TEXAS WATER DEVELOPMENT BOARD

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QUANTITY AND QUALITY OF LOW FLOW IN SABINE AND OLD RIVERS NEAR ORANGE, TEXAS SEPTEMBER 12-15, 1967

By

Jack Rawson, S. L. Johnson, and R. E. Smith
United States Geological Survey

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QUANTITY AND QUALITY OF LOW FLOW IN SABINE AND OLD RIVERS NEAR ORANGE, TEXAS SEPTEMBER 12-15, 1967

INTRODUCTION

The U.S. Geological Survey's stream-gaging and chemical-quality station, Sabine River near Ruliff, Texas, is the lowermost site on the Sabine River for which daily streamflow and water-quality records are available. Downstream from this station, the Old River anabranch of the Sabine River diverts part of the flow into Louisiana, where two large privately owned canal companies pump water for rice irrigation. Similarly, the Sabine River Authority of Texas diverts water from the mainstem Sabine River for industrial and irrigation uses. The Sabine and Old Rivers rejoin in the tidal reach upstream from Orange, Texas. Because the lower reach of the Sabine River is tidal, sea water from the Gulf of Mexico periodically intrudes through Sabine Lake into both the Sabine and Old Rivers. Although several private firms have collected some water-quality information on the tidal reach of the Sabine River (Forrest and Cotton, 1966, p. 5), the effects of tide on water quality and the extent of salt-water intrusion have not been defined adequately. Moreover, neither the quantity of water that flows from the mainstem into Old River nor the quantity or quality of tributary inflow downstream from the station near Ruliff is known. Therefore, in April 1966, the U.S. Geological Survey, in cooperation with the Sabine River Authority of Texas and the Texas Water Development Board, began a series of investigations of the quantity and quality of flow in streams of the Sabine River basin between the Ruliff gaging station and Orange. Purposes of the investigations were: (1) to determine the distribution of flow in the mainstem and anabranches of the Sabine River in the study area; (2) to devise a method whereby the distribution of flow can be estimated from discharge records of the gaging station Sabine River near Ruliff; (3) to define the effects of tide on quality of the water; and (4) to determine the quality and quantity of tributary inflow.

The results of investigations made on April 12, 1966, and during the period October 31 to November 4, 1966, when flow at the Ruliff station was about 1,680 cfs (cubic feet per second) and 500 cfs, respectively, have been described by Rawson, Reddy, and Smith (1967).

A third investigation, the results of which are described herein, was made during the low-flow period September 12-15, 1967, to supplement the earlier investigations.

DESCRIPTION OF STUDY AREA

The area studied extends from the stream-gaging station Sabine River near Ruliff to the head of the ship-turning basin near Orange (Figure 1). Although flow in the mainstem and anabranches of the Sabine was restricted to their channels during this study, the streams overflow frequently. Therefore, much of the area, which ranges from about 15 feet above mean sea level to sea level, is poorly drained swampland. The area is covered by a profuse growth of pine, cypress, and other large trees.

About 5 miles downstream from the station near Ruliff, the Sabine River branches and part of the flow enters Old River through Cutoff Bayou. The Old River anabranch extends gulfward for about 11 miles in Louisiana and then rejoins the mainstem. Periodically, two privately owned companies in Louisiana divert part of the flow from Old River for rice irrigation.

Downstream from the divergence of Indian Bayou, the channel of the Sabine River is blocked by a sandbar Figure 3. Consequently, during low-flow periods, all of the mainstem flow below Cutoff Bayou divergence enters the Indian Bayou anabranch. Periodically, the Sabine River Authority diverts part of this flow for irrigation and industrial use. During previous investigations, part of the flow from Indian Bayou was returned to the mainstem Sabine River through a man-made channel at Swift Lake. However, during this investigation, the man-made channel was completely blocked by a sand dam. Although the lower reach of Indian Bayou was partly blocked by a sandbag dam, some flow passed over the dam and returned to the mainstem.

Downstream from Indian Bayou, the channel of the Sabine River meanders in a series of almost complete loops across the flood plain; Old River is much

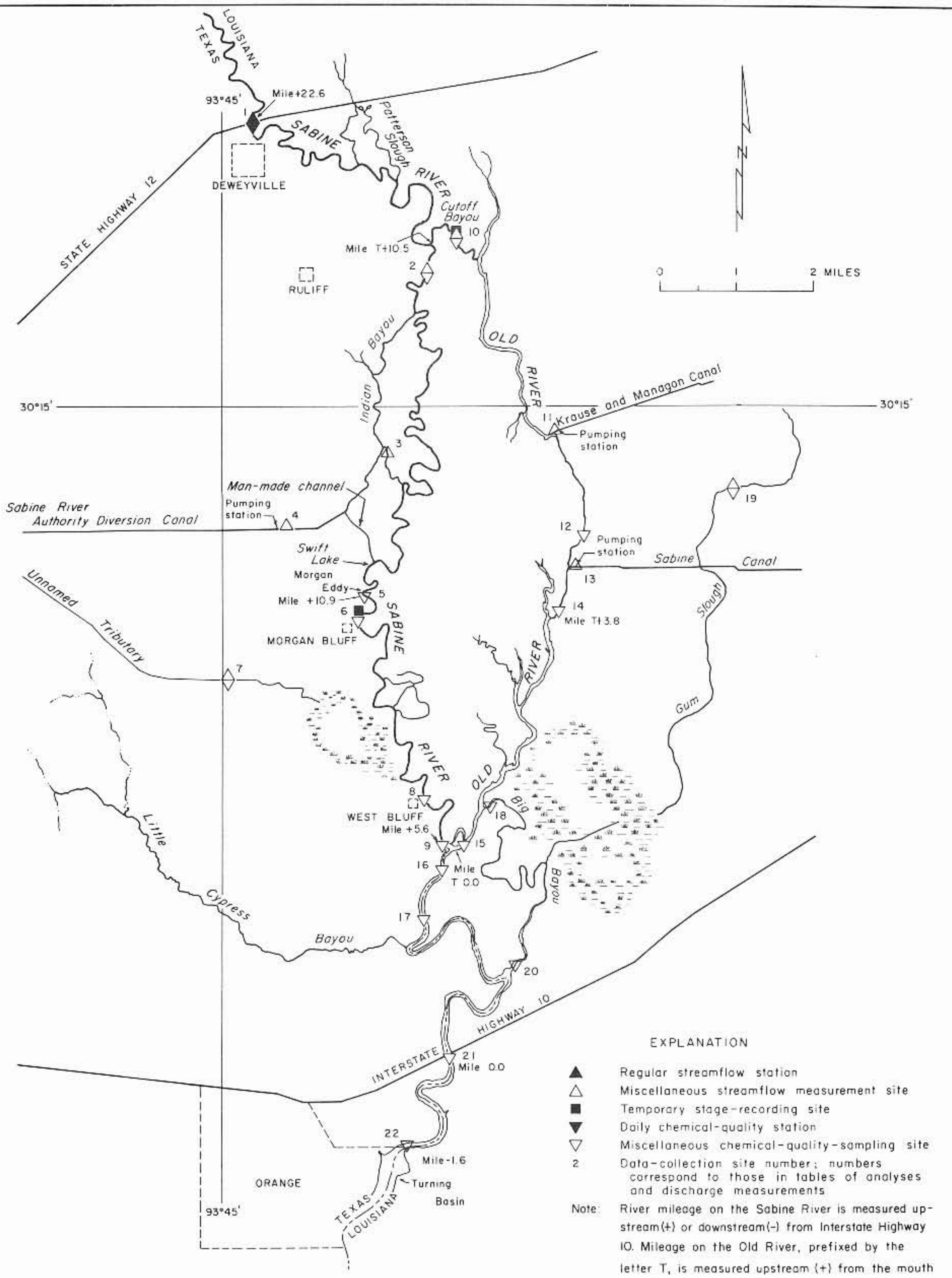

Figure 1

Locations of Streamflow and Chemical-Quality Data-Collection Sites

Base from U.S. Geological Survey topographic maps straighter. Although channel widths differed from site to site, they generally increased in the downstream direction. The channel of the Sabine River near Ruliff was about 145 feet wide, whereas at Interstate Highway 10, it was more than 500 feet wide. The width of the Old River channel increased from about 35 feet in the upper reach to about 175 feet near the mouth. Similarly, depths generally increased in the downstream direction. The maximum depth of water observed in the Sabine River near Ruliff was about 3 feet, but depths of more than 30 feet were noted at Interstate Highway 10. Although the downstream increase in depth was usually gradual, the depth of the Sabine River near the mouth of the Old River increased abruptly from about 10 feet (site 9) to more than 20 feet (site 16). No such abrupt change in depth of the Old River was noted.

In Figure 1 and in the following discussion, river mileage on the mainstem Sabine River (including Indian Bayou) is measured upstream and downstream from Interstate Highway 10, which is designated as mile 0.0. Upstream mileage is designated as positive (+); downstream mileage is designated as negative (-). Mileage on other streams (including Old River) is measured upstream from the mouths, each of which is designated as mile T 0.0.

METHODS OF INVESTIGATION

Water-Level Measurements

Two temporary water-stage recorders were installed to measure the fluctuations of water levels caused by the tide and the diversion of water by the Sabine River Authority and two Louisiana pumping plants (Figure 1). One of these instruments continuously recorded the water-level fluctuations in the Sabine River at Morgan Bluff (site 6). The other recorder was installed in Cutoff Bayou (site 10) to determine if the reach was affected by tide and if the distribution of flow between the Sabine and Old Rivers was affected by operation of pumping plants. During some periods, the recorder in Cutoff Bayou was inoperative. However, the stage record was supplemented by frequent visual observations of water levels.

Streamflow Measurements

To determine the distribution of flow between the Sabine River and the Old River anabranch, discharge was measured repeatedly in Cutoff Bayou (site 10) and once in the Sabine River downstream from the divergence of Old River (site 2). Flow passing the station near Ruliff (site 1) during these measurements was determined from gaging-station records. Also, discharge was measured in all diversion canals, and all accessible tributaries were inspected for flow.

Water-Quality Measurements

Because the specific conductance of a water is related to the number and types of ions in solution, field measurements of specific conductance can be used to detect variations in the salinity of a stream. Therefore, conductance was measured at many sites in the mainstem and anabranches of the Sabine River to detect longitudinal, transversal, and vertical variations of salinity. At most of these sites, specific conductance, temperature, pH, and dissolved oxygen were measured at the surface and bottom in one or more verticals. When vertical variations were detected, the water-quality measurements were made at several intermediate depths. If no change in conductance occurred, a single sample for laboratory analysis was collected. If a sharp change occurred, samples for laboratory analysis were collected from the surface, bottom, and intermediate depths. Also, samples were collected from each flowing tributary located during the study. In the laboratory, the specific conductance and chloride content of each sample were determined and were used to select a number of samples for more complete chemical analysis. The relation of conductance to the concentrations of chloride and dissolved solids in these samples was used to calculate the chloride and dissolved-solids content of water at other points where conductance was measured.

ANALYSIS OF DATA

Water-Stage Records and Observations

Locations at which temporary water-stage recorders were installed are shown in Figure 1; variations of river stage at these sites and records of pumping plant operations are shown graphically in Figure 2. Records of stage for the Sabine River at Morgan Bluff (site 6), supplemented by field observations at upriver sites, indicate that the stage and thus the flow of the Sabine River were affected by tide as far upstream as the partial dam on Indian Bayou (Figure 3). Similarly, field observations and records of stage for Cutoff Bayou (Figure 2, site 10) indicate that the stage and flow throughout Old River were affected by tide (Figure 3).

Streamflow Distribution

Locations where discharge was measured are shown in Figure 1; results of discharge measurements are given in Table 1. During the investigation, flow in the Sabine River near Ruliff receded fairly uniformly from about 315 cfs to about 300 cfs and averaged about 305 cfs. However, the distribution of flow between the Sabine and Old Rivers varied because of the effects of tide and pumping. The discharges measured in Cutoff Bayou (site 10) ranged from 159 cfs to 195 cfs. Because Cutoff Bayou was tidal, the discharge was not directly

Table 1.--Summary of Discharge Measurements, Sabine River Basin Near Orange, Texas

SITE	DATE (1967)	STREAM	LOCATION	RIVER MILES	DISCHARGE, IN CUBIC FEET PER SECOND			
					MAINSTEM	ANABRANCH	TRIBUTARY	DIVERSION
1	Sept. 12	Sabine River	Lat 30°18'13", long 93°44'37", at gaging station, Sabine River near Ruliff, Texas	+22.6	314			
1	Sept. 14	do	do	do	298			
2	Sept. 13	Sabine River	Lat 30°16'30", long 93°42'21", 0.5 mile downstream from Cutoff Bayou	+17.3	a109			
3	do	Indian Bayou	Lat 30°14'30", long 93°42'52", 500 feet downstream from Sabine River Authority's diversion canal, 2.5 miles south-southeast of Ruliff, Texas	+13.9	a,b 54			
3	do	do	do	do	a,b 24			
4	do	Sabine River Authority's diversion canal	Lat 30°13'42", long 93°44'13", about 1.4 miles upstream from Swift Lake					120
7	Sept. 14	Unnamed tributary to Sabine River	Lat 30°11'53", long 93°45'00", at Old Texas State Highway 87	T+1.4			0.2	
10	Sept. 13	Cutoff Bayou (Old River)	Lat 30°16'51", long 93°41'57", 0.8 mile downstream from Sabine River	T+9.8		a,b 185		
10	Sept. 14	do	do	do		a,b 170		
10	do	do	do	do		a,b 175		
10	do	do	do	do		a,b 159		
10	Sept. 15	do	do	do		b 195		
11	Sept. 14	Krause and Managon Canal Co.'s canal	Lat 30°14'44", long 93°40'35", 3.9 miles southeast of Ruliff, Texas					45
13	do	Sabine Canal Co.'s canal	Lat 30°13'10", long 93°40'13", 5.3 miles southeast of Ruliff, Texas					80
19	do	Gum Slough	Lat 30°14'03", long 98°38'21", at Louisiana State Highway 109	T+6.7			2	

a. Probably affected by pumping.
b. Affected by tide.

related to stage (Figure 2). Consequently, the range of measured discharges does not necessarily represent the range that actually occurred. Nevertheless, the discharge measurements indicate that the portion of flow that entered Old River through Cutoff Bayou varied considerably.

Although the effect of pumping-station operations on the stage of Cutoff Bayou was masked by the effect of tide, much of the variation in the distribution of flow between the Sabine and Old Rivers resulted from pumping. For example, during periods when the Sabine River Authority's pumping plant was operating, the amount of water stored in Indian Bayou and thus the amount of water that flowed over the partial dam (site 3) and returned to the mainstem Sabine River decreased. However, lowering the stage by pumping caused the gradient into Indian Bayou to increase. In response to this increased gradient, the proportion of upriver inflow to Indian Bayou increased.

During previous investigations when flow at the Ruliff station was about 1,680 cfs and 500 cfs, about half the flow entered the Indian Bayou anabranch. Therefore, Rawson, Reddy, and Smith (1967, p. 21) concluded that during other periods when streamflow conditions were similar, the daily inflow that enters the mainstem Sabine River through Indian Bayou could be estimated by subtracting the amount of water diverted by the Sabine River Authority from 50 percent of the mean daily discharge of the Sabine River near Ruliff. However, the construction of dams in Indian Bayou and in the man-made channel that connects Indian Bayou to the mainstem and changes in pumping-station operations have altered flow conditions. Under these altered conditions, the streamflow records of the Sabine River near Ruliff cannot be used to estimate accurately the downstream distribution of flow.

Water-Quality Variations

Locations of chemical-quality sampling sites are shown in Figure 1; results of chemical analyses are given in Table 2. Profiles of the weighted-average chloride concentrations for the Sabine and Old Rivers are shown

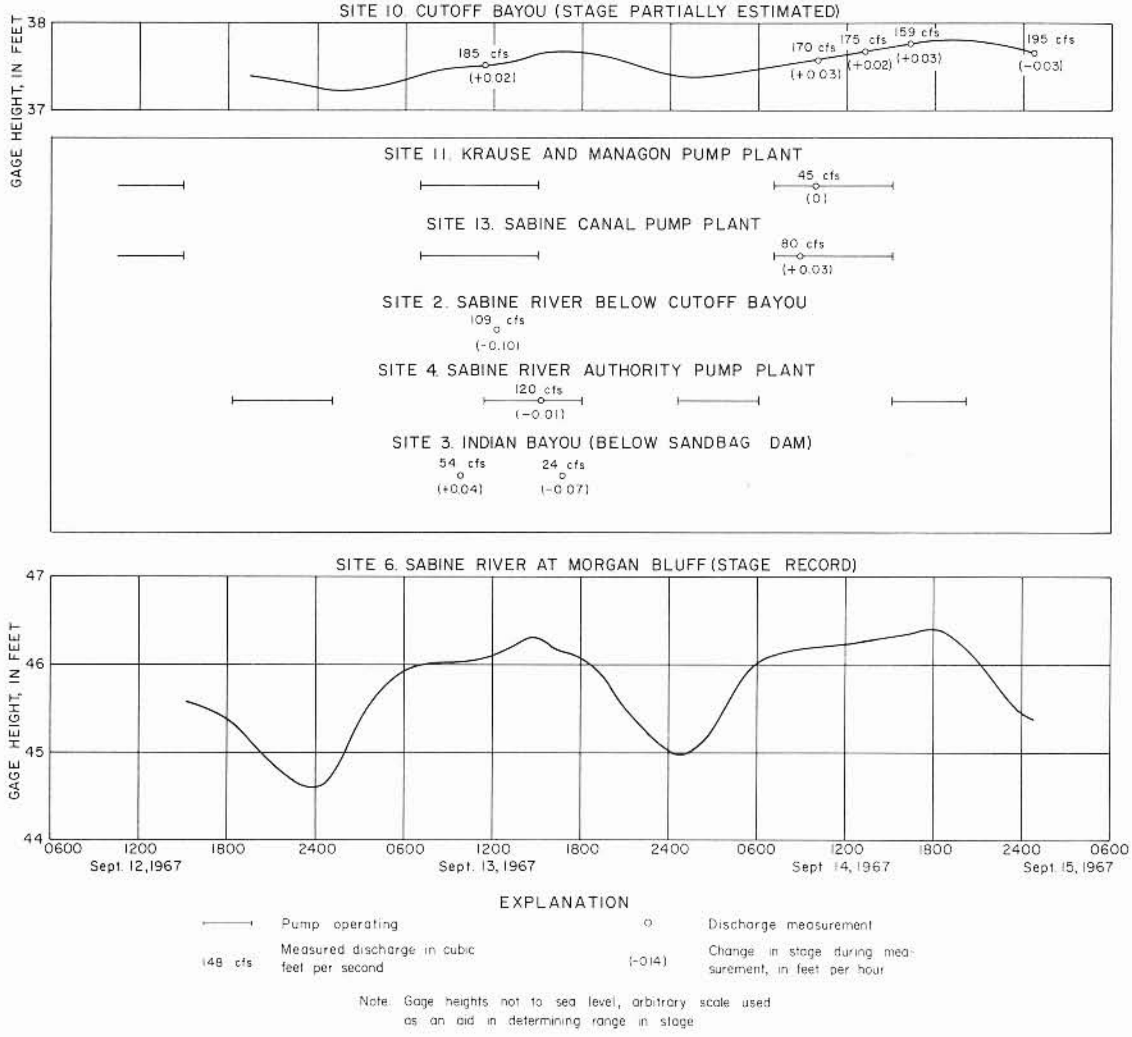

Figure 2.--Summary of Stage and Flow Data for the Tide-Affected Reaches of the Sabine and Old Rivers

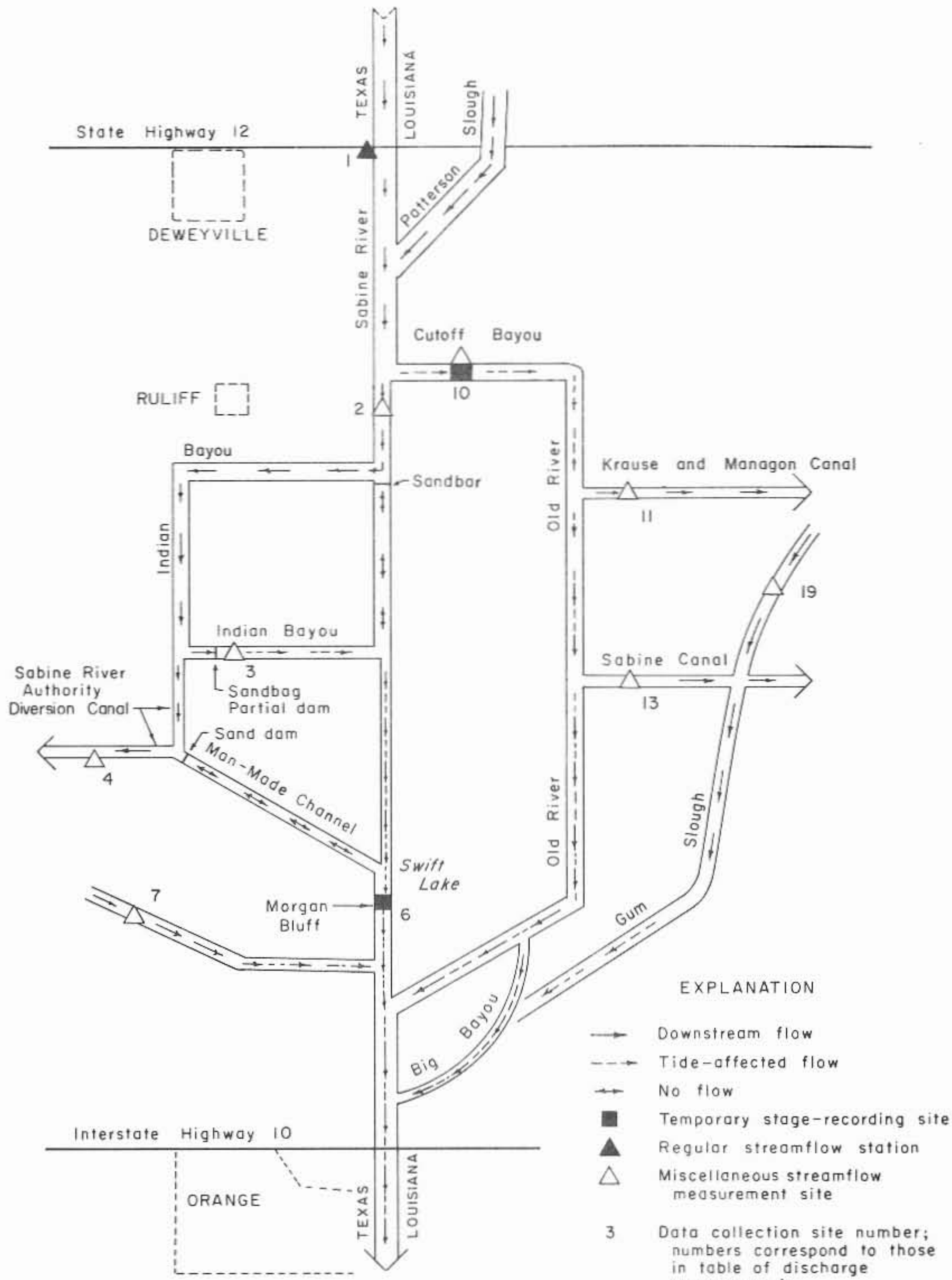

Figure 3

Tide-Affected Reaches of the Sabine and Old Rivers in Figure 4. Because samples were not collected from all sampling sites at the same tidal phase, the chloride profiles do not represent conditions that actually existed at any given time. Instead, the profiles show the average chloride concentration of water in each cross section at the time of sampling and the approximate extent of salt-water intrusion. In the following discussion the chloride profiles were used to subdivide the study area into six reaches.

Sabine River—Mile +22.6 to Mile +10.9

Data in Figure 4 and Table 2 show that the weighted-average chloride content of water in this 11.7-mile reach of the Sabine River increased from 21 ppm (parts per million) at site 1 (mile +22.6) to 60 ppm at site 5 (mile +10.9). Water at sites 1 and 2 was fresh and well mixed—the water contained 90 ppm dissolved solids and 21 ppm chloride at the surface, bottom, and intermediate depths (Figure 5). Although water at site 5 was fresh, the dissolved-mineral content was minimum at the surface and gradually increased with depth. Water at the surface contained 115 ppm dissolved solids and 37 ppm chloride, whereas water at the bottom contained 190 to 278 ppm dissolved solids and 75 to 129 ppm chloride. No tributary inflow was noted in this reach; thus, the downstream increase of dissolved minerals and the corresponding increase of dissolved minerals with increase in depth are attributed to the upstream intrusion of sea water.

Water throughout the upper part of the reach was well aerated; however, the dissolved-oxygen content decreased somewhat in the lower part of the reach. At site 1, water at the surface, bottom, and intermediate depths contained 6.7 ppm dissolved oxygen (86 percent of saturation). At site 5, water at the surface contained 5.7 to 6.3 ppm dissolved oxygen (72 to 80 percent of saturation), whereas water at the bottom contained 4.7 to 5.2 ppm (59 to 67 percent of saturation). Among the more significant factors that affect the dissolved-oxygen content of any stream are the amounts and nature of organic material present, the temperature and dissolved-mineral content of the water, bacterial activity, photosynthesis, and aeration from exposure to the atmosphere. Aeration is influenced greatly by the dissolved-oxygen deficiency; the character of the streambed; and the depth, volume, and velocity of flow. The downstream decrease of dissolved oxygen between sites 1 and 5 probably resulted from a combination of several of these factors. Because dissolved oxygen at

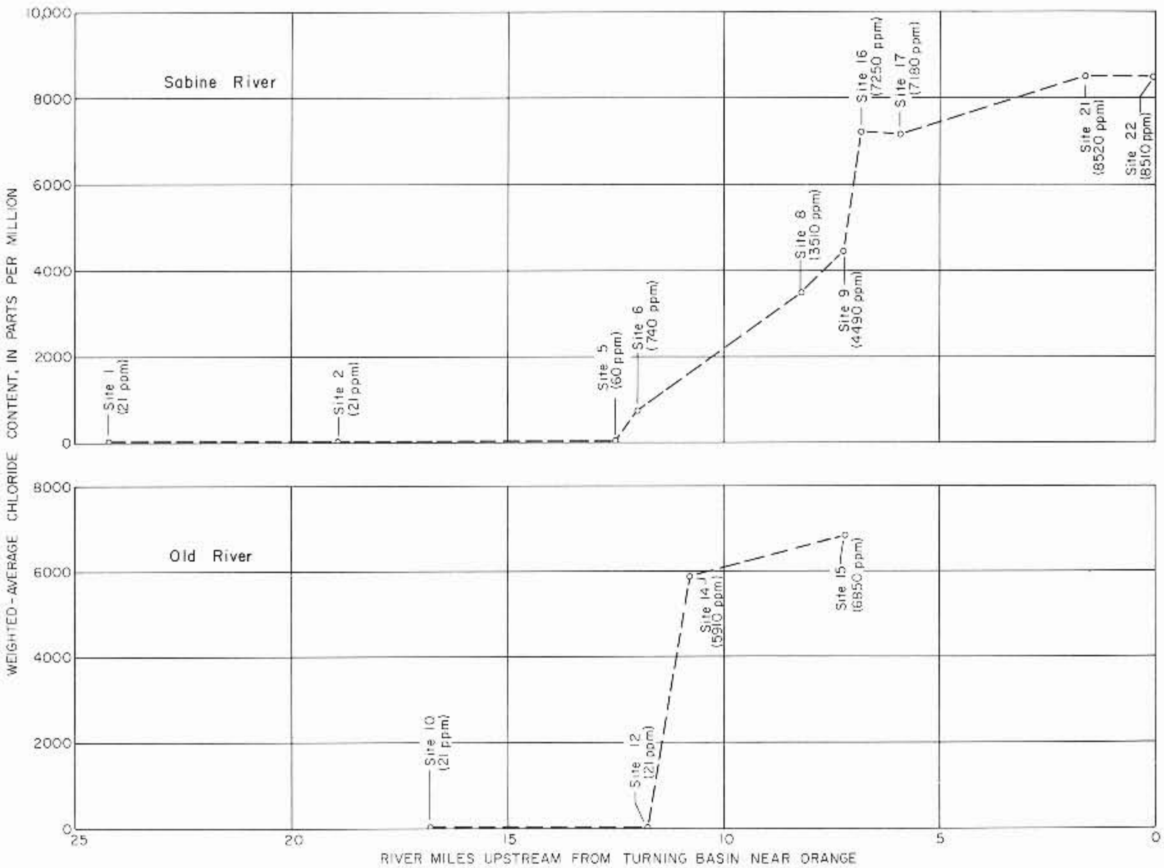

Figure 4.--Profiles of Weighted-Average Chloride in the Sabine and Old Rivers

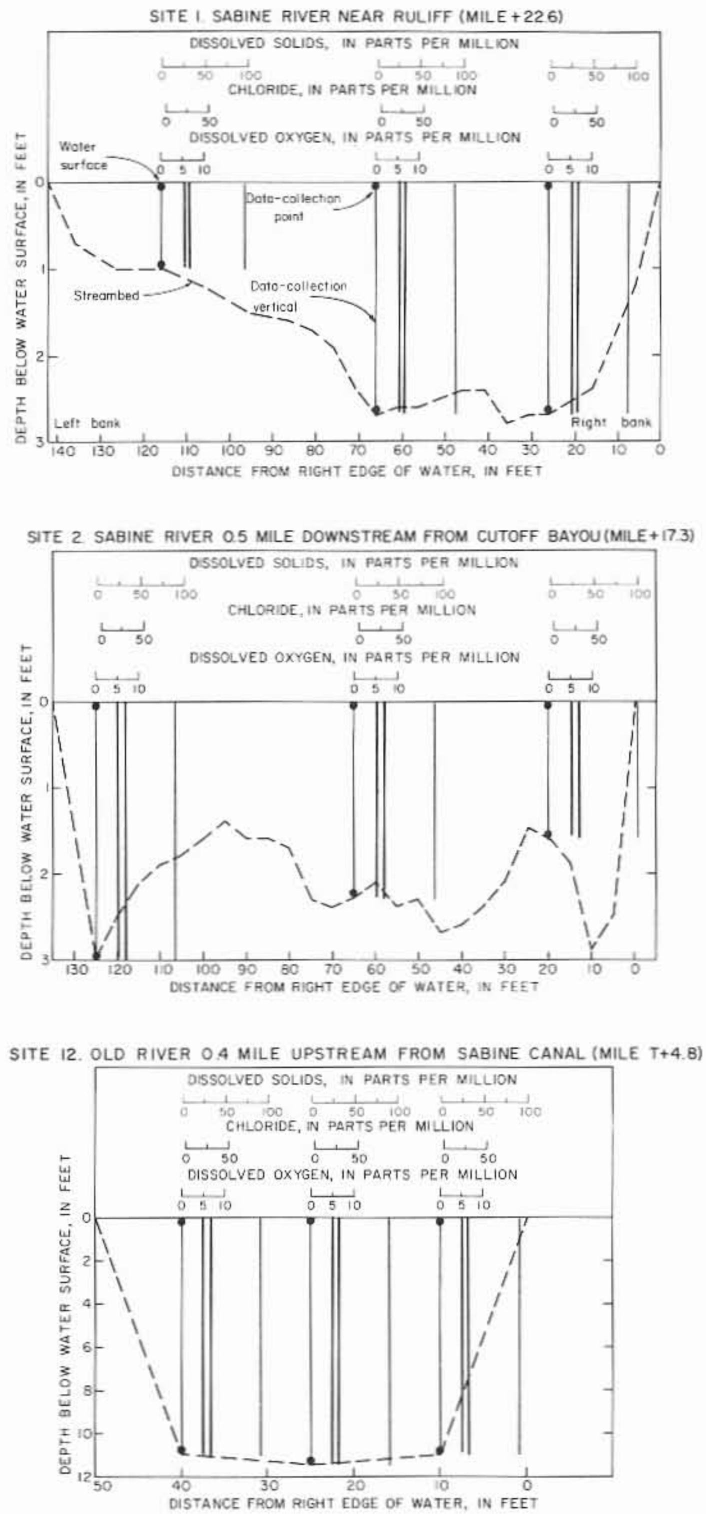

Figure 5

Sections Showing Variations of Dissolved Solids, Chloride, and Dissolved Oxygen at Three Sites in the Sabine and Old Rivers Upstream From the Advance of Sea Water

Table 2.--Chemical Analyses of Water From Streams in the Sabine River Basin Near Orange, Texas

(Results in parts per million except as indicated)

Date (1967)	Hour	Sampling point: Distance from right edge of water (feet)	Sampling point: Depth below water surface (feet)	Water temperature °F	Water temperature °C	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved oxygen (DO) ppm	Dissolved oxygen (DO) Percent saturation	Dissolved solids (calculated)	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness as $CaCO_3$ Noncarbonate	Specific conductance (micromhos at 25° C) Field	Specific conductance Lab	pH Field	pH Lab	Density (gm/ml at 20° C)
SITE 1. SABINE RIVER NEAR RULIFF (Mile -22.6)																								
Sept.12	1526	16	0	84	29.0								a21		6.7	86	90			135		6.9		
do	1526	16	2.4	84	29.0								a21		6.7	86	90			135		6.9		
do	1536	66	0	84	29.0	16	7.0	2.4	16	2.5	38	6.4	21	0.2	6.7	86	90	27	0	135	145	6.9	7.5	
do	1536	66	2.7	84	29.0								a21		6.7	86	90			135		6.9		
do	1543	116	0	84	29.0								a21		6.7	86	90			135		6.9		
do	1543	116	1.0	84	29.0								a21		6.7	86	90			135		6.9		
SITE 2. SABINE RIVER 0.5 MILE DOWNSTREAM FROM CUTOFF BAYOU (Mile +17.3)																								
Sept.13	1427	20	0	82	28.0								a21		6.9	87	90			135		7.0		
do	1427	20	1.6	82	28.0								a21		6.9	87	90			135		7.0		
do	1450	65	0	82	28.0								21		6.9	87	90			135		7.0		
do	1450	65	2.3	82	28.0								a21		6.9	87	90			135		7.0		
do	1515	125	0	82	28.0								a21		6.9	87	90			135		7.0		
do	1515	125	3.0	82	28.0								a21		6.9	87	90			135		7.0		
SITE 5. SABINE RIVER AT MORGAN EDDY (Mile +10.9)																								
Sept.14	1000	15	0	83	28.5								a37		5.7	72	115			175	--	7.0		
do	1000	15	5	83	28.5								a63		5.7	72	165			260	--	6.9		
do	1000	15	9	83	28.5	14	9.2	8.7	75	4.5	36	20	129	0.0	4.7	59	278	59	29	420	524	6.8	7.2	
do	1005	100	0	82	28.0								37		6.1	77	115			175	200	6.9		
do	1005	100	5	82	28.0								63		5.8	73	165			260	293	6.9		
do	1005	100	11.5	84	29.0								a102		5.0	64	240			370	--	6.9		
do	1010	135	0	82	28.0								a37		6.3	80	115			175	--	7.0		
do	1010	135	5	82	28.0								a63		5.4	68	165			260	--	6.9		
do	1010	135	9.5	84	29.0								a75		5.2	67	190			300	--	6.9		
SITE 6. SABINE RIVER AT MORGAN BLUFF (Mile -10.4)																								
Sept.14	0910	15	0	81	27.0	--	--	--	--	--	--	--	a106	--	6.2	77	245	--	--	380	--	6.9	--	
do	0910	15	6	81	27.0	--	--	--	--	--	--	--	106	--	6.1	75	245	--	--	380	442	7.0	--	
do	0912	75	0	82	27.5	--	--	--	--	--	--	--	a106	--	6.1	76	245	--	--	380	--	6.9	--	
do	0912	75	5	82	27.5	--	--	--	--	--	--	--	a106	--	5.5	69	245	--	--	380	--	6.9	--	
do	0914	75	10	82	27.5	14	17	30	256	11	40	64	458	0.8	5.0	63	871	166	133	1500	1670	6.9	7.1	
do	0914	75	12	82	27.5	14	28	60	516	21	44	128	940	1.0	3.2	40	1730	317	281	2800	3230	6.9	7.0	
do	0916	75	15	82	27.5	--	--	--	--	--	--	--	a4340	--	.5	7	7800	--	--	13000	--	6.9	--	
do	0918	75	20	82	27.5	--	--	--	--	--	--	--	5020	--	.5	7	9030	--	--	15000	15800	6.9	--	1.006
do	0920	135	0	82	27.5	--	--	--	--	--	--	--	a106	--	6.1	76	245	--	--	380	--	6.9	--	
do	0920	135	5	82	27.5	--	--	--	--	--	--	--	a106	--	6.1	76	245	--	--	380	--	6.9	--	
SITE 7. UNNAMED TRIBUTARY TO SABINE RIVER AT OLD TEXAS STATE HIGHWAY 87 (Mile T +1.4)																								
Sept.14	1150			82	28.0	7.3	9.5	3.0	52	2.8	40	8.8	80	0.2			184	36	3	345	--		6.8	
SITE 8. SABINE RIVER AT WEST BLUFF (Mile +6.6)																								
Sept.14	1110	50	0	88	31.0	--	--	--	--	--	--	--	a2100		5.1	69	3800	--	--	6700	--	7.1	--	
do	1112	50	2	89	31.5	--	--	--	--	--	--	--	a2100		5.0	68	3800	--	--	6700	--	7.0	--	
do	1114	50	5	90	32.0	--	--	--	--	--	--	--	a3300		2.4	33	5930	--	--	10200	--	7.0	--	
do	1116	50	7	90	32.5	--	--	--	--	--	--	--	a4820		1.2	17	8690	--	--	14500	--	7.0	--	
do	1118	50	9	90	32.5	--	--	--	--	--	--	--	a7250		.3	4	13000	--	--	21000	--	7.0	--	
do	1120	50	11	90	32.5	--	--	--	--	--	--	--	a7250		.3	4	13000	--	--	21000	--	7.0	--	

a Calculated from specific conductance.

(Continued)

Table 2.—Chemical Analyses of Water From Streams in the Sabine River Basin Near Orange, Texas—Continued

(Results in parts per million except as indicated)

Date (1967)	Hour	Sampling point: Distance from right edge of water (feet)	Sampling point: Depth below water surface (feet)	Water temperature °F	Water temperature °C	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved oxygen (DO) ppm	Dissolved oxygen (DO) Percent saturation	Dissolved solids (calculated)	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness as $CaCO_3$ Noncarbonate	Specific conductance (micromhos at 25° C) Field	Specific conductance Lab	pH Field	pH Lab	Density (gm/ml at 20° C)
SITE 8. SABINE RIVER AT WEST BLUFF (Mile +6.6)--Continued																								
Sept.14	1122	125	0	90	32.5	--	--	--	--	--	--	--	a2100		5.0	69	3800	--	--	6700	--	7.2	--	--
do	1124	125	2	91	33.0	--	--	--	--	--	--	--	a2100		4.5	63	3800	--	--	6700	--	7.1	--	--
do	1126	125	5	88	31.0	--	--	--	--	--	--	--	a3300		3.7	51	5930	--	--	10200	--	7.0	--	--
do	1128	125	7	88	31.0	--	--	--	--	--	--	--	a4820		2.0	28	8690	--	--	14500	--	7.0	--	--
do	1130	125	9.5	89	31.5	8.1	164	459	3960	146	91	969	7250	2.8	.3	4	13000	2300	2200	21000	21600	7.0	7.5	1.007
do	1132	220	0	88	31.0	12	53	133	1150	45	50	285	2100		5.4	73	3800	679	638	6700	6880	7.1	6.8	--
do	1134	220	3	89	31.5	--	--	--	--	--	--	--	2280		4.1	56	4140	--	--	7200	7280	7.0	--	--
do	1136	220	5	90	32.0	11	80	214	1860	69	60	455	3370		2.8	39	6090	1080	1030	10500	10800	6.9	6.8	1.002
do	1138	220	7	90	32.5	--	--	--	--	--	--	--	5020		1.4	20	9030	--	--	15000	15500	6.9	--	1.005
SITE 9. SABINE RIVER 100 YARDS UPSTREAM FROM MOUTH OF OLD RIVER (Mile +5.6)																								
Sept.14	1200	50	0	89	31.5								a1630		6.1	82	2970			5400	--	7.3		--
do	1202	50	2	89	31.5								a2320		5.3	73	4200			7300	--	7.2		--
do	1204	50	4	89	31.5								3540		3.4	47	6400			12000	11200	7.1		1.003
do	1206	50	6	90	32.0								a7500		.3	4	13500			22000	--	7.0		--
do	1208	50	8	91	33.0								a8660		.2	3	15600			24000	--	7.2		--
do	1210	50	10	91	33.0								a8660		.2	3	15600			24000	--	7.2		--
do	1212	125	0	92	33.5								1630		5.5	77	2970			5400	5380	7.3		--
do	1214	125	2	92	33.5								a2220		4.9	70	4000			7000	--	7.3		--
do	1216	125	5	91	33.0								a4820		1.7	25	8690			14500	--	7.1		--
do	1218	125	7	90	32.5								a8660		.3	4	15600			24000	--	7.1		--
do	1220	125	9	87	30.5								a8660		.3	4	15600			24000	--	7.2		--
do	1222	200	0	87	30.5	13	42	98	864	32	44	211	1560	2.0	6.2	83	2840	508	472	4800	5220	7.3	7.0	--
do	1224	200	2	87	30.5								a2150		5.9	80	3880			6700	--	7.2		--
do	1226	200	5	89	31.5								a5020		1.6	23	9030			15000	--	7.0		--
do	1230	200	7.5	90	32.5								8660		.3	4	15600			24000	25600	7.1		1.010
SITE 10. CUTOFF BAYOU 0.8 MILE DOWNSTREAM FROM SABINE RIVER (Mile T +9.8)																								
Sept.13	1104	8	0	81	27.0								a21		7.1	88	90			135		7.0		
do	1104	8	2.1	81	27.0								a21		7.1	88	90			135		7.0		
do	1120	41	0	81	27.0								a21		7.1	88	90			135		7.0		
do	1120	41	3.4	81	27.0								21		7.1	88	90			135	144	7.0		
do	1138	72	0	81	27.0								a21		7.1	88	90			135		7.0		
do	1138	72	3.5	81	27.0								a21		7.1	88	90			135		7.0		
SITE 12. OLD RIVER 0.4 MILE UPSTREAM FROM SABINE CANAL (Mile T +4.8)																								
Sept.13	1800	10	0	82	27.5								a21		6.4	80	90			135		7.0		
do	1800	10	11	82	27.5								a21		6.4	80	90			135		7.0		
do	1805	25	0	82	27.5								21		6.4	80	90			135	142	7.0		
do	1805	25	11.5	82	27.5								a21		6.4	80	90			135		7.0		
do	1810	40	0	82	27.5								a21		6.4	80	90			135		7.0		
do	1810	40	11	82	27.5								a21		6.4	80	90			135		7.0		
SITE 14. OLD RIVER 0.6 MILE DOWNSTREAM FROM SABINE CANAL (Mile T +3.8)																								
Sept.15	1000	20	0	81	27.0								a800		6.2	78	1500			2600	--	7.5		
do	1002	20	2	81	27.0								940		6.2	78	1730			2800	3240	7.4		
do	1004	20	5	82	28.0								a6400		.5	7	11500			19000	--	6.9		
do	1006	20	8	83	28.5								a8660		.5	7	15600			24000	--	6.9		
do	1008	20	13	83	28.5								8900		.5	7	16000			25000	26000	6.9		1.011

a Calculated from specific conductance.

(Continued)

Table 2.--Chemical Analyses of Water From Streams in the Sabine River Basin Near Orange, Texas--Continued

(Results in parts per million except as indicated)

Date (1967)	Hour	Sampling point: Distance from right edge of water (feet)	Sampling point: Depth below water surface (feet)	Water temperature °F	Water temperature °C	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved oxygen (DO) ppm	Dissolved oxygen (DO) Percent saturation	Dissolved solids (calculated)	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25° C) Field	Specific conductance Lab	pH Field	pH Lab	Density (gm/ml at 20° C)
SITE 14. OLD RIVER 0.6 MILE DOWNSTREAM FROM SABINE CANAL (Mile T +3.8)--Continued																								
Sept.15	1010	55	0	81	27.0								a800		6.2	78	1500			2600	--	7.5		
do	1012	55	2	81	27.0								a1050		6.2	78	1920			3400	--	7.0		
do	1014	55	5	83	28.5								a6950		.5	7	12500			20000	--	6.9		
do	1016	55	7	83	28.5								a8660		.5	7	15600			24000	--	6.9		
do	1018	55	12	83	28.5								a9000		.5	7	16200			26000	--	6.9		
SITE 15. OLD RIVER 300 YARDS UPSTREAM FROM MOUTH (Mile T +0.2)																								
Sept.14	1350	50	0	82	28.0								a1460		6.2	79	2650			4500	--	7.5		--
do	1352	50	3	82	28.0								a2560		6.0	78	4620			8000	--	7.1		--
do	1354	50	7	83	28.5								a7900		.3	4	14200			23000	--	7.1		--
do	1356	50	12	83	28.5								a8660		.3	4	15600			24000	--	7.1		--
do	1358	50	17	83	28.5								a9000		.3	4	16200			26000	--	7.2		--
do	1400	50	22	83	28.5								9590		.3	4	17200			27000	27800	7.2		1.011
do	1402	150	0	83	28.5								1460		6.2	79	2650			4500	4850	7.5		--
do	1404	150	5	83	28.5								a6950		.9	12	12500			20000	--	7.0		--
do	1406	150	10	83	28.5								a8660		.3	4	15600			24000	--	7.1		--
do	1408	150	15	83	28.5								a9000		.3	4	16200			26000	--	7.2		--
do	1410	150	20	84	29.0								a9000		.3	4	16200			26000	--	7.2		--
do	1412	200	0	84	29.0								a1460		6.2	81	2650			4500	--	7.5		--
do	1416	200	2	84	29.0								1850		6.2	81	3350			5800	6040	7.5		--
do	1418	200	4	85	29.5	10	102	272	2380	87	66	574	4340		3.7	50	7800	1370	1320	13000	13400	7.1	7.3	1.003
do	1420	200	7	85	29.5								a8660		.3	4	15600			24000	--	7.0		
do	1422	200	12	86	30.0								a8900		.3	4	16000			25000	--	7.1		--
do	1424	200	17	86	30.0								a9000		.3	4	16200			26000	--	7.2		--
do	1426	200	22	86	30.0								a9000		.3	4	16200			26000	--	7.2		--
SITE 16. SABINE RIVER 0.2 MILE DOWNSTREAM FROM MOUTH OF OLD RIVER (Mile +5.2)																								
Sept.14	1240	100	0	84	29.0								1340		6.3	82	2460			4300	4470	7.5		--
do	1242	100	2	84	29.0								2200		6.2	82	3990			7200	7040	7.4		--
do	1244	100	5	85	29.5								6950		.8	11	12500			19000	20800	7.1		1.007
do	1246	100	10	86	30.0								a8660		.3	4	15600			24000	--	7.2		--
do	1248	100	15	86	30.0								a8600		.3	4	15600			24000	--	7.4		--
do	1250	100	20	86	30.0								a8600		.3	4	15600			24000	--	7.4		--
do	1252	100	30	87	30.5	6.7	213	619	5340	196	115	1280	9650		.2	3	17400	3080	2980	27000	27800	7.4	7.1	1.010
do	1254	200	0	85	29.5								a1580		6.2	82	2900			5000	--	7.5		--
do	1256	200	5	85	29.5								a6200		1.7	23	11100			18500	--	7.2		--
do	1258	200	10	85	29.5								a8660		.3	4	15600			24000	--	7.3		--
do	1300	200	15	85	29.5								a9000		.3	4	16200			26000	--	7.4		--
do	1302	200	20	86	30.0								a9000		.3	4	16200			26000	--	7.4		--
do	1304	200	24	86	30.0								a9000		.3	4	16200			26000	--	7.4		--
do	1306	300	0	85	29.5								a1380		6.2	82	2540			4400	--	7.7		--
do	1308	300	5	85	29.5								a7250		.5	7	13000			21000	--	7.2		--
do	1310	300	8	85	29.5								a8660		.3	4	15600			24000	--	7.2		--
do	1312	300	13	86	30.0								a8900		.3	4	16000			25000	--	7.4		--
do	1314	300	18	87	30.5								a9000		.3	4	16200			26000	--	7.4		--
do	1316	300	23	87	30.5								a9000		.3	4	16200			26000	--	7.4		--
SITE 17. SABINE RIVER AT SOUTHERN PACIFIC RAILROAD CROSSING (Mile +4.3)																								
Sept.15	1115	50	0	82	28.0								a3050		6.2	81	5500			9500	--	7.4		--
do	1117	50	2	82	28.0								a3240		6.1	79	5850			10000	--	7.4		--
do	1119	50	5	83	28.5								a6950		1.5	21	12500			20000	--	7.1		--
do	1121	50	10	83	28.5								a8660		.3	4	15600			24000	--	7.1		--
do	1123	50	15	83	28.5								a9000		.3	4	16200			25000	--	7.1		--
do	1125	50	20	84	29.0								a9000		.3	4	16200			26000	--	7.0		--
do	1125	50	20	84	29.0								a9000		.3	4	16200			26000	--	7.0		--

a Calculated from specific conductance.

(Continued)

Table 2.—Chemical Analyses of Water From Streams in the Sabine River Basin Near Orange, Texas—Continued

(Results in parts per million except as indicated)

Date (1967)	Hour	Sampling point: Distance from right edge of water (feet)	Sampling point: Depth below water surface (feet)	Water temperature °F	Water temperature °C	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved oxygen (DO) ppm	Dissolved oxygen (DO) Percent saturation	Dissolved solids (calculated)	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25° C) Field	Specific conductance (micromhos at 25° C) Lab	pH Field	pH Lab	Density (gm/ml at 20° C)
SITE 17. SABINE RIVER AT SOUTHERN PACIFIC RAILROAD CROSSING (Mile +4.3)--Continued																								
Sept. 15	1127	100	0	82	28.0								a3240		6.2	81	5860			10000	--	7.4		--
do	1129	100	2	82	28.0								a3600		5.8	75	6500			11000	--	7.4		--
do	1131	100	5	83	28.5								a6950		1.5	21	12500			20000	--	7.1		--
do	1133	100	10	83	28.5								a8660		.3	4	15600			24000	--	7.1		--
do	1135	100	15	83	28.5								a9000		.3	4	16200			25000	--	7.0		--
do	1137	100	20	84	29.0								a9000		.3	4	16200			26000	--	7.0		--
do	1139	200	0	82	28.0								a2900		6.2	81	5220			9000	--	7.3		--
do	1141	200	2	82	28.0								3240		6.0	78	5850			10000	10300	7.2		1.002
do	1143	200	5	83	28.5	8.3	144	396	3430	126	81	851	6260		2.2	30	11300	1990	1920	18000	18900	7.1		1.006
do	1145	200	10	83	28.5								a8660		.3	4	15600			24000	--	7.0		--
do	1147	200	15	84	29.0								a9000		.3	4	16200			25000	--	7.0		--
do	1149	200	21	84	29.0								9000		.3	4	16200			25000	26000	7.0		1.011
SITE 18. BIG BAYOU 200 YARDS DOWNSTREAM FROM UPPER MOUTH (Mile T +5.4)																								
Sept. 15	1050	20	0	82	27.5								1680		6.3	80	3080			5300	5510	7.0		
do	1052	20	2	82	27.6	12	70	177	1560	58	54	380	2850		5.3	68	5130	902	858	8500	8970	6.9	7.0	
do	1054	20	4	82	28.0								a4300		3.4	45	7720			13000	--	6.9		
do	1056	20	5	83	28.5								4680		2.9	39	8460			14000	14000	6.9		1.004
SITE 19. GUM SLOUGH AT LOUISIANA STATE HIGHWAY 109 (Mile T +6.7)																								
Sept. 15	1100			82	28.0								102				220				421			
SITE 20. BIG BAYOU 300 YARDS UPSTREAM FROM LOWER MOUTH (Mile T +0.2)																								
Sept. 15	1205	100	0	84	29.0								a5520		3.8	52	9930			17000	--	7.0		--
do	1207	100	3	83	28.5								a6950		.9	12	12500			20000	--	7.0		--
do	1209	100	8	83	28.5								a8660		.5	4	15600			24000	--	7.0		--
do	1211	100	13	83	28.5								a8660		.3	4	15600			24000	--	7.0		--
do	1213	100	18	83	28.5								a8660		.3	4	15600			24000	--	7.0		--
do	1215	175	0	83	28.5	8.5	131	350	3020	109	74	756	5520		3.9	53	9930	1770	1710	17000	16900	7.0	6.9	1.005
do	1217	175	2	83	28.5								a6950		1.5	21	12500			20000	--	7.0		--
do	1219	175	5	83	28.5								a7500		.8	11	13500			22000	--	7.0		--
do	1221	175	10	83	28.5								a8660		.3	4	15600			24000	--	7.0		--
do	1223	175	17	83	28.5								8660		.3	4	15600			24000	25500	7.0		1.010

a Calculated from specific conductance.

Table 2.--Chemical Analyses of Water From Streams in the Sabine River Basin Near Orange, Texas--Continued

(Results in parts per million except as indicated)

Date (1967)	Hour	Sampling point: Distance from right edge of water (feet)	Sampling point: Depth below water surface (feet)	Water temperature °F	Water temperature °C	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved oxygen (DO) ppm	Dissolved oxygen (DO) Percent saturation	Dissolved solids (calculated)	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25° C) Field	Specific conductance (micromhos at 25° C) Lab	pH Field	pH Lab	Density (gm/ml at 20° C)
SITE 21. SABINE RIVER AT INTERSTATE HIGHWAY 10 (Mile 0.0)																								
Sept. 15	1345	200	0	84	29.0	--	--	--	--	--	--	--	6550		5.1	70	11800	--	--		19700		--	1.007
do	1347	200	4	83	28.5	--	--	--	--	--	--	--	7640		1.7	23	13700	--	--		22500		--	1.008
do	1349	200	8	83	28.5	--	--	--	--	--	--	--	8230		.7	10	14800	--	--		24200		--	1.009
do	1351	200	13	83	28.5	--	--	--	--	--	--	--	8910		.3	4	16000	--	--		26000		--	1.010
do	1353	200	18	83	28.5	--	--	--	--	--	--	--	9210		.3	4	16500	--	--		26700		--	1.010
do	1355	200	23	83	28.5	--	--	--	--	--	--	--	9500		.3	4	17100	--	--		27400		--	1.011
do	1357	200	28	83	28.5	--	--	--	--	--	--	--	9790		.3	4	17600	--	--		28500		--	1.011
do	1359	200	33	83	28.5	--	--	--	--	--	--	--	9940		.3	4	17800	--	--		28600		--	1.011
do	1401	200	38	84	29.0	5.5	225	640	5470	204	113	1340	9980	5.2	.3	4	17900	3190	3100		28700		7.2	1.012
do	1403	300	0	84	29.0	--	--	--	--	--	--	--	5960		5.1	70	10700	--	--		18300		--	1.007
do	1405	300	4	83	28.5	--	--	--	--	--	--	--	7690		1.2	16	13800	--	--		22800		--	1.008
do	1407	300	8	83	28.5	5.5	193	531	4610	167	93	1110	8370		.5	7	15000	2670	2590		24800		7.1	1.010
do	1409	300	13	83	28.5	--	--	--	--	--	--	--	8810		.4	6	15800	--	--		25800		--	1.010
do	1411	300	18	83	28.5	--	--	--	--	--	--	--	9210		.3	4	16500	--	--		26800		--	1.010
do	1413	300	23	83	28.5	--	--	--	--	--	--	--	9450		.3	4	17000	--	--		27600		--	1.011
do	1415	300	28	83	28.5	--	--	--	--	--	--	--	9640		.3	4	17300	--	--		28000		--	1.011
SITE 22. SABINE RIVER AT HEAD OF TURNING BASIN NEAR ORANGE (Mile -1.6)																								
Sept. 15	1435	100	0	84	29.0								6600		4.7	64	11900				19900			1.007
do	1437	100	5	83	28.5								7980		1.4	19	14300				23800			1.009
do	1439	100	10	83	28.5								8660		.6	8	15600				25600			1.010
do	1441	100	15	83	28.5								8910		.3	4	16000				26200			1.010
do	1443	200	0	84	29.0								6600		4.7	64	11900				20000			1.007
do	1445	200	5	83	28.5								8030		1.4	19	14400				23900			1.009
do	1447	200	10	83	28.5								8510		.8	11	15300				25300			1.010
do	1449	200	15	83	28.5								8760		.2	3	15700				25900			1.010
do	1451	200	20	83	28.5								9060		.2	3	16300				26600			1.010
do	1453	200	25	83	28.5								9500		0	0	17100				27800			1.010
do	1455	200	30	83	28.5	4.9	217	613	5390	196	113	1290	9680	5.5	0	0	17500	3060	2970		28300		7.1	1.012
do	1457	300	0	84	29.0								6940		4.7	64	12500				20900			1.009
do	1459	300	5	83	28.5								7890		1.4	19	14200				23500			1.008
do	1501	300	10	83	28.5								8330		.8	11	15000				24600			1.009
do	1503	300	15	83	28.5								9160		.2	3	16400				26800			1.010
do	1505	300	20	83	28.5								9260		.2	3	16600				27300			1.010
do	1507	300	25	83	28.5								9590		0	0	17200				28100			1.011
do	1509	300	30	83	28.5								9690		0	0	17300				28200			1.010

a Calculated from specific conductance.

different sites was measured at different times of the day, differences in photosynthetic activity and water temperature probably caused some variation in the observed concentrations of dissolved oxygen. More important, as the water moves downstream through the profuse vegetation, it picks up natural organic debris, the oxidation of which utilizes dissolved oxygen. Moreover, according to Forrest and Cotton (1966, p. 12-13), the dissolved-oxygen content of water in the lower reaches of the Sabine River is being depleted by pollution. The tidal intrusion of this polluted water upstream would result in depletion of dissolved oxygen at upstream sites. Furthermore, because the stream gradient decreases and the channel widens in the downstream direction, velocity and turbulence decrease; thus, the rate of aeration decreases. The velocity and rate of aeration periodically are decreased still further by the rising tide.

Sabine River—Mile +10.9 to Mile +5.6

The chloride profile (Figure 4) shows that the weighted-average chloride content of water in this reach increased from 60 ppm at site 5 (mile +10.9) to about 4,500 ppm at site 9 (mile +5.6). Although water at site 5 was fresh, Figure 6 shows that salt water advanced as far upstream as site 6 (mile +10.4). At site 6, mixing was poor and considerable horizontal stratification of fresh and salt water occurred. Water from the surface to a depth of about 6 feet contained 245 ppm dissolved solids and 106 ppm chloride; water below a depth of 15 feet contained more than 7,800 ppm dissolved solids and 4,300 ppm chloride. The dissolved-oxygen content of the water also varied greatly with increase in depth. Water at the surface contained 6.1 to 6.2 ppm dissolved oxygen; below a depth of 15 feet, the water contained 0.5 ppm. Although the decrease of dissolved oxygen roughly coincided with the increase in salinity, the increase in salinity was responsible for only a small part of the decrease in dissolved oxygen. The solubility of oxygen in water decreases as the salinity increases; however, the amount of oxygen dissolved by sea water in equilibrium with air is about 80 percent of that dissolved by fresh water. At site 6, water at the surface was 76 to 77 percent saturated with dissolved oxygen; below a depth of 15 feet, the water was only 7 percent saturated. These data indicate that much of the dissolved-oxygen deficit resulted from the oxidation of organic material. Although the source of the organic material was not ascertained, the fact that water which was deficient in dissolved oxygen was also the more saline water indicates that the organic material was from downstream sources.

Although erosion of the salt-water wedge by fresh-water currents and turbulence caused some mixing at downstream sites, the salinity and dissolved-oxygen gradient at site 9 (mile +5.6) near the mouth of Old River remained large. Water at the surface contained 2,840 to 2,970 ppm dissolved solids, 1,560 to 1,630 ppm chloride, and 5.5 to 6.2 ppm dissolved oxygen. Bottom water contained 15,600 ppm dissolved solids, 8,660 ppm chloride, and 0.2 to 0.3 ppm dissolved oxygen.

Old River—Mile T +10.5 to Mile T +4.8

Water in the upper 5.7-mile reach of the Old River was fresh, well aerated, and similar in chemical character to water in the upstream reach of the mainstem Sabine River (Figure 5). Water at sites 10 (mile T +9.8) and 12 (mile T +4.8) contained 90 ppm dissolved solids, 21 ppm chloride, and 6.4 to 7.1 ppm dissolved oxygen.

Old River—Mile T +4.8 to Mile T 0.0

Figure 4 shows that the weighted-average chloride content in this reach increased from 21 ppm at site 12 (mile T +4.8) to more than 6,800 ppm at site 15 (mile T +0.2). Salt water was detected as far upstream as site 14 (mile T +3.8). At this site, mixing was poor and the interface between waters with different salinities and concentrations of dissolved oxygen was fairly sharp (Figure 6). Water at the surface contained 1,500 ppm dissolved solids, 800 ppm chloride, and 6.2 ppm dissolved oxygen (78 percent of saturation). Below a depth of 7 feet, the water contained more than 15,500 ppm dissolved solids, 8,600 ppm chloride, and 0.5 ppm dissolved oxygen (7 percent of saturation).

At site 15, near the mouth of Old River, the dissolved-solids and chloride concentrations of water at the surface were 2,650 ppm and 1,460 ppm, respectively. The salinity gradient from surface to bottom remained large—water at the bottom contained 16,200 to 17,200 ppm dissolved solids and 9,000 to 9,590 ppm chloride. The dissolved-oxygen content also varied greatly with depth. The upper 2 feet of water contained 6.2 ppm dissolved oxygen (79 to 81 percent of saturation); below a depth of 7 feet, the dissolved oxygen decreased abruptly to 0.3 ppm (4 percent of saturation).

Sabine River—Mile +5.6 to Mile -1.6

The weighted-average chloride concentration of water in this 7.2-mile reach increased from about 4,500 ppm at site 9 (mile +5.6) to more than 8,500 ppm at site 22 (mile -1.6). Much of the increase occurred in the upper 0.4 mile of this reach (Figure 4). At site 16 (mile +5.2), for example, the average chloride content of the water was more than 7,200 ppm. In the 0.4-mile reach between sites 9 and 16, depths of water increase abruptly in the downstream direction—from about 10 feet at site 9 to more than 20 feet at site 16 (Table 2). This abrupt increase in depth is a natural barrier to the upstream advance of salt water (Rawson, Reddy, and Smith, 1967, p. 20). Nevertheless, some salt water spilled over the barrier and advanced farther upstream in the mainstem Sabine River. However, the quantity was considerably less than that which advanced into Old River where no such abrupt change in depth occurred (Figure 4).

Although mixing of fresh and salt water generally increased downstream from site 16, complete mixing was not attained. At site 22, the lowermost site in the study area, water at the surface contained 11,900 to 12,500 ppm dissolved solids and 6,600 to 6,940 ppm chloride, whereas water at the bottom contained 16,000 to 17,500 ppm dissolved solids and 8,910 to 9,690 ppm chloride. The dissolved-oxygen content of the water decreased from 4.7 ppm at the surface to 0 ppm below depths of 20 feet.

Big Bayou—Mile T +5.5 to Mile T 0.0

About 0.7 mile upstream from its mouth, Old River branches and part of the flow enters Big Bayou (Figure 1). Big Bayou flows for about 5.5 miles in Louisiana and then joins the Sabine River. The weighted-average chloride content of water in Big Bayou increased from 2,770 ppm at site 18 (mile T +5.4) to 7,830 ppm at site 20 (mile T +0.2). Mixing of the water increased in the downstream direction, but complete homogeneity was not attained. At site 20, for example, water at the surface contained 9,930 ppm dissolved solids, 5,520 ppm chloride, and 3.8 to 3.9 ppm dissolved oxygen; water at the bottom contained 15,600 ppm dissolved solids, 8,660 ppm chloride, and 0.3 ppm dissolved oxygen.

Inflow From Tributaries

Measured tributary inflow to the study reach totaled only about 2.2 cfs—0.2 cfs from an unnamed tributary (site 7) and 2 cfs from Gum Slough (site 19). Water in the unnamed tributary contained 184 ppm dissolved solids and 80 ppm chloride; water in Gum Slough contained 220 ppm dissolved solids and 102 ppm chloride.

SUMMARY OF CONCLUSIONS

During the period September 12-15, 1967, measured tributary inflow to the Sabine and Old Rivers between the stream-gaging station Sabine River near Ruliff and the ship-turning basin near Orange totaled about 2.2 cfs. Streamflow of the Sabine River at the station near Ruliff averaged about 305 cfs and receded fairly uniformly from about 315 cfs on September 12 to about 300 cfs on September 15. Downstream from the Ruliff Station, the distribution of flow between the Sabine River and Old River anabranch varied considerably in response to changes in stage produced by tidal fluctuations and pumping. Therefore, under the conditions that existed during the study, no accurate method can be devised for estimating the distribution of flow between the Sabine and Old Rivers.

Previous investigations (Rawson, Reddy, and Smith, 1967, p. 21) indicated that during low-flow periods the daily inflow that enters the mainstem Sabine River through Indian Bayou could be estimated from streamflow records of the upstream station Sabine River near Ruliff. However, because of changes in channel conditions produced by the construction of dams in Indian Bayou, use of streamflow records of the Sabine River near Ruliff for estimating the daily inflow at downstream sites is no longer possible.

Because the lower reach of the Sabine River is tidal, sea water from the Gulf of Mexico periodically intrudes through Sabine Lake into both the Sabine and Old Rivers. During this investigation, water in the 11.7-mile reach of the Sabine River between the Ruliff station and Morgan Eddy and the upper 5.7-mile reach of the Old River was fresh and well aerated. Water throughout much of these reaches contained less than 100 ppm dissolved solids and 25 ppm chloride and more than 6.0 ppm dissolved oxygen. Farther seaward, the intrusion of sea water resulted in a large increase in the concentrations of dissolved solids and chloride in both the Sabine and Old Rivers. Although mixing of fresh water with sea water increased seaward, complete homogeneity was not attained. At the head of the ship-turning basin near Orange, the lowermost site in the study area, water at the surface contained 11,900 to 12,500 ppm dissolved solids and 6,600 to 6,940 ppm chloride, whereas water at the bottom contained 16,000 to 17,500 ppm dissolved solids and 8,910 to 9,690 ppm chloride. The dissolved-oxygen content of the water at this site decreased from 4.7 ppm at the surface to 0 ppm below depths of 20 feet.

Dissolved-oxygen concentrations in the reach affected by salt-water intrusion generally decreased greatly with depth. Although the decrease of dissolved oxygen coincided roughly with the increase in salinity, only a small part of the dissolved-oxygen deficit resulted from the increase in salinity. Much of the deficit probably resulted from the oxidation of organic pollutants pushed upstream by the periodic rise of the tide.

REFERENCES

Forrest and Cotton, 1966, Water quality study: Sabine River Authority of Texas duplicated rept. 22 p.

Rawson, Jack, Reddy, D. R., and Smith, R. E., 1967, Low-flow studies, Sabine and Old Rivers near Orange, Texas, quantity and quality, April 12, October 31 - November 4, 1966: Texas Water Devel. Board Rept. 66, 23 p.