FLOW AND SALINITY CHARACTERISTICS OF THE SANTEE RIVER ESTUARY, SOUTH CAROLINA

by
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ABSTRACT

A characterization of the relationships among streamflow, tide stage, and specific electrical conductance of water in the Santee River Estuary was the primary objective of this study. Conductivity, temperature, and stage data were collected from October 1996 through August 2002. Three stations, two on the South Santee River and one on the North Santee River, continuously recorded conductivity and temperature data. Stage data were also collected at each station. Longitudinal conductivity profiles of both distributaries were completed.

The flow characteristics for the study period were atypical compared to the flow characteristics since rediversion of the Santee River flow in 1985, based on computed streamflow at Jamestown and dam-release data reported by South Carolina Public Service Authority. Streamflow averaged 11,000 cfs (cubic feet per second) between October 1986 and August 2002. Between October 1997 and September 1998, it averaged 18,000 cfs, and between October 1998 and August 2002 average streamflow decreased to less than 3,700 cfs.

Regression analysis was used to quantify the relationships among streamflow, specific conductance, tide stage, and tide height. Strong correlations ($R^2 > 0.86$) exist between streamflow at Jamestown and dam releases. Good correlations also were found with specific conductance between stations ($0.72 < R^2 < 0.95$). The inverse relationship between dam releases and specific conductance at the stations was quantified. The relationship between dam releases and specific conductance along each river was quantified from longitudinal-profile data. The equations for these relationships can be used to estimate streamflow in the estuary from dam-release data, predict specific conductance at each station, and locate the saltwater interface in each distributary for a specified streamflow condition.

INTRODUCTION

Specific conductance, an indirect measure of dissolved mineral matter in water, is a critical factor in the health of fauna and flora in the Santee River Estuary. Knowing and predicting the specific conductance along a reach is essential to decision making by environmental managers. Specific conductance in the North Santee and South Santee Rivers is controlled by the rate of flow in the rivers and the height of the tide; the former is largely dependent on dam releases by the South Carolina Public Service Authority, referred to hereafter as Santee Cooper.

PURPOSE AND SCOPE

The focus of this study is the characterization of the relationships among specific conductance of water in the Santee River estuary, streamflow, and tide stage and height. Specifically, the purpose is to provide a means of predicting specific conductance to facilitate wetland management at the Santee Coastal Reserve. The study period for these analyses is December 1996 through August 2002. Data collection is ongoing as of this writing.

PREVIOUS STUDIES

Several studies have addressed the conditions of the Santee River and water-quality effects related to the construction of dams and water-management practices. These resulted in reports by the United States Army Corp of Engineers (1966), United States Environmental Protection Agency (1973), and Kjerve (1976).

A number of investigations of the lower reaches of the Santee River were made prior to 1985, before the implementation of current water management practices. Cummings (1970) studied the water quality of the Santee River Estuary from July 1968 to August 1969: he found that saltwater penetrated 5 miles upstream in the North and South Santee Rivers at high tide under normal water releases of 500 to 600 cfs. Nelson (1976) assessed biological and physical parameters, particularly water quality, of the lower Santee River. Kjerfve and Greer (1978) evaluated salinity of the estuary during February and March 1975 under moderate (13,900 and 15,600 cfs) streamflow conditions. Mathews and others (1981) and Mathews and Shealy (1982) briefly described the salinity regimes of the Santee estuary during 1975 and 1976. They noted that the North and South Santee Rivers had similar salinity regimes, despite the much greater streamflow in the North Santee River. The South Santee River was slightly more saline than the North Santee River, and the salinity gradients in the North and South Santee were 4.7 and 3.9 ppt (parts per thousand) per mile, respectively, near the mouth of each river.

Salinity and streamflow relationships have been studied since 1985 when the current water-management practices were implemented by Santee Cooper. Orlando and others (1994) briefly characterized the structure and variability of salinity and identified dominant physical processes affecting 15 major South Atlantic estuaries, including the Santee River Estuary. Data were collected periodically from 1986 through 1992; streamflows ranged from 2,100 to 16,000 cfs. Hockensmith (2000) described the salinity variations in the

Santee estuary during high and low (36,000 and 1,000 cfs, respectively) streamflow conditions during 1997 and 1998.

APPROACH

Analyses were made to qualify and quantify the relationships among specific conductance, streamflow, and tide stage (high vs. low) and height in the Santee River Estuary. A statistical approach using regression, which determines the best-fit equation between an independent and a dependent variable, was used on data collected in the Santee, North Santee, and South Santee Rivers.

Regressions are evaluated by the square of the correlation coefficient (R^2). R^2, also known as *goodness of fit*, is the square of the correlation coefficient for a pair of data sets and can be interpreted as the proportion of variance in the Y variable attributed to the variance in the X variable. Typically, an R^2 value equal to or greater than 0.9 is considered excellent, and a value between 0.9 and 0.8 is considered good. An R^2 of 0.7 was set as an acceptable regression model.

GENERAL HYDROLOGY OF THE STUDY AREA

The Santee River has its headwaters in the Blue Ridge Mountains of North Carolina, passes through much of South Carolina, and drains into the Atlantic Ocean through the North Santee and South Santee Rivers. Its drainage basin, at 17,000 square miles, is the second largest in the Eastern United States.

The Santee River Estuary is a coastal plain, drowned river valley system (Mathews and others, 1981; National Oceanic and Atmospheric Administration, 1990) comprising the Santee River and its two distributaries: the North and South Santee Rivers. It is located approximately 45 miles northeast of Charleston and 17 miles south of Georgetown (Fig. 1).

Prior to 1941, the Santee River had the fourth largest streamflow of any river on the U.S. Atlantic Coast. Lake Marion was formed behind Wilson Dam, on the Santee River, in 1941 as part of a hydroelectric project. An estimated 86 to 90 percent of the Santee River's flow was

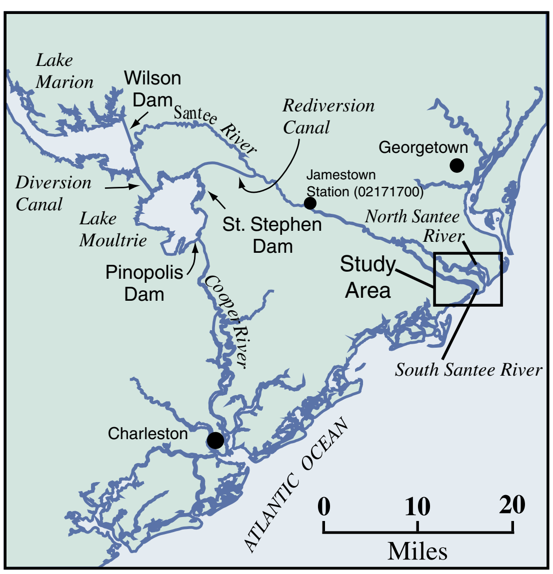


Figure 1. Location of study area.

diverted at that time to the Cooper River through a canal from Lake Marion to Lake Moultrie (Kjerfve and Greer, 1978; Hayes and others, 1993; Orlando and others, 1994). The annual mean discharge (arithmetic mean of individual daily mean discharges for one year) of the Santee River below the dam was reduced from 18,500 to 2,600 cfs (cubic feet per second), thus allowing saltwater intrusion upstream from the ocean.

After 1985, much of the streamflow to the Cooper River was rediverted from Lake Moultrie back into the Santee River. The increased flow caused salinity to decrease dramatically in the estuary. All inflow that enters the Lake Marion and Lake Moultrie system is returned to the Santee River, except for a daily average of 4,500 cfs that goes into the Cooper River (Preston Collins, Santee Cooper, oral communication, 1999). A minimum of 600 cfs enters the Santee River at the Wilson Dam spillway to run a small turbine. Most additional discharge to the Santee River comes from the St. Stephen Dam, through the rediversion canal, and spilling from Wilson Dam. The North Santee is the main channel of the two distributaries, transmitting an estimated 73 to 85 percent of the Santee River's flow (Cummings, 1970; Kjerfve and Greer, 1978). Factors that influence the amount of streamflow in the Santee River include discharge from the lakes, precipitation, evapotranspiration, and recharge and discharge to and from swamps and underlying aquifers. This may account for the instances where streamflow into Lake Marion exceeds the total releases from Lake Moultrie to the Cooper and Santee Rivers and from Lake Marion to the Santee River.

Streamflow in the lower reaches of the Santee River is influenced by interactions with the Tertiary sand aquifer and other shallow aquifers. A potentiometric map of the Tertiary sand aquifer (Hockensmith, 2001) suggests that northwestern Lake Moultrie gains water from the Tertiary sand aquifer while southeastern Lake Moultrie loses water to this aquifer. Downstream of the Wilson dam, along the Santee River, part of the streamflow is contributed by aquifer discharge. The Santee River streamflow is moderated by shallow aquifers that store water during overbank and high flows (bank storage) and subsequently discharge to the river when overbank flow ceases.

The climate for the region is mild, with an average temperature of 64 degrees and average maximum and minimum of 75 and 53 degrees F, respectively. Average annual precipitation is 52 inches.

From 1997 through August 2002, the weather in South Carolina was significantly influenced by the El Nino/La Nina processes in the equatorial Pacific, and the State experienced a wide range of precipitation (Hope Mizzell, South Carolina Department of Natural Resources, written communication, October 2001). The El Nino warm-water pool that migrated to the eastern Pacific Ocean in 1997 resulted in warm and wet conditions for South Carolina during the 1997-1998 winter. The El Nino warm phase was followed by the La Nina cold phase in the equatorial Pacific, which persisted from summer 1998 into 2001. The La Nina process brought drought conditions to South Carolina that persisted until the fall of 2002.

Data from the weather station nearest the study area, located in Georgetown, reflect these phenomenona (Fig. 2). During the winter of 1997-1998, monthly precipitation at Georgetown was as much as 9 inches above the 30-year mean (1971-2001). Precipitation had been below normal since the winter of 1998, with most exceptions resulting from Hurricanes Floyd, Irene, and Gordon in September 1999, October 1999, and September 2000, respectively, and from Tropical Storm Allison in June 2001.

The Santee delta is classified as a mixed-energy delta because the sediment load of the rivers is modest compared to other rivers, and wave and tidal forces influence the outer margins of the delta with similar efficiency (Hayes and others, 1993). The river incised valleys into underlying sediments during glacial and interglacial times, and the valleys later filled with fluvial and deltaic sediments as they were flooded during the Holocene sea-level rise (Aburawi, 1968). Average depth of the estuary is about 8 ft (feet) at midtide level (National Oceanic and Atmospheric Administration, 1990), with depth ranging from less than 1 ft to more than 36 ft throughout the system.

Tides in the Santee River Estuary are semidiurnal, there being two high and two low tides per day, and they are of roughly the same magnitude. Most tidal exchange occurs through the mouths of the North and South Santee Rivers. Some exchange occurs also through the AIWW (Atlantic Intracoastal Waterway) (Mathews and Shealy, 1982), which is connected to other saltwater bodies to the north and southwest. The Santee River is tidally affected at least as far upstream as Jamestown. Spring tides at the mouth of the Santee River Estuary have a range of about 8 ft.

Salinity variability is dependent upon streamflow, tidal fluctuations, wind, mixing and diffusion, interestuary exchange, and meteorological events. According to Orlando and others (1994), freshwater inflow is the dominant influence on the salinity structure of the estuary on a time scale of months or seasons. This also is the case from year to year, with less freshwater inflow during dry years and subsequently higher salinity levels during low-flow periods. Tides are the dominant influence on salinity on an hourly basis, particularly in the middle to lower reaches of the estuary. Wind, reportedly, has a secondary, seasonal effect and a minor short-term effect. Tidal exchanges with Winyah Bay and other bodies through the AIWW have a minor effect on the salinity structure of the Santee estuary (Mathews and Shealy, 1982).

ACKNOWLEDGMENTS

Gratitude is owed to Tommy Strange, Bill Mace, Andrew Jackson, Roger Jenkins, and Gail Fuller at the Santee Coastal Reserve for their assistance in data collection. Many thanks to Preston Collins of Santee Cooper for providing dam-release data and to Paul Drews of the United States Geological Survey for streamflow data.

DATA COLLECTION

Direct measurements of conductivity, temperature, and stage at three stations were used in this analysis. Conductivity and temperature were measured at river mile 7.9 on the South Santee River (SS8), at the Santee Coastal Reserve pier, beginning in October 1996 (Fig. 3) by the Department of Natural Resources (DNR); river stage was measured by the United States Geological Survey (USGS) at their station 02171905. Conductivity, temperature, and stage were measured at South Santee River mile 6.7 (SS7) and North Santee River mile 3.6 (NS4) beginning in December 1997 by DNR.

Stage data in the lower reaches of the Santee River basin were collected as early as 1929 by federal agencies, and most recently by the USGS. Currently, three USGS stations record stage data in the study area (Fig. 3.). Discharge at the USGS station at Jamestown (02171700) was computed

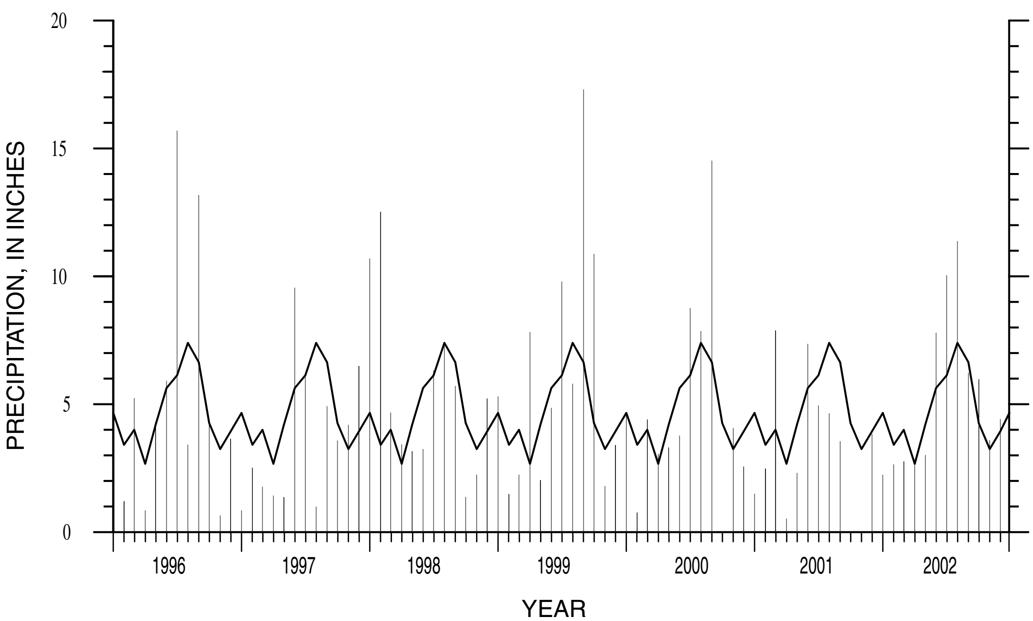


Figure 2. Monthly precipitation at Georgetown, S.C., January 1996 to December 2002 (National Climate Data Center).

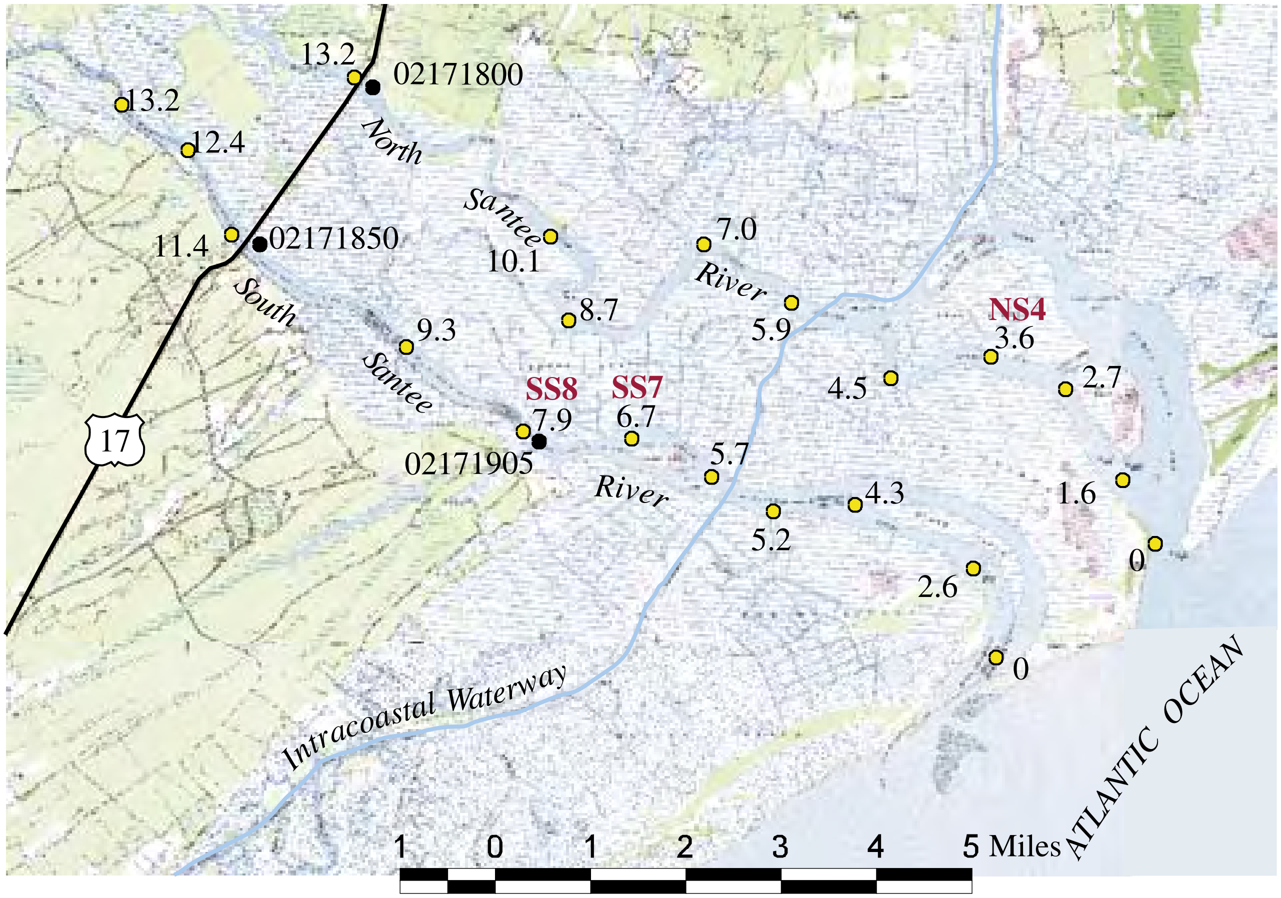


Figure 3. Location of continuous and longitudinal data stations in the Santee River Estuary.

with the one-dimensional unsteady-flow simulation model (BRANCH—Branch-Network Dynamic Flow Model).

CONTINUOUS DATA

Stations SS7 and NS4 are stilling wells attached to docks and equipped with sensors and data recorders. They record water temperature, conductivity, and height above the sensor at 30-minute intervals. The instruments are located within 2 ft of the river bottom so that the maximum conductivity in the water column is measured and to minimize the likelihood of water levels falling below the instruments during low flow or low tide.

Station SS8 is located at the State Pier in the Santee Coastal Reserve. It records water temperature and conductivity within 2 ft of the river's bottom at 30-minute intervals. Stage data are available, at 15-minute intervals, from a USGS station (02171905) at the same location.

VERTICAL AND LOGITUDINAL PROFILING DATA

Conductivity and temperature profiles were obtained throughout the water column, beginning at the mouth of each river and following the tides upstream. Profile data were collected during spring tides, which correspond to the maximum and minimum incursions of saltwater. Data were collected in 1997 and 1998 during varying flow conditions. Longitudinal-profile data were collected at 10 and 11 stations, on the North Santee and South Santee Rivers, respectively, in the deepest part of each channel (Fig. 3). Vertical-profile data were collected at 2-ft intervals throughout the water column from bottom to the surface. Measurements were made with portable water-quality instruments.

FLOW AND SALINITY CHARACTERISTICS

FLOW

Streamflow values for the Santee River at Jamestown (station 2171700), the nearest station to the study area and located 36 miles upstream of the Atlantic Ocean, are computed daily average discharges by the USGS. The streamflow record extends from October 1986 through September 2000. Streamflow generally was greatest from December to April each year (Fig. 4). Low-flow periods occurred mostly during the summer months. The lowest daily average flow since the rediversion (1985) was 460 cfs on November 13, 1986. The maximum flow of 89,500 cfs occurred on March 9, 1987. Flows of less than 2,000 cfs occurred about 28 percent of the time; flows of 20,000 cfs or greater occurred 23 percent of the time. Average and median streamflow values were 10,900 and 7,910 cfs, respectively.

In comparison, the total daily average dam releases from the St. Stephen and Wilson Dams from October 1986 through September 2000 were: average 10,700 cfs; median 7,650 cfs; maximum 111,000 cfs (3/06/87); and minimum 300 cfs (7/24/2000).

Streamflow data reported by USGS at Jamestown and total average daily dam releases reported by Santee Cooper

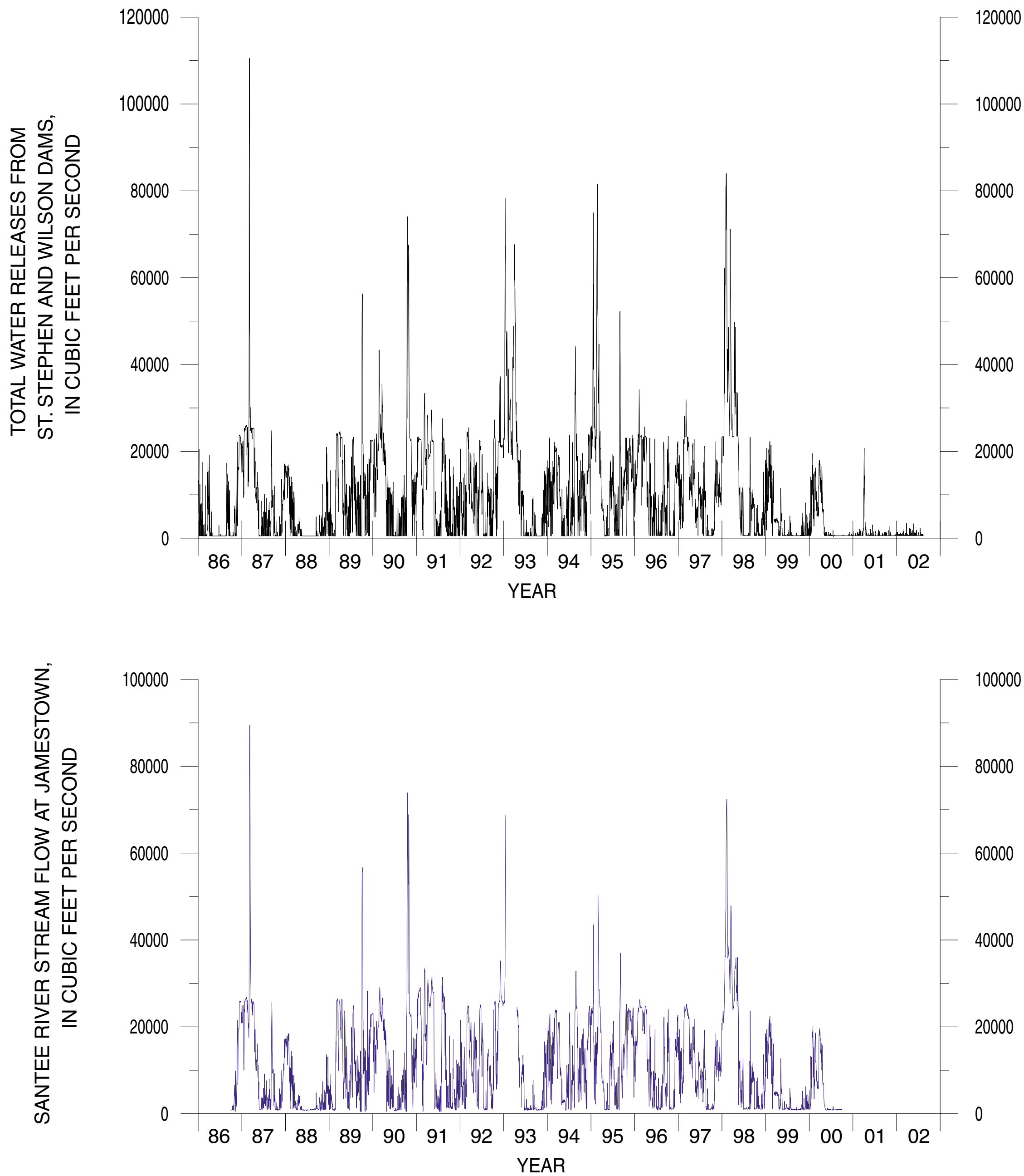


Figure 4. Total water releases from St. Stephen and Wilson Dams and Santee River streamflow at Jamestown.

are shown in Figure 4 for October 1986 through July 2002. There was a strong relationship between the dam releases and the streamflow at Jamestown, as indicated by the similarity of the plots. During peak streamflows, flow at Jamestown generally was less than dam releases, but it remained high for longer periods. Flow at Jamestown was greater than the dam releases during low-flow periods.

Streamflow during the study period (between October 1997 and mid-August 2002) was not normal compared to the entire period of record since rediversion (between October 1986 and mid-August 2002). Table 1 lists the daily average, median, maximum, and minimum streamflows as dam releases for selected time periods. The period from October 1997 through September 1998 had above-average flows and the second greatest flow recorded since the rediversion. Conversely, the flows since September 1998 were far below average, with maximum flows near 20,000 cfs and average flows below 3,700 cfs. The lowest streamflow period on record occurred from October 2001 through mid-August 2002, with an average and maximum streamflow of 730 and 3,500 cfs, respectively. The average streamflow for this latest period was 28 percent of the average flow prior to rediversion.

Table 1. Average, median, maximum, and minimum daily water releases from St. Stephen and Wilson Dams for selected periods (releases in cubic feet per second)

Water Year	Average	Median	Maximum	Minimum
1987 - 2000	10,733	7,654	110,525	300
1987 - 2001	10,096	6,679	110,525	300
1987 - 2002	9,604	5,725	110,525	300
1997	9,774	9,303	31,913	600
1998	18,137	11,461	84,078	600
1999	2,563	1,107	22,338	600
2000	3,704	600	19,513	300
2001	1,165	600	20,721	515
2002*	734	600	3,479	550

Note: A water year is October 1 through September 30 and is designated the year in which it ends.

SALINITY

Electrical conductivity of water is its ability to transmit electricity. It is a property that depends on the nature and amount of dissolved minerals in the water and the water temperature. Generally, the greater the concentration of ions and the higher the temperature, the greater the conductivity will be. Specific conductance is a measure of the conductivity at a specific temperature, usually 25 degrees C (77º F) and is stated in microsiemens per centimeter (µS/cm).

Salinity is another way of expressing the amount of dissolved mineral matter in water and is reported in parts per thousand (ppt). Salinity is calculated from conductivity and temperature, assuming the ionic species are of a specific type and ratio, such as would be found in seawater. According to the Venice classification system of estuarine waters (Kramer and others, 1994), freshwater salinity is less than 0.5 ppt, brackish-water salinity is between 0.5 and 30 ppt, and saltwater salinity is greater than or equal to 30 ppt.

The various instruments used during the study computed salinity with different algorithms, but the differences in results were negligible.

The correlation between salinity and specific conductance is shown in Figure 5. The specific conductance of freshwater is less than 1,200 µS/cm and that of saltwater is greater than 46,000 µS/cm.

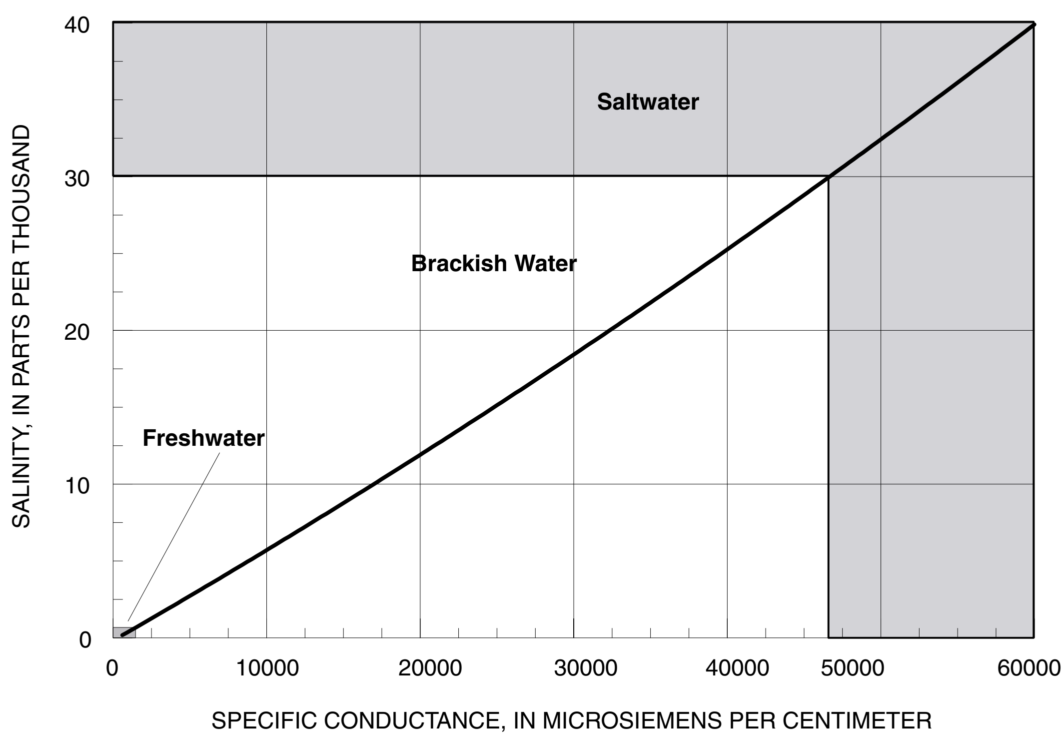


Figure 5. Variation in specific conductance with salinity.

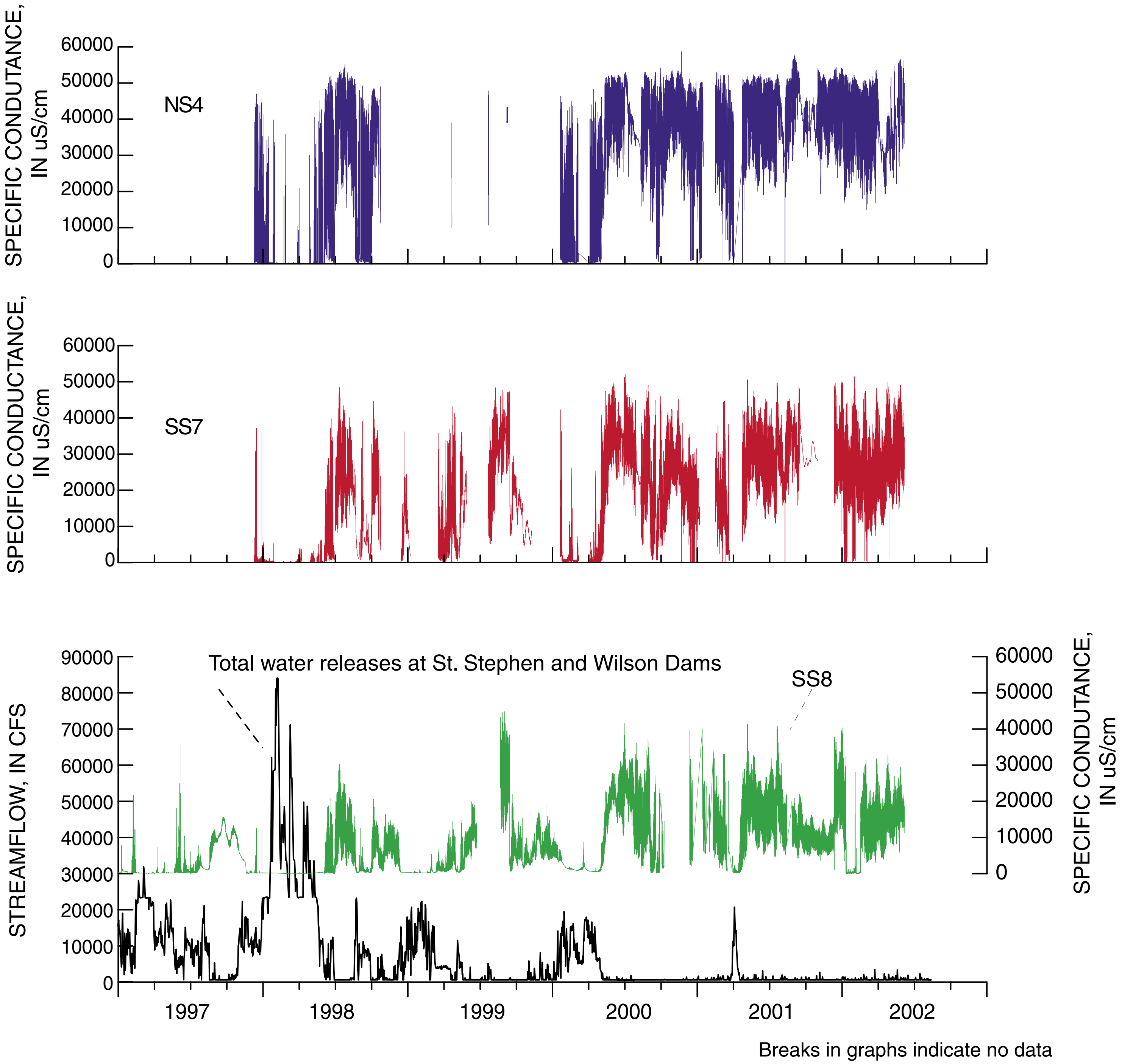


Figure 6. Variation in specific conductance at NS4, SS7, and SS8 with aggregate water releases at St. Stephen and Wilson Dams

Figure 6 relates the daily average aggregate dam releases at the St. Stephen and Wilson Dams to specific conductance of South Santee River stations SS7 and SS8 and North Santee River station NS4 for January 1997 through mid-August 2002. The influence of streamflow on salinity is notable. As streamflow increased, the specific conductance at all three stations generally decreased.

SS8, located farthest upstream of the three stations, showed the least range in specific conductance. For the period 12/10/1997 through 6/7/2002, the specific conductance ranged from 0 to 44,800 µS/cm, with average and median of 9,630 and 8,200 µS/cm, respectively. When flows were above 20,000 cfs, specific conductance at this station was nearly zero. Between 20,000 and 2,000 cfs, specific conductance generally increased as flow decreased. When streamflows were low (less than 2,000 cfs), specific conductance was greatest and was influenced primarily by tide.

SS7 showed a similar pattern of specific conductance; however, the range was greater and tidal influences were more evident. Specific conductance ranged from 0 to 52,000 µS/cm, with an average of 19,600 and a median of 21,500. When streamflow was low, the fluctuations in specific conductance were largely due to tidal fluctuations;

specific conductance generally was greater than 10,000 µS/cm. Occasional spikes of high-conductance water were evident, even when the streamflow exceeded 20,000 cfs.

NS4, nearest the river mouth, showed the greatest range in specific conductance. Values ranged from 0 to 58,700 µS/cm, with the average and median 29,800 and 34,900, respectively, for the period 12/10/1997 through 6/7/2002. Specific-conductance values generally did not approach zero unless streamflow was above 8,000 cfs. When streamflows were at a minimum, specific conductance ranged between 25,000 and 50,000 µS/cm.

Streamflow in the estuary does not equal streamflow at Jamestown or at the Santee Cooper dams for a given date. One reason is that the distance between the Santee Cooper dams, Jamestown, and the estuary causes a lag in the time required for the flow from the dams to reach downstream. Another is that the marshes adjacent to the river influence streamflow by storing (bank storage) or releasing water to the river, depending on conditions. Comparison of the specific-conductance values from SS8, SS7, and NS4 with discharge data during major streamflow fluctuations indicated that there is a 3- to 4-day lag between dam releases from Santee Cooper and the streamflows at these stations.

At each station, the maximum specific conductance normally occurred about 1 hour after the peak stage regardless of streamflow conditions. Figure 7 illustrates the phase-lag for NS4 at high- and low-streamflow conditions and for SS7 at low-streamflow conditions. Similarly, the lowest specific conductance generally occurred about 1 hour following the lowest stage. These phase lags, however, ranged from 30 to 90 minutes.

VERTICAL AND LOGITUDINAL PROFILES

Longitudinal-profile data for the North and South Santee Rivers show the influence of streamflow on the encroachment of saltwater into the estuary (Figs. 8 and 9). Specific conductance is plotted against river mile for the bottom and surface of the water column for both high and low tides, and each plot pair is presented in order of decreasing daily average discharge at Jamestown 3 days prior to that survey date.

Both rivers displayed a trend of decreasing encroachment with increasing streamflow during both high tide and low tide. The saltwater and freshwater fronts were substantially farther upstream during low-flow periods than during high-flow periods. For the purpose of this study, the saltwater front is defined as the interface between saltwater and brackish water; the freshwater front is defined as the interface between brackish water and freshwater.

In the North Santee River, during a high-streamflow period at high tide on January 30, 1998, saltwater was present only at the mouth and brackish water extended from near the mouth to mile 4.0 (Fig. 8). At low tide on this date, water was brackish only at the mouth of the river, with freshwater extending upstream from mile 1.0. During other high-flow period surveys (March 30 and April 23, 1998), however, freshwater extended beyond the mouth of the river. Thus, the freshwater front moved at least 3 miles between daily tides during high streamflow conditions.

During a low-streamflow period at high tide on July 20, 1998, saltwater intruded the north river to mile 4.2 (Fig. 8). Water was brackish upstream to mile 13.0. During low tide, brackish water extended from the mouth to mile 8.0. The saltwater and freshwater fronts moved more than 4 and 5 miles, respectively, during low streamflow conditions.

In the north river, the saltwater front moves more than 4.2 miles between the extreme conditions of low flow-high tide and high flow-low tide conditions. The freshwater front moves more than 13 miles between these conditions.

In the South Santee River, during a high-streamflow period at high tide on January 30, 1998, brackish water was present between miles 0.0 and 5.5 and fresh upstream (Fig. 9). At low tide, freshwater extended to the mouth of the South Santee. The freshwater front moved at least 5.5 miles between tides during high streamflow conditions.

During a low-streamflow period at high tide on July 20, 1998, saltwater intruded from the mouth upstream 5.5 miles (Fig. 9). Water was brackish from mile 5.5 to at least mile 13.2. At low tide, saltwater was not present; however, brackish water extended from the mouth to mile 9.0 and was fresh upstream. The saltwater and fresh water fronts moved more than 5.5 and 4.2 miles, respectively, during low streamflow conditions.

In the south river, the saltwater front moved at least 5.5 miles between the extreme conditions of low flow-high tide and high flow-low tide conditions. The freshwater front moved more than 13 miles between these conditions.

The North Santee River generally was less saline than the South Santee River. Longitudinal-profile plots of specific conductance in the north river do not extend as far upstream as they did in the south river. For example, on June 20, 1998, at high tide and under low-flow conditions, specific conductance fell below 10,000 µS/cm at 9.5 and 11.5 miles upstream in the north and south rivers, respectively.

Stratification in the water column during high tide increased as streamflow increased in both rivers. The plots of surface and bottom specific conductance for low-streamflow periods show very little difference between them (Figs. 8 and 9). The vertical profiles made during large-streamflow periods show greater differences between the bottom and surface specific conductance. The greatest stratification noted for the North Santee occurred during high tide on April 23, 1998, at river mile 1.6 and January 30, 1998, at river mile 2.7 (Fig. 8). The difference between surface and bottom specific conductance was 35,800 µS/cm at these points. Stratification on the South Santee also became more pronounced with increased streamflow, as evidenced by maximum differences per high tide vertical profile of 33,100, 26,800, and 24,800 µS/cm on January 30, April 23 and March 30, 1998 (river miles 4.3, 2.6, and 2.6, respectively) (Fig. 9).

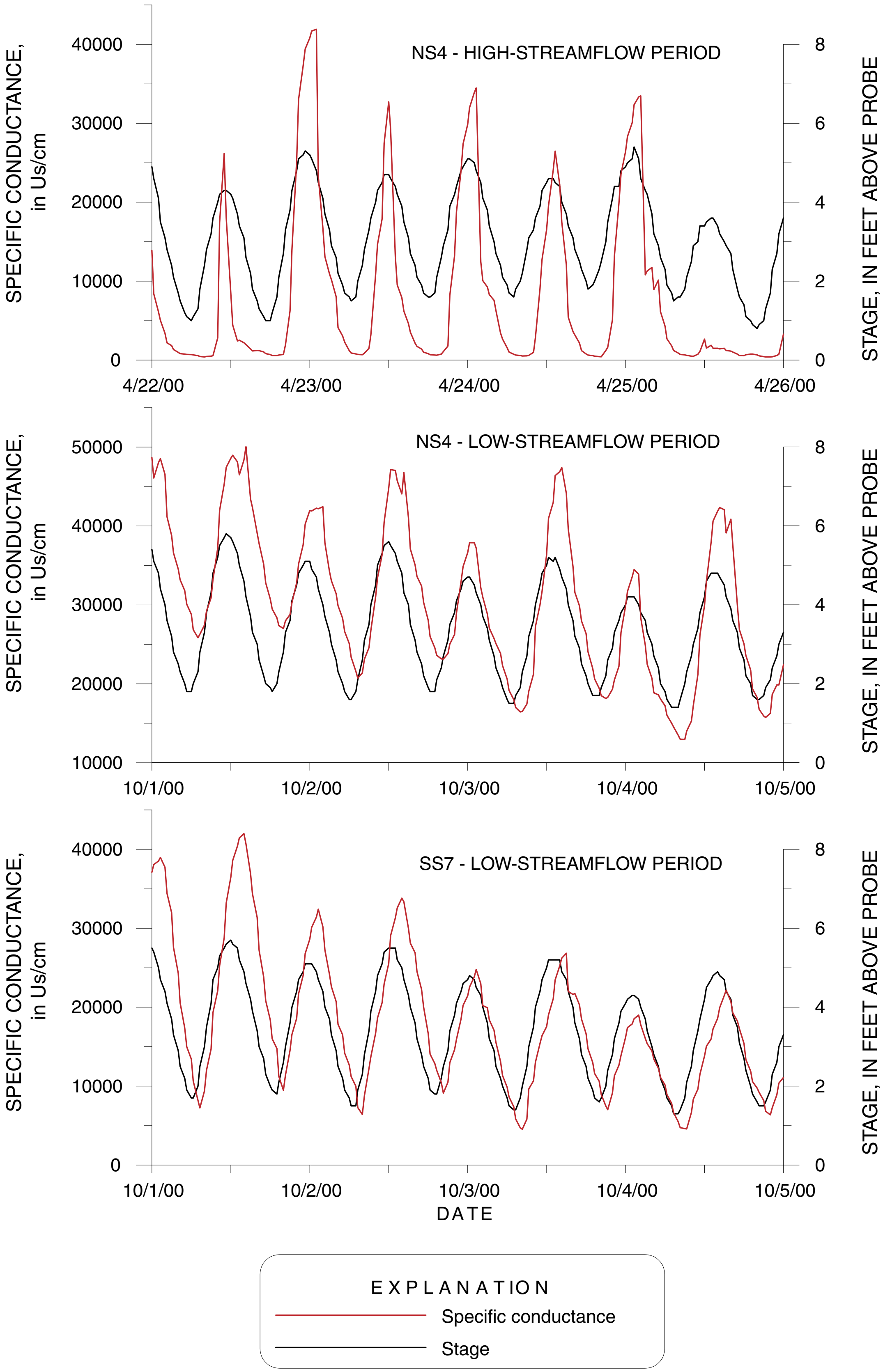


Figure 7. Variation in specific conductance with stage for high- and low-streamflow conditions at NS4 and low streamflow at SS7.

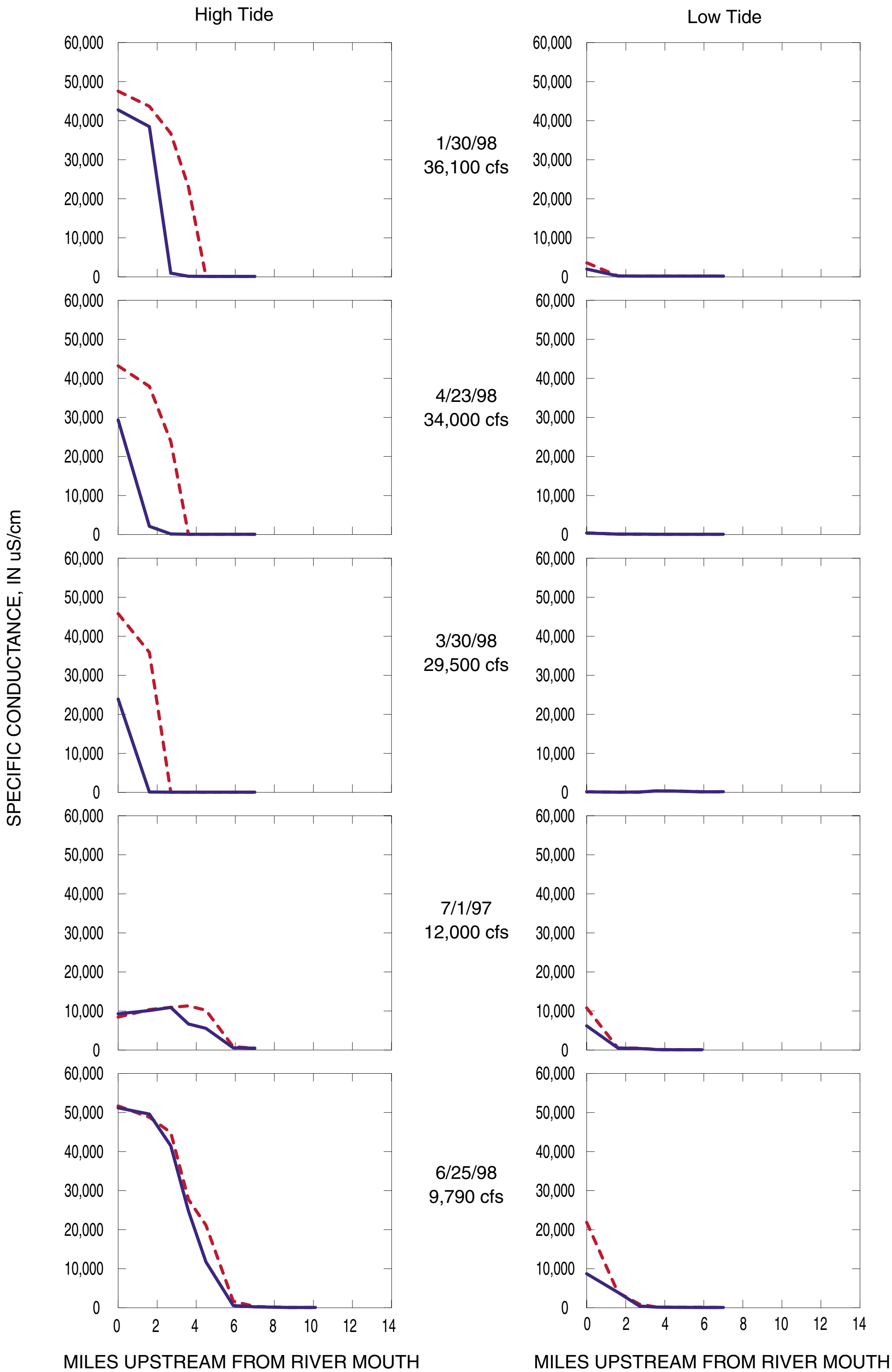
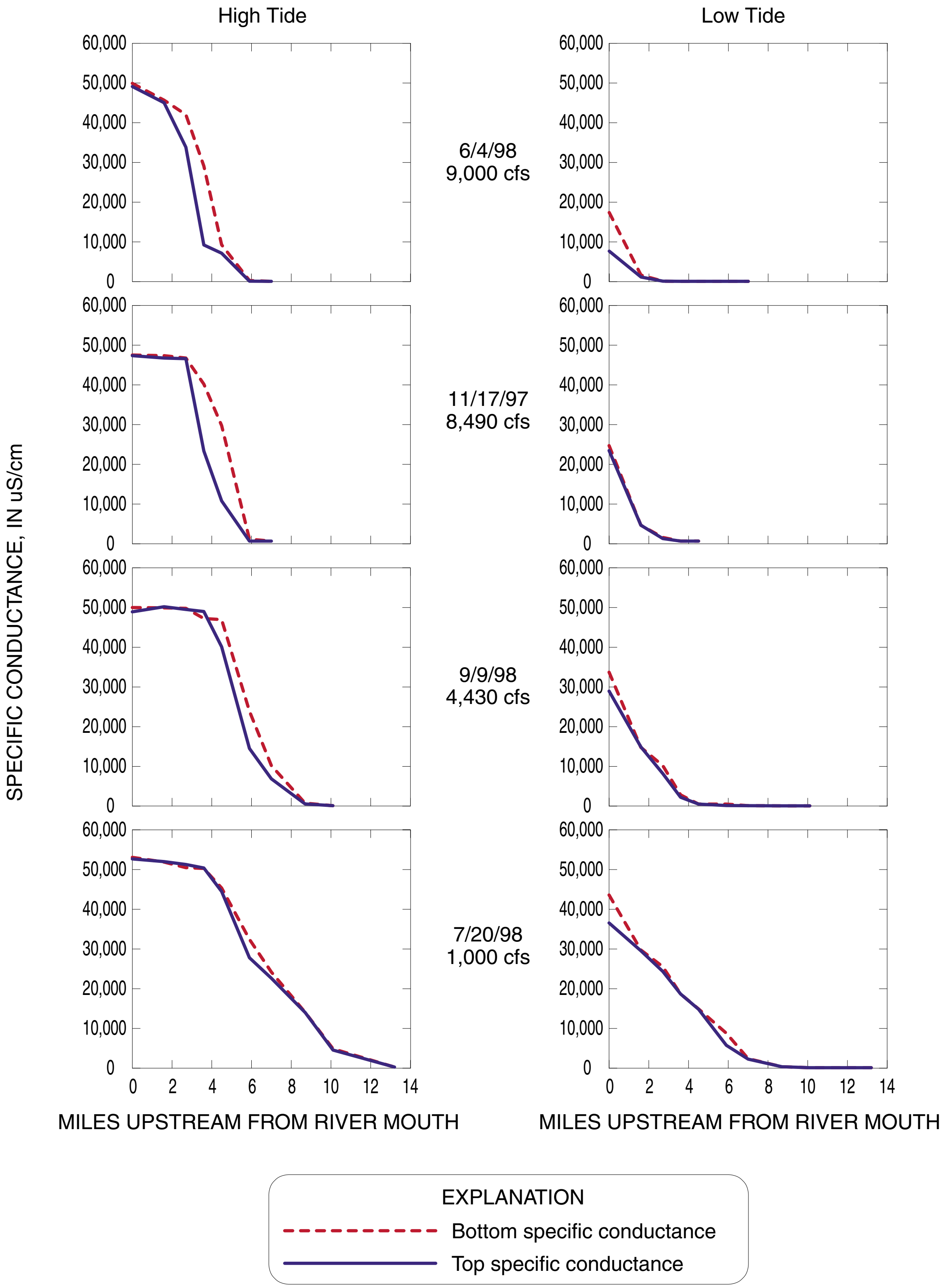


Figure 8. Field measurements of near-surface and near-bottom specific conductance as a function of river mile for the North Santee River.



High Tide
Low Tide
6/4/98
9,000 cfs
11/17/97
8,490 cfs
9/9/98
4,430 cfs
7/20/98
1,000 cfs
SPECIFIC CONDUCTANCE, IN uS/cm
60,000
50,000
40,000
30,000
20,000
10,000
0
0
2
4
6
8
10
12
14
MILES UPSTREAM FROM RIVER MOUTH
MILES UPSTREAM FROM RIVER MOUTH
EXPLANATION
Bottom specific conductance
Top specific conductance

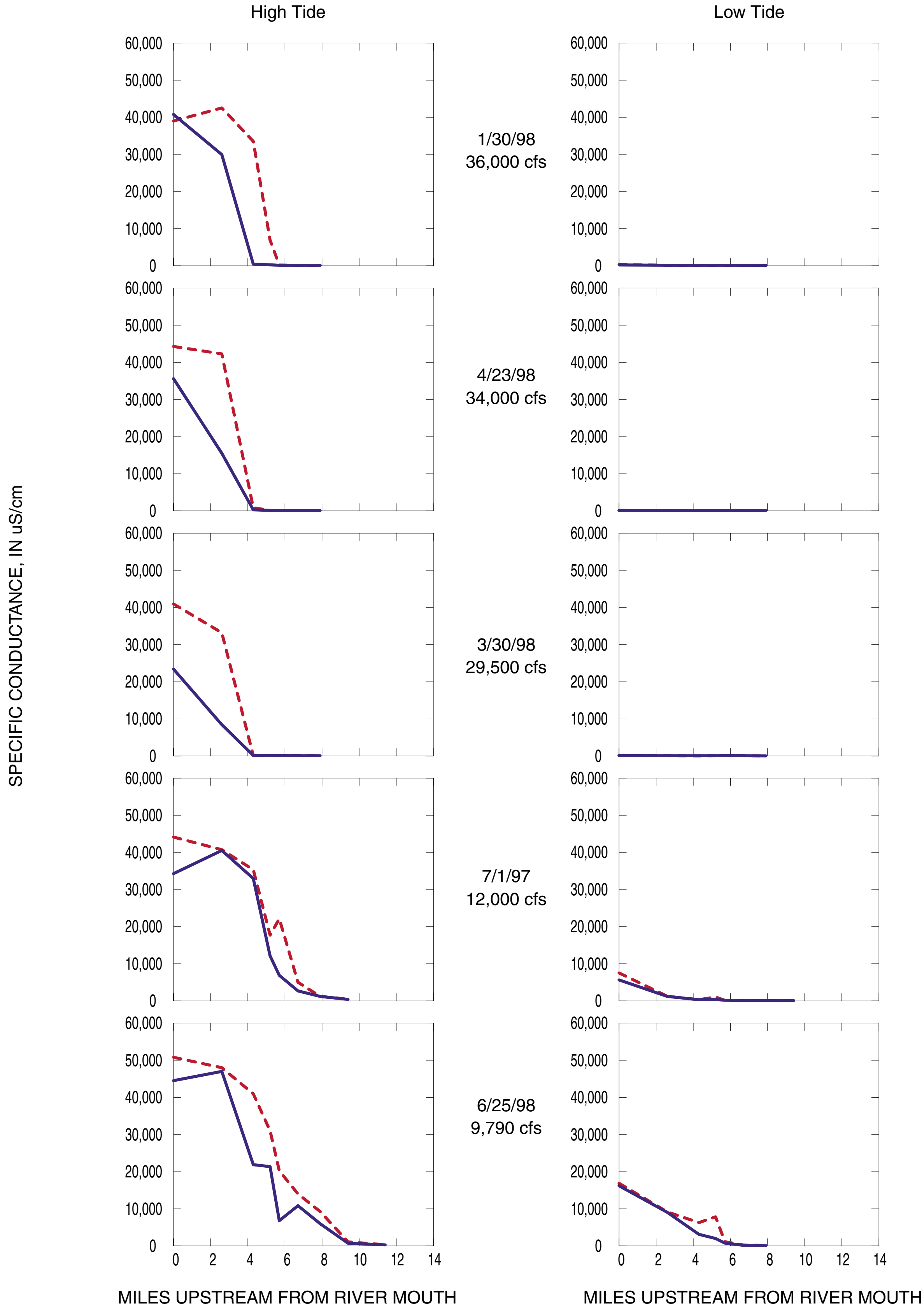
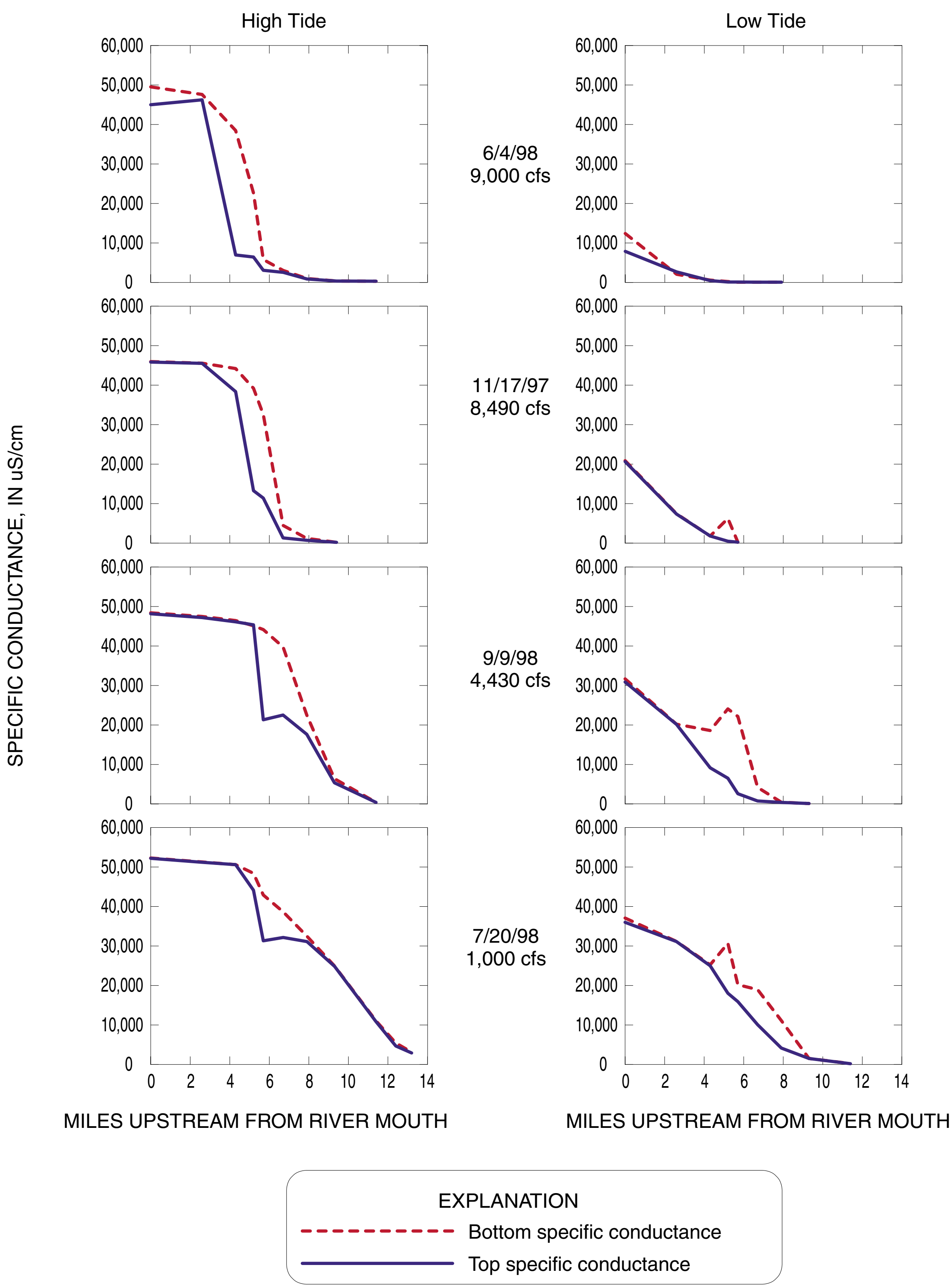


Figure 9. Field measurements of near-surface and near-bottom specific conductance as a function of river mile for the South Santee River.


High Tide
Low Tide
6/4/98
9,000 cfs
11/17/97
8,490 cfs
9/9/98
4,430 cfs
7/20/98
1,000 cfs
SPECIFIC CONDUCTANCE, IN uS/cm
60,000
50,000
40,000
30,000
20,000
10,000
0
0 2 4 6 8 10 12 14
MILES UPSTREAM FROM RIVER MOUTH
MILES UPSTREAM FROM RIVER MOUTH
EXPLANATION
Bottom specific conductance
Top specific conductance

Low tides showed little to no vertical stratification regardless of streamflow for both the North and South Santee Rivers.

The AIWW crosses the South Santee River at river mile 5.6, and data indicated that the AIWW influenced specific conductance in the river where they intersect. Most of the profile data plot as smooth curves except near the AIWW. During high tides and low flows, surface specific conductance decreased near the AIWW, indicating an influx of fresher water from the waterway. Bottom specific conductance appeared largely unaffected during high tide. Low-tide profiles during low-flow periods indicated an influx of saline water along the river bottom near the AIWW. AIWW influences were not apparent in the South Santee during high streamflow periods or in the North Santee.

Factors such as wind speed and direction, longshore currents, and the differences in tidal range and height

Table 2. Tide height at Charleston Harbor during longitudinal profiles

Date*	High tide	Date*	Low tide
6/4/1998	5.73	3/30/1998	-1.37
6/25/1998	5.78	7/20/1998	-0.73
3/30/1998	5.84	4/23/1998	-0.11
7/20/1998	6.15	1/30/1998	0.04
11/17/1997	6.36	6/25/1998	0.04
4/23/1998	6.44	11/17/1997	0.13
9/9/1998	6.88	9/9/1998	0.29
1/30/1998	7.06	7/1/1997	0.62
7/1/1997	7.07	6/4/1998	0.84

* In order of increasing height. Datum is mean lower low water; 1960-1978 epoch.

Table 3. Comparison of streamflow data from Jamestown and dam releases by Santee Cooper

Profile Date	Jamestown Daily mean discharge (in cfs)			Santee Cooper Daily mean releases (in cfs)		
	Day of profile	3 days prior	3-day average	Day of profile	3 days prior	3-day average
7/20/1998	1,100	1,000	1,040	600	600	610
9/9/1998	8,360	4,430	6,900	7,960	6,010	6,500
11/17/1997	15,000	8,490	11,500	18,000	8,100	13,500
6/4/1998	5,000	9,000	6,670	4,640	8,550	6,240
6/25/1998	10,500	9,790	9,940	10,400	9,180	9,600
7/1/1997	10,500	12,000	11,300	10,300	10,100	10,400
3/30/1998	27,700	29,500	28,700	23,500	27,500	24,800
4/23/1998	33,400	34,000	33,800	48,600	30,200	40,300
1/30/1998	41,400	36,100	38,600	58,600	58,400	58,500

* In order of increasing streamflow at Jamestown 3 days prior to survey date

probably caused the deviations from trends discussed above or other anomalies in the profile data. Table 2 shows the predicted tide height at Charleston for the profile dates. Table 3, a comparison of streamflow data from Jamestown and dam releases from Santee Cooper, illustrates the disparity regarding streamflow in the estuary that may contribute to deviations from the specific-conductance trends.

Estimates of the specific conductance in the estuary under various conditions can be made by examining plots of the mean specific conductance of the water column at each profile station against the station location for each longitudinal profile at both high and low tides. A best-fit line for specific conductance, representing an average front, was plotted for each profile (Figs. 10 through 13). Equations for these lines are in Table 4.

Profiles generally show greater saltwater incursion with decreased streamflow. The profile with the lowest streamflow, on 7/20/98, shows the front farthest upstream of any profile in both the North and South Santee during both high and low tides. This is followed by the profile on 9/9/98, which shows the front not penetrating as far upstream as on 7/20/98 under any conditions. Profiles for 11/17/97, 6/4/98, 6/25/98 and 7/1/97 have slightly increasing streamflows, respectively, but are similar in magnitude. These three profiles plot downstream of 9/9/98 for all occurrences. They differ in location by more than 2 miles in some instances, however, and are not explained simply by differences in streamflow or tide height alone. The remaining three profiles, 3/30/98, 4/23/98, and 1/30/98, in order of increasing streamflow, represent high-streamflow conditions. Of these cases, the profile with the greatest streamflow (1/30/98) plots the most upstream for the high-tide profile; however, it has the highest tide. Low-tide profiles are not plotted because the entire reach of both rivers is fresh at low tide during high streamflows. Conversely, the profile with the least streamflow of the three (3/30/98) plots farthest downstream, presumably, because its tide height is the least. At low tide, the freshwater extended beyond the mouth of the rivers, outside the study area. From these graphs, it can be concluded that the average front travels more than 13.6 and 10.6 miles in the South and North Santee Rivers, respectively, under various flow conditions.

The equations for the profile lines can be used to estimate the specific conductance for a given location at high and low tide by selecting the profile date whose daily mean release from the column in Table 3 best suits the conditions of interest. For example, an estimate of today's maximum specific conductance at mile 5 on the South Santee River is needed and the dam release by Santee Cooper 3 days ago was 15,000 cfs. The survey date that best fits the dam release conditions is 7/1/97 (10,100 cfs). Substituting in the equation for this date for high tide on the South Santee River as follows:

$$Y = -12{,}515 \text{ (river mile 5)} - 88{,}781 = 26{,}206 \ \mu S/cm$$

This estimate for specific conductance is likely to be high because the equation is for a streamflow condition less than the example conditions. To estimate a range of specific-conductance values, the survey date that exceeds the example dam release conditions is 3/30/98 (27,500 cfs). Substituting in the equation for this date for high tide on the South Santee River as follows:

$$Y = -15{,}026 \text{ (river mile 5)} - 64{,}753 = 10{,}377 \ \mu S/cm$$

Thus, the maximum specific conductance at mile 5 on the South Santee River should be between 10,400 and 26,200 µS/cm.

REGRESSION ANALYSIS

Regression analysis of data collected from January 1, 1998, through October 24, 1998, was used to quantify relationships among specific conductance, streamflow, and tide stage and height. This period was selected because it had the greatest range of streamflow since monitoring began, and the specific-conductance data from three stations (two on the South Santee River and one on the North Santee River) were available for that year.

Correlation analysis is used to determine the relationship between two properties. The correlation coefficient r is the covariance of two variables divided by the product of their standard deviations (Davis, 1986). It is a dimensionless number ranging from –1 to 1. The closer the correlation coefficient is to 1, the better the positive linear relationship between the two properties. Negative values indicate inverse linear relationship. Correlation coefficients near zero indicate a lack of any linear relationship between the two variables.

A correlation analysis was run on the following parameters: daily maximum, minimum, and average of the specific conductance at NS4, SS7, and SS8; daily average, 2- through 7-day moving averages, and 3- and 4-day lags of dam releases by Santee Cooper; daily average streamflow at Jamestown; maximum, minimum, and average stage at the gaging station at Charleston Harbor; and daily maximum and minimum predicted tide height at Charleston Harbor (Appendix A). Correlation analysis also was run on square root, square, natural log, and inverse of all but stage and streamflow at Jamestown data, and the correlation matrix for these data is shown in Appendix B.

Regression analysis was used for those parameters indicated by the correlation matrix as having a good linear relationship. A best-fit line was then plotted for a pair of data sets. R^2 is the square of the correlation coefficient for those two sets of data and can be interpreted as the proportion of variance in the Y variable attributed to the variance in the X variable. The closer R^2 is to 1, the better the correlation. Linear, natural logarithm, and power equations were used to best fit the data. A complete list of equations and R^2 values is included in Appendix C. Table 5 defines the abbreviations used in the regression analysis.

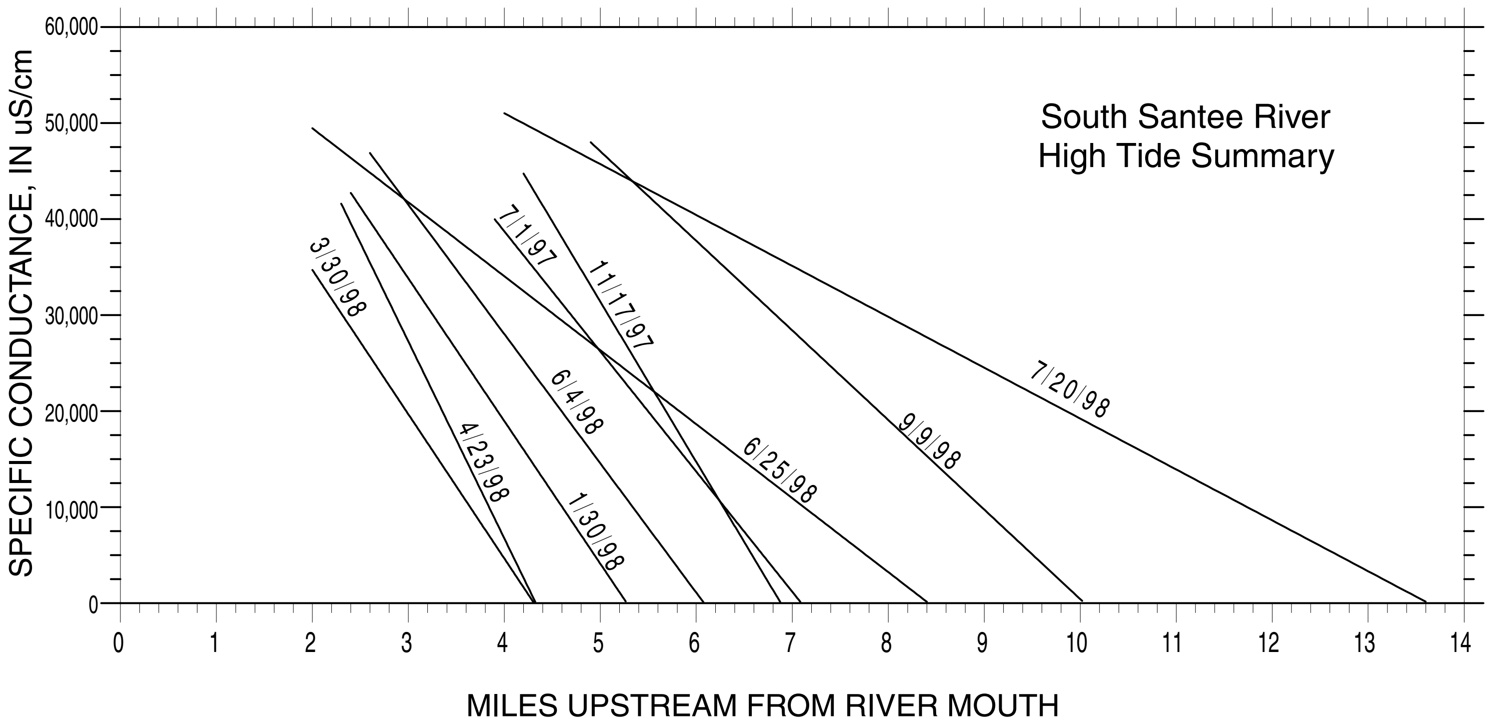


Figure 10. Variation in mean specific conductance with location in miles upstream from mouth for South Santee River at high tide.

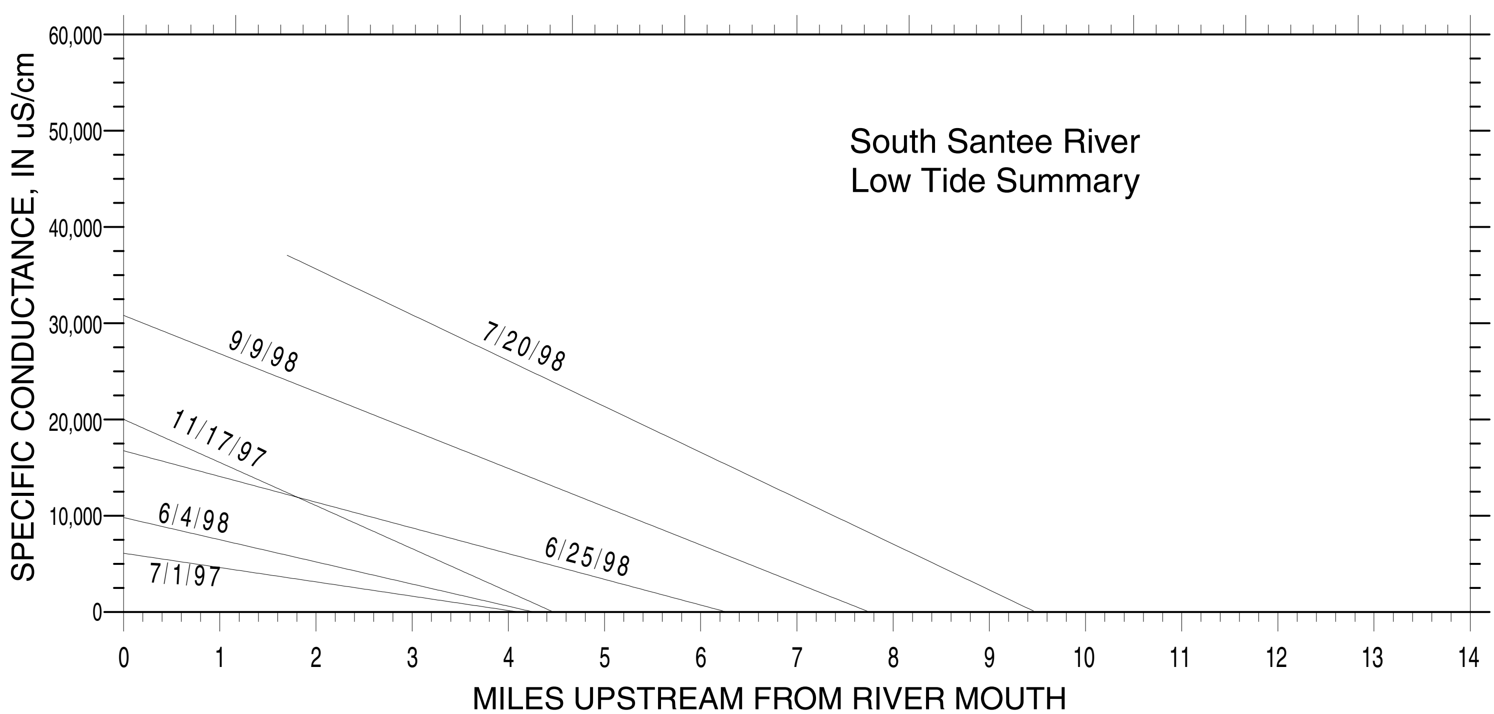


Figure 11. Variation in mean specific conductance with location in miles upstream from mouth for South Santee River at low tide.

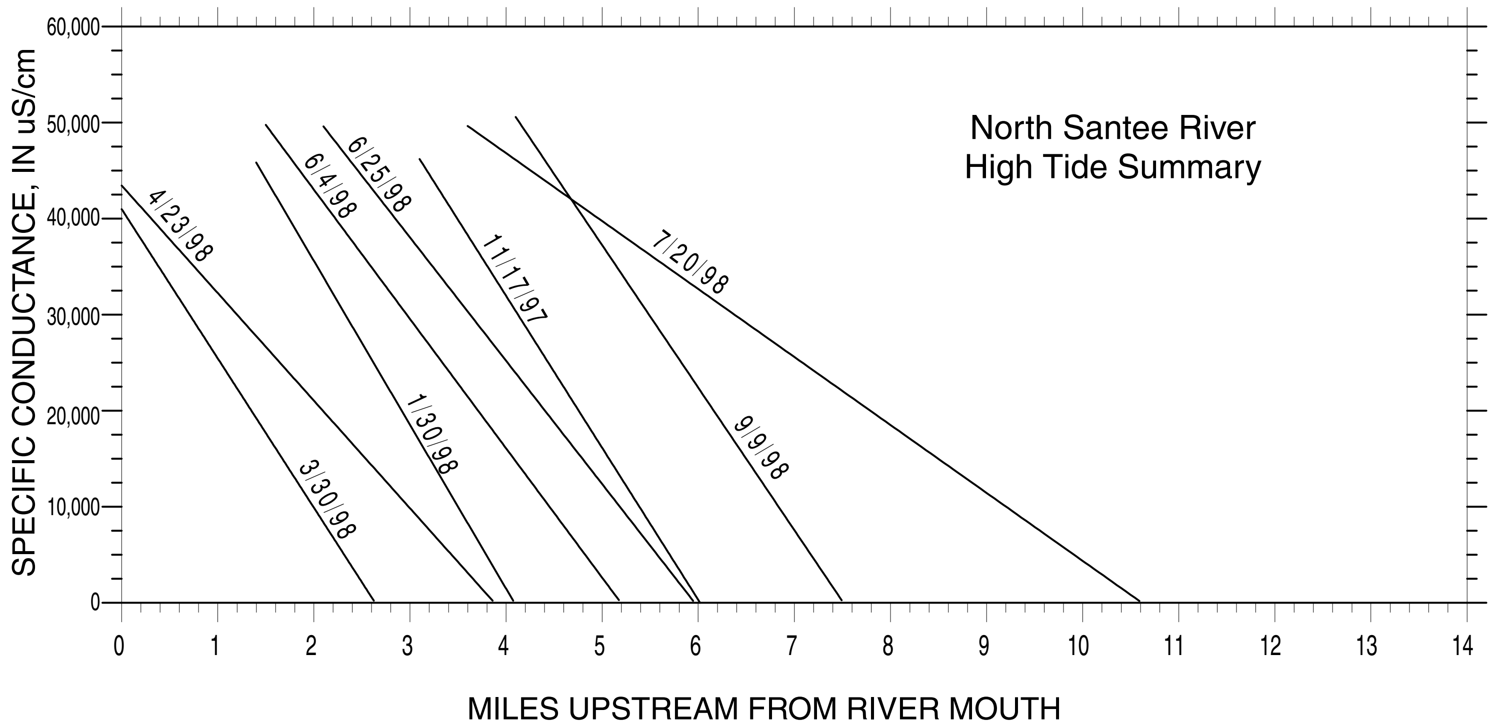


Figure 12. Variation in mean specific conductance with location in miles upstream from mouth for North Santee River at high tide.

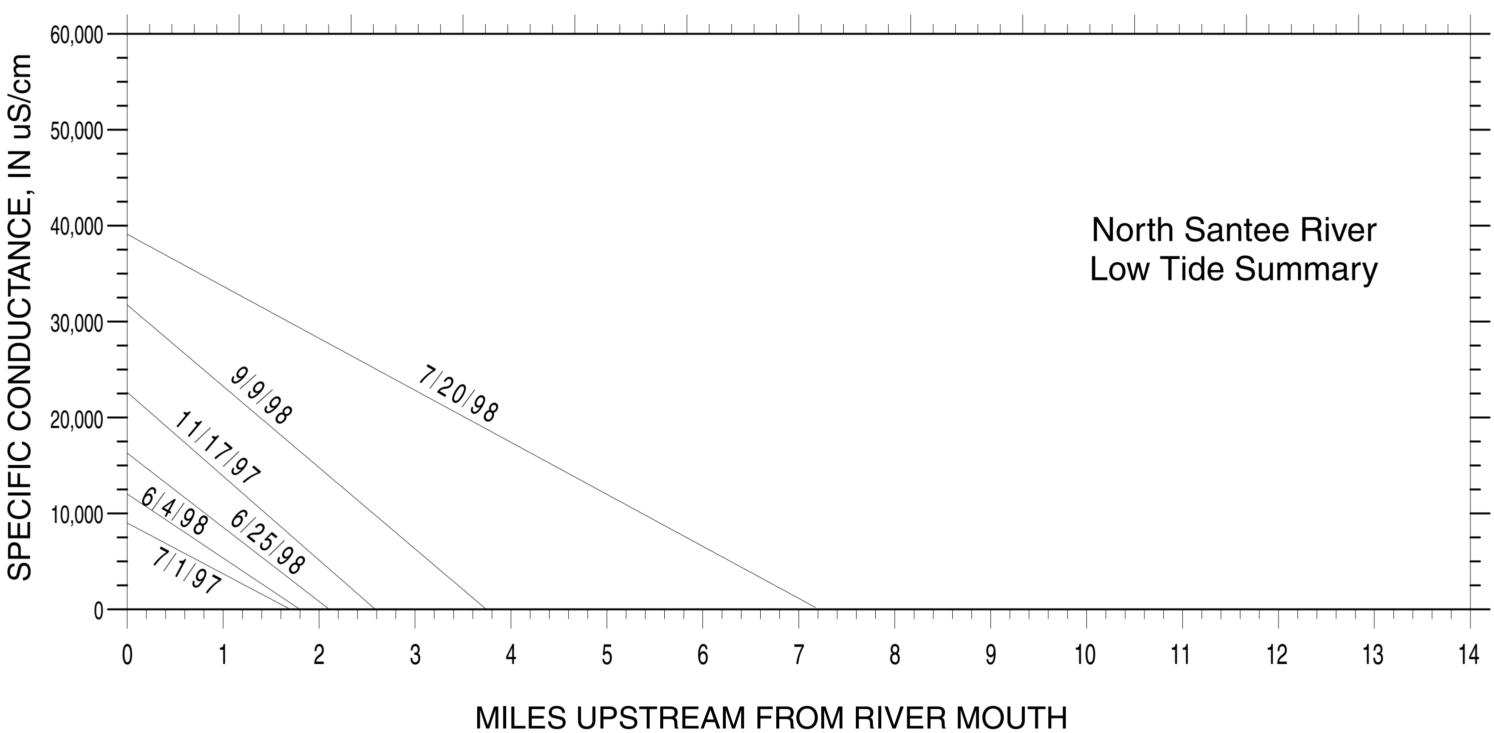


Figure 13. Variation in mean specific conductance with location in miles upstream from mouth for North Santee River at low tide.

Table 4. Relation of vertically averaged specific conductance to river mile on the North and South Santee Rivers at high and low tides and various streamflow rates

SOUTH SANTEE- HIGH TIDE

Date	Fit	Equation	Data points	Average X (river mile)	Average Y (specific conductance)	R-squared
7/1/1997	Linear	Y = -12,515 * X + 88,781	5	5.5	19,700	0.98
11/17/1997	Linear	Y = -16,691 * X + 114,847	4	5.5	23,463	1.00
1/30/1998	Linear	Y = -14,854 * X + 78,375	3	4.0	18,463	1.00
3/30/1998	Linear	Y = -15,026 * X + 64,753	2	3.5	12,912	
4/23/1998	Linear	Y = -20,513 * X + 88,790	2	3.5	18,019	
6/4/1998	Linear	Y = -13,467 * X + 81,887	4	4.5	21,959	0.99
6/25/1998	Linear	Y = -7,704 * X + 64,859	6	5.4	23,259	0.96
7/20/1998	Linear	Y = -5,300 * X + 72,215	9	8.5	27,405	0.98
9/9/1998	Linear	Y = -9,329 * X + 93,704	5	7.0	28,773	0.98

SOUTH SANTEE- LOW TIDE

Date	Fit	Equation	Data points	Average X (river mile)	Average Y (specific conductance)	R-squared
7/1/1997	Linear	Y = -1,486 * X + 6,103	3	2.3	2,685	0.93
11/17/1997	Linear	Y = -4,479 * X + 20,014	3	2.3	9,714	0.98
1/30/1998						
3/30/1998						
4/23/1998						
6/4/1998	Linear	Y = -2,302 * X + 9,809	3	2.3	4,514	0.97
6/25/1998	Linear	Y = -2,671 * X + 16,751	5	3.6	7,240	0.98
7/20/1998	Linear	Y = -4,764 * X + 45,165	7	6.0	16,788	0.97
9/9/1998	Linear	Y = -3,975 * X + 30,811	7	4.6	12,414	0.99

NORTH SANTEE- HIGH TIDE

Date	Fit	Equation	Data points	Average X (river mile)	Average Y (specific conductance)	R-squared
7/1/1997						
11/17/1997	Linear	Y = -15,831 * X + 95,281	3	4.7	21,405	0.99
1/30/1998	Linear	Y = -17,067 * X + 69,732	3	2.6	24,788	1.00
3/30/1998	Linear	Y = -15,540 * X + 40,986	3	1.4	18,711	0.99
4/23/1998	Linear	Y = -11,202 * X + 43,448	4	2.0	21,325	0.97
6/4/1998	Linear	Y = -13,469 * X + 69,957	4	3.1	28,205	0.96
6/25/1998	Linear	Y = -12,841 * X + 76,563	4	4.2	22,951	0.98
7/20/1998	Linear	Y = -7,077 * X + 75,125	6	6.6	28,183	0.99
9/9/1998	Linear	Y = -14,835 * X + 111,400	3	5.8	25,359	0.98

NORTH SANTEE- LOW TIDE

Date	Fit	Equation	Data points	Average X (river mile)	Average Y (specific conductance)	R-squared
7/1/1997	Linear	Y = -5,296 * X + 9,003	2	0.8	4,766	
11/17/1997	Linear	Y = -8,751 * X + 22,632	3	1.4	10,088	0.92
1/30/1998						
3/30/1998						
4/23/1998						
6/4/1998	Linear	Y = -6,682 * X + 12,030	2	0.8	6,685	
6/25/1998	Linear	Y = -7,733 * X + 16,286	2	0.8	10,099	
7/20/1998	Linear	Y = -5,424 * X + 39,106	7	3.6	19,502	0.99
9/9/1998	Linear	Y = -8,479 * X + 31,741	4	2.0	14,994	0.97

Table 5. Abbreviations used in regression analysis

Abbreviation	Definition
SCQ	Total daily dam releases reported by Santee Cooper
JamesQ	Computed daily streamflow at Jamestown
SCQ3DMA	3-day moving average of SCQ
SCQ7DMA	7-day moving average of SCQ
SCQ3DL	3-day lag of SCTotQ
SCQ4DL	4-day lag of SCTotQ
NS4DMX	Daily maximum specific conductance at NS4
SS8DMX	Daily maximum specific conductance at SS8
SS7DMX	Daily maximum specific conductance at SS7
NS4DAV	Daily average specific conductance at NS4
SS8DAV	Daily average specific conductance at SS8
SS7DAV	Daily average specific conductance at SS7
NS4DMN	Daily minimum specific conductance at NS4
SS8DMN	Daily minimum specific conductance at SS8
SS7DMN	Daily minimum specific conductance at SS7

Dam Release and Jamestown Streamflow

A strong correlation (r=0.93) was found between the daily total releases by Santee Cooper and the streamflow at Jamestown. There was a higher correlation (0.94 – 0.98) between flow and the moving average of releases, and the correlation increased as the moving average increased.

The plot of Santee Cooper dam releases and Jamestown streamflow showed a good linear correlation, with an R^2 of 0.86 (Fig. 14). The linear equation appeared to be best used where Santee Cooper releases ranged between 5,000 and 15,000 cfs. At low Santee Cooper releases, Jamestown streamflow tended to be overestimated by the linear equation. Conversely, at Santee Cooper releases above 15,000 cfs, Jamestown streamflows tended to be underestimated. Data scatter was greater as dam releases increased.

Plots of 3- and 7-day moving averages of Santee Cooper dam releases with streamflow at Jamestown both showed excellent linear correlations, where R^2 is 0.90 and 0.96, respectively.

Close inspection of these graphs indicate that when dam releases are low (less than 15,000 cfs), estimates of Jamestown streamflows were best with use of the following power equation:

$$\ln(\text{JamesQ}) = 0.825\,(\ln(\text{SCQ})) + 1.70 \qquad R^2=0.95$$

Overall, but particularly for large streamflows, the best equation was that for the 7-day moving averages of dam releases, shown below.

$$\text{JamesQ} = 0.878\,(\text{SCQ7DMA}) + 1{,}070 \qquad R^2=0.96$$

Given that an objective of the study was to define a method of predicting salinity in a timely manner, that Santee Cooper dam release data are available sooner than Jamestown streamflows (which must be determined through modeling), and the good linear correlations between these parameters, subsequent regression analyses used dam-release data rather than Jamestown streamflows.

Dam Releases and Specific Conductance

The correlation matrix of Santee Cooper dam releases and specific conductance for the three stations indicated that the best correlations were with daily maximum specific conductance at NS4 (r=0.79). The correlations decreased with station distance from the mouth of the river. Correlations were poorer with daily average and minimum specific conductance.

Statistically, the best equation for estimating maximum specific conductance at NS4 is the linear equation, NS4DMX = -1.04 (SCQ4DL) + 47,800 where the independent variable is the 4-day lag of dam releases (R^2=0.73) (Fig. 15).

Maximum specific conductance at SS7 and SS8 are best estimated by using 3-day lag of dam releases with the logarithm and power equations, respectively, as follows:

$$\text{SS7DMX} = -8{,}350(\ln \text{SCQ3DL}) + 88{,}000 \qquad R^2=0.81 \text{ (Fig. 16)}$$

$$\ln(\text{SS8DMX}) = -1.24(\ln \text{SCQ3DL}) + 18.1 \qquad R^2=0.88 \text{ (Fig. 17)}$$

Average specific conductance for the NS4 and South Santee stations are best estimated by logarithm and power equations using 3-day lag (Fig. 18). The equations are:

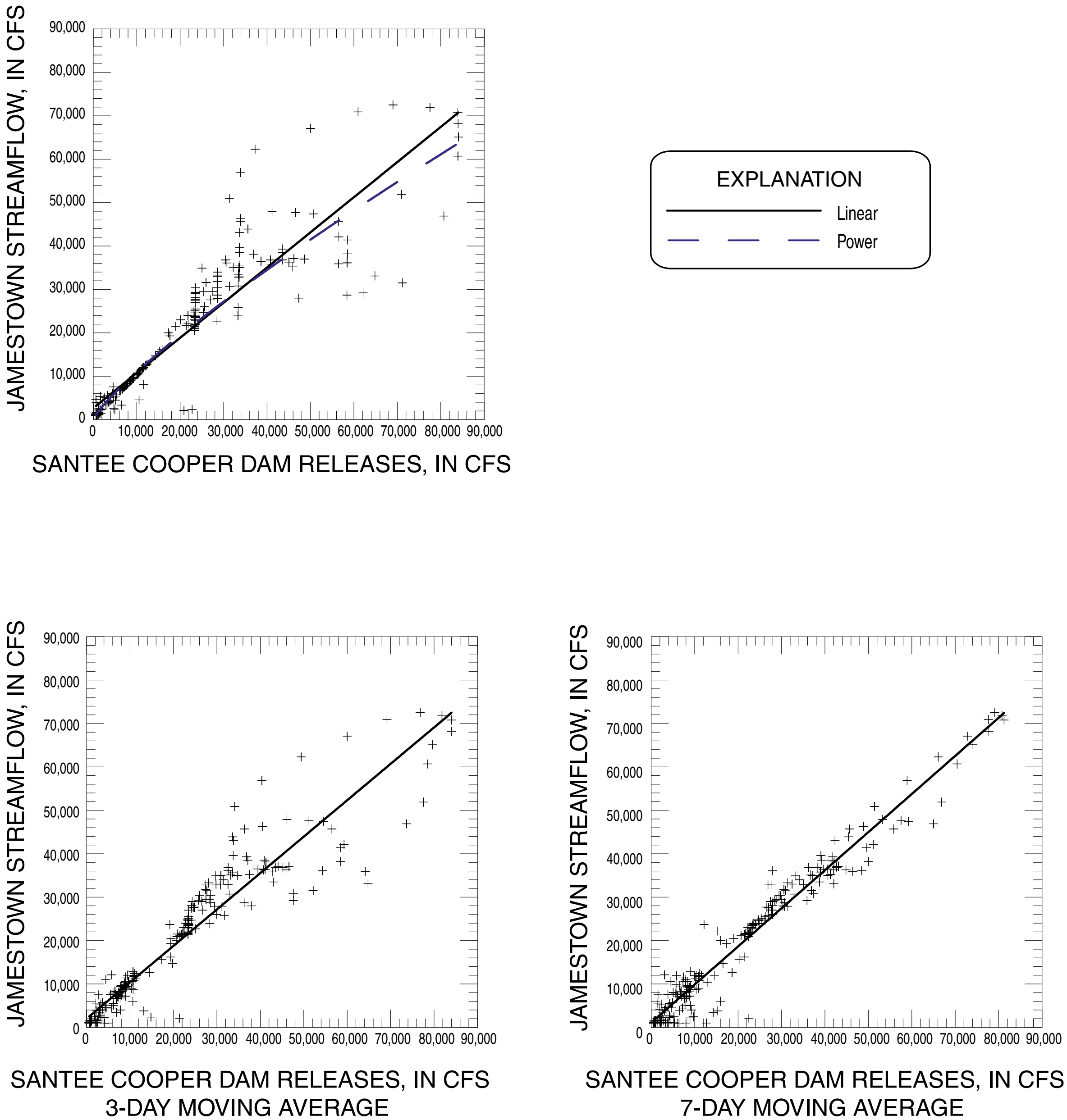


Figure 14. Regression analysis plots of Santee Cooper dam releases, 3- and 7-day moving average with Jamestown streamflow.

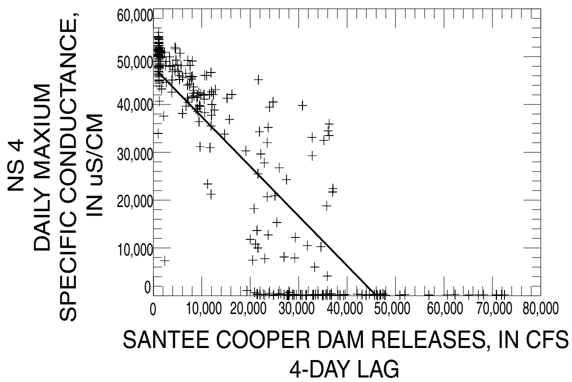


Figure 15. Regression analysis plots of Santee Cooper 4-day lag of dam releases with daily maximum specific conductance at NS4.

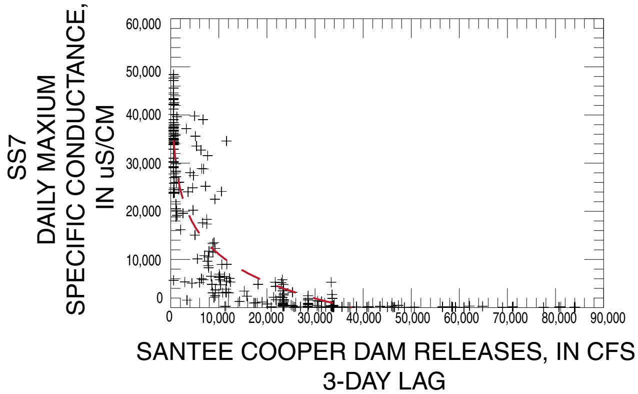


Figure 16. Regression analysis plots of Santee Cooper 3-day lag of dam releases with daily maximum specific conductance at SS7.

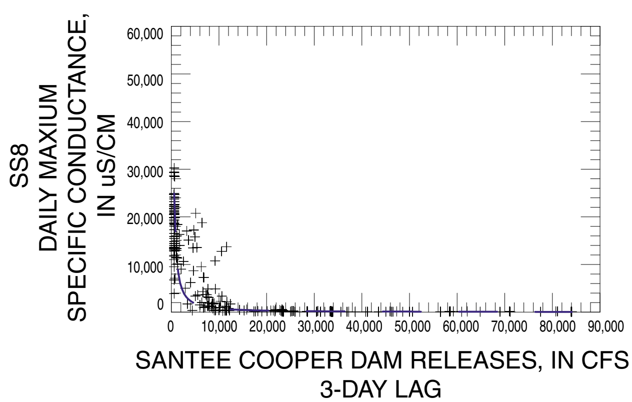
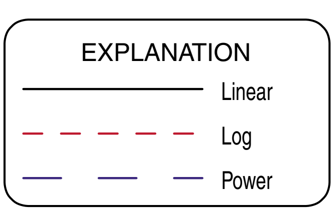


Figure 17. Regression analysis plots of Santee Cooper 3-day lag of dam releases with daily maximum specific conductance at SS8.



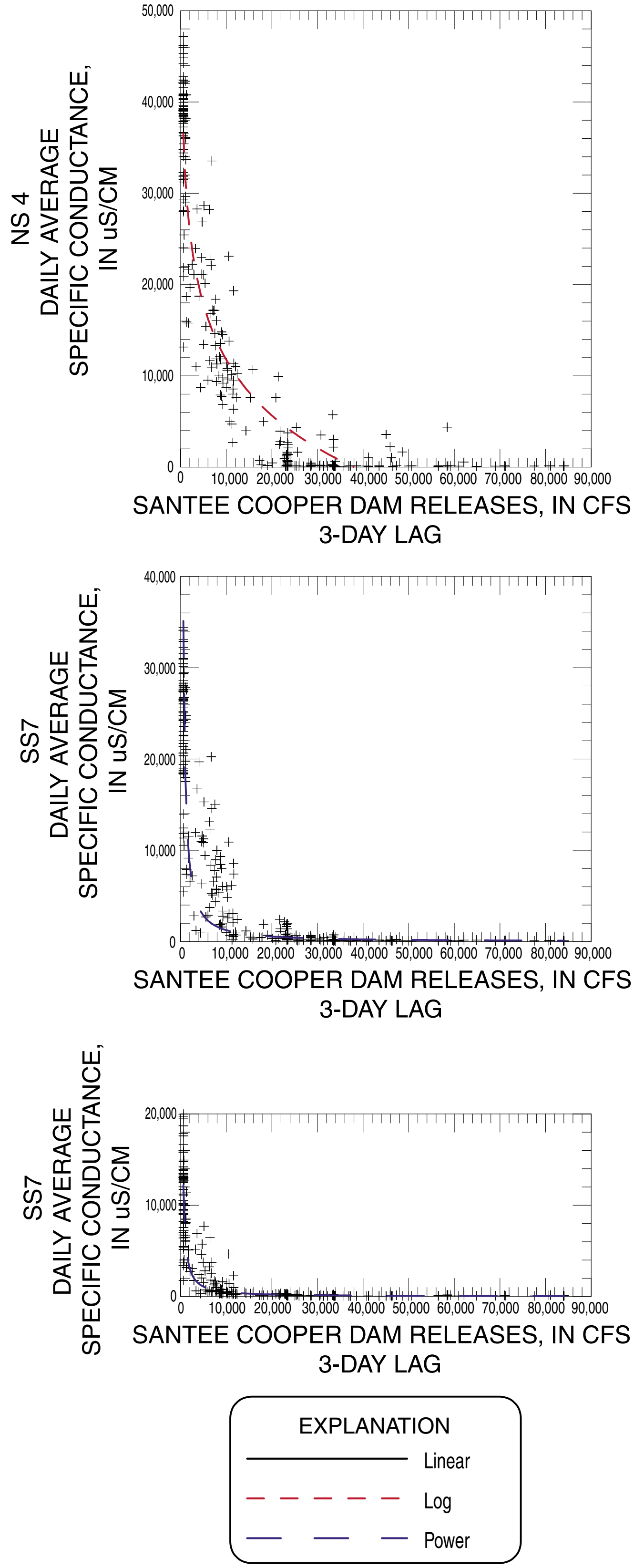


Figure 18. Regression analysis plots of Santee Cooper 3-day lag of dam releases with daily average specific conductance at NS4, SS7, SS8.

$$NS4DAV = -8{,}810(\ln SCQ3DL) + 92{,}900 \qquad R^2=0.90$$

$$\ln(SS7DAV) = -1.18(\ln SCQ3DL) + 18 \qquad R^2=0.84$$

$$\ln(SS8DAV) = -1.14(\ln SCQ3DL) + 17 \qquad R^2=0.91$$

Minimum specific conductance for the three stations is best predicted from 3-day lag of dam releases by using the power equations where R^2 ranges from 0.91 – 0.79 (Fig. 19). The equations are:

$$\ln(NS4DMN) = -1.31(\ln SCQ3DL) + 18 \qquad R^2=0.91$$

$$\ln(SS7DMN) = -1.15(\ln SCQ3DL) + 17 \qquad R^2=0.80$$

$$\ln(SS8DMN) = -0.86(\ln SCQ3DL) + 14 \qquad R^2=0.80$$

Specific Conductance Between Stations

Strong correlations existed between the two South Santee stations. Comparisons between the daily maximums of the stations and the daily averages showed r exceeded 0.95. Daily minimums were slightly weaker correlations at 0.88. The South Santee stations and the North Santee stations showed generally weaker correlations, with correlations between the North Santee station generally better with the downstream South Santee station than with the upstream station. Values exceeded 0.71 for the daily maximum values, but they improved significantly to 0.90 or better for the daily minimums and averages.

Regression analysis showed good linear correlation between the maximum daily specific conductance at the two South Santee stations with an R^2 of 0.90 (Fig. 20). Maximum daily specific conductance at NS4 was best estimated from SS7 and SS8 by a logarithmic equation, with an acceptable R^2 of 0.73 and 0.78, respectively. Equations for estimating daily maximum specific conductance from another station are:

$$SS7DMX = 1.70(SS8DMX) + 2{,}590 \qquad R^2=0.90$$

$$NS4DMX = 8{,}330(\ln SS7DMX) – 38{,}100 \qquad R^2=0.73$$

$$NS4DMX = 8{,}370(\ln SS8DMX) – 29{,}500 \qquad R^2=0.78$$

Plots of daily average specific conductance between SS7, SS8, and NS4 showed good correlations with R^2 greater than 0.91 (Fig. 21). Average specific conductance at NS4 is best predicted by SS7 and SS8 with linear and logarithm equations, respectively. Average specific conductance between South Santee stations can be estimated with a linear equation. Equations for estimating daily average specific conductance from another station are:

$$SS7DAV = 1.98(SS8DAV) + 1{,}560 \qquad R^2=0.92$$

$$NS4DAV = 1.39(SS7DAV) + 2{,}400 \qquad R^2=0.94$$

$$NS4DAV = 7{,}560(\ln SS8DAV) – 35{,}000 \qquad R^2=0.94$$

Plots of minimum specific conductance between SS7, SS8, and NS4 showed poorer linear relationships (R^2 range from 0.78 to 0.89) (Fig. 22). Predictions between the daily minimum specific conductance at the South Santee stations are best by using a logarithm equation. Predictions of the daily minimum specific conductance at NS4 are best obtained by using a linear equation from SS7 and equally good with power and linear equations from SS8. Equations for estimating daily minimum specific conductance from another station are:

$$SS7DMN = 3{,}820(\ln SS8DMN) – 17{,}700 \qquad R^2=0.84$$

$$NS4DMN = 1.52(SS7DMN) - 274 \qquad R^2=0.82$$

$$NS4DMN = 4.71(SS8DMN) + 517 \qquad R^2=0.89$$

Station Specific Conductance and Tide Height

A correlations matrix indicated that the relationship between tide height, either actual or predicted, and specific conductance at the three stations was poor for the data base as a whole. Regression analysis confirmed the poor relationships between these parameters. Plots of specific conductance for NS4 and SS8 with maximum tidal height illustrate this point (Fig. 23).

The Charleston Harbor (Custom House) tide gage was the reference station used for tidal predictions in the study area. For the Cedar Island Point gage, the nearest to the mouth of the South Santee River, an average correction of 0.78 ft and 0.79 ft was added to the height at high and low tide, respectively, predicted at Charleston. Upstream, the average correction generally was smaller. Comparison of actual and predicted maximum tide height shows some correlation in Figure 24. The correlation matrix showed a moderate r value of 0.57. Tide height used for regression analysis was reported Charleston Harbor values.

Comparison of the daily maximum specific conductance at NS4 with the daily maximum tide height at Charleston harbor for 1998 showed that some similarity in trends occurred from June through October, when streamflow was relatively low (Fig. 25).

Regression analysis between daily maximum specific conductance and daily maximum tide height, limited by streamflow, showed poor correlations. Figure 23, which plots maximum specific conductance at NS4 and SS8 with maximum tide height at Charleston, when the 3-day lag of dam releases is less than 1,000 cfs, illustrates the poor relationship between the two parameters.

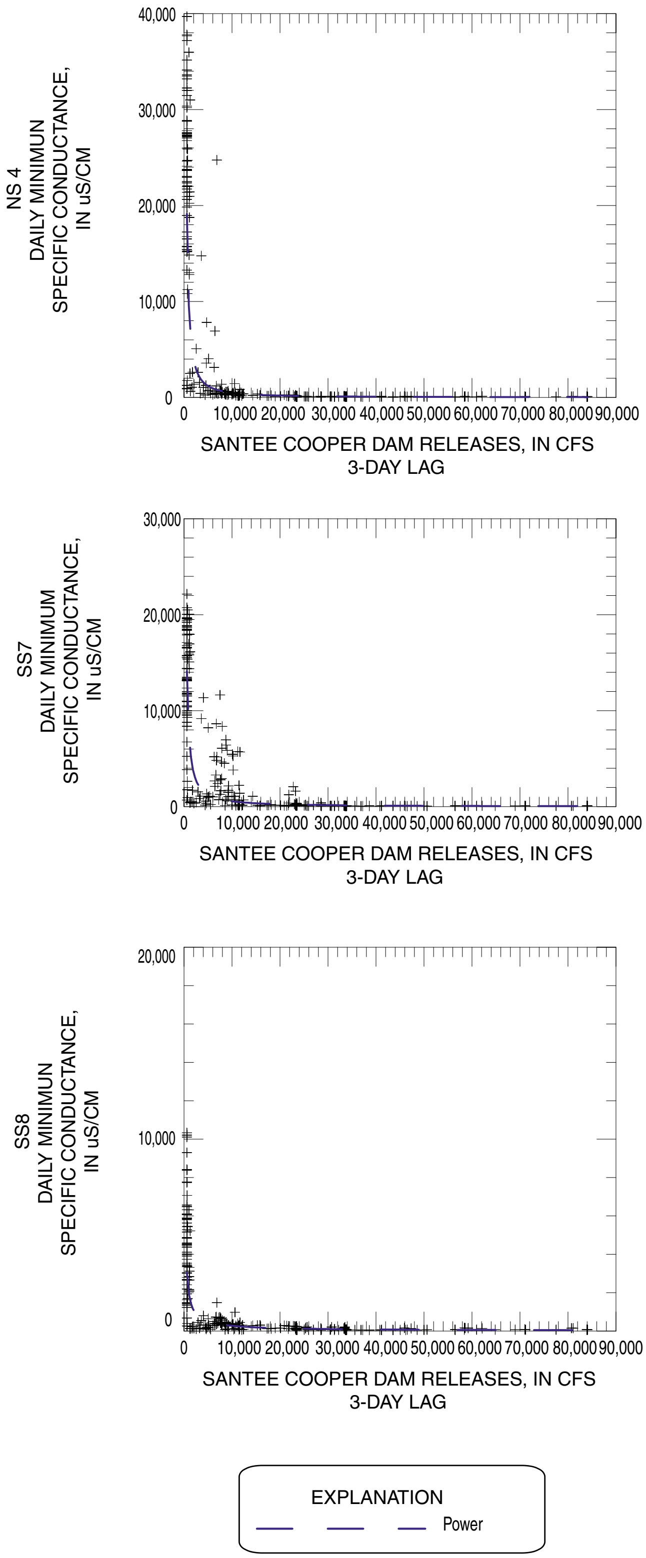


Figure 19. Regression analysis plots of Santee Cooper 3-day lag of dam releases with daily minimum specific conductance at NS4, SS7, SS8.

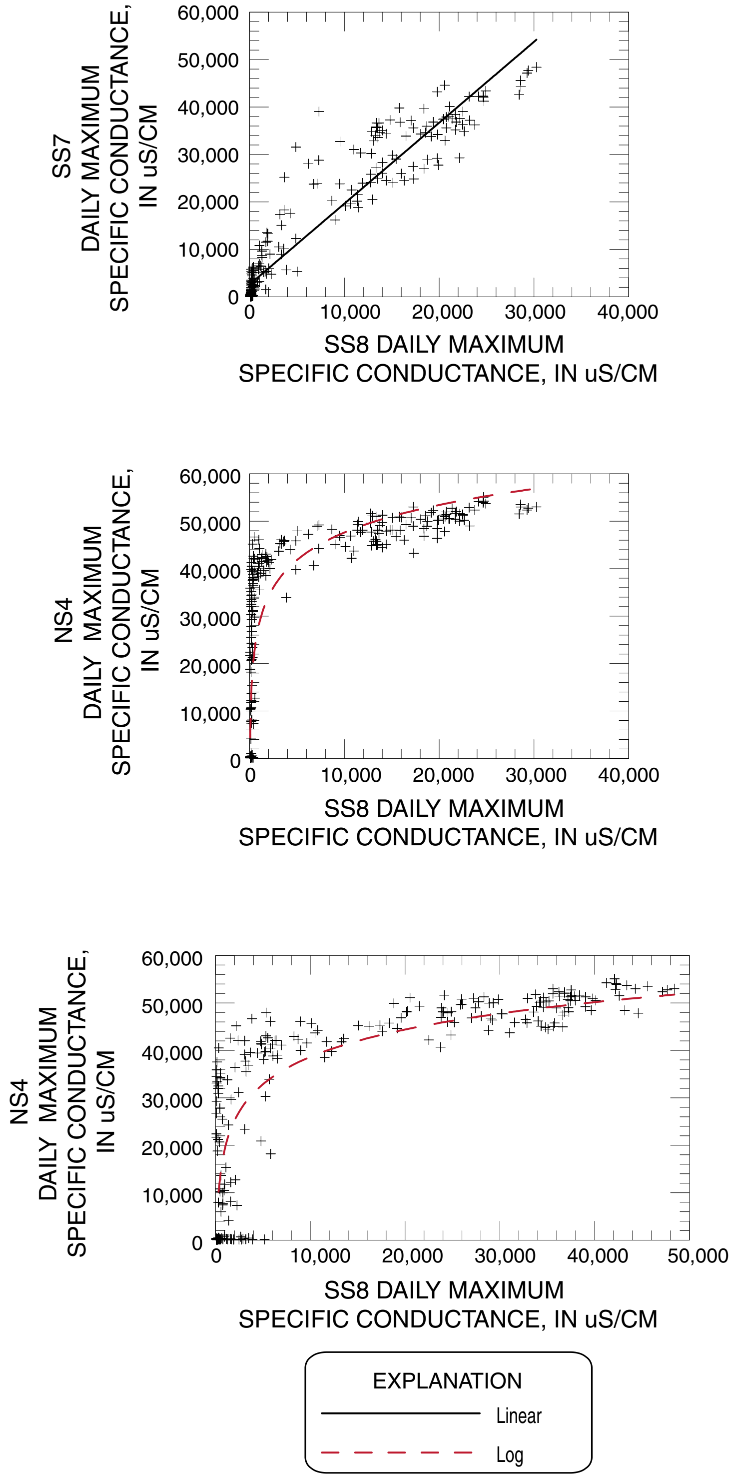


Figure 20. Regression analysis plots of daily maximum specific conductance between NS4 and SS7, NS4 and SS8, and SS7 and SS8.

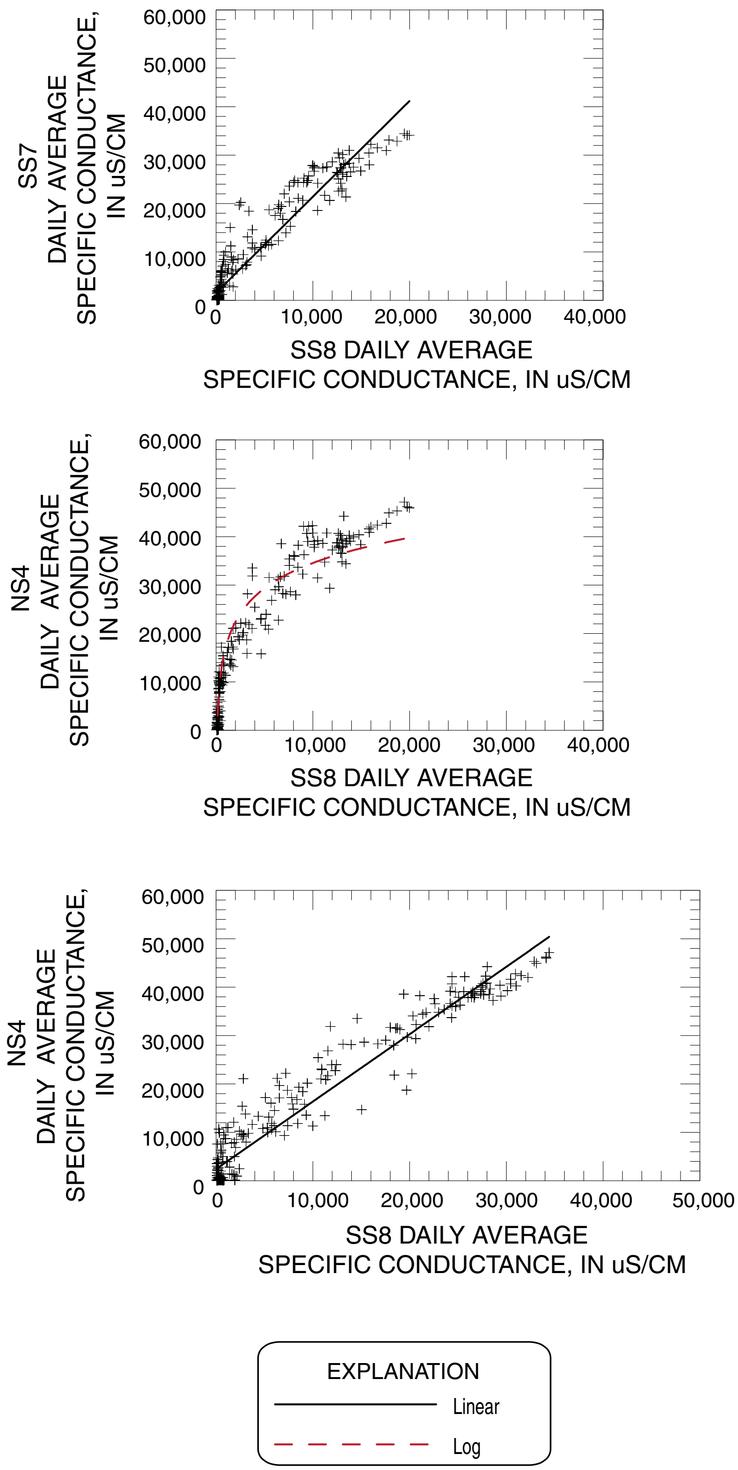


Figure 21. Regression analysis plots of daily average specific conductance between NS4 and SS7, NS4 and SS8, and SS7 and SS8.

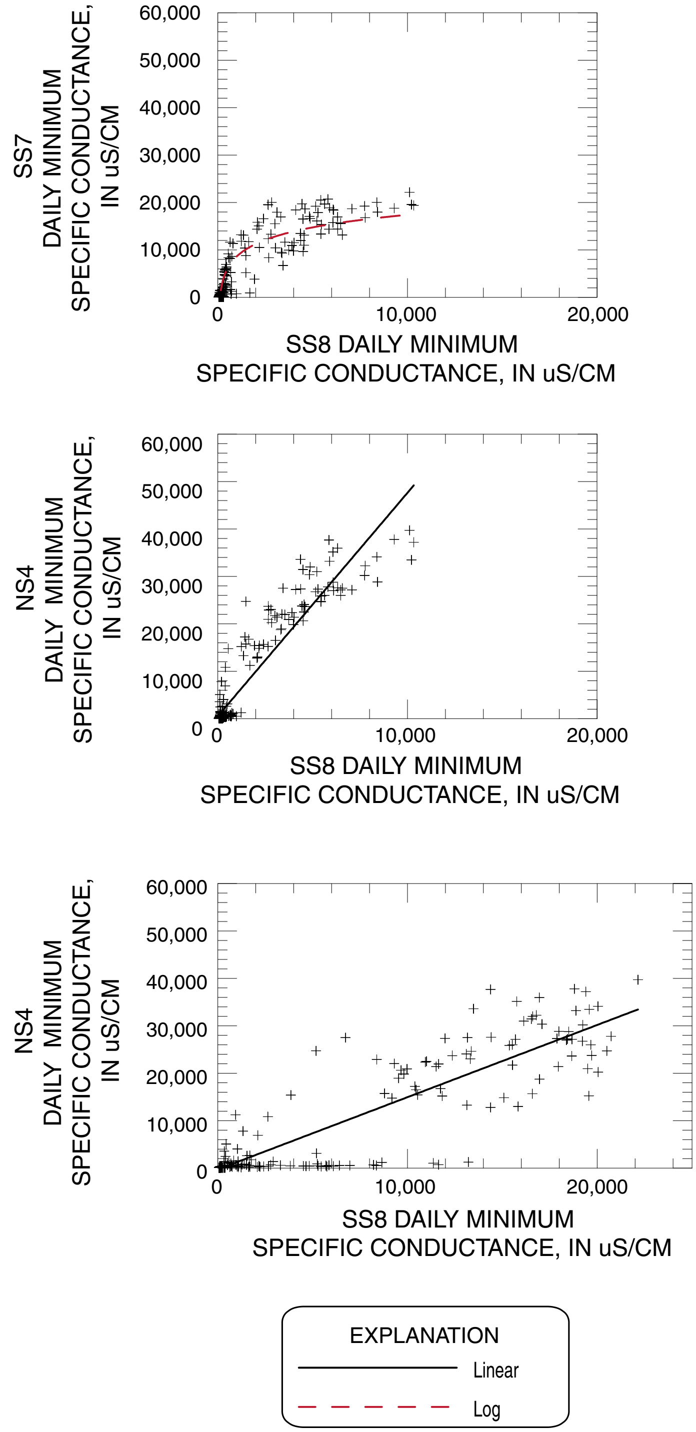


Figure 22. Regression analysis plots of daily minimum specific conductance between NS4 and SS7, NS4 and SS8, and SS7 and SS8.

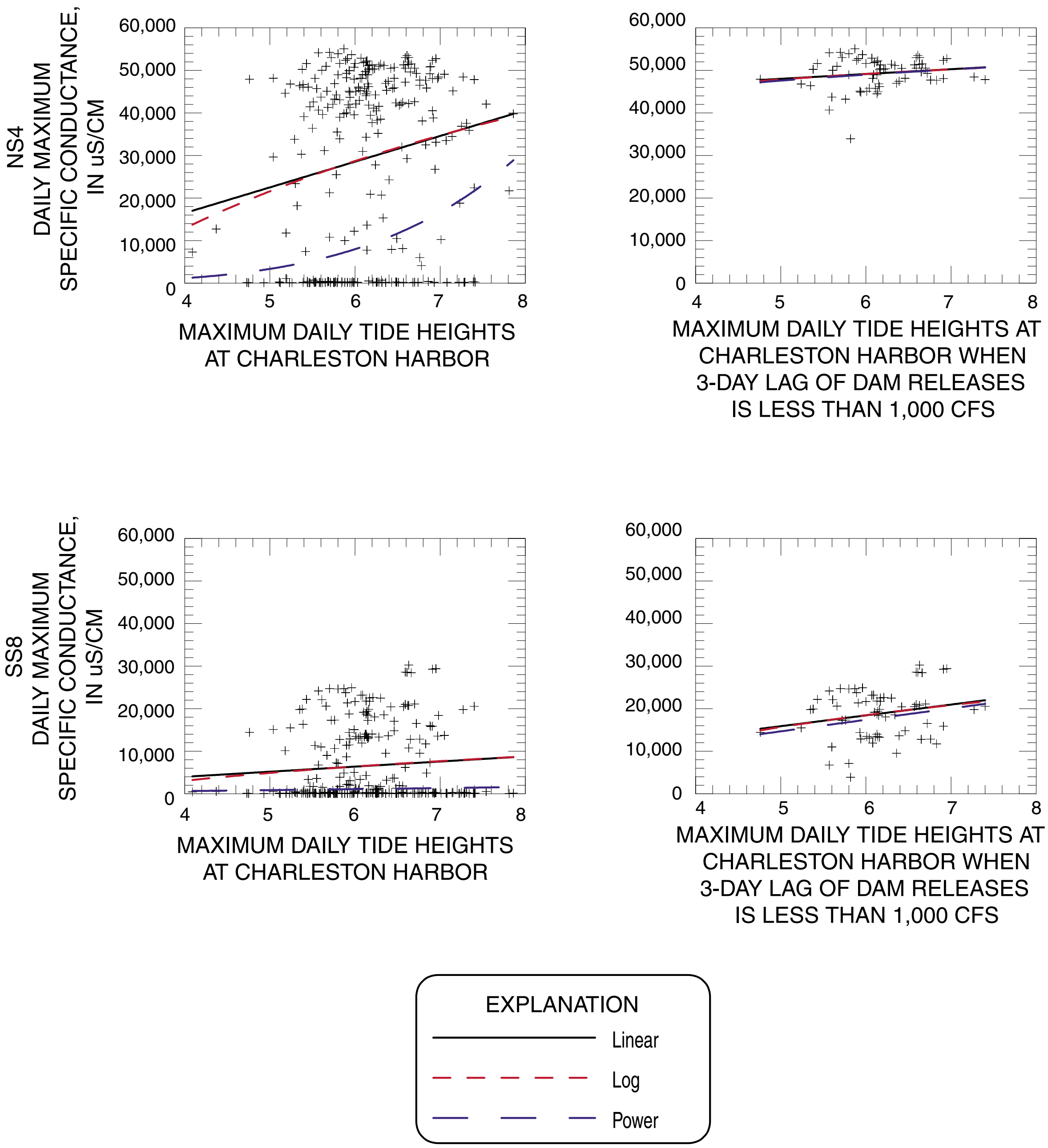


Figure 23. Maximum daily tide height at Charleston Harbor with daily maximum specific conductance at NS4 and SS8 for the entire range of dam releases and dam releases less that 1,000 cfs.

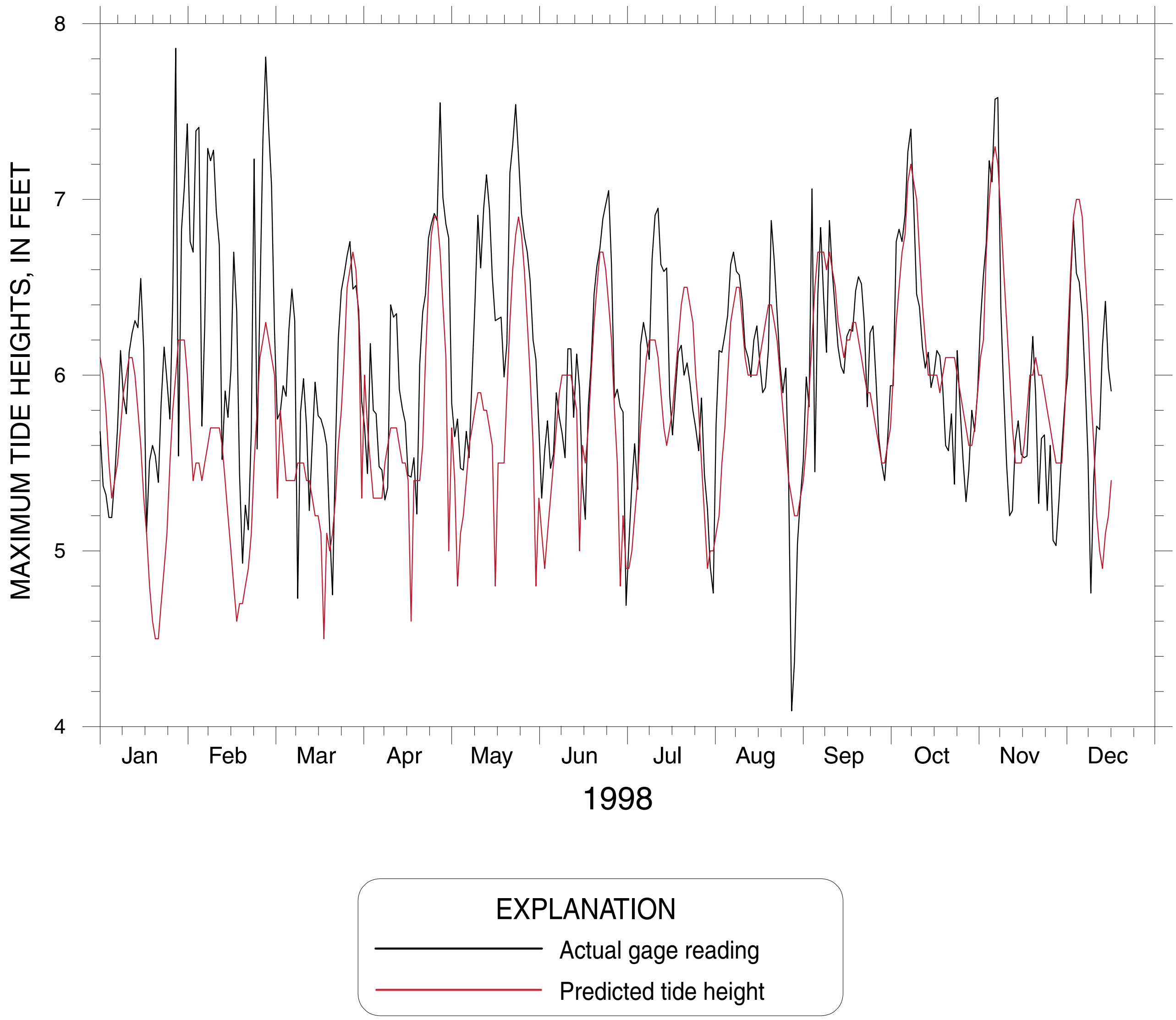


Figure 24. Comparison of recorded and predicted maximum tide height at Charleston Harbor.

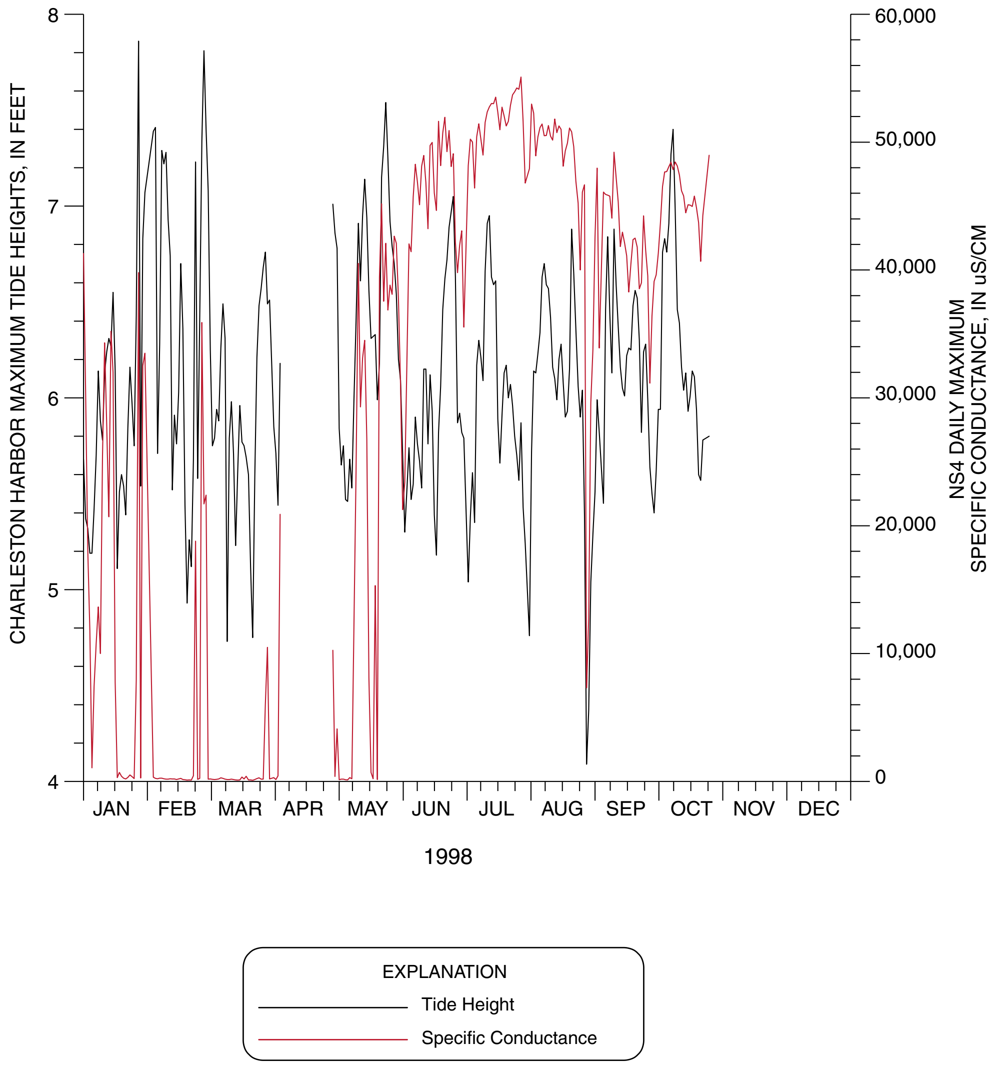


Figure 25. Comparison of recorded maximum tide height at Charleston Harbor with daily maximum specific conductance at NS4.

SUMMARY AND DISCUSSION

Measurements of conductivity, temperature, and stage were made in the Santee estuary between October 1996 and August 2002 at three observation stations on the North and South Santee Rivers. Longitudinal conductance profiles were conducted on the North and South Santee Rivers to determine the maximum and minimum incursion of saltwater under various streamflow and tidal conditions.

Flow characteristics were evaluated with streamflow data from the USGS gaging station at Jamestown, S.C., and from dam-release data reported by Santee Cooper since rediversion occurred in 1985. Streamflow was generally greatest from December through April, and low flows occurred mostly during the summer months. Daily average streamflows from October 1986 through September 2000 were about 11,000 cfs. Average streamflows for the study period, however, were atypical of the 9,600 cfs average for the period of record between October 1986 and mid-August 2002. October 1997 through September 1998 had flows of 18,100 cfs, well above the period-of-record average. Average streamflow for each year from 1998 through 2001 (based on the October through September year) ranged from 1,200 to 3,700 cfs. These disparate streamflows were the direct result of El Nino/La Nina processes influencing precipitation in South Carolina for the 4 years preceding 2003.

Continuous measurements at the three observation sites and eight longitudinal conductivity profiles showed the occurrence of an inverse relationship between streamflow and conductivity in the estuary. The south distributary generally was more saline than the north river because it has the lesser streamflow of the two rivers. Both rivers displayed a trend of decreasing upstream advances of saline water with increasing streamflow at both high and low tides. During high-streamflow periods and low tide, freshwater extended downstream to the mouth of both rivers. During low-streamflow periods, saltwater extended more than 5.2 and 3.6 miles upstream in the south and north rivers, respectively.

Regression analysis was used to quantify the relationships among streamflow, specific conductance at the three stations, and tide height. Good correlations ($R^2 > 0.86$) existed between streamflow at Jamestown and reported Santee Cooper dam releases. Good correlations ($0.72 < R^2 < 0.95$) were found for the daily maximum, average, and minimum specific conductance at the three stations, with the best correlations being between the two South Santee stations. The equations quantifying these relationships can be used to estimate streamflow in the estuary from dam-release data and to predict specific conductance at each station for a particular streamflow condition.

Linear regression also was used to determine the best-fit lines to define the longitudinal conductivity profiles under specified streamflow conditions. These equations may be used to estimate the location of the saltwater/freshwater interface in each distributary.

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APPENDIX A

CORRELATION MATRIX
OF SPECIFIC CONDUCTANCE, STREAMFLOW, AND TIDE HEIGHT IN THE SANTEE ESTUARY USED IN REGRESSION ANALYSIS

	SS8DMX	SS8DMN	SS8DAV	SS7DMX	SS7DMN	SS7DAV	NS4DMX	NS4DMN	NS4DAV
SS8DMX	1.000								
SS8DMN	0.825	1.000							
SS8DAV	0.965	0.929	1.000						
SS7DMX	0.951	0.802	0.912	1.000					
SS7DMN	0.805	0.884	0.877	0.827	1.000				
SS7DAV	0.934	0.898	0.959	0.953	0.946	1.000			
NS4DMX	0.712	0.544	0.651	0.775	0.639	0.726	1.000		
NS4DMN	0.863	0.943	0.941	0.854	0.906	0.936	0.587	1.000	
NS4DAV	0.931	0.843	0.927	0.961	0.888	0.969	0.822	0.911	1.000
SCQ	-0.608	-0.479	-0.565	-0.668	-0.560	-0.633	-0.790	-0.526	-0.706
JamesQ	-0.644	-0.507	-0.598	-0.707	-0.593	-0.669	-0.831	-0.556	-0.746
SCQ2DMA	-0.617	-0.485	-0.573	-0.678	-0.569	-0.642	-0.799	-0.533	-0.716
SCQ3DMA	-0.626	-0.490	-0.580	-0.688	-0.578	-0.651	-0.807	-0.539	-0.725
SCQ4DMA	-0.633	-0.496	-0.586	-0.696	-0.585	-0.659	-0.813	-0.545	-0.732
SCQ5DMA	-0.639	-0.500	-0.591	-0.703	-0.591	-0.665	-0.819	-0.549	-0.738
SCQ6DMA	-0.643	-0.504	-0.595	-0.708	-0.596	-0.671	-0.826	-0.552	-0.743
SCQ7DMA	-0.646	-0.507	-0.597	-0.713	-0.600	-0.675	-0.831	-0.555	-0.746
CHBRDMX	0.085	0.089	0.074	0.136	0.102	0.096	0.175	0.071	0.107
CHBRDMN	-0.143	-0.006	-0.088	-0.154	-0.004	-0.091	-0.102	-0.003	-0.073
CHBRDAV	-0.087	0.029	-0.046	-0.049	0.066	-0.016	0.015	0.030	0.000
PDTMX	0.327	0.258	0.286	0.454	0.342	0.389	0.523	0.271	0.425
PDTMN	-0.062	0.021	-0.024	-0.039	0.073	0.015	0.055	0.057	0.053
SCQ3DL	-0.631	-0.493	-0.583	-0.695	-0.586	-0.658	-0.803	-0.539	-0.727
JamesQ3DL	-0.631	-0.494	-0.582	-0.696	-0.587	-0.660	-0.803	-0.540	-0.726
SCQ4DL	-0.669	-0.524	-0.618	-0.733	-0.621	-0.696	-0.855	-0.572	-0.770
JamesQ4DL	-0.668	-0.525	-0.617	-0.734	-0.621	-0.697	-0.854	-0.573	-0.769

	SCQ	JamesQ	SCQ2DMA	SCQ3DMA	SCQ4DMA	SCQ5DMA	SCQ6DMA	SCQ7DMA
SCQ	1.000							
JamesQ	0.926	1.000						
SCQ2DMA	0.993	0.940	1.000					
SCQ3DMA	0.983	0.953	0.996	1.000				
SCQ4DMA	0.973	0.963	0.988	0.997	1.000			
SCQ5DMA	0.963	0.972	0.979	0.991	0.998	1.000		
SCQ6DMA	0.954	0.978	0.970	0.983	0.992	0.998	1.000	
SCQ7DMA	0.944	0.981	0.961	0.975	0.986	0.994	0.998	1.000
CHBRDMX	0.108	0.100	0.106	0.101	0.098	0.100	0.101	0.101
CHBRDMN	0.086	0.112	0.086	0.088	0.096	0.105	0.112	0.119
CHBRDAV	0.194	0.188	0.193	0.189	0.190	0.196	0.199	0.202
PDTMX	-0.352	-0.367	-0.355	-0.359	-0.364	-0.369	-0.374	-0.379
PDTMN	-0.252	-0.240	-0.254	-0.254	-0.250	-0.245	-0.239	-0.233
SCQ3DL	0.909	0.959	0.928	0.951	0.972	0.982	0.983	0.981
JamesQ3DL	0.880	0.959	0.899	0.919	0.941	0.962	0.973	0.977
SCQ4DL	0.843	0.951	0.861	0.881	0.900	0.918	0.933	0.946
JamesQ4DL	0.822	0.936	0.837	0.855	0.874	0.893	0.911	0.926

	CHBRDMX	CHBRDMN	CHBRDAV	PDTMX	PDTMN	SCQ3DL	JamesQ3DL	SCQ4DL	JamesQ4DL
CHBRDMX	1.000								
CHBRDMN	-0.027	1.000							
CHBRDAV	0.680	0.650	1.000						
PDTMX	0.571	-0.515	0.047	1.000					
PDTMN	-0.550	0.680	0.057	-0.531	1.000				
SCQ3DL	0.084	0.116	0.187	-0.365	-0.229	1.000			
JamesQ3DL	0.106	0.136	0.209	-0.372	-0.215	0.971	1.000		
SCQ4DL	0.056	0.136	0.165	-0.415	-0.182	0.925	0.944	1.000	
JamesQ4DL	0.047	0.146	0.168	-0.424	-0.166	0.897	0.926	0.984	1.000

Where:

SS8DMX	Daily maximum specific conductance at SS8
SS8DMN	Daily minimum specific conductance at SS8
SS8DAV	Daily average specific conductance at SS8
SS7DMX	Daily maximum specific conductance at SS7
SS7DMN	Daily minimum specific conductance at SS7
SS7DAV	Daily average specific conductance at SS7
NS4DMX	Daily maximum specific conductance at NS4
NS4DMN	Daily minimum specific conductance at NS4
NS4DAV	Daily average specific conductance at NS4
SCQ	Total daily dam releases reported by Santee Cooper
JamesQ	Computed daily streamflow at Jamestown
SCQ2DMA	2-day moving average of SCQ
SCQ3DMA	3-day moving average of SCQ
SCQ4DMA	4-day moving average of SCQ
SCQ5DMA	5-day moving average of SCQ
SCQ6DMA	6-day moving average of SCQ
SCQ7DMA	7-day moving average of SCQ
CHBRDMX	Daily maximum tide height recorded in Charleston Harbor
CHBRDMN	Daily minimum tide height recorded in Charleston Harbor
CHBRDAV	Daily average tide height recorded in Charleston Harbor
PDTMX	Predicted daily maximum tide height in Charleston Harbor
PDTMN	Predicted daily minimum tide height in Charleston Harbor
SCQ3DL	3-day lag of SCQ
JamesQ3DL	3-day lag of JamesQ
SCQ4DL	4-day lag of SCQ
JamesQ4DL	4-day lag of JamesQ

APPENDIX B

CORRELATION MATRIX OF SPECIFIC CONDUCTANCE AND STREAMFLOW IN THE SANTEE ESTUARY USED IN REGRESSION ANALYSIS, INCLUDING SQUARES, SQUARE ROOTS, LOGARITHMS, AND INVERSES OF SELECTED VARIABLES

		SS8DMX	SS8DMN	SS8DAV	SS7DMX	SS7DMN	SS7DAV	NS4DMX	NS4DMN	NS4DAV	SCQ	SCQ3DL	SCQ4DL	SCQ3MA
	SS8DMX	1.000												
	SS8DMN	0.825	1.000											
	SS8DAV	0.965	0.929	1.000										
	SS7DMX	0.951	0.802	0.912	1.000									
	SS7DMN	0.805	0.884	0.877	0.827	1.000								
	SS7DAV	0.934	0.898	0.959	0.953	0.946	1.000							
	NS4DMX	0.712	0.544	0.651	0.775	0.639	0.726	1.000						
	NS4DMN	0.863	0.943	0.941	0.854	0.906	0.936	0.587	1.000					
	NS4DAV	0.931	0.843	0.927	0.961	0.888	0.969	0.822	0.911	1.000				
	SCQ	-0.608	-0.479	-0.565	-0.668	-0.560	-0.633	-0.790	-0.526	-0.706	1.000			
	SCQ3DL	-0.631	-0.493	-0.583	-0.695	-0.586	-0.658	-0.803	-0.539	-0.727	0.909	1.000		
	SCQ4DL	-0.669	-0.524	-0.618	-0.733	-0.621	-0.696	-0.855	-0.572	-0.770	0.843	0.925	1.000	
	SCQ3MA	-0.626	-0.490	-0.580	-0.688	-0.578	-0.651	-0.807	-0.539	-0.725	0.983	0.951	0.881	1.000
SQRT	SCQ	-0.740	-0.607	-0.707	-0.787	-0.684	-0.765	-0.847	-0.669	-0.835	0.960	0.890	0.869	0.949
SQRT	SCQ3DL	-0.782	-0.635	-0.740	-0.832	-0.730	-0.810	-0.862	-0.696	-0.871	0.886	0.959	0.931	0.922
SQRT	SCQ3MA	-0.772	-0.631	-0.736	-0.819	-0.716	-0.797	-0.865	-0.696	-0.865	0.947	0.924	0.899	0.962
SQ	SCQ	-0.395	-0.300	-0.358	-0.451	-0.366	-0.416	-0.592	-0.328	-0.473	0.927	0.810	0.683	0.902
SQ	SCQ3DL	-0.399	-0.303	-0.361	-0.458	-0.371	-0.422	-0.602	-0.329	-0.479	0.818	0.927	0.789	0.865
SQ	SCQ3MA	-0.404	-0.306	-0.365	-0.462	-0.374	-0.426	-0.608	-0.334	-0.484	0.909	0.868	0.733	0.928
LN	SCQ	-0.826	-0.714	-0.816	-0.845	-0.770	-0.849	-0.805	-0.786	-0.899	0.836	0.787	0.800	0.828
LN	SCQ3DL	-0.882	-0.758	-0.864	-0.902	-0.834	-0.911	-0.818	-0.828	-0.947	0.779	0.832	0.843	0.805
LN	SCQ3MA	-0.879	-0.763	-0.870	-0.895	-0.828	-0.904	-0.826	-0.838	-0.946	0.825	0.811	0.825	0.838
INV	SCQ	0.819	0.765	0.848	0.798	0.778	0.840	0.634	0.832	0.847	-0.610	-0.582	-0.612	-0.607
INV	SCQ3DL	0.877	0.826	0.907	0.859	0.849	0.911	0.641	0.890	0.901	-0.576	-0.611	-0.641	-0.592
INV	SCQ3MA	0.880	0.842	0.923	0.851	0.853	0.906	0.632	0.905	0.893	-0.581	-0.578	-0.610	-0.590
SQRT	SS8DMX	0.979	0.776	0.923	0.972	0.811	0.938	0.795	0.837	0.961	-0.686	-0.712	-0.755	-0.706
SQRT	SS7DMX	0.909	0.734	0.854	0.978	0.801	0.922	0.839	0.796	0.953	-0.747	-0.779	-0.814	-0.769
SQRT	NS4DMX	0.636	0.484	0.578	0.703	0.578	0.655	0.986	0.523	0.755	-0.784	-0.791	-0.845	-0.800
SQ	SS8DMX	0.958	0.850	0.956	0.863	0.748	0.869	0.596	0.833	0.837	-0.503	-0.519	-0.551	-0.517
SQ	SS7DMX	0.948	0.860	0.937	0.970	0.817	0.940	0.675	0.880	0.919	-0.574	-0.595	-0.632	-0.591
SQ	NS4DMX	0.807	0.624	0.747	0.856	0.712	0.810	0.978	0.668	0.891	-0.775	-0.796	-0.845	-0.794
LN	SS8DMX	0.892	0.683	0.822	0.933	0.770	0.884	0.884	0.751	0.940	-0.776	-0.807	-0.859	-0.798
LN	SS7DMX	0.779	0.605	0.716	0.867	0.701	0.804	0.855	0.661	0.859	-0.820	-0.864	-0.892	-0.848
LN	NS4DMX	0.543	0.412	0.492	0.610	0.500	0.565	0.934	0.446	0.664	-0.755	-0.758	-0.814	-0.770
INV	SS8DMX	-0.604	-0.457	-0.546	-0.681	-0.554	-0.630	-0.844	-0.496	-0.710	0.764	0.815	0.896	0.790
INV	SS7DMX	-0.457	-0.345	-0.412	-0.535	-0.425	-0.486	-0.638	-0.375	-0.541	0.730	0.822	0.850	0.773
INV	NS4DMX	-0.426	-0.324	-0.384	-0.484	-0.396	-0.447	-0.789	-0.349	-0.531	0.653	0.664	0.719	0.667

		SQRT SCQ	SQRT SCQ3DL	SQRT SCQ3MA	SQ SCQ	SQ SCQ3DL	SQ SCQ3MA	LN SCQ	LN SCQ3DL	LN SCQ3MA	INV SCQ	INV SCQ3DL	INV SCQ3MA
SQRT	SCQ	1.000											
SQRT	SCQ3DL	0.928	1.000										
SQRT	SCQ3MA	0.986	0.961	1.000									
SQ	SCQ	0.797	0.719	0.783	1.000								
SQ	SCQ3DL	0.728	0.794	0.759	0.837	1.000							
SQ	SCQ3MA	0.789	0.760	0.802	0.967	0.911	1.000						
LN	SCQ	0.952	0.883	0.937	0.611	0.578	0.612	1.000					
LN	SCQ3DL	0.878	0.952	0.909	0.570	0.605	0.593	0.904	1.000				
LN	SCQ3MA	0.936	0.916	0.951	0.606	0.595	0.619	0.977	0.945	1.000			
INV	SCQ	-0.780	-0.718	-0.767	-0.381	-0.374	-0.385	-0.925	-0.810	-0.899	1.000		
INV	SCQ3DL	-0.711	-0.784	-0.738	-0.371	-0.378	-0.380	-0.806	-0.929	-0.855	0.813	1.000	
INV	SCQ3MA	-0.740	-0.728	-0.757	-0.365	-0.363	-0.371	-0.873	-0.843	-0.912	0.937	0.879	1.000
SQRT	SS8DMX	-0.812	-0.855	-0.843	-0.458	-0.466	-0.469	-0.873	-0.928	-0.919	0.819	0.875	0.862
SQRT	SS7DMX	-0.846	-0.892	-0.877	-0.529	-0.544	-0.545	-0.869	-0.923	-0.912	0.772	0.826	0.808
SQRT	NS4DMX	-0.822	-0.829	-0.837	-0.607	-0.614	-0.624	-0.761	-0.766	-0.775	0.576	0.579	0.566
SQ	SS8DMX	-0.630	-0.660	-0.657	-0.319	-0.321	-0.325	-0.729	-0.771	-0.780	0.765	0.810	0.838
SQ	SS7DMX	-0.700	-0.738	-0.730	-0.373	-0.377	-0.381	-0.784	-0.835	-0.837	0.789	0.845	0.856
SQ	NS4DMX	-0.856	-0.881	-0.879	-0.560	-0.571	-0.574	-0.844	-0.868	-0.874	0.701	0.714	0.713
LN	SS8DMX	-0.879	-0.918	-0.906	-0.540	-0.561	-0.557	-0.893	-0.936	-0.926	0.771	0.810	0.785
LN	SS7DMX	-0.876	-0.921	-0.904	-0.629	-0.668	-0.658	-0.839	-0.880	-0.869	0.680	0.713	0.690
LN	NS4DMX	-0.771	-0.771	-0.783	-0.605	-0.612	-0.624	-0.693	-0.690	-0.701	0.502	0.500	0.486
INV	SS8DMX	0.807	0.838	0.826	0.559	0.636	0.595	0.745	0.758	0.756	-0.554	-0.558	-0.537
INV	SS7DMX	0.709	0.768	0.737	0.639	0.766	0.703	0.609	0.633	0.623	-0.423	-0.425	-0.410
INV	NS4DMX	0.654	0.657	0.664	0.529	0.553	0.549	0.573	0.569	0.577	-0.399	-0.395	-0.383

		SQRT SS8DMX	SQRT SS7DMX	SQRT NS4DMX	SQ SS8DMX	SQ SS7DMX	SQ NS4DMX	LN SS8DMX	LN SS7DMX	LN NS4DMX	INV SS8DMX	INV SS7DMX	INV NS4DMX
SQRT	SS8DMX	1.000											
SQRT	SS7DMX	0.960	1.000										
SQRT	NS4DMX	0.723	0.776	1.000									
SQ	SS8DMX	0.887	0.794	0.523	1.000								
SQ	SS7DMX	0.927	0.907	0.602	0.915	1.000							
SQ	NS4DMX	0.877	0.903	0.934	0.695	0.767	1.000						
LN	SS8DMX	0.961	0.969	0.829	0.762	0.844	0.934	1.000					
LN	SS7DMX	0.859	0.947	0.815	0.653	0.758	0.887	0.933	1.000				
LN	NS4DMX	0.630	0.688	0.978	0.439	0.513	0.852	0.749	0.751	1.000			
INV	SS8DMX	-0.704	-0.777	-0.841	-0.486	-0.570	-0.824	-0.850	-0.875	-0.820	1.000		
INV	SS7DMX	-0.536	-0.652	-0.642	-0.366	-0.433	-0.624	-0.658	-0.835	-0.638	0.811	1.000	
INV	NS4DMX	-0.503	-0.557	-0.856	-0.340	-0.401	-0.698	-0.624	-0.635	-0.928	0.760	0.588	1.000

Where:	SS8DMX	Daily maximum specific conductance at SS8
	SS8DMN	Daily minimum specific conductance at SS8
	SS8DAV	Daily average specific conductance at SS8
	SS7DMX	Daily maximum specific conductance at SS7
	SS7DMN	Daily minimum specific conductance at SS7
	SS7DAV	Daily average specific conductance at SS7
	NS4DMX	Daily maximum specific conductance at NS4
	NS4DMN	Daily minimum specific conductance at NS4
	NS4DAV	Daily average specific conductance at NS4
	SCQ	Total daily dam releases reported by Santee Cooper
	SCQ3DL	3-day lag of SCQ
	SCQ4DL	4-day lag of SCQ
	SCQ3DMA	3-day moving average of SCQ
	SQRT	Square root
	SQ	Square
	LN	Natural logarithm
	INV	Inverse

APPENDIX C

EQUATIONS DEFINING THE RELATIONSHIPS AMONG SPECIFIC CONDUCTANCE, STREAMFLOW, AND TIDE HEIGHT IN THE SANTEE ESTUARY

X	Y	Type	Equation	Data points	Average X or ln(X)	Average Y or ln(Y)	R-squared
SCQ	JamesQ	Linear	Y = 0.810 * X + 2,650	263	X = 18,336	Y = 17,503	0.86
SCQ	JamesQ	Log	Y = 8,690 * ln(X) - 59,600	263	ln(X) = 8.87151	Y = 17,503	0.71
SCQ	JamesQ	Power	ln(Y) = 0.825 * ln(X) + 1.70	263	ln(X) = 8.87151	ln(Y) = 9.02459	0.95
SCQ3DMA	JamesQ	Linear	Y = 0.839 * X + 2000	263	X = 18,486	Y = 17,503	0.91
SCQ3DMA	JamesQ	Log	Y = 9,027.4 * ln(X) - 63,108	263	ln(X) = 8.92957	Y = 17,503	0.72
SCQ3DMA	JamesQ	Power	ln(Y) = 0.850 * ln(X) + 1.44	263	ln(X) = 8.92957	ln(Y) = 9.02459	0.94
SCQ7DMA	JamesQ	Linear	Y = 0.878 * X + 1070	263	X = 18,711	Y = 17,503	0.96
SCQ7DMA	JamesQ	Log	Y = 9,210 * ln(X) - 65,300	263	ln(X) = 8.99035	Y = 17,503	0.71
SCQ7DMA	JamesQ	Power	ln(Y) = 0.848 * ln(X) + 1.40	263	ln(X) = 8.99035	ln(Y) = 9.02459	0.89
SCQ	NS4DMX	Linear	Y = -0.846 * X + 448	263	X = 18,336	Y = 29,262	0.62
SCQ	NS4DMX	Log	Y = -10,200 * ln(X) + 120,000	263	ln(X) = 8.87151	Y = 29,262	0.65
SCQ	NS4DMX	Power	ln(Y) = -0.991 * ln(X) + 17.8	263	ln(X) = 8.87151	ln(Y) = 9.05429	0.48
SCQ	SS7DMX	Linear	Y = -0.526 * X + 23,400	263	X = 18,336	Y = 13,722	0.45
SCQ	SS7DMX	Log	Y = -7,840 * ln(X) + 83,300	263	ln(X) = 8.87151	Y = 13,722	0.71
SCQ	SS7DMX	Power	ln(Y) = -1.09 * ln(X) + 17.7	263	ln(X) = 8.87151	ln(Y) = 8.08604	0.70
SCQ	SS8DMX	Linear	Y = -0.267 * X + 11,400	263	X = 18,336	Y = 6,527	0.37
SCQ	SS8DMX	Log	Y = -4,280 * ln(X) + 44,500	263	ln(X) = 8.87151	Y = 6,527	0.68
SCQ	SS8DMX	Power	ln(Y) = -1.19 * ln(X) + 17.6	263	ln(X) = 8.87151	ln(Y) = 7.01678	0.80
SCQ3DMA	NS4DMX	Linear	Y = -0.869 * X + 45,300	263	X = 18,486	Y = 29,262	0.65
SCQ3DMA	NS4DMX	Log	Y = -10,800 * ln(X) + 12,500	263	ln(X) = 8.92957	Y = 29,262	0.68
SCQ3DMA	NS4DMX	Power	ln(Y) = -1.04 * ln(X) + 18.3	263	ln(X) = 8.92957	ln(Y) = 9.05429	0.49
SCQ3DMA	SS7DMX	Linear	Y = -0.545 * X + 23,800	263	X = 18,486	Y = 13,722	0.47
SCQ3DMA	SS7DMX	Log	Y = -8590 * ln(X) + 90,400	263	ln(X) = 8.92957	Y = 13,722	0.80
SCQ3DMA	SS7DMX	Power	ln(Y) = -1.17 * ln(X) + 18.5	263	ln(X) = 8.92957	ln(Y) = 8.08604	0.76
SCQ3DMA	SS8DMX	Linear	Y = -0.277 * X + 11,600	263	X = 18,486	Y = 6,527	0.39
SCQ3DMA	SS8DMX	Log	Y = -4710 * ln(X) + 48,600	263	ln(X) = 8.92957	Y = 6,527	0.77
SCQ3DMA	SS8DMX	Power	ln(Y) = -1.28 * ln(X) + 18.4	263	ln(X) = 8.92957	ln(Y) = 7.01678	0.86
SCQ3DL	NS4DMX	Linear	Y = -0.851 * X + 45,200	263	X = 18,684	Y = 29,262	0.64
SCQ3DL	NS4DMX	Log	Y = -10,300 * ln(X) + 121,000	263	ln(X) = 8.89471	Y = 29,262	0.67
SCQ3DL	NS4DMX	Power	ln(Y) = -0.983 * ln(X) + 17.800	263	ln(X) = 8.89471	ln(Y) = 9.05429	0.48
SCQ3DL	SS7DMX	Linear	Y = -0.542 * X + 23,800	263	X = 18,684	Y = 13,722	0.48
SCQ3DL	SS7DMX	Log	Y = -8,350 * ln(X) + 88,000	263	ln(X) = 8.89471	Y = 13,722	0.81
SCQ3DL	SS7DMX	Power	ln(Y) = -1.14 * ln(X) + 18.2	263	ln(X) = 8.89471	ln(Y) = 8.08604	0.77
SCQ3DL	SS8DMX	Linear	Y = -0.274 * X + 11,700	263	X = 18,684	Y = 6,527	0.40
SCQ3DL	SS8DMX	Log	Y = -4,550 * ln(X) + 47,000	263	ln(X) = 8.89471	Y = 6,527	0.78
SCQ3DL	SS8DMX	Power	ln(Y) = -1.24 * ln(X) + 18.1	263	ln(X) = 8.89471	ln(Y) = 7.01678	0.88
SCQ4DL	NS4DMX	Linear	Y = -1.04 * X + 47,800	263	X = 17,854	Y = 29,262	0.73
SCQ4DL	NS4DMX	Log	Y = -12,500 * ln(X) + 142,000	263	ln(X) = 9.04646	Y = 29,262	0.70
SCQ4DL	NS4DMX	Power	ln(Y) = -1.21 * ln(X) + 20.0	263	ln(X) = 9.04646	ln(Y) = 9.05429	0.52
SCQ3DMA	NS4DAV	Linear	Y = -0.578 * X + 25,200	263	X = 18,486	Y = 14,547	0.53
SCQ3DMA	NS4DAV	Log	Y = -9,140 * ln(X) + 96,100	263	ln(X) = 8.92957	Y = 14,547	0.90
SCQ3DMA	NS4DAV	Power	ln(Y) = -1.24 * ln(X) + 19.2	263	ln(X) = 8.92957	ln(Y) = 8.07936	0.74
SCQ3DMA	SS7DAV	Linear	Y = -0.361 * X + 15,400	263	X = 18,486	Y = 8,711	0.42
SCQ3DMA	SS7DAV	Log	Y = -6,070 * ln(X) + 62,900	263	ln(X) = 8.92957	Y = 8,711	0.82
SCQ3DMA	SS7DAV	Power	ln(Y) = -1.21 * ln(X) + 18.3	263	ln(X) = 8.92957	ln(Y) = 7.50641	0.82
SCQ3DMA	SS8DAV	Linear	Y = -0.156 * X + 6,480	263	X = 18,486	Y = 3,605	0.34
SCQ3DMA	SS8DAV	Log	Y = -2820 * ln(X) + 28,800	263	ln(X) = 8.92957	Y = 3,605	0.76
SCQ3DMA	SS8DAV	Power	ln(Y) = -1.17 * ln(X) + 17.0	263	ln(X) = 8.92957	ln(Y) = 6.5615	0.89

X	Y	Type	Equation	Data points	Average X or ln(X)	Average Y or ln(Y)	R-squared
SCQ3DL	NS4DAV	Linear	Y = -0.570 * X + 25,200	263	X = 18,684	Y = 14,547	0.53
SCQ3DL	NS4DAV	Log	Y = -8810 * ln(X) + 92,900	263	ln(X) = 8.89471	Y = 14,547	0.90
SCQ3DL	NS4DAV	Power	ln(Y) = -1.19 * ln(X) + 18.7	263	ln(X) = 8.89471	ln(Y) = 8.07936	0.73
SCQ3DL	SS7DAV	Linear	Y = -0.359 * X + 15,400	263	X = 18,684	Y = 8,711	0.43
SCQ3DL	SS7DAV	Log	Y = -5,900 * ln(X) + 61,200	263	ln(X) = 8.89471	Y = 8,711	0.83
SCQ3DL	SS7DAV	Power	ln(Y) = -1.18 * ln(X) + 18.0	263	ln(X) = 8.89471	ln(Y) = 7.50641	0.84
SCQ3DL	SS8DAV	Linear	Y = -0.154 * X + 6,480	263	X = 18,684	Y = 3,605	0.34
SCQ3DL	SS8DAV	Log	Y = -2,700 * ln(X) + 27,700	263	ln(X) = 8.89471	Y = 3,605	0.75
SCQ3DL	SS8DAV	Power	ln(Y) = -1.14 * ln(X) + 16.7	263	ln(X) = 8.89471	ln(Y) = 6.5615	0.91
SCQ3DMA	NS4DMN	Linear	Y = -0.309 * X + 12,600	263	X = 18,486	Y = 6,893	0.29
SCQ3DMA	NS4DMN	Log	Y = -5,820 * ln(X) + 58,900	263	ln(X) = 8.92957	Y = 6,893	0.70
SCQ3DMA	NS4DMN	Power	ln(Y) = -1.36 * ln(X) + 18.7	263	ln(X) = 8.92957	ln(Y) = 6.59164	0.91
SCQ3DMA	SS7DMN	Linear	Y = -0.197 * X + 8,350	263	X = 18,486	Y = 4,706	0.33
SCQ3DMA	SS7DMN	Log	Y = -3,420 * ln(X) + 35,300	263	ln(X) = 8.92957	Y = 4,706	0.69
SCQ3DMA	SS7DMN	Power	ln(Y) = -1.18 * ln(X) + 17.2	263	ln(X) = 8.92957	ln(Y) = 6.69557	0.79
SCQ3DMA	SS8DMN	Linear	Y = -0.056 * X + 2,390	263	X = 18,486	Y = 1,353	0.24
SCQ3DMA	SS8DMN	Log	Y = -1,060 * ln(X) + 10,800	263	ln(X) = 8.92957	Y = 1,353	0.58
SCQ3DMA	SS8DMN	Power	ln(Y) = -0.880 * ln(X) + 13.7	263	ln(X) = 8.92957	ln(Y) = 5.88196	0.79
SCQ3DL	NS4DMN	Linear	Y = -0.304 * X + 12,600	263	X = 18,684	Y = 6,893	0.29
SCQ3DL	NS4DMN	Log	Y = -5,540 * ln(X) + 56,200	263	ln(X) = 8.89471	Y = 6,893	0.69
SCQ3DL	NS4DMN	Power	ln(Y) = -1.31 * ln(X) + 18.2	263	ln(X) = 8.89471	ln(Y) = 6.59164	0.91
SCQ3DL	SS7DMN	Linear	Y = -0.196 * X + 8,380	263	X = 18,684	Y = 4,706	0.34
SCQ3DL	SS7DMN	Log	Y = -3,320 * ln(X) + 34,200	263	ln(X) = 8.89471	Y = 4,706	0.69
SCQ3DL	SS7DMN	Power	ln(Y) = -1.15 * ln(X) + 16.9	263	ln(X) = 8.89471	ln(Y) = 6.69557	0.80
SCQ3DL	SS8DMN	Linear	Y = -0.056 * X + 2,390	263	X = 18,684	Y = 1,353	0.24
SCQ3DL	SS8DMN	Log	Y = -1,010 * ln(X) + 10,400	263	ln(X) = 8.89471	Y = 1,353	0.57
SCQ3DL	SS8DMN	Power	ln(Y) = -0.857 * ln(X) + 13.5	263	ln(X) = 8.89471	ln(Y) = 5.88196	0.80
SS8DMX	SS7DMX	Linear	Y = 1.70 * X + 2,590	263	X = 6,527	Y = 13,722	0.90
SS8DMX	SS7DMX	Log	Y = 6,500 * ln(X) - 31,900	263	ln(X) = 7.01678	Y = 13,722	0.87
SS8DMX	SS7DMX	Power	ln(Y) = 0.908 * ln(X) + 1.72	263	ln(X) = 7.01678	ln(Y) = 8.08604	0.87
SS8DMX	NS4DMX	Linear	Y = 1.73 * X + 17,900	263	X = 6,527	Y = 29,262	0.51
SS8DMX	NS4DMX	Log	Y = 8,370 * ln(X) - 29,500	263	ln(X) = 7.01678	Y = 29,262	0.78
SS8DMX	NS4DMX	Power	ln(Y) = 0.803 * ln(X) + 3.42	263	ln(X) = 7.01678	ln(Y) = 9.05429	0.56
SS7DMX	NS4DMX	Linear	Y = 1.05 * X + 14,800	263	X = 13,722	Y = 29,262	0.60
SS7DMX	NS4DMX	Log	Y = 8,330 * ln(X) - 38,100	263	ln(X) = 8.08604	Y = 29,262	0.73
SS7DMX	NS4DMX	Power	ln(Y) = 0.828 * ln(X) + 2.36	263	ln(X) = 8.08604	ln(Y) = 9.05429	0.56
SS8DAV	SS7DAV	Linear	Y = 1.98 * X + 1,560	263	X = 3,605	Y = 8,711	0.92
SS8DAV	SS7DAV	Log	Y = 5,050 * ln(X) - 24,400	263	ln(X) = 6.5615	Y = 8,711	0.87
SS8DAV	SS7DAV	Power	ln(Y) = 1.02 * ln(X) + 0.816	263	ln(X) = 6.5615	ln(Y) = 7.50641	0.89
SS8DAV	NS4DAV	Linear	Y = 2.76 * X + 4,600	263	X = 3,605	Y = 14,547	0.86
SS8DAV	NS4DAV	Log	Y = 7,560 * ln(X) - 35,000	263	ln(X) = 6.5615	Y = 14,547	0.94
SS8DAV	NS4DAV	Power	ln(Y) = 1.04 * ln(X) + 1.25	263	ln(X) = 6.5615	ln(Y) = 8.07936	0.79
SS7DAV	NS4DAV	Linear	Y = 1.39 * X + 2,400	263	X = 8,711	Y = 14,547	0.94
SS7DAV	NS4DAV	Log	Y = 6,520 * ln(X) - 34,400	263	ln(X) = 7.50641	Y = 14,547	0.82
SS7DAV	NS4DAV	Power	ln(Y) = 0.959 * ln(X) + 0.882	263	ln(X) = 7.50641	ln(Y) = 8.07936	0.79

X	Y	Type	Equation	Data points	Average X or ln(X)	Average Y or ln(Y)	R-squared
SS8DMN	SS7DMN	Linear	Y = 2.63 * X + 1,150	263	X = 1,353	Y = 4,706	0.78
SS8DMN	SS7DMN	Log	Y = 3,820 * ln(X) - 17,700	263	ln(X) = 5.88196	Y = 4,706	0.84
SS8DMN	SS7DMN	Power	ln(Y) = 1.21 * ln(X) - 0.428	263	ln(X) = 5.88196	ln(Y) = 6.69557	0.82
SS8DMN	NS4DMN	Linear	Y = 4.71 * X + 517	263	X = 1,353	Y = 6,893	0.89
SS8DMN	NS4DMN	Log	Y = 6,330 * ln(X) - 30,400	263	ln(X) = 5.88196	Y = 6,893	0.82
SS8DMN	NS4DMN	Power	ln(Y) = 1.33 * ln(X) - 1.24	263	ln(X) = 5.88196	ln(Y) = 6.59164	0.86
SS7DMN	NS4DMN	Linear	Y = 1.52 * X - 274	263	X = 4,706	Y = 6,893	0.82
SS7DMN	NS4DMN	Log	Y = 4,100 * ln(X) - 20,600	263	ln(X) = 6.69557	Y = 6,893	0.62
SS7DMN	NS4DMN	Power	ln(Y) = 0.976 * ln(X) + 0.058	263	ln(X) = 6.69557	ln(Y) = 6.59164	0.83

CHNHBRMX	NS4DMX	Linear	Y = 6,040 * X - 7,710	263	X = 6.1	Y = 29,262	0.03
CHNHBRMX	NS4DMX	Log	Y = 39,000 * ln(X) - 41,200	263	ln(X) = 1.80636	Y = 29,262	0.03
CHNHBRMX	NS4DMX	Power	ln(Y) = 4.76 * ln(X) + 0.448	263	ln(X) = 1.80636	ln(Y) = 9.05429	0.04
CHNHBRMX Q<1000 cfs	NS4DMX	Linear	Y = 1,120 * X + 42,500	64	X = 6.2	Y = 49,380	0.02
CHNHBRMX Q<1000 cfs	NS4DMX	Log	Y = 6,970 * ln(X) + 36,700	64	ln(X) = 1.81483	Y = 49,380	0.02
CHNHBRMX Q<1000 cfs	NS4DMX	Power	ln(Y) = 0.159 * ln(X) + 10.5	64	ln(X) = 1.81483	ln(Y) = 10.8043	0.03
CHNHBRMX	SS8DMX	Linear	Y = 1,200 * X - 802	263	X = 6.1	Y = 6,527	0.01
CHNHBRMX	SS8DMX	Log	Y = 8,230 * ln(X) - 8,350	263	ln(X) = 1.80636	Y = 6,527	0.01
CHNHBRMX	SS8DMX	Power	ln(Y) = 1.33 * ln(X) + 4.61	263	ln(X) = 1.80636	ln(Y) = 7.01678	0.00
CHNHBRMX Q<1000 cfs	SS8DMX	Linear	Y = 2,520 * X + 3,370	64	X = 6.2	Y = 18,911	0.05
CHNHBRMX Q<1000 cfs	SS8DMX	Log	Y = 15,300 * ln(X) - 8,800	64	ln(X) = 1.81483	Y = 18,911	0.05
CHNHBRMX Q<1000 cfs	SS8DMX	Power	ln(Y) = 0.928 * ln(X) + 8.11	64	ln(X) = 1.81483	ln(Y) = 9.78898	0.04

Where:	SCQ	Total daily dam releases reported by Santee Cooper
	JamesQ	Computed daily streamflow at Jamestown
	SCQ3DMA	3-day moving average of SCQ
	SCQ7DMA	7-day moving average of SCQ
	SCQ3DL	3-day lag of SCTotQ
	SCQ4DL	4-day lag of SCTotQ
	NS4DMX	Daily maximum specific conductance at NS4
	SS8DMX	Daily maximum specific conductance at SS8
	SS7DMX	Daily maximum specific conductance at SS7
	NS4DAV	Daily average specific conductance at NS4
	SS8DAV	Daily average specific conductance at SS8
	SS7DAV	Daily average specific conductance at SS7
	NS4DMN	Daily minimum specific conductance at NS4
	SS8DMN	Daily minimum specific conductance at SS8
	SS7DMN	Daily minimum specific conductance at SS7
	CHBRDMX	Daily maximum tide height recorded in Charleston Harbor
	Q<1,000 cfs	SCQ3DL is less than 1,000 cfs