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## INTRODUCTION

The U.S. Geological Survey, in cooperation with the Kentucky Geological Survey, has been gathering temperature data on streams throughout Kentucky for several decades. Periodic water-temperature observations have been collected at a frequency of about once a month from more than 140 surface-water sites during the past 15 years. More comprehensive water-temperature information, weekly or daily readings, have been collected at approximately 50 locations and reported in various Geological Survey Water-Supply Papers (U.S. Geol. Survey, 1950-58, 1959-63, 1964, 1965-74, 1975).

Initial computer analysis of the previously unpublished periodic data has been completed and results are summarized herein. Three temperature characteristics are reported for those sampling sites where sufficient observations were available. These parameters are the maximum median monthly water temperature, minimum median monthly water temperature, and annual average water temperature. The purpose of this report is to present a summary of temperature data that could be useful for (1) the appraisal of the capacity of the stream to assimilate waste and of the water quality of streams, (2) the management of aquatic biota, and (3) the appraisal of the potential use of the stream for cooling.

## TEMPERATURE CHARACTERISTICS

The annual cycle of water temperature at periodic sampling stations was delineated by fitting a simple sine function to stream temperature observations made during the period 1960-74. This analysis was simplified by using a computer program by Steele (1974) which has both analytic and graphic capabilities. This program has been expanded and modified substantially from an earlier undocumented version. The sine function used is

$$T(x) = A[\sin(bx + C)] + M$$

where  $T(x)$  is the stream temperature on any day in degrees Celsius ( $^{\circ}\text{C}$ ),  $x$  is the day of the water year; (that is,  $x = 1$  for October 1,  $x = 2$  for October 2, and so forth),  $A$  is the amplitude of the harmonic in  $^{\circ}\text{C}$ ,  $M$  is the mean

of the harmonic; (that is, annual average water temperature) in  $^{\circ}\text{C}$ ,  $C$  is the phase angle of the harmonic in radians, and  $b$  is a constant. An example of a harmonic fitted temperature curve for station 03250000, Triplett Creek at Morehead, Ky., is shown in Figure 1.

Derivation of the harmonic function is given by Ward (1963) and Gilroy and Steele (1972). The adequacy of the computer program to define annual stream temperature characteristics was demonstrated by Thomann (1967) and Kothandaraman (1971). These studies indicate that 90 to 99 percent of the annual temperature variation is explained by a simple harmonic. The program does not, however, adjust the input data to account for diel variations.

Output from the computer analysis includes: the harmonic parameters  $A$ ,  $C$  and  $M$ ; median monthly

water temperatures; statistics describing the standard error and variance of the harmonic function; and graphical displays of the observed temperature data, harmonic function, and residuals between observed and simulated temperatures. All of the above information for specific locations can be acquired from the Kentucky district of the U.S. Geological Survey, Louisville, Ky.

Stream temperatures in Kentucky vary between  $0^{\circ}$  and  $30^{\circ}\text{C}$  during the year. Maximum median monthly water temperatures occur in July and are typically between  $23^{\circ}$  and  $27^{\circ}\text{C}$ , whereas minimum median monthly water temperatures are recorded in January and are usually within the  $2^{\circ}$  and  $6^{\circ}\text{C}$  range. Annual average water temperatures of Kentucky streams are between  $10^{\circ}$  and  $18^{\circ}\text{C}$ .

## ADDITIONAL TEMPERATURE ANALYSIS STUDIES

The bulk of existing periodic temperature data has been statistically analyzed and documented, but statistical analysis of daily and weekly records remains to be accomplished as does the analysis of the influence of reservoir releases on downstream temperatures.

A long-term objective would be to regionalize stream temperatures in the Commonwealth and to develop a procedure for predicting, within assumed or specified accuracy levels, water temperatures at sites where data are not currently available. Analysis concerned with the latter objective may include a multiple regression analysis between certain water temperature characteristics and various independent parameters such as air temperature, stream discharge, elevation, latitude, longitude, and solar-radiation intensity.

## CONVERSION TABLE

Degrees Celsius ( $^{\circ}\text{C}$ ) to Degrees Fahrenheit ( $^{\circ}\text{F}$ )  
(Temperature reported to nearest  $0.5^{\circ}\text{C}$ )

$^{\circ}\text{C}$	$^{\circ}\text{F}$	$^{\circ}\text{C}$	$^{\circ}\text{F}$	$^{\circ}\text{C}$	$^{\circ}\text{F}$
0	32	10.0	50	20.0	68
0.5	33	10.5	51	20.5	69
1.0	34	11.0	52	21.0	70
1.5	35	11.5	53	21.5	71
2.0	36	12.0	54	22.0	72
2.5	37	12.5	55	22.5	73
3.0	38	13.0	56	23.0	74
3.5	39	13.5	57	23.5	75
4.0	40	14.0	58	24.0	76
4.5	41	14.5	59	24.5	77
5.0	41	15.0	59	25.0	77
5.5	42	15.5	60	25.5	78
6.0	43	16.0	61	26.0	79
6.5	44	16.5	62	26.5	80
7.0	45	17.0	63	27.0	81
7.5	45	17.5	63	27.5	81
8.0	46	18.0	64	28.0	82
8.5	47	18.5	65	28.5	83
9.0	48	19.0	66	29.0	84
9.5	49	19.5	67	29.5	85

$$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32) \text{ or } ^{\circ}\text{F} = 9/5 (^{\circ}\text{C}) + 32$$

## SELECTED REFERENCES

Gilroy, E. J., and Steele, T. D., 1972, An analysis of sampling frequency alternatives for fitting a daily stream temperature model: Proceedings International Symposium on Uncertainties in Hydrologic and Water-Resources Systems, Tucson, Arizona, December 1972, p. 594-608.

Kothandaraman, V., 1971, Analysis of water temperature variations in large rivers: Proc. Am. Soc. Civil Engr., Sanitary Engr. Div., v. 97, no. SA1, February 1971, p. 19-31.

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1965-74, Water resources data for Kentucky, part 2, Water quality records: Louisville, Ky., annual reports published for each year indicated.

1975, Water resources data for Kentucky water year 1975: Louisville, Ky.

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## EXPLANATION

Station with no known man-made influence on ambient stream temperatures

Station where stream temperature records are definitely influenced by reservoir releases, power plant effluents, and so forth.

Station with definite flow regulation from reservoir releases, power plant effluents, and so forth, but where the resulting influence on ambient stream temperatures is uncertain.

Station number  
03318800  
24.5-3.5-14.0  
Annual average water temperature  
Minimum median monthly water temperature  
Maximum median monthly water temperature

All temperatures are expressed in degrees Celsius ( $^{\circ}\text{C}$ )

