PREPARED IN COOPERATION WITH THE
STATE OF LOUISIANA
LOUISIANA DEPARTMENT OF PUBLIC WORKS

TIME OF TRAVEL OF SOLUTES IN MISSISSIPPI RIVER FROM BATON ROUGE TO NEW ORLEANS, LOUISIANA

Photograph courtesy of Louisiana Department of Public Works

Aerial view of Mississippi River at Baton Rouge showing dye injection site and location of sunken chlorine barge

INTRODUCTION

On September 9, 1965, the Baton Rouge area prepared for the tropical storm officially designated as Hurricane Betsy. During the night of September 9 and early morning of September 10, Baton Rouge experienced winds of nearly 100 miles per hour. By daylight on September 10, the winds had abated considerably and a study of damages started immediately.

The high winds during the night had torn scores of barges from their moorings along the Mississippi River. Many barges were sunk, including one that contained 600 tons of liquid chlorine. A search for the missing chlorine barge was started, and President Johnson declared a national emergency in the Baton Rouge area. The resources and capabilities of the Armed Services and government agencies were organized to cope with the emergency.

The Louisiana Water Resources Division office previously had completed long-range plans for a time-of-travel study on the Mississippi River between Baton Rouge and New Orleans. On September 13 the feasibility of making a time-of-travel study on very short notice was discussed with personnel in the Washington office, U.S. Geological Survey. Because of the possibility of leakage from the sunken barge, it was decided to make such a study immediately. Many downstream water users, especially the city of New Orleans, needed to know travel time of solutes in the event of a large chlorine leak.

The index map of Louisiana shows in red the part of the Mississippi River that was included in the study.

PREPARATIONS FOR INJECTING DYE

A decision was made on September 13 that the Mississippi River would be dosed with Rhodemine B dye on September 15. This bright-red dye is fluorescent and can be easily detected even when present in less than one part per billion. To provide peak concentrations of at least one part per billion throughout the study reach, it was necessary to dump two tons of dye. Personnel in the Washington office located 2,500 pounds of dye (40-percent solution) in Atlanta and 1,600 pounds of dye (40-percent solution) in New Jersey. The Washington office agreed to purchase the dye and to arrange commercial air transportation for delivery of the dye from New Jersey to Baton Rouge. The Georgia District, U.S. Geological Survey, arranged for the Army to fly the 2,500 pounds of dye from Atlanta to Baton Rouge. Two specialists in time-of-travel studies were made available from the Washington office, and the Mississippi District, U.S. Geological Survey, furnished one experienced man.

The U.S. Public Health Service furnished a 37-foot boat for use on the upper reaches of the study area, and the Corps of Engineers, New Orleans District, furnished a 60-foot boat and made their dock facilities available for the New Orleans sampling. A commercial barge and towboat were leased in Baton Rouge and two small powerboats were borrowed for standby duty. The commercial barge was necessary to transport the 4,100 pounds of dye to midstream and dump at one point as quickly as possible.

The Louisiana Department of Public Works provided financial assistance.

Because of the emergency, the military authorities were apprehensive about dumping the red dye into the river where the general public could see the operation but might not understand its purpose. To prevent undue concern by local citizens who might not be informed, it was agreed to put the dye into the river at night. By daylight the dye would be mixed and there would be no visible color in the water. The information officer in Washington prepared a press release that was given to newspapers and radio and television stations for public announcement.

COLLECTION OF FIELD DATA

The dye was dumped at night to avoid the possibility of further alarming local citizens. The U.S. Coast Guard provided an escort from the dock to the injection site so that a safe route would be followed; that is, a route previously surveyed to make sure the sunken chlorine barge would not be encountered. The towboat positioned the barge just downstream from the mainstream pier of the interstate bridge under construction (river mile 229.2). The 4,100 pounds of dye (40-percent solution) was dumped manually at 2030 on September 15. The injection point is indicated on the photograph. The point where the sunken chlorine barge was found is also shown on the photograph.

After the dye was injected at Baton Rouge, the long chase was underway. Four downstream sampling sites had been selected; Plaquemine, Sunshine Bridge, Reserve, and New Orleans. Collection procedures were as follows: (1) surface samples were obtained at several points near midstream and near each bank at the four sampling sites, (2) samples at 0.5 depth were obtained where practicable to check on vertical mixing, (3) fluorescence values were measured with fluorometers and (4) all samples were tagged and later analyzed in the laboratory to determine concentrations in parts per billion

At Plaquemine (river mile 208.0) a State owned and operated ferry had landing facilities and 110-volt power available. At Sunshine Bridge (river mile 167.5) a portable generator was used to provide 110-v power and the fluorometer was housed in a camper trailer. A passenger-ferry landing at Reserve (river mile 138.2) was the third sampling site and the camper trailer and portable generator were again used. At New Orleans (river mile 102.8), the Corps of Engineers dock facilities were used. Sampling was concluded at 0630 September 20.

River cross sections (from reports by the Corps of Engineers) for the injection site and for all sampling sites are shown keyed to the appropriate places on the river map. Five sampling points were used at Plaquemine and Sunshine Bridge, and three sampling points were used at Reserve and New Orleans. The location of three sampling points at all four sites are shown on the graphs of river cross sections.

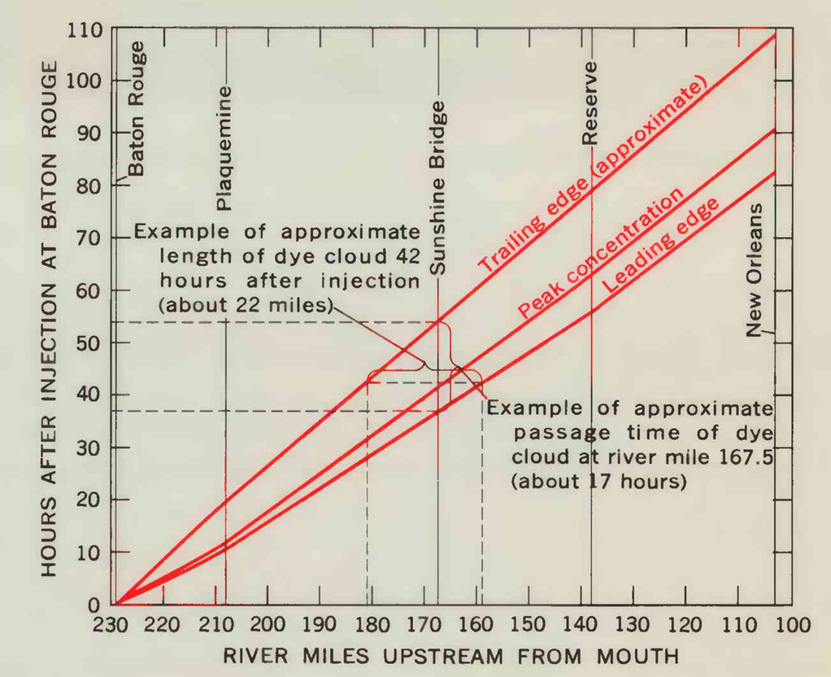
RESULTS OF DYE STUDY

The dye was fairly well mixed laterally by the time it reached Plaquemine and just about completely mixed by the time it reached Sunshine Bridge. Samples at 0.5 depth showed that uniform vertical mixing had occurred at Plaquemine and downstream at Sunshine Bridge and Reserve. Depth samples were not taken at New Orleans because of the uniformity observed at the other sampling sites.

Three time-concentration curves are presented for Plaquemine. A curve is shown for a mid-channel point as well as for each bank. Only two curves are shown for Sunshine Bridge because concentrations near each bank were similar.

At Reserve and New Orleans the concentration was similar at all points in the cross section, so only one curve is shown for each site.

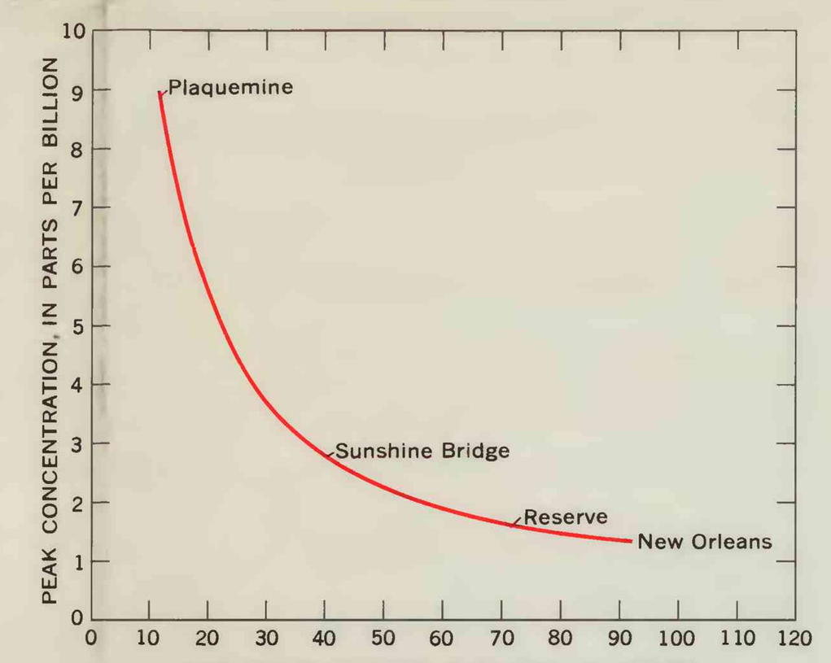
The arrival time (expressed in hours after injection) of the leading edge, peak concentration, and trailing edge of the dye cloud at each sampling site is shown in the following graph:



Travel time-distance curves, giving passage time and length of dye cloud

The graph shows that the leading edge reached Plaquemine about 11 hours after injection; it reached Sunshine Bridge 37 hours after injection, Reserve 55 hours after injection, and New Orleans 83 hours after injection. This graph can also be used to approximate the length of the dye cloud at any point. For example, when the peak concentration was at Sunshine Bridge, the leading edge was at river mile 159 and the trailing edge at mile 181. The dye cloud was 22 miles long. It is also possible to estimate from this graph the number of hours for the dye to pass a point. For example, at Sunshine Bridge the leading edge arrived 37 hours after injection and the trailing edge left 54 hours after injection; hence it took 17 hours to pass Sunshine Bridge.

The following graph illustrates how dispersion caused the peak concentration to decrease as the dye cloud traveled downstream. Loss of dye, due to adsorption, decay, and dilution, was heaviest in the upper part of the study reach and does not appear to have affected any of the results significantly.



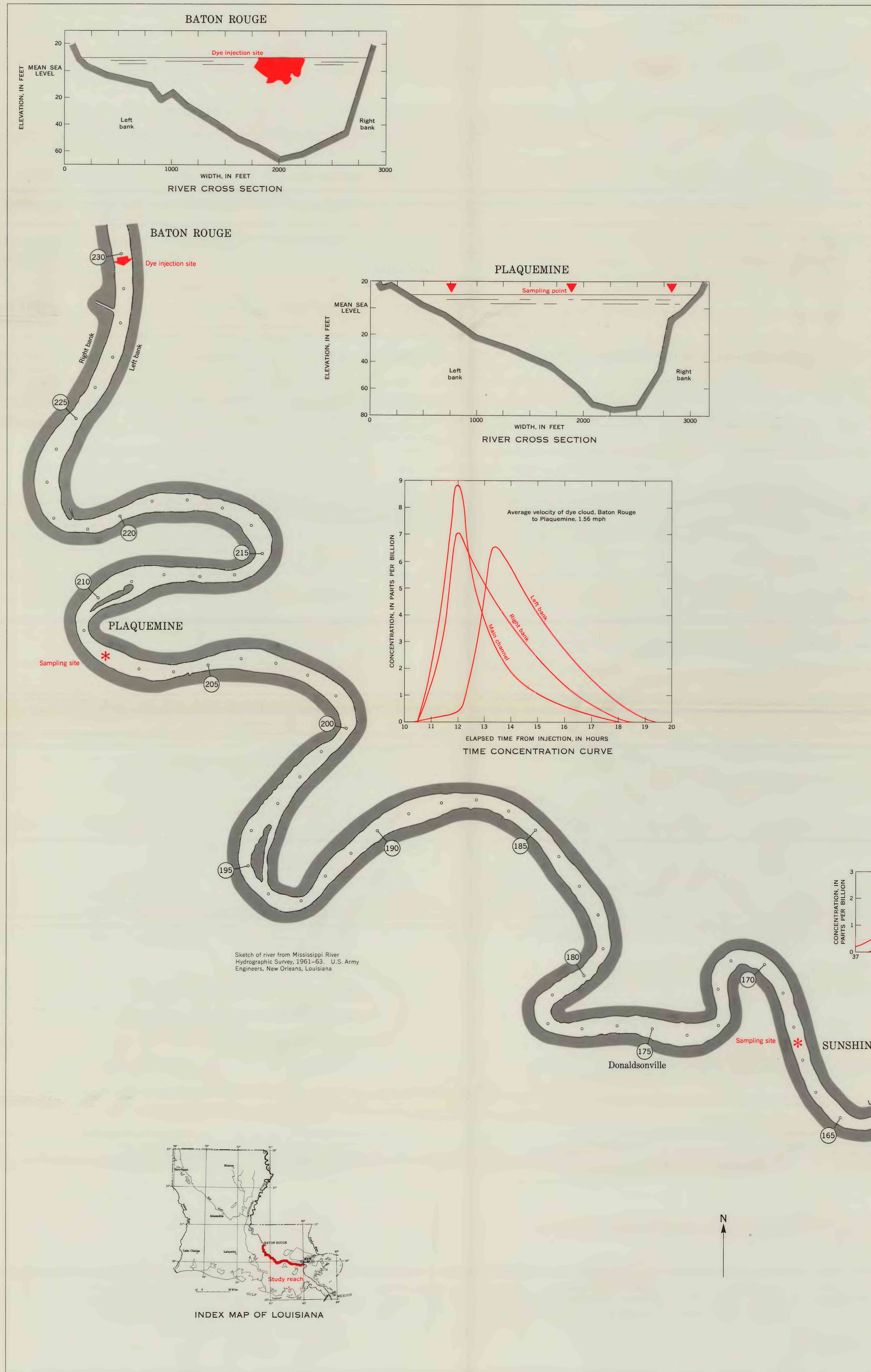
Reduction of peak concentration of dye in the study reach

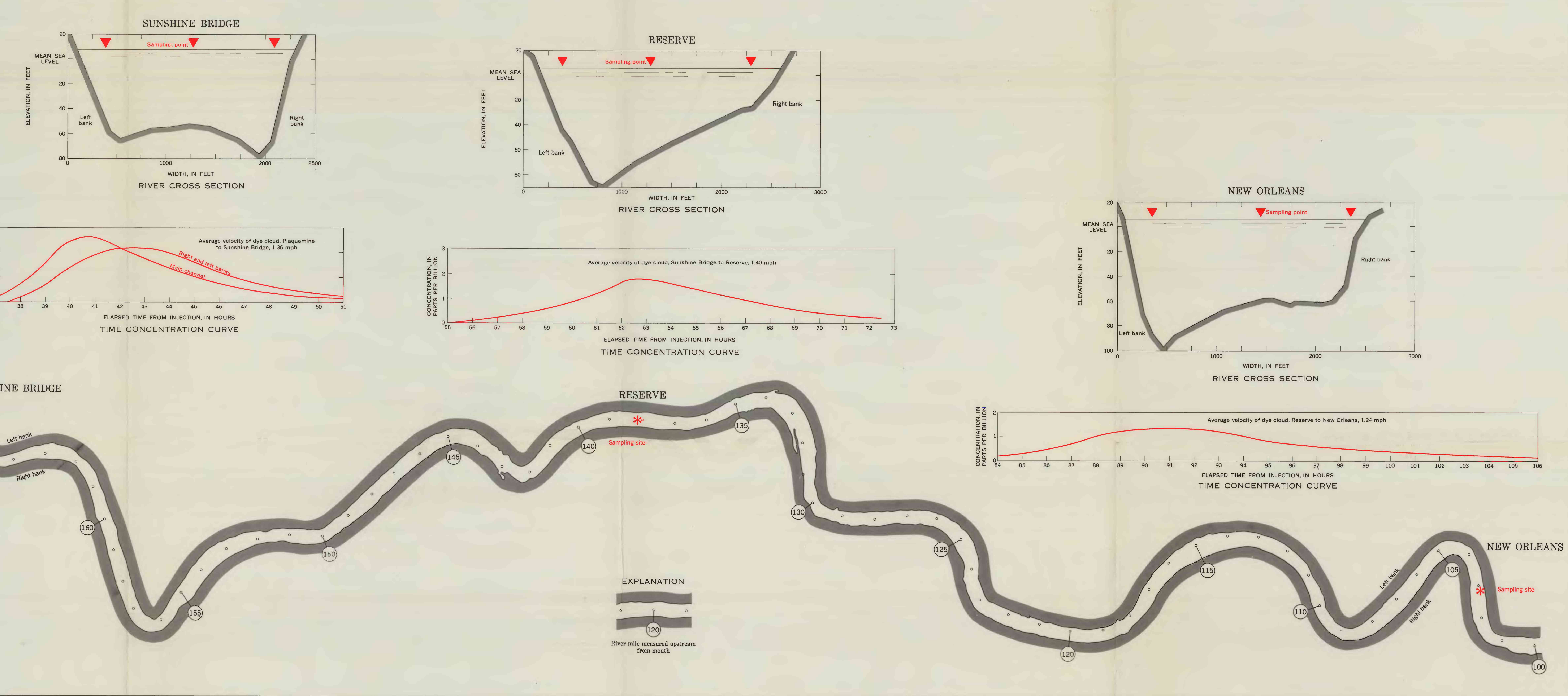
The flow of the Mississippi River at Baton Rouge was approximately 240,000 cfs (cubic feet per second) at the time the dye was injected; there was no significant inflow or outflow in the study reach. Different times of travel between Baton Rouge and New Orleans are to be expected with larger or smaller flow in the Mississippi River. It would be possible to estimate reasonable travel times for any flow condition if a similar dye study were made at a higher discharge. This could be done by straight-line interpolation and extrapolation of the results of the two dye studies. Even with just this one time-of-travel study it is possible to approximate travel time at other discharges. Adjustments could be made to account for different discharges and the corresponding change in cross-sectional areas of the channel.

Some modification of the curves presented in this report would be required if a contaminant were injected into the river at a point a considerable distance from Baton Rouge. Travel time between sites would be the same if the discharge were the same as that observed (240,000 cfs) for this study, but the time-concentration curves would have to be modified.

SELECTED REFERENCES

Buchanan, T. J., 1964, Time of travel of soluble contaminants in streams: Am. Soc. Civil Engineers Proc., v. 90, no. SA3, Paper 3932, 12 p.
Godfrey, R. G., and Frederick, B. J., 1963, Dispersion in natural streams: U.S. Geol. Survey open-file report, 75 p.
Wilson, J. F., Jr., and Forrest, W. E., 1965, Potomac River time of travel measurements: Lamont Geol. Observatory Symposium on Diffusion in Oceans and Fresh Waters, Palisades, N. Y., 1964 Proc., p. 1-21.
Wilson, J. F., Jr., and McAvoy, R. L., 1966, Water Movement in the Patuxent River Basin, in Crooks, J. W., O'Bryan, D., and others, Water resources of the Patuxent River Basin: U.S. Geol. Survey Hydrol. Inv. Atlas HA-244.
Norton, Lt. Col. L. W., 1966, Salvage of the "602"; The Military Engineer, v. 58, no. 383, p. 160-1.





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By
M. R. Stewart

1967

For sale by U.S. Geological Survey, price 50 cents