STATE OF LOUISIANA

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

OFFICE OF PUBLIC WORKS

Water Resources
TECHNICAL
REPORT
NO. 13

TIME OF TRAVEL OF SOLUTES IN MISSISSIPPI RIVER FROM BELLE CHASSE TO THE VICINITY OF HEAD OF PASSES, LOUISIANA

Prepared by

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

In cooperation with

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

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ILLUSTRATIONS

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FACTORS FOR CONVERTING ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

Multiply English units	By	To obtain SI units
cubic feet per second (ft^3/s)	28.32	liters per second (L/s)
	.02832	cubic meters per second (m^3/s)
feet (ft)	.3048	meters (m)
miles (mi)	1.609	kilometers (km)
pounds (lb)	.4536	kilograms (kg)

TIME OF TRAVEL OF SOLUTES IN MISSISSIPPI RIVER FROM BELLE CHASSE TO THE VICINITY OF HEAD OF PASSES, LOUISIANA

By Anthony J. Calandro

ABSTRACT

A water tracer was injected into the Mississippi River near Belle Chasse, La., (mile 77.0) to determine the traveltime, the maximum concentration, the dispersion characteristics, and the duration of a tracer cloud for the reach from Belle Chasse, La., to the vicinity of Head of Passes. The average flow in the reach was 468,000 cubic feet per second during the study.

Information from this study and from previous studies was used to calibrate a mathematical model developed by the U.S. Geological Survey at the Gulf Coast Hydroscience Center. The model was then used to generate time-of-travel curves of the leading edge, the peak, and the trailing edge of the tracer cloud for discharges ranging from 200,000 to 1,200,000 cubic feet per second.

INTRODUCTION

Accidental spills of pollutants are of general concern and could be harmful to water users along the river. Planners and downstream water users should have knowledge of the behavior of dissolved pollutants accidently spilled into the river.

The purpose of this report is to make available the results of a study of the time of travel of the Mississippi River from Belle Chasse, La., (mile 77.0) to Head of Passes (mile 0.0) and to summarize graphically the observations of the rate of lateral and longitudinal dispersion of solutes at two locations in the reach.

The reach from the Arkansas-Louisiana State line to Belle Chasse was covered in two previous studies (Martens and others, 1974; Calandro, 1976).

This study was made by the U.S. Geological Survey in cooperation with the Louisiana Office of Public Works.

The study was made in April 1976 when the riverflow was 468,000 ft^3/s in the reach. A water tracer was injected into the Mississippi River just above Belle Chasse, La., (mile 77.0) on April 27, 1976, to determine the traveltime, the maximum concentration, the dispersion characteristics, and the duration of the tracer cloud as it moved downstream to Head of Passes.

Data collected during this study were used to calibrate a mathematical model developed by the U.S. Geological Survey (McQuivey and Keefer, 1976a) at the Gulf Coast Hydroscience Center. The model was then used to generate time-of-travel information for discharges ranging from 200,000 to 1,200,000 ft^3/s. A comparison of information generated by the model and observed data from the earlier study on the lower Mississippi shows good agreement.

The results of this study apply only to those solutes whose density and behavior characteristics are similar to those of water. Additional considerations, outside the scope of this report, must be taken into account when materials that are not soluble in water are accidentially spilled.

TRAVELTIME

Rhodamine WT, a fluorescent tracer, was injected in the center of the channel at mile 77.0. The tracer was observed in passage at four locations (see map figures at back) over the 77.0-mile reach to the mouth of the river (mile 0.0). The tracer was further observed at three sites below Head of Passes (mile 0.0) as follows:

1. Southwest Pass (mile -8.0).
2. South Pass (mile -7.5).
3. Pass-a-Loutre (mile -5.0).

Time-of-travel curves in figures 1, 2, and 3 show the leading edge, the peak, and the trailing edge of the tracer cloud, respectively, as observed and as computed for other flow rates.

Time-location observations made in this study are displayed graphically in red in figures 1, 2, and 3. The curves computed for selected discharges are shown in black on the same figures.

The leading edge is defined as the time the tracer was first detected at the measuring site. (Concentrations were measured to the nearest 0.1 microgram per liter.)

The trailing edge is defined as occurring when the concentration is equal to 10 percent of the peak concentration.

LATERAL DISPERSION

Lateral-dispersion data were collected at two sites below the site where the tracer was injected. The water tracer was injected near the midpoint of the river (mile 77.0). Curves showing the lateral dispersion at the two downstream sites (mile 70.0 and mile 61.0) are shown in figure 4.

At mile 70.0 near Greenwood, La., the tracer cloud extended across the width of the river, and the peak concentration occurred near the center of the river. As the cloud moved downstream to mile 61.0 near Burbridge, La., it became more evenly dispersed from the right bank to the left bank. The maximum concentration was fairly uniform across the river starting from approximately 400 ft from each bank (fig. 4).

LONGITUDINAL DISPERSION AND PEAK CONCENTRATION

The effects of contamination can be minimized if some knowledge of the time it takes a contaminant to first arrive and to pass a selected site is known. The location of the leading edge, the peak, and the trailing edge for any elapsed time after a spill or injection in the reach studied can be estimated from curves in figures 1, 2, and 3.

Time-location observations were made in Southwest Pass (mile -8.0), South Pass (mile -7.5), and Pass-a-Loutre (mile -5.0). The traveltime rate in the three passes was about equal to the traveltime rate in the main channel. Therefore, on this basis the curves for this study (figs. 1, 2, and 3) were extended to mile -8.0. The curves for the other discharges were not extended due to constantly changing tide effects from the Gulf of Mexico.

If the discharge rate, time, and place of injection are known, the approximate longitudinal dispersion of a tracer or contaminant cloud passing a point can also be derived from the curves in figures 1, 2, and 3. For example, assume that an accidental spill occurred at mile 70.0 near Greenwood when the flow was 400,000 ft^3/s and the longitudinal dispersion at Pointe a la Hache was needed. Using the example in figure 1, the traveltime of the leading edge from Greenwood (mile 70.0) to Pointe a la Hache (mile 49.0) is 13 hours (17 hours minus 4 hours). Similarly, the trailing edge would reach Pointe a la Hache in 19 hours (see example in fig. 3); hence, the passage time or longitudinal dispersion is 6 hours. The time of arrival of the peak concentration is 15 hours (fig. 2).

For a given amount of tracer, the greater the river discharge, the less the concentration because of dilution. To allow comparison of concentration data from different tests on the same stream, all observed concentrations were reduced to "unit concentration," using a method developed by F. A. Kilpatrick (written commun., 1970). For practical use, unit concentration is that concentration which would result at a point downstream from the injection of 1 lb of tracer into 1 ft^3/s of flow.

Peak unit concentrations for the study are shown versus traveltime on the right side of figure 5. The curve in figure 5 is identical to the curve representing conditions between Baton Rouge and Pointe a la Hache, La. (Martens and others, 1974). It is identical also to curve B (Calandro, 1976) representing conditions between Old River (mile 314.0) and Plaquemine, La. (mile 208.0). Data from this study check this curve and should be used from Old River (mile 314.0) to Head of Passes (mile 0.0).

By use of the unit-concentration curves in figure 5, the magnitude of the peak concentration can be determined from the nomograph (fig. 5) where the traveltime, the river discharge, and the weight of the contaminant spilled are known, as demonstrated in the following example.

Assume that 200,000 lb of a soluble conservative contaminant was accidentally spilled at Greenwood, La., (mile 70.0) when the river discharge was 400,000 ft^3/s. It is desirable to know the traveltime of the peak and the peak contaminant at Pointe a la Hache, La. (mile 49.0). From figure 2 the traveltime of the peak is 15 hours (20 hours minus 5 hours). Enter the nomograph at 15 hours and determine a unit concentration of 1,700. Draw a straight line between a unit concentration of 1,700 and a weight of 200,000 lb, and mark the intersection of this straight line on the match line. Draw a straight line between the mark on the match line and a discharge of 400,000 ft^3/s, and determine a peak concentration of 850 micrograms per liter at Pointe a la Hache, La. (mile 49.0).

The peak concentration can also be determined using the equation

$$\text{Peak concentration} = \frac{\text{unit concentration times weight of contaminant spilled}}{\text{discharge at the sampling site}}$$

after entering the nomograph (fig. 5) to obtain the unit concentration. Therefore,

$$\text{Peak concentration} = \frac{1{,}700 \text{x} 200{,}000 \text{ lb}}{400{,}000 \text{ ft}^3/\text{s}} = 850 \text{ micrograms per liter.}$$

ACKNOWLEDGMENTS

Special thanks are due the U.S. Army Corps of Engineers, New Orleans District, and the Louisiana Department of Transportation and Development, Office of Public Works for their assistance during the study.

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