MEASUREMENT OF SEDIMENT IN BOOMER CREEK RESERVOIR, PAYNE COUNTY, OKLAHOMA

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During the winter of 1924-25 an earth dam was constructed across the valley of Boomer Creek approximately 1½ miles north of Stillwater, Oklahoma. This location is near the north side of the NW ¼ of Sec. 11, T. 19 N., R. 2 E. in Payne County. The dam was designed and the construction supervised by V. V. Long and Company, consulting engineers, of Oklahoma City, Oklahoma. The elevation of the concrete spillway as originally constructed is 910 feet above sea level, and the reservoir had a maximum depth of 27.5 feet at the intake tower. The storage capacity of the original reservoir was calculated to be 660 million gallons, and the total surface area at the spillway level was 228 acres. The area of the watershed is 9.2 square miles. Very little water was collected in the reservoir during 1925 because the total rainfall for that year was nearly 11 inches below normal. The reservoir did not fill rapidly until the fall of 1926. The first overflow occurred on April 12, 1927. Water did not pass over the spillway more than four or five times from 1925 to 1933, and no overflow occurred from 1933 to 1940. This is a desirable condition from the standpoint of extending the life of a reservoir, which would fill with sediment more rapidly if large quantities of runoff water carrying an average load of silt and clay passed through the reservoir at frequent intervals. In 1933 the spillway level of this reservoir was raised 2 feet, which increased the surface area from 228 to 253 acres and the storage capacity from 660 to 810 million gallons. Water has not been higher than the old spillway level since this addition was made; consequently sediments which have accumulated in the lake are confined entirely to the area below the 910-foot contour line. In March, 1940, the water in the Boomer Creek Reservoir was only 13 feet deep at the gauge on the intake tower. This provided an excellent opportunity to study the accumulation of sediments by direct measurement on a large percentage of the area which is normally covered by water. Since the sediments which have been deposited in this reservoir are composed chiefly of silt and clay, it was easy to determine the contact between this material and the surface of the original sandy soil; consequently an accurate measure of the accumulated sediment could be obtained. It would be very easy to make a serious error in measurement if a probe were used since the plowed layer of soil on this land is very soft, and hard strata do not appear until the subsurface layers of the original soil are encountered.

A plane table map of the area was made on a scale of 12 inches per mile for the purpose of delineating the areas where varying amounts of sediment had accumulated. All control lines were measured with a steel tape. East-west lines were established at 200-foot intervals, and the depth of the sediment was determined every 50 feet along these lines on all areas not covered by water. As the shore line receded, additional measurements were secured until the mud flats were suddenly covered by water as a result of spring rains. In November, 1940, the water level in the reservoir was reduced to 12½ feet, and data were obtained on the depth of sediment in that portion of the reservoir which was covered with water. These measurements were made with a steel tube which had a slot cut in one side in order that the character of the material in the tube could be examined in an undisturbed condition. Stratification of the sediments and in some instances the density and texture of the material in the tube were used to identify the boundary between the clay or silt and the original soil or soil material. Some variation in depth of the mud occurred at

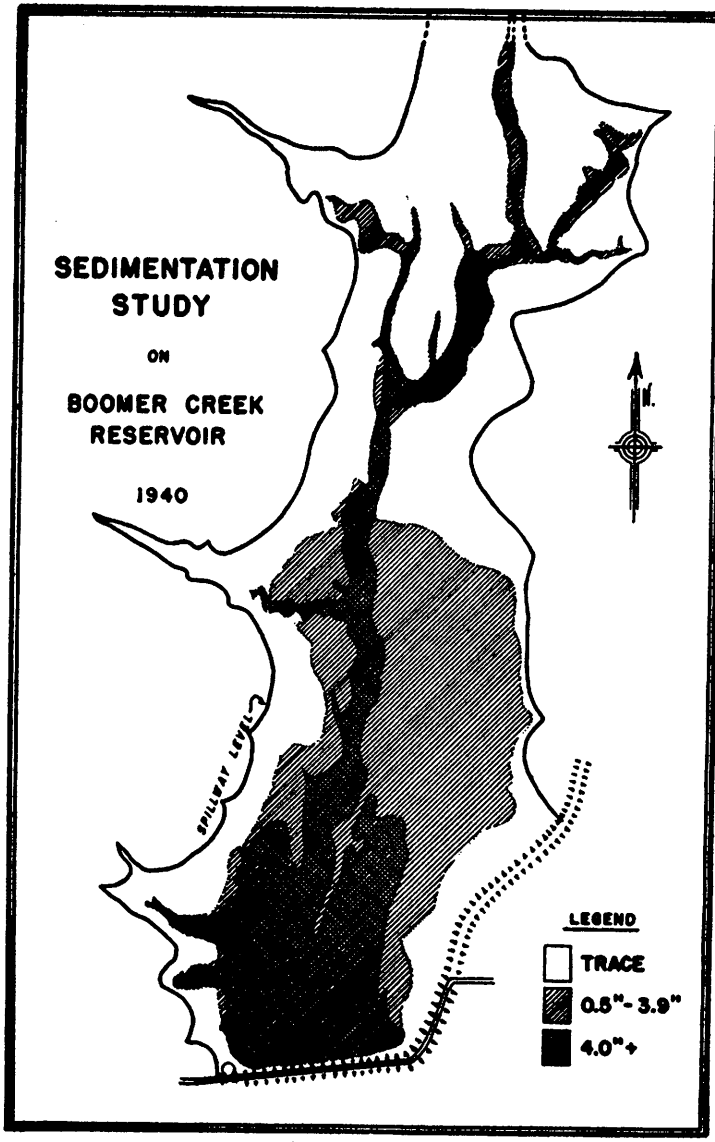
SEDIMENTATION
STUDY
ON
BOOMER CREEK
RESERVOIR
1940
N.
SPILLWAY LEVEL
LEGEND
TRACE
0.5"- 3.9"
4.0"+

FIGURE 1

different points in the reservoir as a result of wave action on the steeper portions of the shore line, especially along the old stream channel. Granulated colloidal material which is formed on mud flats exposed to freezing and thawing or alternate wetting and drying for a short period of time has been deposited in small drifts by wind action where encroaching vegetation was dense enough to collect this material. These deposits were several inches deep in places while the area from which they originated was relatively free from sediment. A large number of measurements should tend to reduce the error occurring as a result of these variations. Very little silt accumulation was found on the bank of the old stream channel because the sediments in this area have been moved into the lower part of the channel as a result of wave action. These observations indicate that a high degree of accuracy in estimating the quantity of sediment in this reservoir could not be obtained unless a very large number of measurements were made at close intervals.

The quantity of sediments which have accumulated in the Boomer Creek Reservoir and the relation of these sediments to the 912-foot contour which is the present spillway level are shown in Figure 1. After the depth of clay accumulation in the lower portion of the reservoir was found to be closely associated with the depth of the water, it was necessary to subdivide that portion of the area which was covered with sediment to a depth of 4 inches or more. Areas where the depth of sediment was similar were indicated on the plane table map, and the total number of acres in each area was calculated from planimeter measurements. The number of observations made, the average depth of the sediment, total acreage, and volume of sediment in acre-feet for each area are given in Table I.

TABLE I

Sedimentation studies of Boomer Reservoir north of Stillwater, Oklahoma, showing number of observations made in silted area, average depth of sediment, total area covered, and estimated acre-feet of silt and clay in each area.

	Observations made	Average depth of sediment	Area	Volume of sediment
		in.	*acres*	*acre-feet*
	178	1.46	51.9	6.31
	24	2.80	6.5	1.82
	24	5.00	11.5	4.78
	56	15.50	23.8	30.74
	10	12.00	6.0	6.00
	6	8.00	3.0	2.00
Total	298		102.7	51.65

It was quite evident from this study that the greatest depth of sediment in this reservoir had accumulated in the old stream channel and in a narrow area north of the dam which was excavated to provide soil for the earth fill. No delta development has occurred in the old stream channel at the north end of the reservoir. Narrow benches of sandy soil in this area which were subject to occasional overflow before the dam was constructed are covered with a layer of red silty clay which varies from 6 to 8 inches deep. Sediment in the old channel where it crosses the south half of Section 35 averages about 12 inches deep.

A determination of apparent density was made on 5 samples of mud collected from areas where more than 6 inches of silt clay had been de-

posited. A pipe approximately 1½ inches in diameter and 4 inches long having a total volume of 128.4 ml. was used to obtain these samples. The oven-dry weights of these samples were as follows: 84.5, 88.8, 92.0, and 99.2 grams, and the apparent densities were thence 0.67, 0.69, 0.72, 0.75, and 0.77. The variations in weight and density were attributed either to the difference in quantity of recently deposited clay in different areas, or to the facts that the pipe was forced to a variable distance below the surface of the sediment and some of the more recent deposits which had a very low density were removed in smoothing off at the top end of the pipe after it was extracted from the mud.

The rate of sedimentation based on the measurements given in Table I and an estimated capacity of the reservoir of 2479 acre-feet has averaged .14 percent each year for the 15-year period 1925-1940. These results are much lower than the data obtained by Thomas A. Kelser and reported by Eakin and Brown in U. S. D. A. Technical Bulletin 524, which indicated that 171 acre-feet of sediment had accumulated in the Boomer Creek Reservoir between March 1, 1925, and June 1, 1935.

No such quantity of sediment could be found in this study. The water-holding capacity of the reservoir according to the survey by Kelser was also greater than values given by V. V. Long and Company, who designed and supervised the construction of the dam.

At the time the Boomer Creek Reservoir was built, terrace ridges had been constructed on some of the cultivated land of the watershed to reduce erosion from runoff water. An increase in the acreage of farm land protected by terrace ridges occurred during the period 1934 to 1939 as a result of the location of a soil conservation project on the Stillwater Creek watershed, of which Boomer Creek is a tributary. Some individuals believe that the development of soil-conserving practices on this watershed has been responsible for the limited accumulation of water in the Boomer Creek Reservoir. Rainfall records obtained from an official weather bureau station on the campus of the Oklahoma A. and M. College which is about 1½ miles from the south end of the reservoir indicate that a marked decrease in total rainfall has occurred during the last 5 years of the 15-year period from 1925-1939. The annual rainfall for each of these years is given in Table II.

TABLE II

Annual rainfall at Stillwater, Oklahoma, from 1925 to 1939, inclusive

Year	Inches of rain	Year	Inches of rain
1925	22.44	1933	35.75
1926	32.73	1934	30.67
1927	38.10	1935	33.59
1928	33.69	1936	18.29
1929	37.13	1937	25.49
1930	26.05	1938	35.29
1931	30.90	1939	26.95
1932	39.08		

Average for 15-year period, 1925-1939 .....31.07 inches
Average for 43-year period, 1897-1939 .....33.32 inches

These results show that the average rainfall for the 15-year period is 2.25 inches less than the average for the 43-year period 1897-1939. Since the rainfall for the last 5-year period was more than 4 inches below the average for the 15-year period, the opportunity to collect a normal amount

of runoff as well as the rate of sedimentation may be somewhat less than would have occurred under average rainfall conditions.

Data obtained from the Agricultural Adjustment Administration during the summer of 1940 show that less than one-fourth of the watershed has been affected by soil-conserving practices. Land use of that portion of the Boomer Creek watershed occurring above the reservoir is as follows: 3,370 acres are in pasture or meadow, and 1,875 acres are used for the production of cultivated crops of which 1,115 acres are protected from soil erosion by terrace ridges, leaving 760 acres which are subject to a more rapid rate of accelerated erosion. Since a large number of ponds have been constructed in the pastures on the Boomer Creek watershed to provide water for livestock, sand and the coarser soil aggregates which are removed from the steeper slopes by runoff will be retained near the point of origin, and only the finer material which escapes from the spillway of these smaller reservoirs will find its way into Boomer Creek. A similar condition occurs on terraced land where the terrace ridges reduce the velocity of runoff water, and only the clay and very fine particles of silt are transported from higher to lower elevations during periods of torrential rainfall.

The percentage of total rainfall which becomes runoff water depends upon several factors such as slope of land, vegetative cover, texture and moisture content of the soil, and the intensity and duration of the rainfall. Experiments conducted by the Soil Conservation Service of the United States Department of Agriculture show that a higher percentage of runoff occurs from cultivated soil than from land which is covered with grass or forest. Also the quantity of sediment in runoff water is greater from areas which are planted to cultivated crops. Although the percentage of runoff varies with different crops and with different soils because of differences in texture and slope, from 10 to 20 percent of the total rainfall in the Great Plains region will appear as runoff from cultivated land. A much lower percentage will be obtained from meadowland and pasture areas. If 10 percent of the average annual rainfall on the Boomer Creek watershed escapes as runoff, about 500 million gallons of water will collect in the reservoir each year. Since the capacity of the reservoir at the 912 contour was 810 million gallons and since evaporation each year would remove from 3 to 5 feet of water, depending upon temperature, wind velocity, and relative humidity during the summer months, the Boomer Creek Reservoir could still hold all of the average annual runoff until 37.5 percent of the total capacity had been filled with mud. This, of course, would not leave a very large reserve, in view of the fact that the water requirement of the City of Stillwater at the present time is approximately one million gallons per day. Assuming that the rate of sedimentation will remain relatively constant, it would require more than 200 years to reduce the volume of the reservoir to 62.5 percent of the original capacity. This rate of silting is much lower than in Clinton Lake, which has been studied by the Soil Conservation Service. A report issued by that organization states that 69 percent of the total area of the watershed is used for the production of cultivated crops and that storage capacity was being reduced at the rate of 1.33 percent per year. These results indicate that the rate of silting of Boomer Creek Reservoir is only one-ninth as rapid as that of the Clinton Reservoir.

SUMMARY

A study of the Boomer Creek reservoir located 1½ miles north of Stillwater indicates that the average annual rate of sedimentation for the 15-year period, 1925-1939, has been .14 percent. The average annual rainfall has been 2.25 inches less than the 43-year average for that area. Protective

cover on the watershed is favorable for a low rate of silting since 64 percent of the total area is used for pasture or meadow, and nearly 60 percent of the cultivated land is protected from severe erosion by terrace ridges. The total capacity of the reservoir was 2479 acre-feet when constructed with a total surface area of 253 acres. Sediment in measurable quantities was found on 102.7 acres. Two hundred and ninety-eight examinations were made in this area, and the total quantity of sediment was calculated from six areas based on the average depth of sediment in each area. The acre-feet of mud which has accumulated in this reservoir in 15 years was 51.65, which was considerably less than calculations made by another survey party in 1935.