MORPHOMETRIC CHARACTERISTICS OF RESERVOIRS OF OKLAHOMA

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Ranges and central tendency values of the morphometric characteristics of the 59 reservoirs in Oklahoma exceeding 200 ha are presented. Recreation is listed as a use for all 59 reservoirs, while water supply is listed for 41. The median values are as follows: drainage basin (880 km^2), surface area (1271 ha), volume (8350 ha-m), length (10.6 km), shoreline developments (4.8), maximum depth (16.4 m), and mean depth (5.4 m).

INTRODUCTION

Gomez and Grinstead (1) summarized in 1973 morphometric information for the 54 reservoirs in Oklahoma with a surface area exceeding 200 ha. At least five reservoirs exceeding this size have been completed and filled since this summary. Information on specific reservoirs is also given in Oklahoma's water atlas (2) and on data sheets or leaflets available from various sources such as the U.S. Army Corps of Engineers (USACE), Bureau of Reclamation, or Oklahoma Department of Tourism & Recreation. However, few attempts have been made to summarize this information. The objective of this paper is to provide a statistical summary of the morphometric data and some relationships among these data for the 54 reservoirs described by Gomez and Grinstead and for the following reservoirs not included in their publication: Lake McMurtry, Birch Lake, Waurika Lake, Sooner Lake, and Tom Steed Reservoir. Potential problems may be suggested if a particular reservoir is considerably different from the others, by having a low ratio of the drainage basin to the surface area or a low mean depth.

Construction and Uses

The oldest reservoir exceeding 200 ha in Oklahoma is Lake Lawtonka, which was constructed in 1905. Lake Overholser was impounded in 1919, while five reservoirs including Spavinaw Lake, Okmulgee Lake, and Lake Murray were built in the 1920's. Until 1937 most of the reservoirs were small as seen by the relationship between the cumulative number of reservoirs and size (Figure 1). The construction of Grand Lake in 1940 and Lake Texoma in 1944 resulted in large increases in cumulative area and volume. The cumulative area and volume curves were similar to each other except for the period from 1952-1963 when several lakes with a large ratio between volume and area were constructed such as Tenkiller Ferry Reservoir and Lake Bluestem. A large increase in the area and volume curves occurred in 1964 when Lake Eufaula was produced. The increases in the number of reservoirs and cumulative size have been similar since 1964. The cumulative area and volume of the 59 reservoirs exceeding 200 ha are 233,156 ha and 1,757,163 ha-m, respectively.

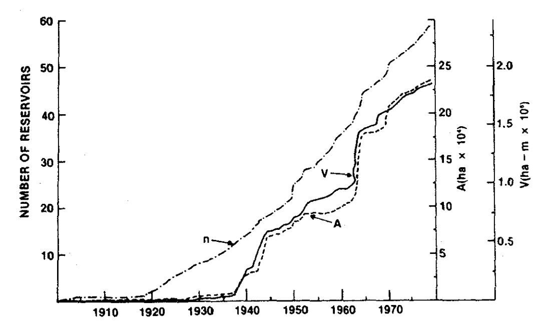

FIGURE 1. Cumulative number (n), surface area (A), and volume (V) of reservoirs exceeding 200 ha in Oklahoma from 1905-1980.

Most of the reservoirs in Oklahoma are operated by municipalities (23) or by the USACE (21). Six reservoirs are operated by the Bureau of Reclamation and nine by groups such as Oklahoma State University, Oklahoma Gas & Electric, and The United States Navy.

Reservoir use is described in the references listed previously. Recreation is listed as a use for all 59 reservoirs, while water supply is listed for 41. Other uses include fish and wildlife management (25), flood control (24), and power (10).

Morphometric Data

The reservoirs of Oklahoma exhibit extensive variation in morphometric characteristics (Table 1). The minimum values of the variables are influenced by the conditions of the study since only reservoirs exceeding 200 ha are considered. Eighteen reservoirs have a surface area from 200-1000 ha and only two exceed 36,000 ha. Thus, the variables do not follow a normal distribution. Since the arithmetic means are large and do not provide the most informative measure of central tendency, medians are also presented in Table 1. The clumping of values in the lower parts of the range can also be observed in graphs relating morphometric features (Figures 2, 3, and 4).

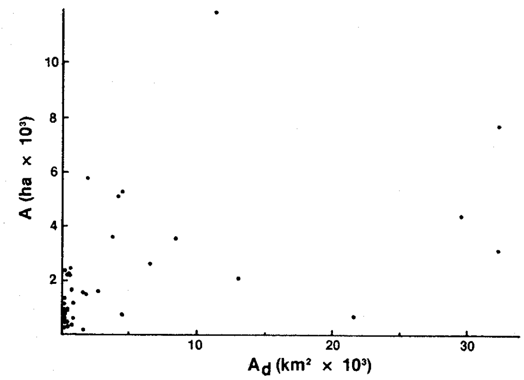

FIGURE 2. Relation between area of the drainage basin (A_d) and surface area (A) of Oklahoma reservoirs ($r = 0.51$) (Kerr, Keystone, Webbers Falls, Eufaula, Kaw, Texoma, and Grand have extremely large drainage basins and are not shown on the graph).

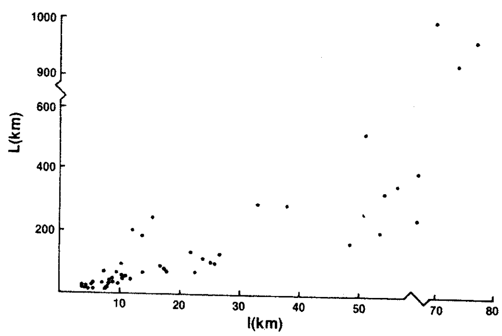

FIGURE 3. Relation between length (l) and shoreline length (L) of Oklahoma reservoirs ($r = 0.87$).

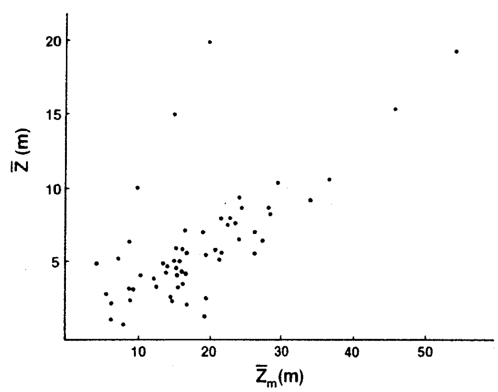

FIGURE 4. Relations between maximum depth (z_m) and mean depth ($\bar{z}$) of Oklahoma reservoirs ($r = 0.89$).

TABLE 1. *Ranges and means of morphometric characteristics of the 59 reservoirs in Oklahoma exceeding 200 ha and means of 309 natural lakes.*

Parameter	Oklahoma Reservoirs			Natural Lakes (3,4) (Mean)	
	Range	Median	Mean		
Drainage basin (A_d)	18 — 382,688	880	27,264	272	km^2
Surface area (A)	222 — 41,482	1,271	3,952	560	ha
A_d/A	8 — 5,697	80	690	33	—
Volume (V)	238 — 335,759	8,350	29,782	—	ha-m
Length (l)	3.9 — 76.1	10.6	21.6	—	km
Shoreline length (L)	11 — 1,004	62.8	155	—	km
Shoreline development (D_L)	1.3 — 20.7	4.8	6.5	2.9	—
Maximum depth (z_m)	6.7 — 54.8	16.4	19.0	10.7	m
Mean depth ($\bar{z}$)	1.0 — 19.7	5.4	5.9	4.5	m

Drainage Basin, Reservoir Area and Volume

Six reservoirs in the state have extremely large drainage areas (A_d). Kerr Reservoir has the largest $\mathbf{A_d}$, 382,688 km^2 (Table 1) The A_d of Webber Falls, Keystone Reservoir, Lake Eufaula, Kaw Reservoir, and Lake Texoma exceed 100,000 km^2. The values of A_d of all other reservoirs in the state are less than 33,000 km^2 (Figure 2). The influence of these six reservoirs results in an extremely high mean $A_{d.}$ The drainage is less than 200 km^2 for 18 impoundments. The median A_d is 880 km^2.

Two reservoirs in the state have a surface area (A) about twice as large as that of any other impoundment; Eufaula Reservoir is 41,482 ha and Lake Texoma is 36,018 ha. Surface area exceeds 10,000 ha in Grand Lake, Kerr Reservoir, Oologah Reservoir, and Keystone Reservoir. Eighteen reservoirs are between 200 and 1000 ha. The mean A of Oklahoma reservoirs is four times that of the median.

Examining the ratio A_d/A provides information on the extensiveness of the drainage basin in relationship to the surface area. The ratio is 5697 for Webber's Falls and 3125 in Lake Overholser, while only four other ratios exceed 1000: Kerr, Keystone, Kaw, and Canton reservoirs. Several reservoirs have small drainage basins in relation to their surface areas. These include Murray (6), Holdenville (8), Henryetta (10), Shawnee Twin lakes (10), Shell Creek (12), Carl Blackwell (14), Atoka (18), Clear Creek (19), and Overholser (20). The median A_d/A is 80. The correlation between A_d and A in Oklahoma reservoirs is 0.51, which is low but highly significant ($p < 0.01$).

The largest volume (V) of water is contained in Lake Texoma, while the values of V in three other reservoirs exceed 100,000 ha-m; Lake Eufaula, Grand Lake, and Broken Bow Reservoir. These four impoundments contain 57% of the total volume of water in Oklahoma reservoirs exceeding 200 ha, while 78% of the water is in the nine largest reservoirs. The correlation between A_d and V in Oklahoma reservoirs is low, 0.36.

Length

Since impoundments in Oklahoma typically have been produced in relatively narrow valleys, the lengths of the reservoirs exceeding 200 ha would be expected to be long. The lengths range from 3.9 to 76.1 km (Table 1) and the values are concentrated in the lower part of the range (Figure 3). The lengths (1) of Lakes Eufaula, Texoma, and Grand exceed 70 km, while 11 reservoirs exceed 48 km. The median value of 1 is 10.6 km, about one-half the mean value. Since impoundments in Oklahoma have been constructed in dendritic valleys, the shoreline lengths (L) would also be expected to be large. The value of L exceeds 930 km in the three longest reservoirs and is less than 535 km in all other impoundments. The median L is about half the mean L.

The correlation between the length of the lakes and shoreline lengths would be expected to be high unless a wide variety of different shapes existed. The correlation between 1 and L in Oklahoma reservoirs is 0.87 which is highly significant ($p < 0.01$).

An estimate of the extensiveness of the shoreline can be obtained by comparing the ratio between L and the circumference of a circle equal to the lake area. This estimate is called the shoreline development (D_L) and values approach unity in circular lakes and increase in elongated lakes. Only two lakes in Oklahoma have a D_L less than 2.0, Lakes Overholser and Francis. The value of D_L is between 2.0 and 2.5 in Pauls Valley Reservoir and Lake Lawtonka. Grand Lake has an extremely large D_L, 20.7. The value of D_L exceeds 10.0 in ten reservoirs.

Depth

The maximum depths (z_m) of Broken Bow and Tenkiller Ferry are 54.8 and 46.0 m, respectively. The value of z_m exceeds 20 m in 20 reservoirs. Only nine impoundments with a surface area exceeding 200 ha have a z_m less than 10 m. The median z_m is 16.4 m. The mean depth ($\bar{z}$), obtained by dividing the volume by the surface area, exceeds 15 m in the two deepest reservoirs and is less than 4 m in nine impoundments: Lake Francis (1.0), Great Salt Plains (1.3), Ponca City (1.5), Brown (2.2), Wister (2.3), Ft. Supply (2.5), Heyburn (2.6), McAlester (2.8), and Hulah (2.9). The mean depth is the only morphometric measurement that follows a normal curve resulting in similar values for the median and mean.

The correlation between maximum and mean depths would be expected to be high unless a wide variety of bottom shapes exists. The correlation between z_m, and ($\bar{z}$) is 0.89, which is highly significant ($p < 0.01$).

Comparison Between Reservoirs and Lakes

The morphometric characteristics of Oklahoma reservoirs are similar to those reported for 107 U.S. Army Corps of Engineers reservoirs (3, 4). However, differences exist between the reservoirs and characteristics of the 309 natural lakes in the National Eutrophication Survey. Comparisons are biased since the latter survey was not limited to lakes exceeding 200 ha such as in the present study. However, although the mean surface area of the Oklahoma reservoirs is eight times that of the natural lakes, the drainage basin is 200 times as great in the reservoirs. Thus, the ratio of A_d/A in the reservoirs is twenty times that in the lakes. The impoundments also have a considerably greater shoreline development, with a mean D_L of 6.5 compared to 2.9 in the lakes. The maximum depth of the impoundments is considerably greater because of the deep stream channels, but the lakes and reservoirs are similar in mean depth. In summary, Oklahoma reservoirs have larger drainage basins, surface areas, shoreline development ratios, and maximum depth than the natural lakes in the National Eutrophication Survey.

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