	18. 7	462
July 17	1. 88	3. 7	. 6	118
July 19	6. 98	13. 8	10. 1	536
July 20–25	1. 22	2. 4	1. 1	334
Aug. 5–7	34. 5	68. 4	44. 5	478
Aug. 8–14	2. 82	5. 6	1. 7	242
Sept. 3–6	20. 3	40. 3	23. 3	425
Sept. 7–10	1. 83	3. 6	. 8	162
Sept. 14–15	1. 18	2. 3	. 5	157
Sept. 21–24	2. 39	4. 7	1. 1	170
1959				
Feb. 22–28	8. 25	16. 4	1. 2	54
Mar. 25–31	8. 0	15. 9	1. 7	79
May 2–6	22. 4	44. 9	43. 6	721
May 7–17	5. 37	10. 7	4. 1	283
May 18	10. 6	21. 0	23. 0	804
May 19–22	7. 07	14. 0	5. 6	293
May 23–31	10. 0	19. 9	7. 1	263
June 1–6	2. 02	4. 0	. 7	128
June 30	7. 18	14. 2	2. 2	113
July 1–5	3. 46	6. 9	1. 1	118
Total	250. 54	497. 5	397. 3	----------

flow was 32.8 cfs; peak suspended-sediment concentration of outflow was 3,400 ppm; maximum instantaneous sediment discharge was 275 tons per day; and total sediment discharge was 135 tons. The peak inflow of about 700 cfs, or about 905 cfs per square mile, is indicative of the intensity of the precipitation and runoff during this storm.

The peak inflow probably would have exceeded 700 cfs if the upstream control structures had not been present. Figure 14 is an aerial view of the reservoirs and part of the subwatershed on June 24, 1955.

Summaries of other selected periods of major discharge from reservoir 1 are shown in figures 15–20.

About 77 percent of the total sediment discharge from reservoir 1 during 1955–59 occurred during seven outflow periods, each of which was less than 5 days in duration. About 88 percent of the total sediment discharge was during 11 outflow periods that had a combined duration of 30 days.

TABLE 6.—*Summary of outflow from reservoir 1A, 1955–59*

Date	Discharge		Sediment discharge (tons)	Weighted suspended-sediment concentration (ppm)
	Cubic feet per second—days	Acre-feet		
1955				
Apr. 23	0.9	1.8	6.0	2,470
June 24	6.2	12.3	94	5,620
June 28	1.0	2.0	7.0	2,590
1956				
July 2–3	1.8	3.6	10	2,060
July 31	1.0	2.0	7.0	2,590
Aug. 18	2.6	5.2	8.0	1,140
1957				
Apr. 2–4	1.8	3.6	10	2,060
June 17	1.0	2.0	2.6	960
July 1	1.1	2.2	3.5	1,180
1958				
Mar. 5–29	1.6	3.2	1.2	280
July 10–11	5.7	11.3	12	780
July 17–25	3.6	7.1	7.4	760
Aug. 5–6	11.7	23.2	30	950
Sept. 3–6	3.7	7.3	12	1,200
Sept. 14–24	1.3	2.6	2.0	570
1959				
Mar. 13–20	2.1	4.2	4.0	710
Mar. 25–31	1.4	2.8	2.4	630
May 2–5	4.0	7.9	15	1,390
May 6–14	.7	1.4	1.8	950
May 18	4.7	9.3	24	1,890
May 19–31	2.5	5.0	6.5	960
June 30	2.2	4.4	4.7	790
Total	62.6	124.4	271.1	----------

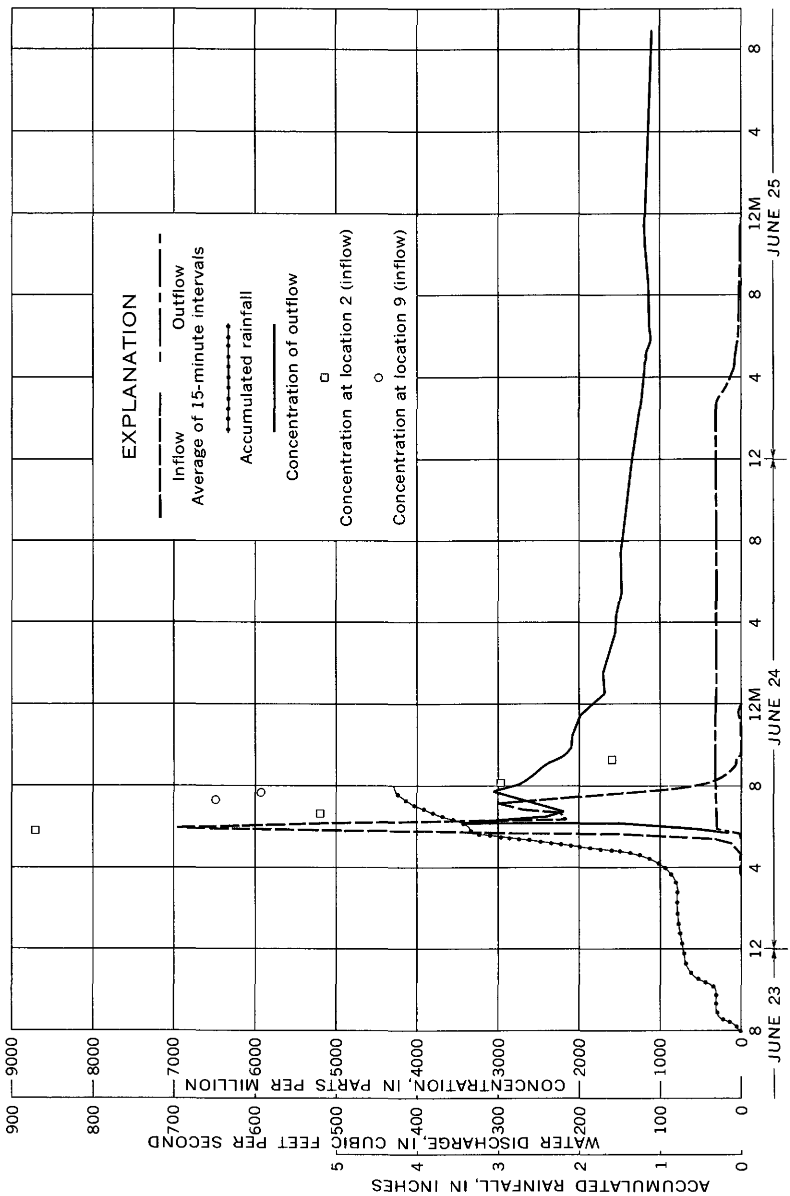

Figure 12.—Water discharge (inflow and outflow), accumulated rainfall, and suspended-sediment concentration, reservoir 1, June 23–25, 1955.

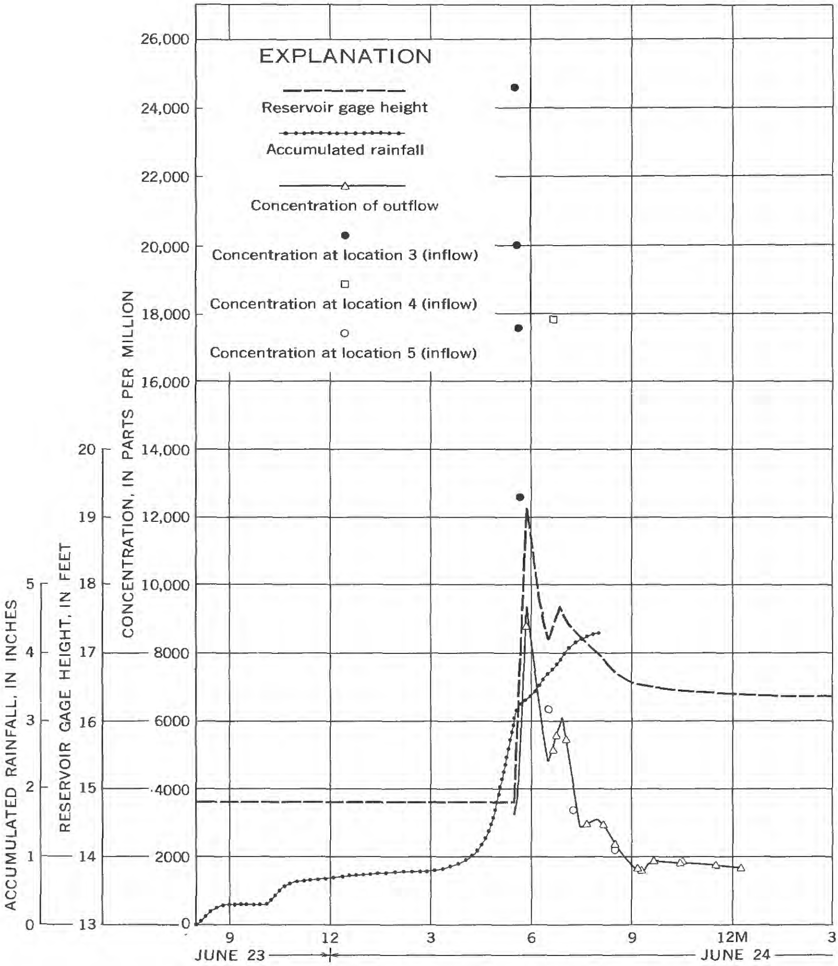

Figure 13.—Reservoir gage height, accumulated rainfall, and suspended-sediment concentration, reservoir 1A, June 23–24, 1955.

FIGURE 14.—Downstream view of part of Brownell Creek subwatershed, June 24, 1955 Photograph by Soil Conservation Service.

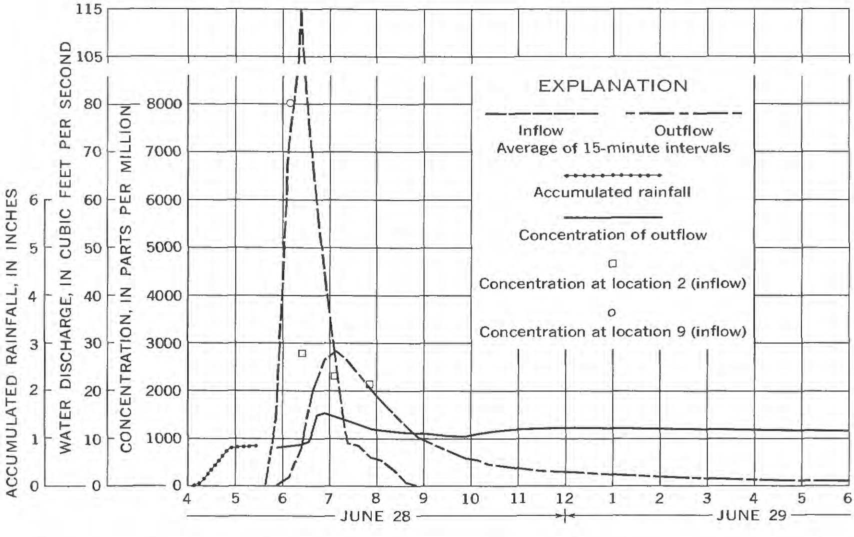

FIGURE 15.—Water discharge (inflow and outflow), accumulated rainfall, and suspended-sediment concentration, reservoir 1, June 28–29, 1955.

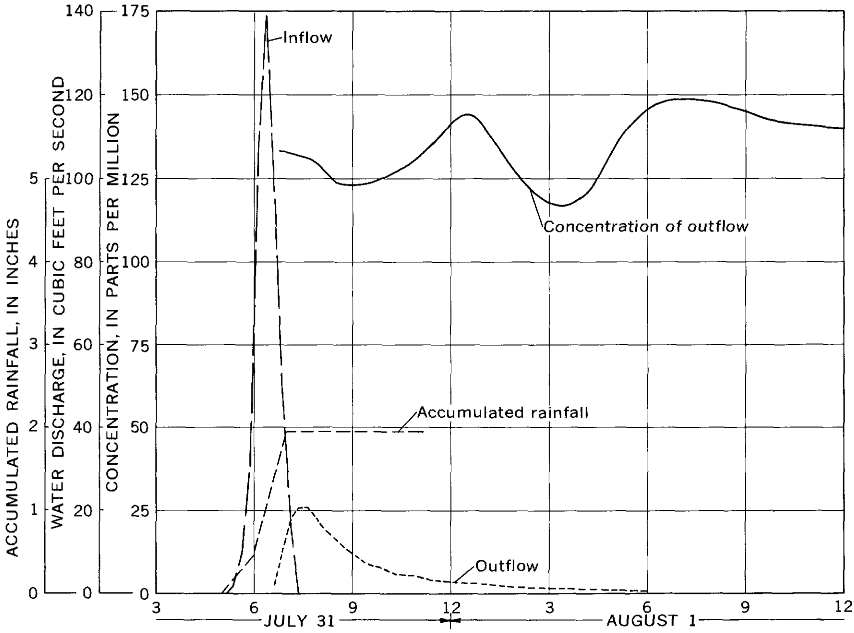

FIGURE 16.—Water discharge (inflow and outflow), accumulated rainfall, and suspended-sediment concentration, reservoir 1, July 31–Aug. 1, 1956.

The large upstream reservoir, which was completed in 1959, retains much of the sediment derived from the eastern part of the subwatershed and reduces significantly the sediment discharge into reservoir 1. The sediment discharge from both the upstream reservoir and reservoir 1A is predominantly clay; therefore runoff from about 70 percent of the subwatershed transports mainly clay into reservoir 1. Although some of this clay is undoubtedly deposited in reservoir 1, a large part remains in suspension and is discharged from the reservoir. Since May 1959, a disproportionately large percentage of the sediment deposited in reservoir 1 is derived from the northwestern part of the subwatershed because the runoff flows directly into reservoir 1 without first passing through the other reservoirs.

Field observations and data on inflow and outflow concentrations indicate that an inflow of high suspended-sediment concentration may behave as a density (turbidity) current upon entering the reservoir. The relation of outflow concentration to inflow concentration for a given runoff period varies with such factors as the intensity and duration of runoff, reservoir stage at the beginning of the runoff period, maximum reservoir stage during the runoff period, antecedent inflow conditions, and water temperature of inflow and reservoir water.

Suspended-sediment discharge cannot be computed for the different inflow sampling sites; however, the instantaneous suspended-sediment discharge into the reservoir at selected times can be computed from partly estimated data. On June 24, 1955, the maximum instantaneous suspended-sediment discharge into the reservoir was probably about 35,000 tons per day; this discharge probably prevailed for only a few minutes. Maximum discharges of 10,000–25,000 tons per day probably occurred for periods of a few minutes in 1956, 1958, and 1959. The data indicate that maximum inflow concentration and suspended-sediment discharge either precede or coincide with maximum water discharge.

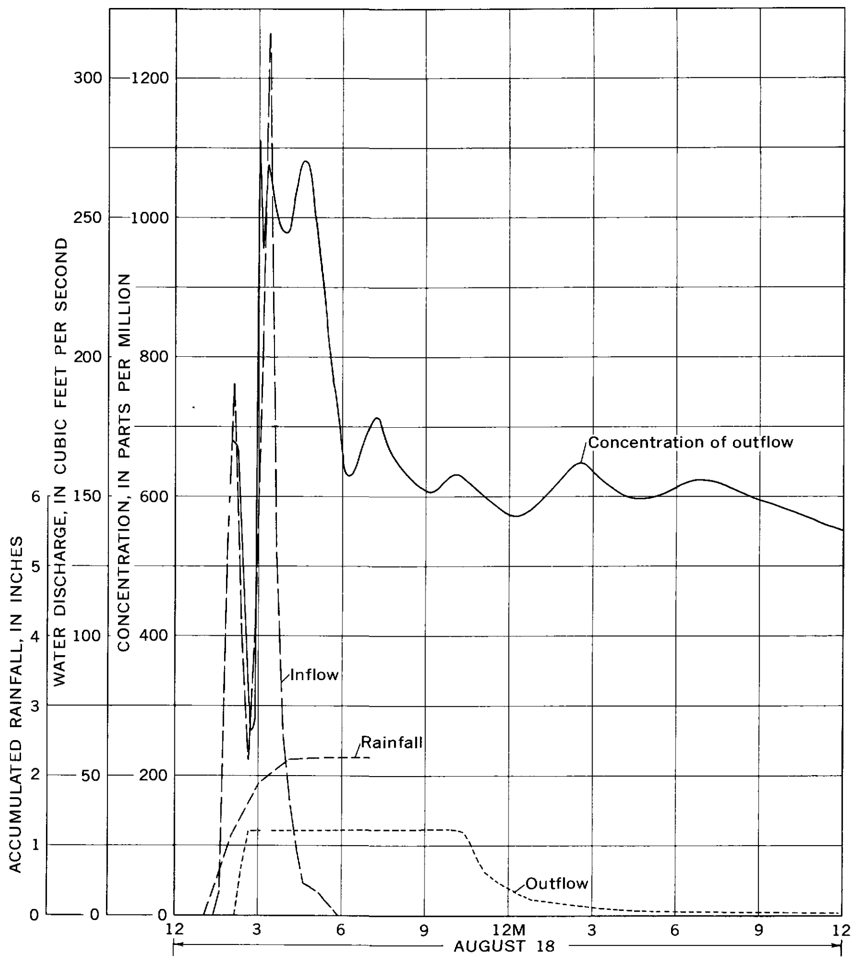

FIGURE 17.—Water discharge (inflow and outflow), accumulated rainfall, and suspended-sediment concentration, reservoir 1, Aug. 18, 1956.

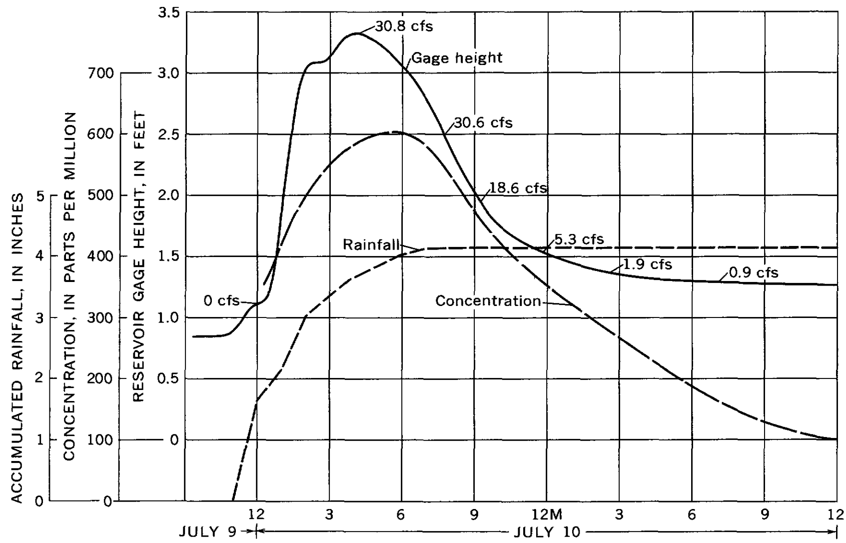

FIGURE 18.—Gage height, accumulated rainfall, suspended-sediment concentration, and water discharge, reservoir 1, July 9–10, 1958.

PARTICLE-SIZE OF SUSPENDED SEDIMENT

Particle-size distribution of suspended-sediment samples (shown graphically in figure 21,) indicates that the outflow (tables 7, 8) has a higher percentage of clay than the inflow (tables 9, 10), that most of the sand entering reservoir 1A is trapped, and that all the sand and much of the silt and clay entering reservoir 1 are trapped.

Figure 22 shows that the percentage of clay is related to the suspended-sediment concentration of inflow to reservoirs 1 and 1A. Although the plotted points show considerable scatter, the curve indicates a general tendency for the percentage of clay to decrease as suspended-sediment concentration increases. The concentration of clay generally increases, however, as the total suspended-sediment concentration increases.

For selected inflow and outflow samples, particle-size distribution of the silt-clay fraction was determined by two different settling mediums—distilled water having a dispersing agent added and native water. (See tables 7–10.) Such data on size distribution may indicate roughly the degree and extent of flocculation and deposition in a reservoir; however, a considerable part of the clay shown for the dispersed analysis may have been transported into the reservoir as silt- or sand-size soil aggregates, and preparation of the sample for analysis under dispersed conditions destroys these aggregates. Differences between size distribution in the two different mediums may be caused as much by destruction of original soil aggregates as by the flocculating ability of the native water.

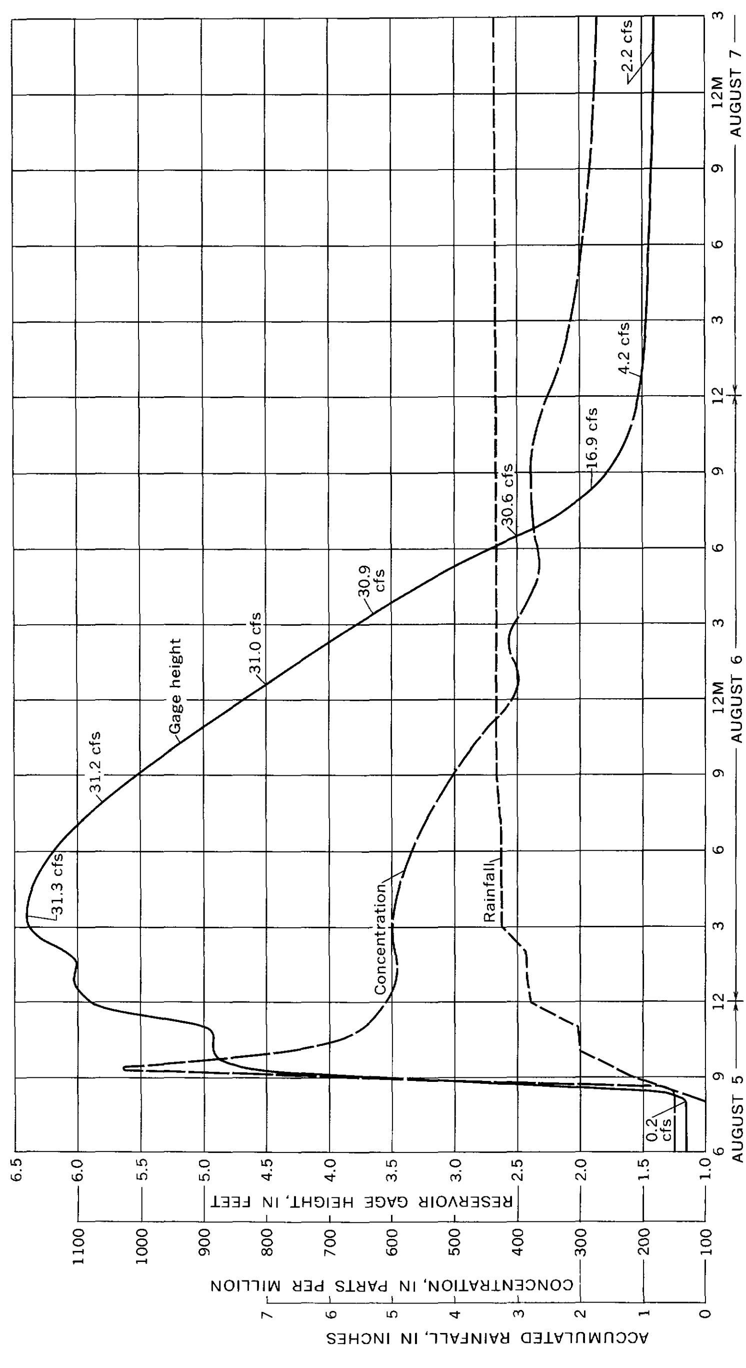

Figure 19.—Gage height, accumulated rainfall, suspended-sediment concentration, and water discharge, reservoir 1, Aug. 5–7, 1958.

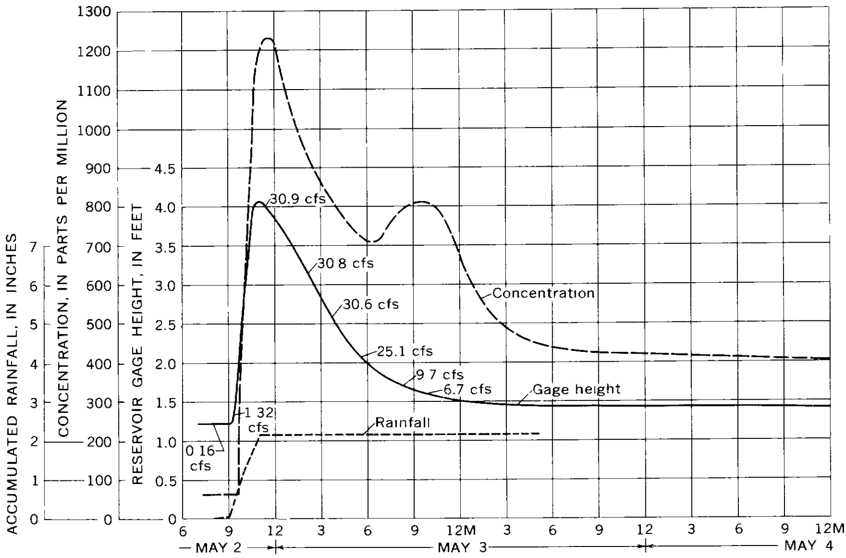

Figure 20.—Gage height, accumulated rainfall, suspended-sediment concentration, and water discharge, reservoir 1, May 2–4, 1959.

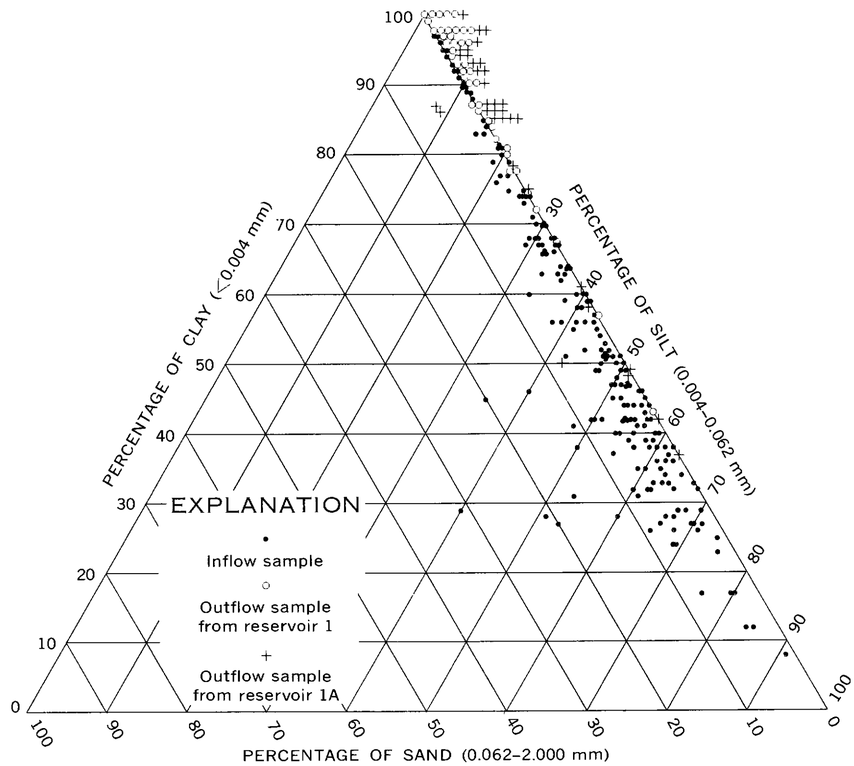

Figure 21.—Percentage of clay, silt, and sand in samples from Brownell Creek subwatershed.

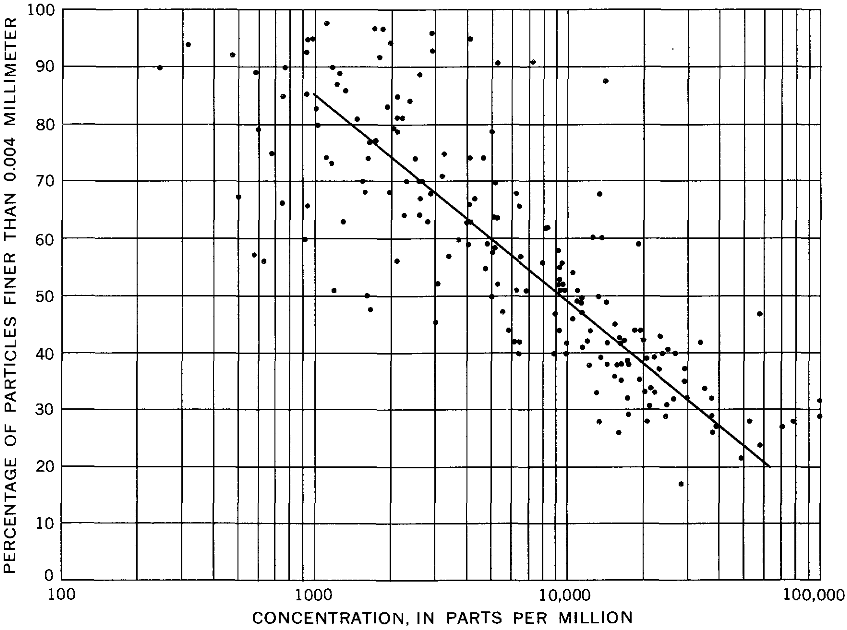

FIGURE 22.—Relation of percentage of clay to suspended-sediment concentration, inflow to reservoirs 1 and 1A.

DEPOSITED SEDIMENT

The trap efficiency of reservoir 1 eventually will be computed using data from reservoir surveys and data on sediment discharge from the reservoir. At present (1961), the results of the surveys are not available and the amount of sediment deposition in the reservoir is not known. Deposition in reservoir 1 can be computed, however, from the available data on concentration and particle-size distribution of inflow from different parts of the subwatershed, on sediment discharge from reservoirs 1 and 1A, data on estimates of runoff distribution within the subwatershed, and from a small amount of data on bulk density of reservoir deposits. About 4.5 acre-feet of sediment is estimated to have been deposited in reservoir 1 and in backwater reaches of channels leading into this reservoir. Trap efficiency of reservoir 1 is estimated to have been between 90 and 95 percent during 1955–59, but the trap efficiency (computed as the ratio, expressed as a percentage, of the weight of sediment retained in the reservoir to the weight of sediment entering the reservoir) has probably decreased since the completion of the large upstream reservoir in 1959. Much less sediment probably enters reservoir 1, and of the sediment that does enter, the percentage of clay is probably higher than it was before construction of the upstream reservoir. Most of the sediment that is discharged from the upstream reservoir is clay, and much of this clay probably remains in suspension and is discharged from reservoir 1. The decrease in sediment inflow to reservoir 1 is probably greater than the decrease in sediment discharge from reservoir 1, and the result should be an apparent decrease in trap efficiency of reservoir 1; however, the upstream reservoir probably has a trap efficiency similar to that of reservoir 1, and the actual decrease in trap efficiency of reservoir 1 will, no doubt, be slight. The rate of sediment accumulation in reservoir 1 has probably decreased markedly since about May 1959.

Reservoir bottom samples from eight locations in reservoir 1 and from three locations in reservoir 1A (fig. 23) were obtained and analyzed by the Agricultural Research Service during the spring of 1958. For reservoir 1, the average bulk density of the samples, expressed as grams per cubic centimeter, was 1.16; for reservoir 1A, the average bulk density of the three samples was 0.89. For reservoir 1, the bulk density generally increased with depth and averaged 1.06 for about the upper 4 inches of sediment deposited, 1.19 for the material about 4–8 inches below the surface of the deposit, and 1.25 for the material more than 8 inches below the surface. For the samples collected at reservoir 1A, bulk density was not related to depth. (See table 11.)

The correlation between particle-size distribution of deposited material and bulk density is only fair. However, the sample having the highest percentage of sand had the highest bulk density (reservoir 1), and the sample having the highest percentage of clay had the second lowest bulk density (reservoir 1A). Figure 24 shows the relation between percentage of sand and bulk density.

For reservoir 1, the percentage of sand ranged from 9 to 43, and the percentage of clay ranged from 23 to 40; for reservoir 1A, the percentage of sand ranged from 8 to 20, and the percentage of clay from 27 to 46. The particle-size classification used for this series of samples is that followed by the U.S. Department of Agriculture: sand, 0.05 to 2.0 mm; silt, 0.002 to 0.05 mm; clay, less than 0.002 mm. Particle-size analyses were made on about half the samples obtained and the results are given in table 11.

In February 1957, samples of deposited sediment were collected between the northeast corner of the reservoir and the junction of the two main channels that drain the northern two-thirds of the subwatershed. Figure 23 shows the location of the sampling sections, and table 12 shows the particle-size distribution of the sampled material. In the reach from the downstream edge of the delta to the termination of channel backwater, the particle-size distribution of

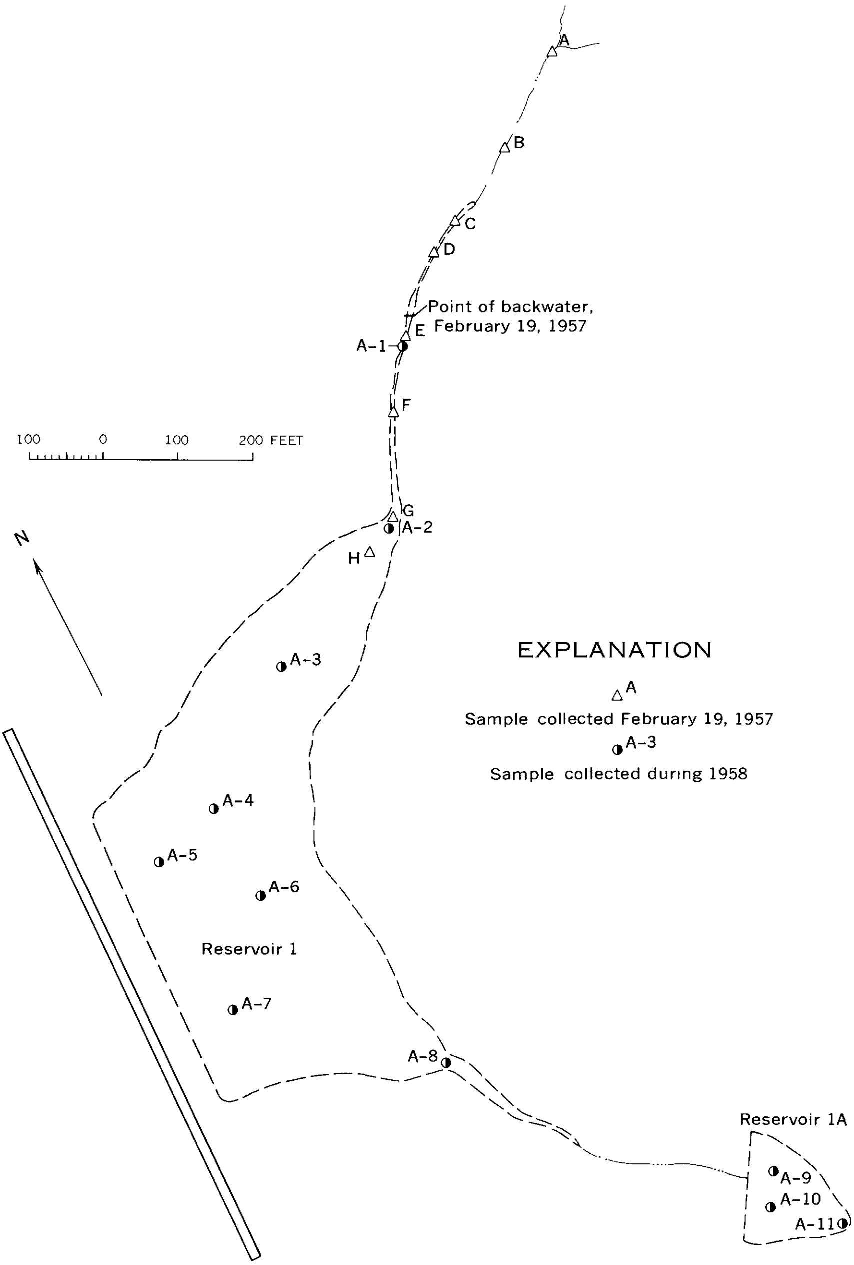

FIGURE 23.—Locations of sampling sections for deposited sediment.

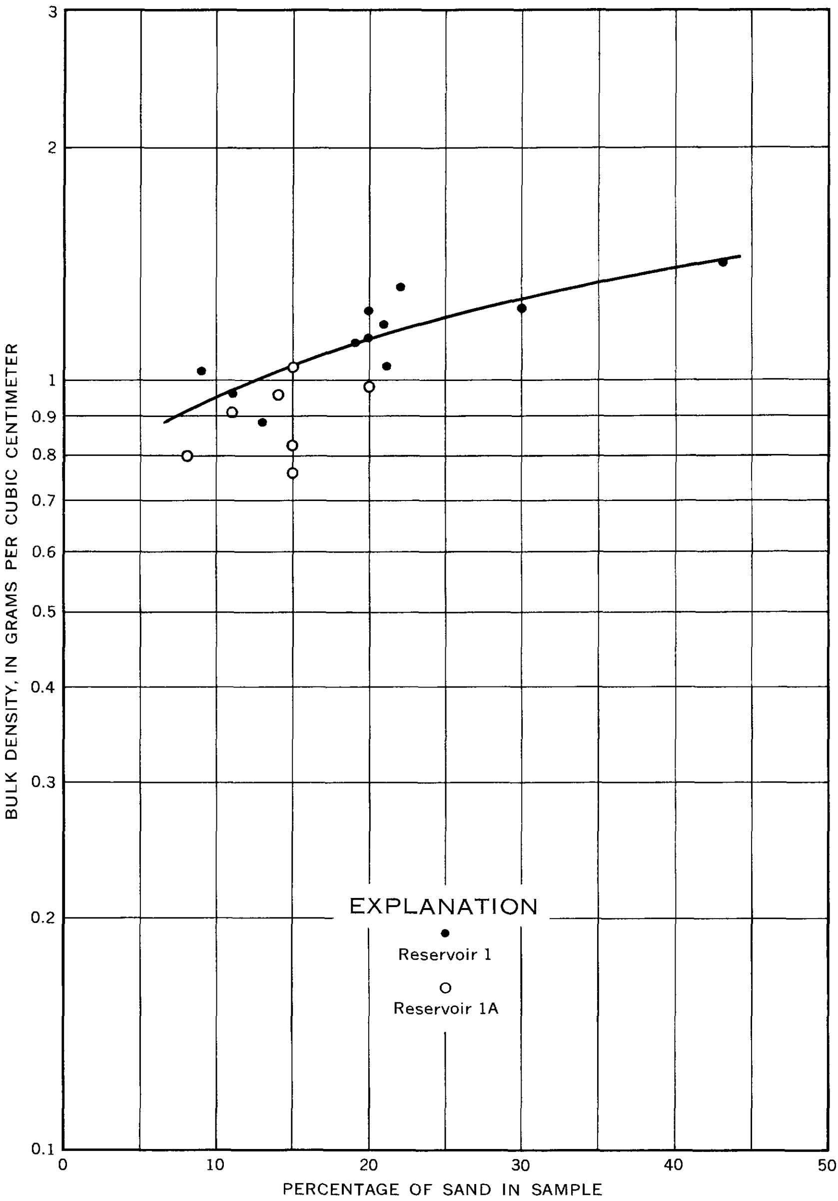

FIGURE 24.—Relation of bulk density to percentage of sand in deposited sediment.

deposited sediment was relatively uniform. Upstream from the channel backwater, the material contained a high percentage of sand and some gravel.

Field observations indicate that the extent and particle-size composition of the channel deposits are affected by reservoir stage at the beginning of a runoff period, maximum reservoir stage during a runoff period, characteristics and duration of channel flow, recurrence of minor flows after major flows, and the season in which the flow occurs. An appreciable part of the sediment deposited in channel backwater during high reservoir stages is probably transported as bedload into the reservoir by subsequent minor flows during low reservoir stages.

In April 1957, a composite sample of material from the delta was obtained at the upstream end of reservoir 1A. Particle-size analysis of this sample showed 26 percent silt and clay, 69 percent sand, and 5 percent gravel.

The major source of the transported sand and gravel is probably the glacial till deposits; minor sources are valley alluvium and severely eroding road surfaces and ditches.

A comparison of suspended-sediment size analyses in native water and in distilled water containing a dispersing agent shows that the native water is of such chemical quality as to induce significant flocculation of sediment during quiescent settling in the laboratory; however, flocculation under natural conditions in the reservoir is not necessarily of this same magnitude. Results of chemical analyses of water samples (inflow and outflow) are shown in table 13.

CONCLUSIONS

The following conclusions resulted from sedimentation investigations that were made in Brownell Creek subwatershed during 1955–59:

1. Average annual runoff in the subwatershed was 3.3 inches.
2. The sediment transported into reservoirs 1 and 1A was mostly silt and clay. All the sand and most of the silt and clay that entered reservoir 1 were trapped. The trap efficiency of reservoir 1, computed from partly estimated data, was between 90 and 95 percent.
3. A large dam, completed upstream from reservoir 1 in 1959, will reduce the quantity of sediment transported into, and the trap efficiency of, reservoir 1.
4. During 1955–59, about three-fourths of the total sediment discharged from reservoir 1 occurred during seven outflow periods, each of which was less than 5 days in duration.

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TABLES

TABLE 7.—*Particle-size analyses of suspended sediment, inflow to reservoir 1*

[Methods of analysis; P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube. Sampling location shown in fig. 1]

Date	Time		Sampling location	Suspended sediment												Methods of analysis
				Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters										
	a.m.	p.m.				0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	
1955																
June 24			7	49,200	14,500	18	23	31	43	65	98	100				VPWCM
			7	39,600	11,900	22	27	34	44	70	97	99	100			VPWCM
			6	28,200	9,080	12	17	28	39	74	97	99	100			VPWCM
	7:20		9	6,480	8,360	35	42	50	60	78	93	97	99	100		VPWCM
	7:20		9	6,480	7,080	15	27	41	56	78	93	97	99	100		VPN
	7:40		9	5,920	5,710	38	44	52	62	81	97	99	99	100		VPWCM
June 28			7	14,200	3,970	42	49	52	66	84	96	99	100			VPWCM
			8	16,300	4,390	29	35	44	56	79	95	98	100			VPWCM
	6:10		9	8,040	3,260	49	56	62	76	92	99	100				VPWCM
1956																
June 24		12:30	7	34,100	13,400	39	42	48	62	84	97	99	99	100		VPWCM
July 2		1:30	6	16,300	12,500	18	26	32	47	79	97	99	99	100		VPWCM
		1:00	7	100,000	21,500	30	32	38	49	80	94	96	97	99	100	VPWCM
		1:00	7	100,000	21,200	20	26	34	48	80	94	96	97	99	100	VPN
		1:05	7	58,000	12,100	30	33	37	50	80	97	98	99	100		VPN
		1:05	7	58,000	12,200	43	47	52	63	83	97	98	99	100		VPWCM
		1:20	7	14,700	11,100	26	38	48	60	84	99	100				VPWCM
		1:15	8	58,400	26,300	19	24	31	43	78	93	97	99	100		VPWCM
		1:15	8	58,400	20,700	12	17	26	40	75	93	97	99	100		VPN
		1:25	8	5,580	6,180	43	47		63		98	100				VPWCM
		3:40	9	2,260	4,340	72			91		100					SPWCM
July 3	9:15		9	810	1,990	54			91		100					SPWM
	9:55		7	1,020	2,520	80	83		89		99	100				VPWCM
	10:00		10	1,760	3,740	71	77		90		99	100				VPWCM
	10:05		6	1,620	3,780	71	74		88		99	99	100			VPWCM
	10:10		8	1,680	3,880	72	77		90		98	99	99	100		VPWCM
	10:45		6	1,310	3,240	81	86		91		97	99	99	100		VPWCM

TABLE 7.—*Particle-size analyses of suspended sediment, inflow to reservoir 1*—Continued

Date	Time		Sampling location	Suspended sediment												Methods of analysis
				Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters										
	a.m.	p.m.				0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	
1956—Continued																
July 31		7:00	9	6,940	4,220	49	51	59	73	91	98	100				SPWCM
		7:00	9	6,940	4,060	24	36	53	70	89	98	100				SPN
		8:00	9	2,130	1,050	85	85	88	94	97	100					SPWCM
		6:40	6	100,000	5,040	27	29	30	42	72	97	98	99	100		VPWCM
		6:40	6	100,000	4,700	9	12	18	39	68	97	98	99	100		VPN
		6:25	7	35,200	7,460	30	34	41	54	80	99	99	100			VPWCM
		6:25	7	35,200	7,310	5	8	15	26	48	99	99	100			VPN
		6:35	8	37,200	7,200	27	29	35	46	76	96	98	99	100		VPWCM
		6:35	8	37,200	7,200	8	12	20	35	68	96	98	99	100		VPN
Aug. 18	2:40		9	4,970	4,280	48	50	57	72	87	99	100				VPWCM
	2:40		9	4,970	4,210	24	36	52	68	87	99	100				VPN
	3:10		9	1,220	2,700	79	87	94	99	100						PWCM
	2:10		7	21,500	6,890	30	34	39	49	79	97	98	99	100		VPWCM
	2:10		7	21,500	7,120	12	27	32	48	76	97	98	99	100		VPN
	2:15		8	78,600	8,400	28	28	34	46	76	95	98	99	100		VPWCM
1957																
Apr. 1		9:00	10	8,940	7,070	41	47		62		98	99	100			VPWCM
		11:00	10	14,700	9,700	34	42		57		96	98	100			VPWCM
Apr. 2	1:00		10	17,200	10,100	27	38		67		97	99	100			VPWCM
	1:00		6	11,200	7,000	38	49		59		96	99	100			VPWCM
May 16		5:50	10	1,130	2,100	97					100					SPWCM
June 17	7:30		7	10,500	3,040	49	54	60	69	87	99	100				VPWCM
	8:00		7	6,300	1,950	22	40	60	74	92	99	100				VPWCM
	7:20		10	20,600	3,640	28	31		43		84	91	96	99	100	VPWCM
	7:30		10	21,400	4,700	25	28		40		88	95	98	100		VPWCM
	7:50		10	15,300	3,000	34	36		55		97	99	100			VPWCM
	7:45		6	26,900	3,920	40	40	49	60	85	99	100				VPWCM
	7:55		6	11,400	2,890	42	47	51	62	77	97	99	100			VPWCM
	8:10		6	25,000	6,070	35	41	48	59	83	98	100				VPWCM
	8:25		6	11,100	2,980	44	51	53	60	78	99	100				VPWCM
		12:30	7	1,820	1,640		92		98		100					SPWCM
		12:20	10	2,630	1,230		70		83		99	100				VPWCM
		12:35	6	2,230	1,890	74	81		91		100					VPWCM
		12:40	6	2,170	2,060	74	79		92							PWCM

July 1		12:30	7	6,590	3,800	50	57		81		100					SPWCM
		12:45	7	6,230	3,990	61	68		83		100					SPWCM
		12:45	10	15,900	4,400	33	38		55		88	90	95	100		VPWCM
		1:00	10	12,600	7,360	33	38		57		95	97	99	100		VPWCM
		12:45	6	9,700	3,100	50	51		68		98	99	100			VPWCM
		12:55	6	8,390	4,720	48	56		71		98	99	100			VPWCM
		1:20	6	18,600	5,010	38	44		63		100					VPWCM
		1:05	6	9,450	5,740	44	53		70		99	100				VPWCM
		3:35	10	2,160	1,680	80	81		90		100					SPWCM
		3:45	6	2,130	1,120	73	79		85		100					SPWCM
Oct. 12	8:55		7	592	1,720	75	79		80		100					SPWCM
	8:50		10	1,020	2,840	76	80		94		100					SPWCM
	10:45		10	756	2,310		85		93		100					SPWCM
	11:35		10	2,670	4,050	82	89		98		100					SPWCM
	11:45		10	1,990	2,890	87	94		96		100					SPWCM
Oct. 22	9:25		10	2,920	5,800	93	96		100							PWCM
	9:45		10	4,100	5,890	91	95		99		100					SPWCM
	9:35		6	2,910	5,320	89	93		96		100					SPWCM
1958																
Feb. 27	10:50		10	3,090	4,720	47	52		70		99	100				VPWCM
	10:35		7	1,690	2,320	46	48		57		98	99	100			VPWCM
	10:40		6	1,750							94	96	99	100		V
Apr. 3	10:30		9	4,060	5,300	56	59		82		100					VPWCM
Apr. 12	8:30		9	13,400	4,100	65	68		81		98	99	100			VPWCM
July 9	11:30		7	70,300	13,200	25	27		42		80	90	96	99	100	VPWCM
July 10	12:30		6	19,400	6,270	52	59		82		100					VPWCM
	1:00		6	23,400	7,060	40	43		62		99	100				VPWCM
	12:50		7	7,220	5,610	57	62		77		98	100				VPWCM
July 17	9:15		10	601							98	99	100			V
	9:10		7	1,180	2,860	87	90		94		100					VPWCM
	9:05		6	1,270	3,400	84	89		95		100					VPWCM
July 19	12:30		10	24,000	7,940	35	40		60		96	98	100			VPWCM
	12:50		7	19,500	6,970	40	44		63		99	100				VPWCM
	12:10		7	51,800	10,600	26	28		41		94	96	99	100		VPWCM
	12:20		7	29,400	12,500	32	35		53		97	99	100			VPWCM
	12:15		6	11,000	5,630	44	49		68		100					VPWCM
	12:35		6	23,100	15,900	33	37		56		99	100				VPWCM
	12:55		6	20,800	5,820	40	42		62		99	99	100			VPWCM
Aug. 5		9:00	10	28,700	8,280	32	37		55		92	98	100			VPWCM
		8:45	6	36,700	15,500	28	32		54		97	99	100			VPWCM
		9:10	6	12,900	10,200	30	33		50		96	99	100			VPWCM

TABLE 7.—*Particle-size analyses of suspended sediment, inflow to reservoir 1*—Continued

Date	Time		Sampling location	Suspended sediment												Methods of analysis
				Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters										
	a.m.	p.m.				0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	
1958—Continued																
Aug. 6		1:10	10	633	1,240	54	56		63		94	98	100			VPWCM
		3:50	10	503	1,010	67	67		71		96	99	100			VPWCM
Sept. 3		11:15	10	21,900	6,360	35	39		55		95	99	100			VPWCM
		11:30	10	11,500	3,990	38	41		57		97	99	100			VPWCM
		10:50	7	8,810	6,490	37	40		56		94	98	99	100		VPWCM
		11:05	7	9,870	7,070	37	40		58		96	99	100			VPWCM
		11:15	7	13,400	7,880	26	28		40		79	92	96	99	100	VPWCM
		11:00	6	13,500	8,340	44	50		68		100					VPWCM
		11:10	6	38,400	14,200	23	26		40		91	97	99	100		VPWCM
		11:20	6	13,600	5,220	36	39		56		97	99	100			VPWCM
		11:45	6	9,290	5,390	40	44		61		97	99	100			VPWCM
1959																
Mar. 26	8:40		10	21,100	3,350	50	56		72		97	100				VPWCM
	8:50		6	13,500	4,030	51	60		72		99	100				VPWCM
	9:00		7	3,000	3,140	40	45		54		80		95	99	100	VPWCM
Apr. 19		2:00	10	14,200	2,150	77	88		96		100					VPWCM
		2:10	6	7,360	2,810	79	91		96		100					VPWCM
May 2		9:25	7	10,000	6,260	38	42		56		92	97	99	100		VPWCM
		9:35	6	11,200	3,400	47	49		77		99	100				VPWCM
		9:40	7	9,420	5,550	46	51		65		93	96	98	100		VPWCM
		9:55	7	9,170	6,340	52	55		70		96	98	99	100		VPWCM
		9:55	6	12,000	3,720	38	42		58		96	99	100			VPWCM
		10:00	10	22,100	6,370	29	33		47		95	99	100			VPWCM
		10:05	7	9,650	4,310	47	52		67		96	98	99	100		VPWCM
		10:10	7	9,080	5,010	52	58		73		98	99	100			VPWCM
		10:10	6	9,260	3,080	50	51		67		98	99	100			VPWCM
		10:15	10	19,300	5,680	31	35		50		94	99	100			VPWCM

May 3	9:30	-----	10	2,110	2,210	50	56	-----	64	-----	95	99	100	-----	-----	VPWCM
	10:25	-----	6	1,620	2,820	47	50	-----	62	-----	97	99	100	-----	-----	VPWCM
May 9	-----	2:00	10	334	1,670	69	94	-----	95	-----	100	-----	-----	-----	-----	VPWCM
May 18	-----	12:30	7	16,600	6,660	40	42	-----	61	-----	96	98	99	100	-----	VPWCM
	-----	12:55	6	17,300	13,000	35	38	-----	55	-----	98	99	100	-----	-----	VPWCM
	-----	1:25	7	5,030	6,470	69	79	-----	93	-----	98	99	99	100	-----	VPWCM
	-----	1:35	6	2,620	2,900	58	64	-----	78	-----	100	-----	-----	-----	-----	VPWCM
May 19	-----	12:25	10	30,000	8,200	28	32	-----	45	-----	94	97	99	100	-----	VPWCM
	-----	12:45	10	26,200	5,590	29	32	-----	46	-----	92	97	100	-----	-----	VPWCM
	-----	12:55	10	24,900	6,090	29	31	-----	46	-----	92	97	100	-----	-----	VPWCM
May 26	5:15	-----	6	4,060	2,480	56	63	-----	75	-----	99	100	-----	-----	-----	VPWCM
May 29	5:35	-----	6	5,190	3,090	64	70	-----	85	-----	100	-----	-----	-----	-----	VPWCM
June 18	1:00	-----	6	4,210	3,900	65	74	-----	92	-----	100	-----	-----	-----	-----	VPWCM
June 30	-----	2:25	6	1,560	1,860	67	68	-----	76	-----	98	100	-----	-----	-----	VPWCM
	5:15	-----	6	17,400	5,070	39	42	-----	62	-----	99	100	-----	-----	-----	VPWCM
	-----	2:20	7	931	1,140	91	-----	-----	95	-----	100	-----	-----	-----	-----	SPWCM
Sept. 18	10:20	-----	6	2,390	2,770	83	84	-----	89	-----	100	-----	-----	-----	-----	VPWCM
	-----	7:50	6	5,270	3,160	85	91	-----	100	-----	-----	-----	-----	-----	-----	PWCM
Sept. 19	6:20	-----	6	1,890	1,050	97	97	-----	98	-----	100	-----	-----	-----	-----	SPWCM
Sept. 20	-----	10:00	6	2,950	3,970	63	68	-----	82	-----	100	-----	-----	-----	-----	VPWCM

TABLE 8.—*Particle-size analyses of suspended sediment, inflow to reservoir 1A*

[Methods of analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube. Sampling locations are shown in fig. 1]

Date	Time		Sampling location	Suspended sediment												Methods of analysis
				Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters										
	a.m.	p.m.				0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	
1955																
June 24	5:30		3	24,600	9,680	24	29	40	55	80	99	100				VPWCM
	5:35		3	20,000	7,800	26	33	45	60	90	100					VPWCM
	5:38		3	17,600	7,120	24	32	45	65	90	100					VPWCM
	5:40		3	12,600	1,610	56	60	67	75	91	100					VPWCM
	6:30		5	6,360	5,870	38	51	61	75	90	98	99	100			VPWCM
	6:30		5	6,360	4,960	17	27	44	63	88	98	99	100			VPN
	6:40		4	17,800	7,530	25	29	33	38	52	69	81	90	92	95	VPWCM
	7:15		5	3,380	5,080	44	57	66	76	89	99	100				VPWCM
	8:30		5	2,210	3,210	56	64	71	76	88	99	100				VPWCM
June 28		6:00	3	3,730	1,470	60	60	60	76	91	100					VPWCM
		6:03	3	10,700	3,820	41	46	55	69	89	100					VPWCM
		6:05	3	16,300	5,610	30	38	50	65	87	100					VPWCM
		6:20	5	3,240	2,080	66	75		84	94	100					VPWCM
1956																
July 2		1:20	3	913	1,450	84			95		100					SPWCM
		4:00	5	380	1,810	50			74		94	97	100			VPWM
July 3	9:10		5	906	2,520	58	60		70		93	96	98	100		VPWCM
	9:15		11	1,490	3,830	78	81		91		100					VPWCM
	9:20		12	1,110	3,130	70	74		84		99	100				VPWCM
	9:25		13	1,180	4,190	69	73		85		99	100				VPWCM
	10:00		5	320	1,660	57			83		97	99	100			VPWM
July 31		7:10	5	733	1,510	62	66	74	80	95	99	100				SPWCM
		8:15	5	210							100					S
Aug. 18	2:45		5	5,360	5,300	54	64	73	85	97	100					SPWCM
	2:45		5	5,360	5,130	27	45	64	81	96	100					SPN
	3:15		5	5,180	5,830	52	64	73	85	97	100					SPWCM
	3:15		5	5,180	5,750	25	46	64	81	94	100					SPN

1957																
June 14	6:45		13	6,420	2,380	65	66		78		98	100				VPWCM
	7:00		13	4,830	1,390		59		72		97	99	99	100		VPWCM
	7:10		13	4,060	980		66		74		98	99	100			VPWCM
July 1	10:30		13	4,830	3,660	48	55		70		99	99	100			VPWCM
	10:45		13	2,860	1,850	55	63		76		96	98	100			VPWCM
	11:00		13	4,340	3,130	61	67		88		100					SPWCM
	11:50		5	2,500	6,450	60	74	84	91	98	100					VPWCM
		12:30	5	1,300	3,260	57	63	67	76	87	98	100				VPWCM
		1:40	5	682	1,650	68	75		86		98	99	100			VPWCM
		3:30	5	243	972		90				100					SPWCM
Oct. 12	11:10		5	473	1,430	71	92		94		100					SPWCM
	11:25		13	1,240	3,820	46	51		60		98	100				VPWCM
	11:20		14	594	1,210	86	89		93		100					SPWCM
Oct. 22	9:55		5	954	1,780	95			96		100					SPWCM
	10:00		11	1,740	2,680	91	97		100							PWCM
	10:03		12	987	1,860	95	95		99		100					SPWCM
	10:07		13	1,550	3,220	68	70		77		100					SPWCM
1958																
Feb. 27	10:00		13	2,180	3,110	34			44		94	95	97	100		VPWCM
July 17	8:45		5	761	1,820	89	90		94		100					VPWCM
July 19	7:05		13	947	2,980	63	66		73		98	100				VPWCM
Aug. 5		8:20	13	5,130	4,210	54	58		78		99	100				VPWCM
		8:25	13	6,280	4,560	39	42		59		92	98	100			VPWCM
1959																
Mar. 26	9:20		13	5,330	6,950	48	52		72		98	99	100			VPWCM
May 2		9:30	13	20,500	8,070	35	39		56		98	99	100			VPWCM
May 3		9:45	13	15,700	4,370	39	42		59		97	99	100			VPWCM
May 4		10:15	13	3,200	3,300	66	71		85		99	100				VPWCM
May 18		1:10	4	1,970	2,130	63	68		78		97	99	100			VPWCM
May 26	2:30		13	12,300	3,080	43	44		60		98	99	100			VPWCM
May 30	5:15		13	15,700	4,320	42	45		62		97	99	100			VPWCM
June 18		1:35	13	2,340	2,400	66	70		79		100					SPWCM
June 29		9:10	13	4,560	3,690	43	46		55		86	94	100			VPWCM
June 39		1:00	13	6,170	7,060	37	41		55		89	96	99	100		VPWCM
Sept. 18		7:30	13	4.730	6,270	65	74		81		100					VPWCM
Sept. 19		3:45	13	1,950	2,560	76	83		89		98	100				VPWCM
Sept. 20		10:15	13	2,640	2,980	64	67		78		98	99	100			VPWCM

TABLE 9.—*Particle-size analyses of suspended sediment, outflow from reservoir 1A*

[Methods of analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube. Sampling location 2 is shown in fig. 1]

Date	Time		Discharge (cfs)	Suspended sediment									Methods of analysis
				Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters							
	a.m.	p.m.				0.002	0.004	0.008	0.016	0.031	0.062	0.125	
1955													
June 24	5:50		73	8,730	7,240	36	49	62	79	97	100		SPWCM
	5:50		73	8,730	7,310	12	25	38	58	90	100		SPN
	6:56		37	5,260	5,860	45	58	72	85	96	100		SPWCM
	6:56		37	5,260	6,240	20	37	58	79	98	100		SPN
	9:18		2.4	1,590	1,310	78	87	89				100	SPWCM
	9:18		2.4	1,590	1,060	28	50	79				100	SPN
		12:15	.10	1,640	2,180	84	90	95	100				PWCM
June 28		7:06	34	2,320	2,090	75	85	88	100				PWCM
		7:06	34	2,320	1,650	28	49	79	99	100			PN
		7:51	13	2,190	2,460	71	86	93	93		95	100	SPWCM
1956													
July 3	9:35		2.7	1,100	3,280	68	70		73		100		SPWCM
July 31		7:05	10	1,380	1,520	72	75	86	93	97	100		SPWCM
		7:05	10	1,380	1,400	35	61	87	97	98	100		SPN
		8:10	1.6	658	884	84	86	94	96	99	100		SPWCM
		10:05	.17	719	1,240	84	87	89	91	93	100		SPWCM
Aug. 18	3:00		47	4,840	6,000	58	67	80	92	99	100		SPWCM
	3:00		47	4,840	6,190	23	42	65	86	97	100		SPN
	4:00		12	1,540	1,760	86	93			97	100		SPWCM
	6:45		.36	1,420	1,640	84		97		97	100		SPWCM
1957													
June 17	8:15		14.4	1,210	1,930	73	86		97		100		SPWCM
	8:45		11.8	1,040	1,780	77	85		94		100		SPWCM
	9:20		5.7	917	1,200	87	94		100				PWCM
		1:35	1.0	713	1,220	93			99		100		SPWCM
		3:10	.17	1,090	1,690	81	87		94		100		SPWCM

July 1	----	1:00	2.7	1,480	2,500	80	85	----	93	----	100	----	SPWCM
	----	1:30	2.2	1,450	1,790	87	92	----	98	----	100	----	SPWCM
1958													
July 17	9:40	----	4.0	181	1,080	98	----	----	----	----	100	----	SPWCM
	11:25	----	.7	148	698	----	----	----	----	----	100	----	S
July 19	7:15	----	2.7	845	2,580	87	92	----	97	----	100	----	VPWCM
Sept. 4	12:40	----	2.9	1,150	4,860	79	86	----	96	----	100	----	SPWCM
	2:10	----	.7	748	1,530	----	87	----	96	----	100	----	SPWCM
1959													
Mar. 26	9:55	----	5.0	670	1,950	87	93	----	98	----	100	----	SPWCM
May 4	----	9:55	3.1	1,300	1,320	95	----	----	96	----	100	----	SPWCM
May 6	12:30	----	.36	1,000	1,290	95	98	----	98	----	100	----	SPWCM
May 18	----	2:00	2.4	1,520	4,080	70	78	----	90	----	100	----	SPWCM
	----	4:20	.36	1,220	3,300	85	94	----	99	----	100	----	SPWCM
	----	5:15	.22	1,100	1,560	88	95	----	100	----	----	----	PWCM
May 21	10:55	----	.05	765	1,060	94	96	----	97	----	100	----	SPWCM
May 31	----	12:20	.03	659	1,390	96	100	----	----	----	----	----	PWCM
June 30	----	1:45	4.8	982	2,630	80	85	----	97	----	100	----	SPWCM

TABLE 10.—*Particle-size analyses of suspended sediment, outflow from reservoir 1*

[Methods of analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube. Sampling location 1-D is shown in fig. 1]

Date	Time		Discharge (cfs)	Suspended sediment								Method of analysis
	a.m.	p.m.		Concentration (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size, in millimeters						
						0.002	0.004	0.008	0.016	0.031	0.062	
1955												
June 24	6:10		31.1	1,480	1,600	85	87	94	95	98	100	SPWCM
	6:10		31.1	1,480	1,610	46	78	89	96	97	100	SPN
	6:35		31.2	2,410	8,480	44	57	72	88	99	100	SPWCM
	9:10		31.5	1,460	1,700	88	96	96	96	100		PWCM
	9:10		31.5	1,460	1,670	56	80	97	100			PN
	9:15		31.5	2,280	3,970	67	81	91	99	99	100	SPWCM
		12:10	31.4	1,770	2,310	86	86	96	100			PWCM
		12:10	31.4	1,770	2,350	48	72	90	99	99	100	SPN
		3:10	31.3	1,510	3,710	83	96	98	100			PWCM
June 25	5:05		11.5	1,170	2,790	86	98	100				PWCM
June 28		7:15	30.2	1,450	2,090	85	90	92	97	99	100	SPWCM
		7:30	28.8	1,320	1,860	91	92	95	96	98	100	SPWCM
June 29	7:00		[1] .39	1,140	1,490	100						PWCM
1956												
July 3	9:45		[1] 2.14	505	1,160	96			97		100	SPWCM
	11:30		[1] 2.14	500	2,540	76			100			PWM
		1:10	[1] 2.14	482	1,870	80			100			PWM
		2:10	[1] 2.14	452	1,110	77			97		100	SPWM
Aug. 1	2:30		5.1	121	724	86	87	88	91	93	100	SPWCM
Aug. 18	3:47		31.0	983	1,740	69	74	86	96	97	100	SPWCM
	4:30		31.1	1,070	1,600	41	43	71	89	89	100	SPN
	7:00		30.9	699	964	93	94		96	97	100	SPWCM
	9:00		30.8	607	844	79	84	91	100			PN
1957												
Apr. 5	8:30		.13	495	4,180		98				100	SPWCM
	10:30		.09	502	3,280		97				100	SPWCM
Apr. 10	11:15		0.01	267	2,340		97				100	SPWCM
July 1		2:30	26.9	441	724	100						PWCM
		3:00	20.3	488	744	90	90		97		100	SPWCM
		5:00	7.5	333	527	100						PWCM
		7:00	3.4	275	492	98	98				100	SPWCM

1958												
July 10	9:30		15.7	338	1,880	92	98				100	SPWCM
July 11	10:10		1.6	286	992	90	92		96		100	SPWCM
July 17	10:15		8.6	109	1,250	98	99				100	SPWCM
	11:15		5.8	113	658	95	100					PWCM
July 19	9:30		5.3	540	2,610	92	95		100			PWCM
Aug. 6		1:00	31.0	401	1,860	88	96		98		100	SPWCM
	12:00		31.1	412	2,610	86	93		97		100	SPWCM
		12:30	31.1	395	938		93		98		100	SPWCM
Sept. 4	12:20		30.9	498	2,360	73	78		95		100	SPWCM
	1:55		30.8	649	1,590	76	82		94		100	SPWCM
1959												
Mar. 26	9:45		6.1	91	603		97				100	SPWCM
May 2		12:00	30.9	1,220	1,710	77	83		93			PWCM
May 3	1:00		30.9	1,070	1,400	82	85		93		100	SPWCM
	10:30		6.1	796	1,170	93	95		97		100	SPWCM
	11:50		4.6	684	2,570	90	98		98		100	SPWCM
		12:40	4.0	612	1,350	98	98				100	SPWCM
May 9		2:30	1.8	311	1,270	100						PWCM
May 18		4:00	30.8	776	3,220	81	91		98		100	PWCM
May 19		1:00	1.7	752	3,110	64	67		78		100	VPWCM

[1] Daily mean.

TABLE 11.—*Bulk density and particle-size distribution of samples of deposited sediment in reservoirs 1 and 1A, 1958*

[Data from Agr. Research Service, Lincoln, Nebr.]

Sampling location	Depth of sample below surface of deposit (inches)	Bulk density (g per cc)	Percentage finer than indicated size, in millimeters				
			0.002	0.005	0.020	0.050	2.000
A-1	2–5	1.15	-----	-----	-----	-----	-----
	5–9	1.19	31	31	54	79	100
	9–13	1.30	-----	-----	-----	-----	-----
	13–17	1.11	35	37	56	81	100
	17–21	1.30	-----	-----	-----	-----	-----
A-2	2–6	.89	33	34	57	87	100
	6–10	1.01	-----	-----	-----	-----	-----
	10–14	1.25	29	30	51	70	100
	14–18	1.32	-----	-----	-----	-----	-----
A-3	1–4	1.23	33	38	59	80	100
	4–8	1.36	-----	-----	-----	-----	-----
A-4	1–4	1.42	23	24	41	57	100
	4–8	1.51	-----	-----	-----	-----	-----
A-5	1–4	.88	-----	-----	-----	-----	-----
	4–8	.97	40	43	70	89	100
A-6	1–5	.80	-----	-----	-----	-----	-----
	5–9	1.05	34	35	58	79	100
	9–13	1.14	-----	-----	-----	-----	-----
A-7	1–3	1.03	38	43	70	91	100
A-8	2–5	1.14	33	34	59	80	100
	5–8	1.21	-----	-----	-----	-----	-----
	8–12	1.32	33	34	57	78	100
A-9	2–7	.87	-----	-----	-----	-----	-----
	8–12	.96	31	31	57	86	100
	12–16	.86	-----	-----	-----	-----	-----
	19–23	1.04	27	29	54	85	100
	25–29	.85	-----	-----	-----	-----	-----
A-10	3–7	.80	46	50	75	92	100
	12–16	.89	-----	-----	-----	-----	-----
	16–20	.83	38	39	64	85	100
	20–24	.70	-----	-----	-----	-----	-----
A-11	2–6	.76	29	33	54	85	100
	7–11	.98	-----	-----	-----	-----	-----
	11–15	.91	40	40	66	89	100
	15–19	1.02	-----	-----	-----	-----	-----
	19–23	.99	33	35	57	80	100

TABLE 12.—*Particle-size distribution of deposited-sediment samples in channel and in reservoir 1, Feb. 19, 1957*

[Sampling locations shown in fig. 23]

Sampling location	Percent finer than indicated size, in millimeters													
	0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
A	-----	-----	-----	-----	-----	78	80	87	95	99	99	99	100	-----
B	-----	-----	-----	-----	-----	49	51	59	81	91	94	95	96	100
C	-----	-----	-----	-----	-----	36	37	47	85	99	100	-----	-----	-----
D	-----	-----	-----	-----	-----	38	39	45	67	81	89	95	98	100
E	24	27	31	42	67	89	94	99	100	-----	-----	-----	-----	-----
F	24	28	33	42	67	90	96	100	-----	-----	-----	-----	-----	-----
G	17	21	26	39	75	94	96	98	99	100	-----	-----	-----	-----
H	18	22	26	35	67	91	95	99	100	-----	-----	-----	-----	-----

TABLE 13.—*Chemical analyses, Brownell Creek subwatershed near Syracuse*

[Sampling locations shown in fig. 1]

Date	Sampling location	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$	Percent sodium	Sodium-adsorption-ratio	Specific conductance (micromhos per cm at 25°C)	pH
1955														
June 16	1-U	27	6.9	8.8	6.9	114	------	------	96	3	15	0.4	254	7.8
June 24	9	8.0	2.2	1.4	3.3	------	54	0.07	29	------	8	.1	72.8	6.7
	9	9.0	2.8	1.4	3.5	------	60	.08	34	------	7	.1	78.7	6.6
	4	13	3.0	3.0	3.2	------	81	.11	45	------	12	.2	117	6.6
	5	8.0	2.2	1.3	2.6	------	53	.07	29	------	8	.1	89.9	6.8
	2	12	2.4	2.7	3.1	------	63	.08	40	------	12	.2	101	6.7
	1-D	23	5.2	6.4	6.1	------	129	.18	79	------	14	.3	200	7.0
1956														
July 2	9	8.0	2.9	3.7	9.8	------	123	.17	32	------	15	.3	103	7.8
July 3	9	9.5	2.5	4.1	11	------	135	.18	34	------	16	.3	112	7.8
	5	7.5	2.3	3.0	4.7	------	79	.11	28	------	16	.2	84.2	7.8
	2	8.5	2.1	2.5	4.4	------	66	.09	30	------	13	.2	93.9	7.6
	1-D	21	5.3	4.6	4.7	------	103	.14	74	------	11	.2	177	8.3
July 31	9	12	2.0	4.4	9.1	------	106	.14	38	------	16	.3	127	7.4
	5	11	2.3	4.1	8.5	------	88	.12	37	------	16	.3	113	7.5
Aug. 18	9	6.5	1.9	3.9	6.1	------	114	.16	24	------	21	.3	87.5	7.3
	5	5.0	1.3	3.0	5.8	------	------	------	18	------	21	.3	57.0	7.0
	2	6.5	2.1	3.4	5.8	------	------	------	25	------	19	.3	71.0	7.2
	1-D	18	3.9	4.1	2.9	------	124	.17	61	------	12	.2	154	6.0
1957														
Feb. 19	1-U	27	5.5	5.0	5.7	112	119	.16	90	0	10	.2	210	8.0
Apr. 5	1-U	20	4.9	4.1	5.2	86	107	.15	70	0	10	.2	169	7.3
Oct. 1	1-U	33	7.4	6.1	6.7	148	148	.20	113	0	10	.3	258	7.7
1958														
June 19	1-U	45	13	19	7.5	------	242	.33	166	------	19	.6	400	7.7
1959														
Feb. 25	1-U	24	6.1	6.8	12	112	159	.22	85	0	13	.3	233	6.7

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