The Effects of Lake Monroe on the Flow of Salt Creek, South Central Indiana

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Introduction

In 1964, construction was completed at the Lake Monroe dam site, and in 1965 the reservoir was filled. This undertaking resulted in the creation of the largest man-made lake in Indiana. Since its completion, studies and speculations have been made about its usefulness as well as its effects upon the surrounding environment.

To this date, no work has been done concerning the dam's effects on Salt Creek, the stream which has been impounded. The purpose of this study is to determine how the reservoir has affected the flow of Salt Creek. Unit dydrograph analysis, double-mass analysis, and analysis of variance are executed to help achieve this purpose.

Since its construction, the reservoir has been shown to add many economic benefits to the area. However, the Lake Monroe Project was constructed primarily as a means of flood control for the Salt Creek Basin and as a part of a flood control network for the Mississippi River. This study is designed to evaluate the flood control aspect of the Lake Monroe dam site.

Study Area

The study area is Salt Creek, downstream from the Monroe Reservoir. Salt Creek is a tributary to the East Fork of White River, a short distance downstream from Bedford, Indiana. It drains approximately two-thirds of Brown County, the lower half of Monroe County and parts of Lawrence and Jackson Counties. The drainage area is 1146.6 sq. km.. The slope is .23 m. per km.. The length is 151.3 km.. Salt Creek is located in the Southern Thin Drift Region of Indiana (2).

Data

Diurnal discharge data was attained by the U.S. Geological Survey, Surface Water Supply Records, Part 3 Volume 3, Ohio River-Lousiville, Kentucky to Wabash River. The data was taken from Salt Creek gage near Harrodsburg, Indiana. The length of record for the Harrodsburg gage is 21 years; conveniently divided in half by the completion date of the man-made lake. That is 1955 to 1965 comprises the pre-impoundment period; and 1966 to 1975 comprises the post-impoundment period of record.

Methods and Interpretation

The derivation of a unit of hydrograph from a simple hydrograph is straightforward. The ordinates of the required unit hydrograph are equal to the corresponding ordinates of the given direct runoff hydrograph divided by the total amount of runoff in inches (1, 4). The percentage of runoff per day is calculated for each unit hydrograph storm. An average is taken for the runoff for each day, and a model unit hydrograph is derived (See Table 1). It is found that on the average, a large storm would produce a fluctuation in the direct runoff hydrograph that would last about five days.

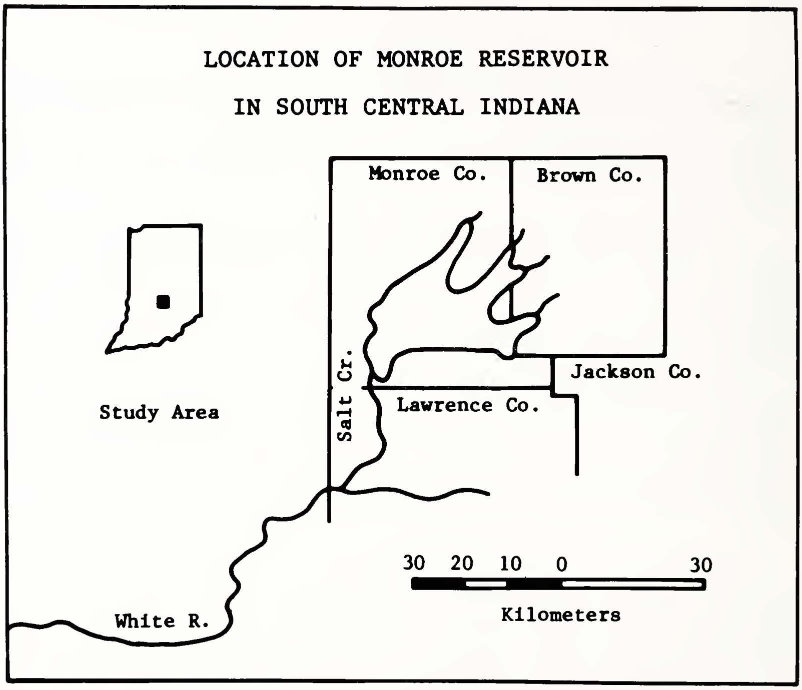


TABLE 1 *Unit Hydrograph Analysis Daily Distribution (5 day storm)*

Days	1st	2nd	3rd	4th	5th
Pre-Impoundment	12.8%	34.7%	35.1%	13.4%	3.9%
Post-Impoundment	10.5%	33.8%	30.3%	17.7%	7.7%
Comparison	17.9%*	2.6%*	13.7%*	32.0%+	72.0%+

* decrease after impoundment
\+ increase after impoundment

The unit hydrograph suggests, that the flow after a major storm, has been controlled by man. The rationale is as follows: On the first day, there is a great deal of retention of the surge of upstream water (approximately 18%). Between the second and third day, peak flow is expected, and less water is retained to prevent the reservoir from reaching a dangerously high level. On the fourth and fifth days, a great amount of water is released, in order to return the reservoir to normal levels. There is little danger in such a release by the dam because there is small percentage of runoff expected on these last two days. Furthermore, the downstream, portion of Salt Creek will begin to approach baseflow. Therefore a greater release by the dam on these last two days is more easily transported by Salt Creek, which by this time is in less danger of flooding.

Analysis of variance is a statistical technique which seeks to determine the equality or inequality of two population means (3). The hypothesis for this study is μpre = μpost. That is, the mean of the pre-impoundment period *is equal* to the mean of the post-impoundment period (see Table II).

TABLE II *Analysis of Variance Source Table*

Data Source	d.f.	F values*	Result
Annual Mean	1	.040	μ(pre) = μ(post)
Discharge	16		
Annual	1	4.6	μ(pre) = μ(post)
Maximum Flow	10		
Annual	1	8.69	μ(pre) $\neq$ μ(post)
Minimum Flow	10		
March Monthly	1	2.16	μ(pre) = μ(post)
Means	16		
March Daily	1	46	μ(pre) $\neq$ μ(post)
Discharges	237		
October Monthly	1	.475	μ(pre) = μ(post)
Means	16		
October Daily	1	1662	μ(pre) $\neq$ μ(post)
Discharges	237		

* .01 Probability of error.

TABLE III *Storms Used in Unit Hydrographs*

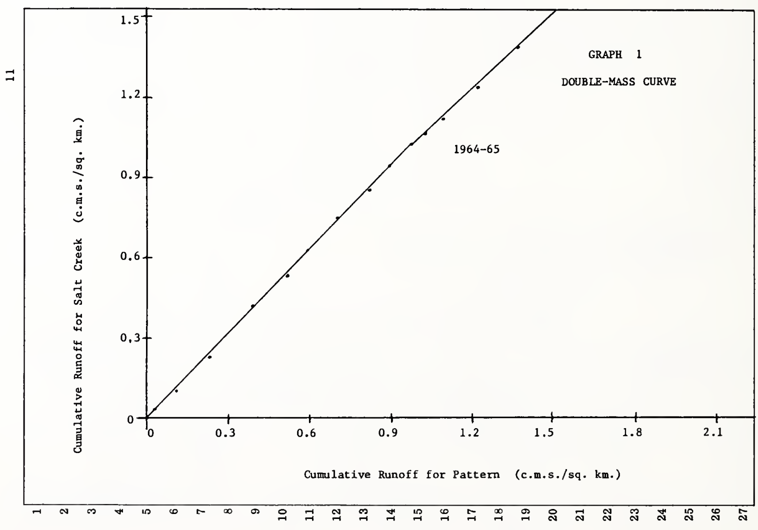
Pre-Impoundment		Post-Impoundment	
Storm I	February 17-21, 1961	Storm I	April 14-17, 1969
Storm II	March 31-April 4, 1962	Storm II	May 10-15, 1971
Storm III	April 19-23, 1963	Storm III	April 7-12, 1972
		Storm IV	February 4-8, 1973

Annual Basis: Analysis of the annual mean discharge for pre- versus post-impoundment reveals that there is no significant difference between the two groups. Likewise, the annual maximum flows were not significantly different between pre- and post-impoundment. However, it was found that a significant difference exists in annual minimum flows between the two periods. This suggests that Monroe dam is used more often to augment low flow, and less often to retain high flows.

High flows: Examination of the data reveals March as the month with the highest flow. March daily discharges were analyzed and it was found that the two periods differ significantly. This significant difference suggests that March daily discharges have been controlled by the dam. Daily discharges for March have been reduced since the construction of the dam. However, this significant difference is lost when March monthly means were analyzed.

Low Flows: The data reveals October as the month with the lowest flow. October daily discharges were anlayzed and it was found that they too, differ significantly between pre- and post-impoundment. The significance difference here suggests that October daily discharges have also been controlled by the dam. Daily discharges for October have been augmented since the construction of Monroe Dam. In analyzing October monthly means, again, the significant difference between pre- and post-impoundment is lost.

The graph of the cumulative data of one variable versus the cumulative data of a related pattern is a straight line so long as the relation between the variables is a fixed ratio. A break in the slope will indicate a disruption in the system. The difference in the slope of the lines on either side of the break indicates the degree of change (5). The pattern is an average of four streams in the area of Salt Creek not impounded by any dam. They were: (1) East Fork of the White River at Bedford, (2) North Fork of Salt Creek at Belmont, (3) East Fork of White River near Shoals, (4) North Fork of Salt Creek near Nashville.



Graph I reveals two remarkable features. First, there is a very slight but still visible break in the slope of the line. The ordinate and abscissa of these particular coordinates corresponded to the period of time in which the dam construction was completed and the reservoir was being filled. Second, it is remarkable that the break in the slope is very slight. As a safeguard against personal bias, regresion slopes were calculated on either side of the alleged break, and their slope coefficients were compared. It was found that they were indeed different, but the difference is very minute (1.06 as compared to 1.02).

Conclusions

It appears that Lake Monroe affects the flow of Salt Creek on a short term basis. This is exemlified by the unit hydrograph analysis which shows the change in flow caused by a controlled slide gate at Monroe dam. The distribution of flow in the model unit hydrographs differ, showing control of a major storm event by man.

However, on a long term basis, it appears that Lake Monroe has had no effect on Salt Creek. This is exemplified by the double-mass analysis which shows that the 21 year record of the Harrodsburg station has remained in balance with surrounding unimpounded streams. One minute disruption was noted in the double-mass curve during the time the reservoir was being filled.

Analysis of variance seems to support both arguments. On a short term basis, that is March and October daily discharges, pre- and post-impoundment periods were found to be significantly different. However, on a long term basis, that is March and October monthly means, and annual mean discharges the pre- and post-impoundment periods were not statistically different. Information is lost in the calculation of any mean value. This loss of information may effect the significance of values in the analysis of variance program. However, it is not certain that this is the case here.

It would appear that Lake Monroe does affect the flow of Salt Creek but only on a day to day basis, e.g. retention of flood waters, and augmentation of low flow periods. However when examining the situation on a monthly or yearly basis it would appear that Lake Monroe has no effect what-so-ever on the flow of Salt Creek.

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