PRELIMINARY STAGE-DISCHARGE RELATIONS FOR BLACK WARRIOR RIVER AT WILLIAM BACON OLIVER LOCK AND DAM, AT TUSCALOOSA, ALABAMA

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U.S. GEOLOGICAL SURVEY

Open-File Report 84-056

Prepared in cooperation with the

U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT

Montgomery, Alabama

1983

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
acre-foot (acre-ft)	1,233	cubic meter (m^3)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level."

Water-surface elevation is referred to as stage in this report. Stage and elevations used in this report are references to NGVD of 1929.

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ABSTRACT

The construction of William Bacon Oliver lock and dam (Oliver Dam) completed in April 1940, has resulted in changes to the stage-discharge relations in the vicinity. The scarcity of current-meter measurements, coupled with backwater conditions makes definition of single stage-discharge relation impossible. However, limit curves can be defined that would encompass such a relation. Backwater is defined as water backed up or retarded in its course as compared with water flowing under normal or natural conditions. This results in a rise in stage above its normal water level while the discharge remains unaffected. This is usually caused by temporary obstruction(s) to the flow downstream. Backwater at Oliver Dam tailwater results primarily from flood plain flows returning to the main channel during recessions. The discharges obtained from 18 current-meter measurements, along with mean daily discharge values for a gaging station upstream were plotted versus tailwater stage. The plot illustrates, by the scatter of data points, variations in backwater. Curves drawn to envelope the extreme plot patterns showing possible ranges of several feet for any given discharge.

INTRODUCTION

Oliver Dam is an integral part of the Black Warrior River Navigational System. Changes resulting from its completion has also resulted in changes in some streamflow characteristics in the vicinity. Definition for one characteristic, the stage-discharge relation, is needed for future planning.

The purpose of this report is to define the ranges in stage and discharge of potential stage-discharge relations (rating curves) for the tailwater and to portray the scatter of the plotted data points by the use of limit curves. The scope of work was limited to plotting available current-meter measurements made since March 1960, and 27 mean daily discharge values versus tailwater stage for three floods since 1979.

This report has been prepared by the U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers, Mobile District. Appreciation is expressed to the Corps for their assistance.

DESCRIPTION OF STUDY AREA

Oliver lock and dam is located on the Black Warrior River at Tuscaloosa, Tuscaloosa County (fig. 1). The lock is 95 feet wide, 460 feet long, and has a lift capability of 28 feet. The dam consists of a fixed crest spillway section that is 900 feet long. Normal pool elevation is 122.9 feet.

Drainage area at the dam is about 4,830 square miles. William Bacon Oliver Lake (fig. 1), formed by the dam, has a storage capacity of 12,340 acre-feet at normal pool elevation.

The reach of the river downstream from Oliver Dam to Warrior lock and dam is about 77 miles in length (fig. 1). It is characterized by a well developed meandering channel with moderate to steep sloped banks. Its banks are densely covered with trees and undergrowth. The flood plain is relatively wide and level, and is wooded except for scattered areas cultivated for crops or pasture. Major tributaries to the reach are Big Sandy and Fivemile Creeks.

STAGE-DISCHARGE RELATIONS

Definition of a single stage-discharge relation for the tailwater is impossible due to backwater effects. Backwater is defined as water backed up or retarded in its course as compared with water flowing under normal or natural conditions. This results in a rise in stage above normal level while the discharge remains unaffected. Backwater is usually caused by temporary obstruction(s) to flow downstream. Backwater at Oliver Dam tailwater occurs in varying degrees caused primarily by flood plain flow returning to the main channel during recessions. At times, backwater may also be partially caused by seasonal changes in vegetation and minor changes in channel geometry.

Normally, little or no backwater effect is evident during rising stage of a flood. The effect is often greatest during the recession. This results in different stages for a given discharge; usually a lower stage during rises and a higher stage during recessions. The most useful presentation of a stage-discharge relation at this time would be limit curves that are the boundaries of possible rating curves.

Methods

Discharge versus stage was plotted to define limit curves for the tailwater. Eighteen current-meter measurements are available (table 1). The measurements were made using conventional methods from a highway bridge upstream. Selected computed discharge values with corresponding stages were also used as additional data to better define the curves. These discharge values were computed by the automatic data processing unit for the gaging station upstream. Verification of and improvements to the curves will necessitate acquiring additional current-meter measurements.

Tailwater

Tailwater limit curves define a probable range in stage and discharge resulting from backwater effects (fig. 2). The curves are based on 18 discharge measurements made since March 1960 (table 1) and 27 mean daily discharge values selected from three separate floods since March 1979. The limit curve representing rising stages is labeled "TR" and that representing falling stages is labeled "TF".

SUMMARY

The stage-discharge relation for the tailwater section at Oliver Dam is affected by backwater that makes definition of a single stage-discharge relation impossible. Backwater is defined as water backed up or retarded in its course as compared with water flowing under normal or natural conditions. This results in a rise in stage above normal water level while the discharge remains unaffected. Backwater is usually caused by temporary obstruction(s) to flow downstream. As a useful alternative, limit curves have been developed to define possible extremes of a series of stage-discharge relations. Backwater at Oliver Dam tailwater results primarily from flood plain flows returning to the main channel during recessions. The curves are preliminary and represent conditions of flow that existed between March 1960 and April 1981. Verification of and improvements to the curves will necessitate acquiring additional current-meter measurements.

REFERENCES

U.S. Geological Survey, 1982, Water resources data for Alabama, U.S. Geological Survey Water-Data Report AL81-1, 540 p.

Table 1. List of current-meter measurements made since March 1960 at Oliver Dam.

Measurement number	Date	Tailwater Stage (ft)	Discharge (ft^3/s)
380	Mar. 1, 1960	97.30	8,020
382	Feb. 22, 1961	148.55	211,000
384	Feb. 24, 1961	145.72	147,000
385	Mar. 14, 1961	109.80	18,800
386	Dec. 18, 1961	142.08	132,000
387	Feb. 23, 1962	128.00	47,000
389	Jan. 9, 1964	117.65	44,900
391	Mar. 15, 1964	136.53	139,000
392	Apr. 6, 1964	135.90	102,000
393	Feb. 12, 1965	133.22	82,400
394	Feb. 14, 1966	128.68	49,000
395	Apr. 27, 1966	133.66	90,000
397	Dec. 20, 1967	129.71	61,400
398	Jan. 11, 1968	135.75	121,000
401	Feb. 23, 1971	132.28	69,400
402	Mar. 14, 1975	134.83	95,000
403	May 15, 1976	135.51	99,000
404	Apr. 13, 1979	147.70	255,000

Table 2. List of mean daily discharges for selected periods at Oliver Dam.

Date	Mean Tailwater Elevation (ft)	Mean Discharge (ft^3/s)
1979		
Mar. 2	106.53	15,600
Mar. 3	113.63	43,300
Mar. 4	139.73	154,000
Mar. 5	138.23	111,000
Mar. 6	135.22	82,100
Mar. 7	128.26	45,900
Mar. 8	121.08	27,700
Mar. 9	116.73	23,200
Mar. 15	114.25	13,200
Apr. 13	145.95	233,000
Apr. 14	144.27	190,000
Apr. 15	140.38	124,000
Apr. 16	134.90	76,100
Apr. 17	126.50	35,200
Apr. 18	119.99	23,300
1980		
Apr. 12	130.96	104,000
Apr. 13	137.57	96,300
Apr. 14	138.14	134,000
Apr. 15	133.15	93,300
1981		
Mar. 30	123.46	67,500
Mar. 31	126.95	54,400
Apr. 1	120.98	37,100
Apr. 2	117.32	29,600
Apr. 3	112.68	23,800
Apr. 4	108.29	14,700
Apr. 5	113.06	32,000