

INTRODUCTION

The U.S. Geological Survey (USGS), in cooperation with the Sabine River Authority, did a time-of-travel study in the Sabine River Basin during low flow from August to November 1996. The study was done to provide accurate estimates of the time-of-travel and dispersion characteristics for solutes during low flow in a 1.8-mile (mi) reach of Grace Creek, a 23.9-mi reach of the mainstem Sabine River, a 3.4-mi reach of Hawkins Creek, and a 1.9-mi reach of Rocky Creek. This report explains the approach and documents the results of the study. The results of the study will be used by the Texas Natural Resource Conservation Commission in a water-quality model to determine waste-load allocation in Segment 0505 of the Sabine River Basin. The time-of-travel and dispersion characteristics also provide useful information on the probable behavior of soluble contaminants that might be introduced into the streams measured in this study.

Approach

Dye tracing frequently is used to estimate time of travel in streams. A slug of a known amount of dye is injected into the stream at some location, and the response, or the dye cloud, is measured downstream at the locations of interest (Kilpatrick and Wilson, 1989). A commonly used dye is rhodamine WT, which is red, water soluble, strongly fluorescent, highly diffusive, harmless in small concentrations, and stable in a natural water environment. The dye has a low sorptive tendency that makes it a good tracer. In solution, rhodamine WT dye has a specific gravity that is nearly equivalent to freshwater, thus the time-of-travel characteristics of the dye are expected to be similar to most soluble contaminants in freshwater. Water samples are collected at specified downstream sites at regular intervals, and the concentration of dye in each water sample is measured with a fluorometer (Wilson and others, 1986). On the basis of stage measured with temporary staff gages, streamflow measurements are made as needed to estimate the mean streamflow at each sampling site. Time-concentration curves are plotted to estimate the times associated with the leading edge, peak, centroid, and trailing edge of the dye cloud. The leading edge is defined as the initial concentration of the dye detected. The peak is defined as the maximum concentration of dye detected. The centroid is defined as the concentration when 50 percent of the dye has passed the sampling site, which generally occurs after the peak. The trailing edge is defined, for this study, as a dye concentration of 0.5 microgram per liter (µg/L). The amount of dye recovered is estimated by multiplying the area under the time-concentration curve by the mean streamflow. The mean velocity in each subreach is computed by dividing the upstream distance to the next site by the time of travel from the next upstream site.

Acknowledgments

John Payne and Troy Henry of the Sabine River Authority assisted with the field reconnaissance and access to the injection and sampling sites. The firms of Texas Eastman and Le Tourneau, the City of Longview, and several local residents provided access to the Sabine River, Grace Creek, and Hawkins Creek on their properties. Jeffrey Sandlin, Bradley Mansfield, Martin Danz, and Bruce Goddard of the USGS assisted with the collection and measurement of dye samples.

TIME OF TRAVEL OF SOLUTES

Time of travel of solutes was measured during low flow using dye tracing for 2 sites on a 1.8-mi reach of Grace Creek, 6 sites on a 23.9-mi reach of the Sabine River, 2 sites on a 3.4-mi reach of Hawkins Creek, and 1 site on a 1.9-mi reach of Rocky Creek. The results for each site are presented in the table. A map of the study area shows the locations of injection and sampling sites, and graphs show the time-concentration curves for the sampling sites.

The Grace Creek dye study was done on August 6, 1996, from the City of Longview wastewater outfall (site G-0) downstream 1.8 mi to 0.2 mi upstream from the confluence with the Sabine River (site G-2). Most low flow in Grace Creek is from the City of Longview wastewater-treatment plant that discharges into Grace Creek about 0.2 mi downstream from site G-1. Streamflow measurements were made at sites G-1 and G-2. The mean streamflow at site G-1 was about 75 percent of that at site G-2 because the flow increased during sampling from the operation of the wastewater-treatment plants. No rainfall occurred

in the basin during the sampling. The amounts of dye recovered were 97.2 percent at site G-1 and 86.4 percent at site G-2; and the times of travel of the peak from injection were 0.83 hour to site G-1 and 5.95 hours to site G-2.

The Sabine River dye study was done during September 17–20, 1996, from 1–20 downstream 23.9 mi to 4.4 mi upstream from State 43. The study section was divided into two reaches to reduce the time required to complete the study. Dye concentrations were measured at 4 sites in 14.3-mi reach 1 (S-1, S-2, S-3, and S-4) and 2 sites in 9.6-mi reach 2 (S-5 and S-6). The dye was injected at site S-4 for reach 2. The daily mean streamflow on September 17 of 91 cubic feet per second (cfs) at Sabine River near Gladewater station (08020000), 35.1 mi upstream from site S-1, was equalled or exceeded 86 percent of the time during the 16-year period of 1980–95. Streamflow was measured at sites S-1 and S-3 in reach 1 and at site S-6 in reach 2 during the study to estimate the mean streamflow at each site. The streamflow was higher at site S-1 than at the Gladewater station due to tributary inflows to the Sabine River, including Grace Creek. The mean streamflow at site S-2 was estimated from the streamflow measured at site S-1. The mean streamflow at site S-4 was estimated from the streamflow measured at site S-3. The mean streamflow at site S-5 was estimated from the streamflow measured at site S-6. No major tributaries flow into the Sabine River between sites S-1 and S-4. Scattered rainfall occurred in the basin on the afternoons of September 18 and 19. More intense rainfall mainly occurred in the upper basin and had little effect on the stage and streamflow of the downstream dye-sampling sites during the study. Most of the dye clouds were downstream of sites S-2 and S-5 by the time rain began on September 18. The streamflow at sites S-3 and S-4 was slightly affected by rainfall. Some of the additional flow between sites S-2 and S-3 (table) was from an industrial wastewater-treatment plant outfall. Heavy rain began early in the morning on September 20, but all dye sampling had been completed. In reach 1, the amounts of dye recovered ranged from 87.2 percent at site S-1 to 66.7 percent at site S-4; and the time of travel of the peak from injection ranged from 18.17 hours to site S-1 to 46.92 hours to site S-4. In reach 2, the amounts of dye recovered were 86.6 percent at site S-5 and 66.9 percent at site S-6; and the times of travel of the peak from injection were 19.58 hours to site S-5 and 50.58 hours to site S-6.

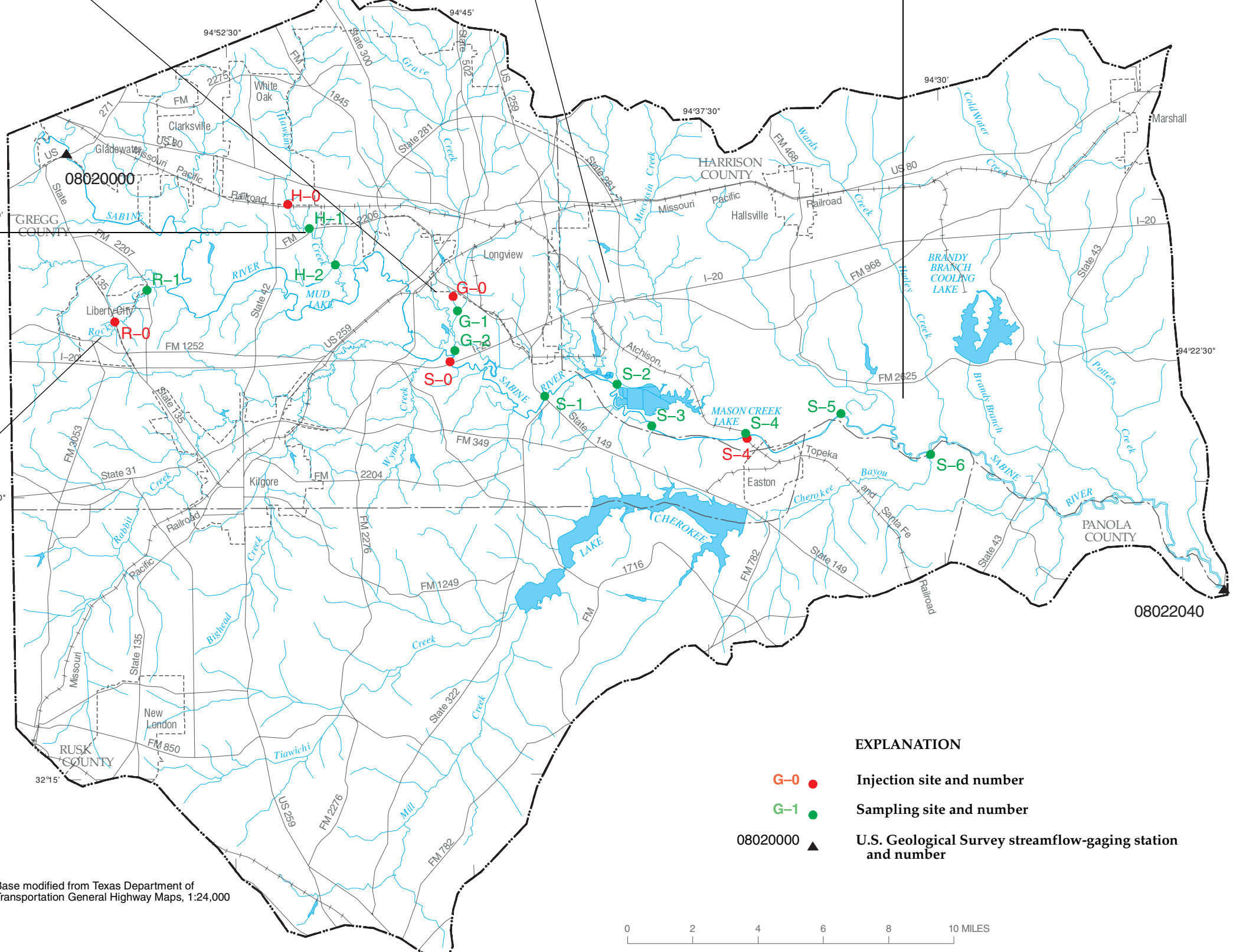
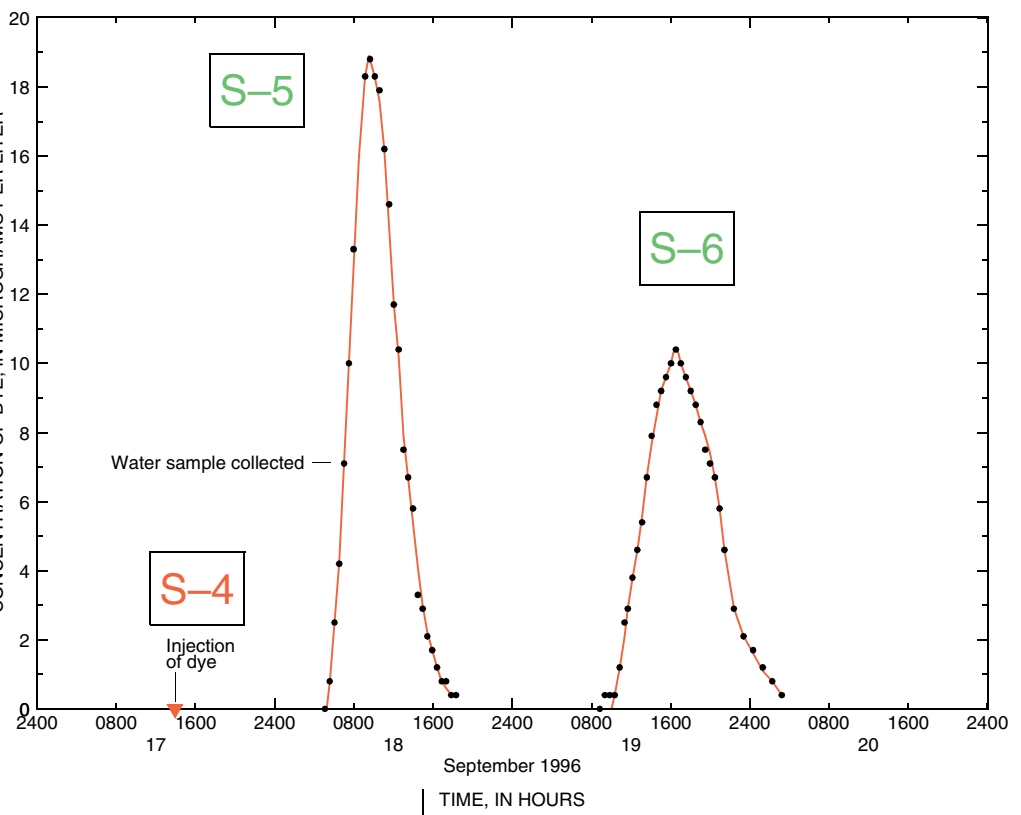
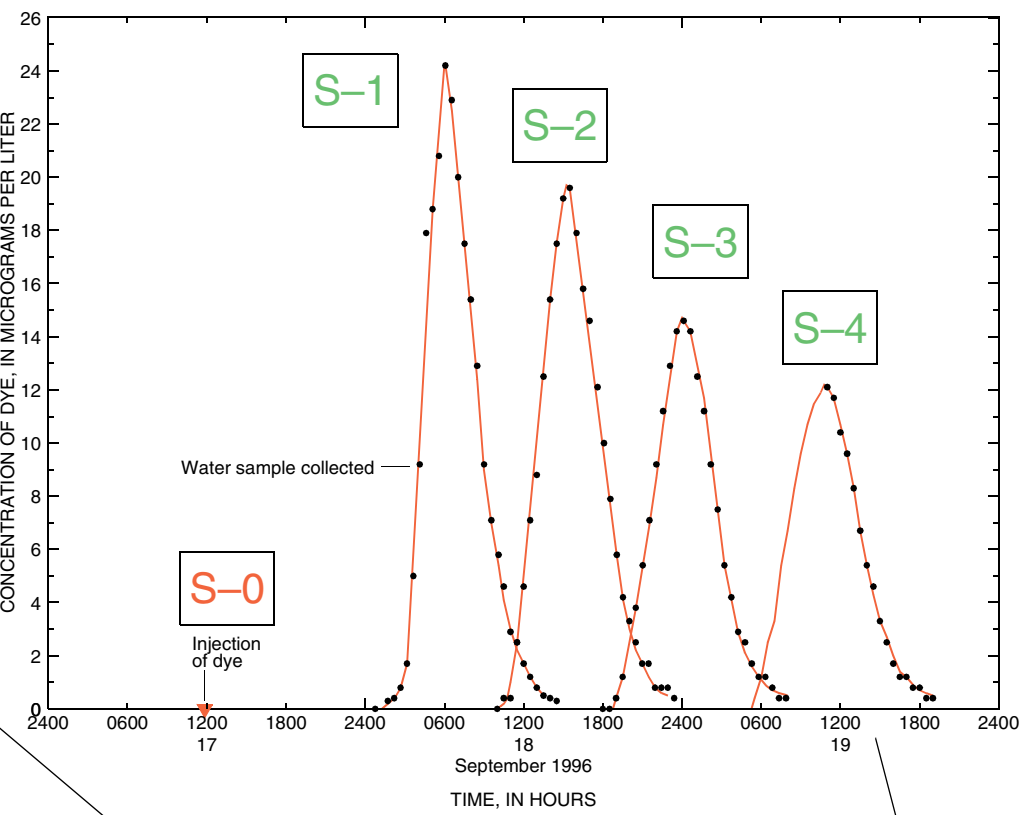
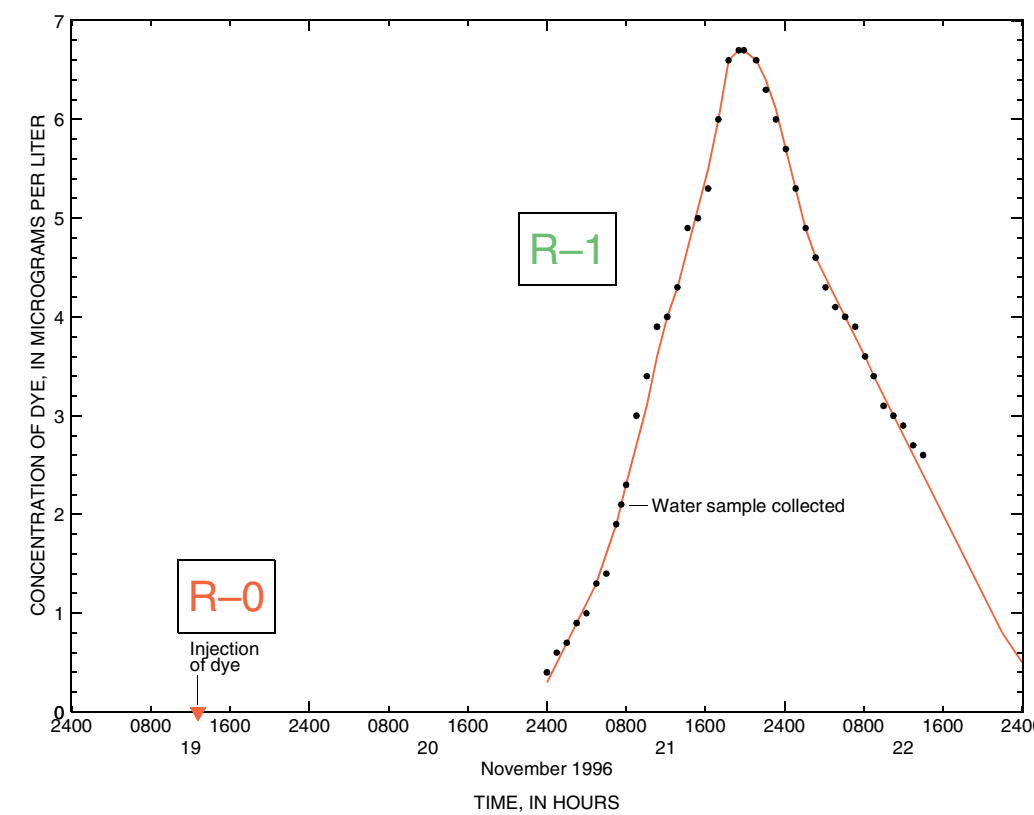
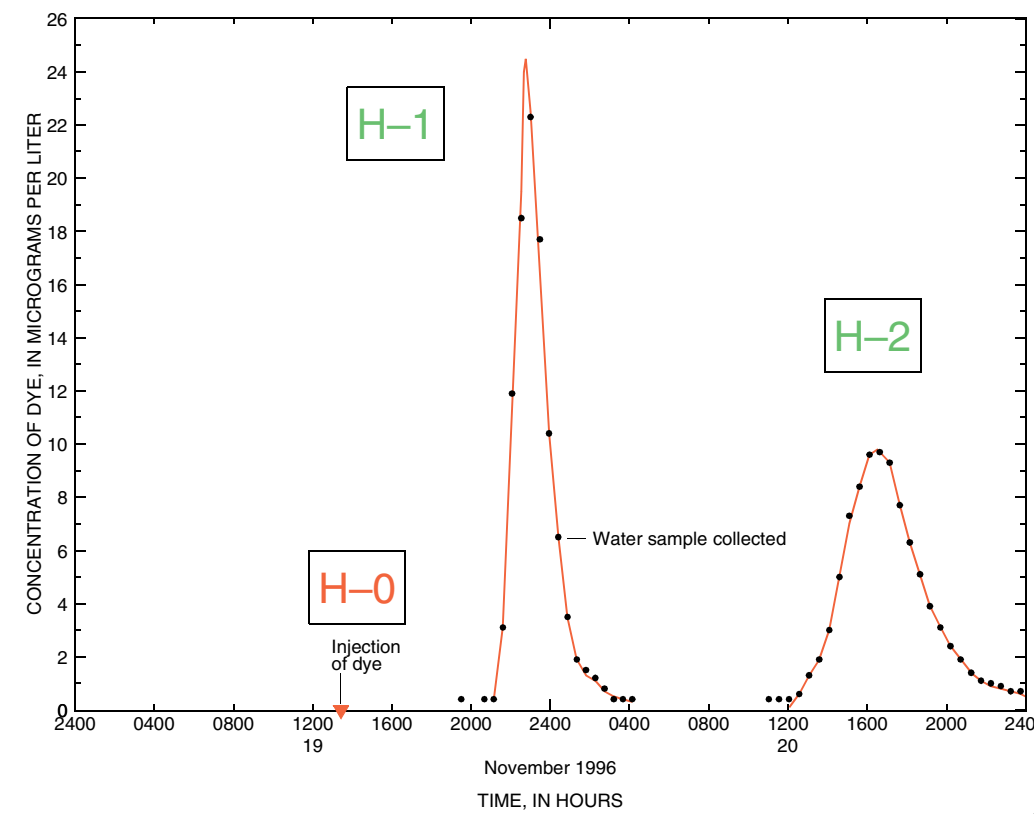
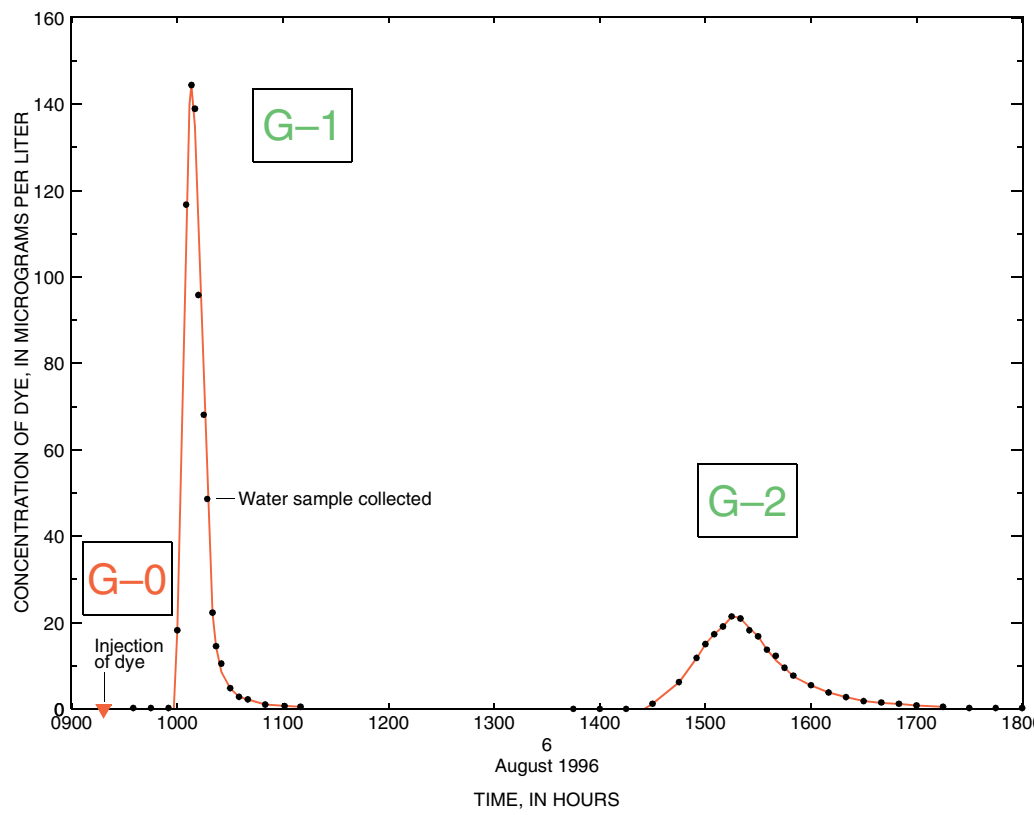
The Hawkins Creek dye study was done during November 19–20, 1996, from the Texas and Pacific Railroad bridge downstream 3.4 mi to 2.2 mi upstream from the confluence with the Sabine River. Streamflow was measured at sites H-1 and H-2. The mean streamflow at site H-2 was about 60 percent of that at site H-1 because Hawkins Creek splits into two channels about 200 ft upstream from site H-2; the remaining 40 percent flows into Mud Lake about 0.9 mi downstream from Hawkins Creek. No rainfall occurred in the basin during the sampling. The amounts of dye recovered at sites H-1 and H-2 were 80.3 and 77.9 percent (see footnote 4 of table), respectively, and the times of travel of the peak to sites H-1 and H-2 from injection were 9.33 and 27.08 hours, respectively.

The Rocky Creek dye study was done during November 19–22, 1996, from State 135 downstream 1.9 mi to FM 2207. The mean streamflow for the reach was estimated from streamflow measured at site R-1. The flow in Rocky Creek was slowed and dispersed by several large pools on a golf course in the upper one-half of the basin. No rainfall occurred in the basin during the sampling. The amount of dye recovered at site R-1 was 77.7 percent, and the time of travel of the peak from injection to site R-1 was 55.00 hours.

REFERENCES CITED

- Kilpatrick, F.A., and Wilson, J.F., Jr., 1989, Measurement of time of travel in streams by dye tracing (rev.); U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A9, 27 p.
- Wilson, J.F., Jr., Cobb, E.D., and Kilpatrick, F.A., 1986, Fluorometric procedures for dye tracing (rev.); U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A12, 34 p.

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.



Map showing locations of injection and sampling sites and graphs showing time-concentration curves for sampling sites.

Summary of time-of-travel results for the Sabine River Basin, August–November 1996

[mi, miles; ft, feet; ft³/s, cubic feet per second; g, grams; ft/s, feet per second; --, not applicable]

Reach			Subreach					Dye recovered		Dye cloud									
Stream	Description	Length ¹ (mi)	From	To	Site	Distance from next upstream site ¹ (mi)	Change in stage during sampling ² (ft)	Mean streamflow ² (ft ³ /s)	Weight (g)	Percent	Leading edge		Peak		Centroid		Trailing edge		
											Time of travel from injection site (hours)	Mean velocity in subreach ³ (ft/s)	Time of travel from injection site (hours)	Mean velocity in subreach ³ (ft/s)	Time of travel from injection site (hours)	Mean velocity in subreach ³ (ft/s)	Time of travel from injection site (hours)	Mean velocity in subreach ³ (ft/s)	
Grace Creek	City of Longview wastewater-treatment plant outfall to 0.2 mi upstream from confluence with Sabine River	1.8	City of Longview wastewater-treatment plant outfall	Confluence of unnamed tributary with Grace Creek	G-0	--	Injected 51.5 g of rhodamine WT dye at 0918 08/06/96												
					G-1	0.6	0.08	16.0	50.1	97.2	0.67	1.31	0.83	1.06	0.85	1.04	1.87	0.47	
					G-2	1.2	.06	21.4	44.5	86.4	5.12	.40	5.95	.34	6.03	.34	7.95	.29	
Sabine River, reach 1	I-20 to Atchison, Topeka, and Santa Fe Railroad bridge	14.3	I-20	State 149	S-0	--	Injected 1,560 g of rhodamine WT dye at 1150 09/17/96												
					S-1	5.6	.04	125	1,360	87.2	13.42	.61	18.17	.45	18.48	.44	25.67	.32	
					S-2	2.5	.06	125	1,330	85.3	22.42	.41	27.42	.40	27.58	.40	35.17	.39	
					S-3	2.7	.20	135	1,100	70.5	30.92	.47	36.17	.45	36.26	.45	44.17	.44	
					S-4	3.5	.24	135	³ 1,040	66.7	³ 41.42	.49	46.92	.48	³ 47.0	.48	55.17	.47	
Sabine River, reach 2	Atchison, Topeka, and Santa Fe Railroad bridge to 4.4 mi upstream of State 43	9.6	Atchison, Topeka, and Santa Fe Railroad bridge	10.4 mi upstream of State 43	S-4	--	Injected 1,570 g of rhodamine WT dye at 1355 09/17/96												
					S-5	3.6	-.06	125	1,360	86.6	15.33	.34	19.58	.27	19.92	.27	27.58	.19	
					S-6	6.0	.02	125	1,050	66.9	44.08	.31	50.58	.28	50.72	.29	61.08	.26	
Hawkins Creek	Texas and Pacific Railroad bridge to 2.2 mi upstream from confluence with Sabine River	3.4	Texas and Pacific Railroad bridge	FM 2206	H-0	--	Injected 36.0 g of rhodamine WT dye at 1325 11/19/96												
					H-1	1.8	-.01	5.82	28.9	80.3	7.58	.35	9.33	.28	9.47	.28	14.58	.18	
					H-2	1.6	-.01	3.53	17.0	⁴ 77.9	22.58	.16	27.08	.13	27.22	.13	35.08	.11	
Rocky Creek	State 135 to FM 2207	1.9	State 135	FM 2207	R-0	--	Injected 20.6 g of rhodamine WT dye at 1245 11/19/96												
					R-1	1.9	.00	.99	16.0	77.7	35.25	.08	55.00	.05	56.92	.05	83.25	.03	

¹ From Sabine River Authority.

² When dye cloud was in subreach.

³ Estimated.

⁴ Flow-adjusted percent; that is, percent computed on the basis of about

22 rather than 36 g of dye potentially recoverable because of diversion of

about 40 percent of streamflow to Mud Lake between sites H-1 and H-2.



TIME OF TRAVEL OF SOLUTES IN THE SABINE RIVER BASIN, TEXAS, AUGUST–NOVEMBER 1996

By
Timothy H. Raines

1997

For additional information write to:
U.S. Geological Survey
District Chief
8011 Cameron Rd.
Austin, TX 78754-3698

Copies of this report can be purchased from:
U.S. Geological Survey
Branch of Information Services
Box 25086
Denver, CO 80225-0286