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A Reconnaissance of the Hydrology of the Intracoastal Waterway from Bucksport to Little River Inlet, South Carolina

By

F. A. Johnson

Prepared by
U. S. Geological Survey, Water Resources Division
in cooperation with
South Carolina Water Resources Commission
Columbia, South Carolina

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ABSTRACT

Some of the physical and chemical characteristics of the Intracoastal Waterway (ICWW) between Bucksport and Little River Inlet have been related to tidal conditions and freshwater inflow; also the suitability of the water for use has been considered. Dye tracing techniques have been used to determine the time-of-travel from mile 375 where the Waccamaw River enters the ICWW to Little River Inlet below mile 342.

Fresh surface-water flow is contributed only by one major tributary, the Waccamaw River, which divides at mile 375, with two-thirds flowing southward. The one-third that flows northward takes about 6 days to reach Little River Inlet. The position of the saltwater interface at high tide, in the ICWW is largely controlled by the portion of the Waccamaw River flow that goes northward and is itself probably governed by the amount of backwater caused by the Pee Dee River through Bull Creek.

The interface at high-slack tide changes position by only a few miles between low and high freshwater inflow, usually remaining within 6 to 10 miles of Little River Inlet. The reconnaissance indicates that the water above the interface is probably of good quality and suitable for most uses.

INTRODUCTION

Purpose and Scope of the Investigation

This report summarizes the results of a limited reconnaissance (made during the period July 1975 to June 1976) of the hydrology of the ICWW from Bucksport (mile 377) to Little River Inlet (mile 341). The purpose was to define some of the major physical and chemical characteristics (with primary emphasis on saltwater intrusion) and to relate them to tidal conditions and freshwater inflow.

Acknowledgments

The South Carolina Water Resources Commission aided significantly in the study by providing personnel, technical aid and other supporting services. Especially helpful were: Frank Nelson, Assistant Executive Director; Jeffrey Havel and Ed Duncan, Environmental Biologists; and Joe Dennis, Graphic Supervisor.

Appreciation is extended to the officials of Myrtle Beach Airport, to Myrtlewood Country Club, and Bucksport Marina for permission to install gages on their property.

Cooperation

The reconnaissance was part of a cooperative program between the U.S. Geological Survey and the South Carolina Water Resources Commission, Mr. Clair P. Guess, Jr., Executive Director.

Conversion Table

For readers interested in metric units, a conversion table is given here for English units which are used in this report.

Multiply English unit	By	To obtain metric unit
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
cubic feet per second (ft^3/s)	2.832×10^{-2}	cubic meters per second (m^3/s)

DESCRIPTION OF THE STUDY AREA

Location

Figure 1 is a map of the ICWW from south of Bull Creek to Little River Inlet at the North Carolina border. The study area is primarily that reach of ICWW between gages A and D (Fig 1) at Little River and Bucksport, respectively. The Waccamaw River south of ICWW mile 375 and Little River from mile 347 to mile 343 are a part of the ICWW. Little River meanders to the north of the ICWW between miles 343 to 342 and then meanders southeasterly from mile 342 for another mile to Little River Inlet. The ICWW is basically an excavated canal with well defined banks from mile 347 southward to mile 375 although there is a tendency for the sides to become swampy south of Socastee Creek at mile 369.

Channel Geometry

Figure 2 shows cross-sectional profiles of the ICWW at high tide in the study-area reach. Because the reach is dredged with some regularity by the U.S. Army Corps of Engineers as the need arises, there is little variation in width or depth except where greater widths or depths occur in nature. During the study period, the Corps of Engineers was clearing the channel of snags and dredging extensively because of the banks sloughing off along much of the reach. Nautical Chart 835-SC published by the National Ocean Survey (NOS) (1974) notes that the project depth of the reach is 10 feet below mean low water.

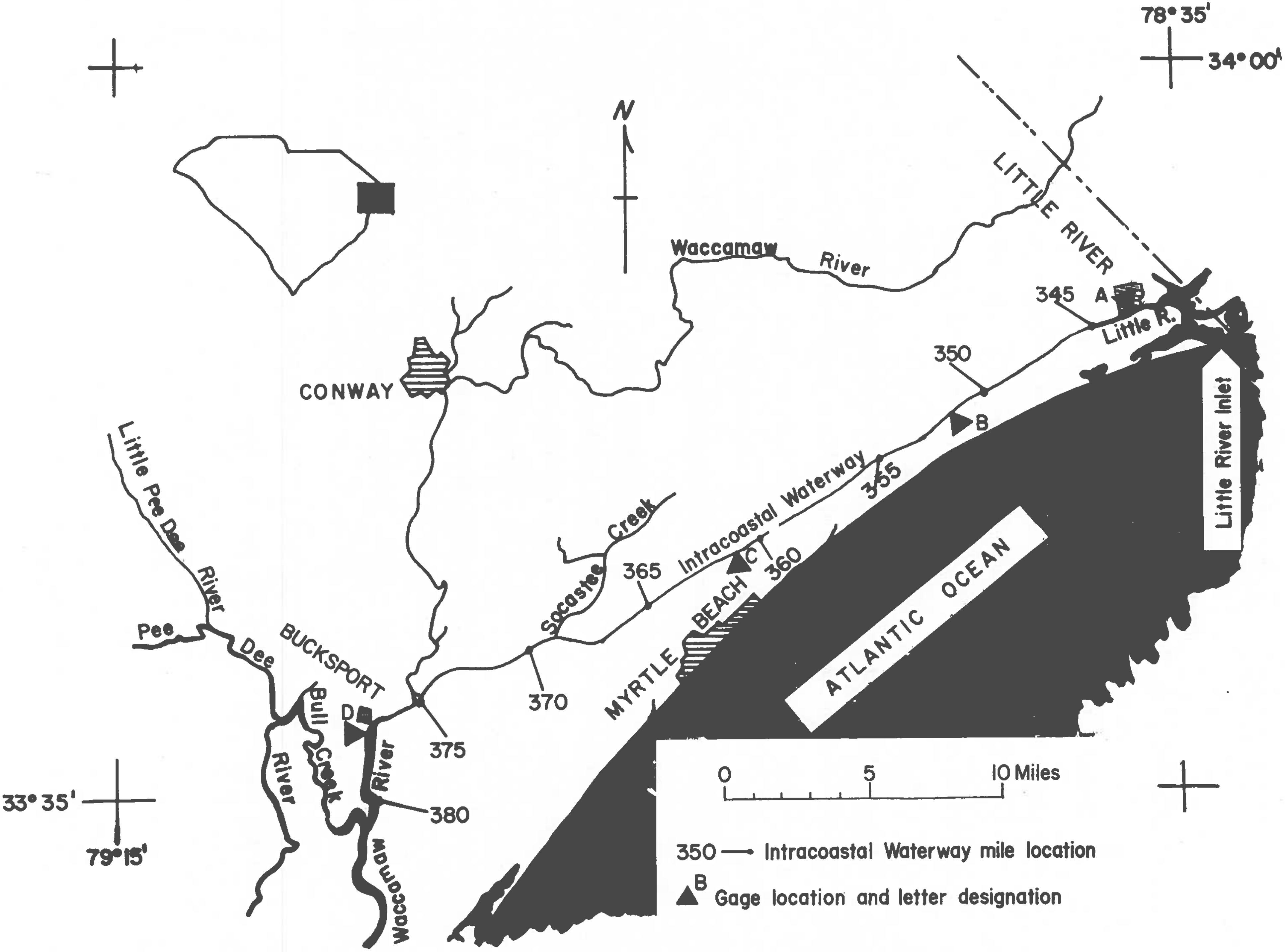

Figure 1. Map of study area.

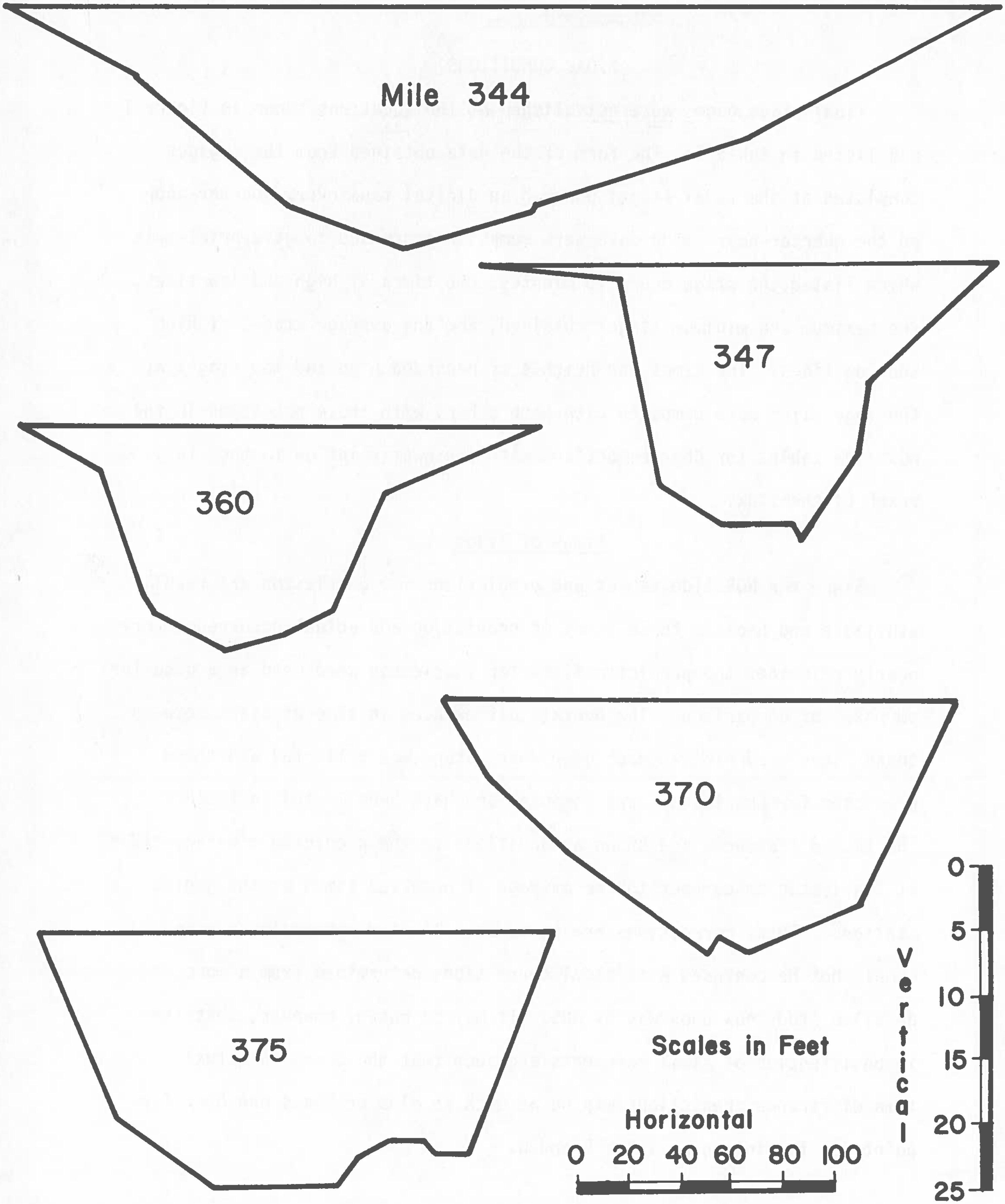

Figure 2. Typical cross-sectional profiles (facing northerly) at high tide of the Intracoastal Waterway at indicated mile points before 1976 dredging operations by the U.S. Army Corps of Engineers.

TIDAL CONDITIONS

Tidal-stage gages were established at the locations shown in figure 1 and listed in table 1. The form of the data obtained from these gages consisted of the tidal stages punched on digital tape every quarter-hour on the quarter-hour. The data were computer processed to give print-outs which listed the stage every 15 minutes, the times of high and low tides, the maximum and minimum stages obtained, and the average stages of high and low tides. The times and heights of recorded high and low stages at the gage sites were compared with each other, with those predicted in the NOS tide tables for Charleston, and with freshwater inflow to the study reach of the ICWW.

Times of Tides

Since the NOS tide tables and predictions for Charleston are readily available and because those times of prediction and actual occurrence very nearly coincide, the predicted tides for Charleston were used as a base for purposes of comparison. The average differences in time-of-tides between those tides occurring at each gage where stage was collected and those predicted for Charleston were computed and have been listed in table 2. The time differences are shown as additions to the predicted times-of-tides at Charleston to correct to the average of observed times at the gaging stations. These corrections are based on a limited reconnaissance and should not be confused with tidal corrections determined from a more detailed study now underway by NOS. It may be noted, however, that the inconsistencies of tidal movements are such that the error in actual time difference predictions may be as much as plus or minus one hour for points as far inland as sites C and D.

Table 1. Location of tide gages and type of data collected

Gage site	Gage name	Data collected*	Location
A	Little River at Little River	1,2	Lat 33°52'15", long 78°36'24" on clusters of pilings driven into streambed near west bank at east end of fishing pier at Little River, S. C., and at ICWW mile 344.3.
B	ICWW at North Myrtle Beach Airport	2	Lat 33°49'13", long 78°43'08" on east bank of ICWW near north end of airport runway at ICWW mile 351.5.
C	ICWW at Myrtlewood Golf Course	1,2	Lat 33°44'34", long 78°51'53", on east bank of ICWW on Myrtlewood Golf Course water pump intake pier at ICWW mile 361.5.
D	Waccamaw River at Bucksport	1,2	Lat 33°38'56", long 79°05'40" on west bank of ICWW on boatshed pier at Bucksport Marina and at ICWW Mile 377.4.

*1, Stage data every 15 minutes; 2, Specific conductance data every 15 minutes.

Table 2. Time corrections to be applied to daily predictions for Charleston (found in NOS tide tables) to obtain probable time-of-tide at tide gages.

Gage site	ICWW mile	Gage name	Time difference High tide	 Low tide
A	344.3	Little River at Little River	+0h 19m*	+0h 02m*
C	361.5	ICWW at Myrtlewood Golf Course	+2h 22m	+3h 35m
D	377.4	Waccamaw River at Bucksport	+3h 52m	+4h 48m

*Time difference obtained from NOS tide tables

Note.--Specific conductance data only, at site B.

The reasons for such an error are obscured by the large number of factors affecting tides. Probably the major factor is the influence of wind -- its direction, velocity, and duration.

Heights of Tides

The heights of tides at the gages were compared with those heights predicted for Charleston and with freshwater inflow. The heights of the tides at the gages did not relate closely to the freshwater inflow or the tidal heights predicted for Charleston. However, the tidal ranges and maximum stages have been listed in table 3 for comparison with each other.

It should be pointed out that the tides at Bucksport (site D) move from the south while tides at Myrtlewood (site C) and Little River (site A) move from the north. The null point of the tides along the studied reach is at the ICWW side of a small island dividing the Waccamaw River flow at the point of its interception with the ICWW (mile 375). During the period of study, the observed tides consistently reached this point from both directions simultaneously and proceeded up the Waccamaw River. It seems possible, however, that during times of drought in the Waccamaw River basin, the null point of the tides could move southward perhaps as far as Bull Creek (mile 381.4) where freshwater from the Pee Dee River would be a major influence.

Dye Studies of Tidal Movement

The ICWW (Waccamaw River) entrance of Bull Creek (mile 381.4) was slug injected Sept. 29, 1975, with 5 gallons of 20 percent Rhodamine WT dye at high-slack tide. The purpose was to discover if a solute in Pee Dee River water might move northward and influence water quality north of the null point (mile 375). The results of this dye injection showed

Table 3. Comparison of tide heights

Gage site	ICWW mile	Gage name	Range-in-tide during period of study (feet)	Maximum height above mean low water for period of study (feet)	Average tidal range (feet)	Comparison of average tidal range with that predicted for Charleston (percent)
-	-	Charleston (predictions)	8.3	7.0	5.2	-
A	344.3	Little River at Little River	7.6	6.3	4.4	85
C	361.5	ICWW at Myrtlewood Golf Course	4.4	3.2	1.8	35
D	377.4	Waccamaw River at Bucksport	4.9	3.3	2.4	46

Note.--Specific conductance data only, collected at site B.

that the Pee Dee water did not move northward as far as the null point. These results are not conclusive, however, because during severe droughts over the Waccamaw River basin, some water from the Pee Dee could possibly move northward.

On June 9, 1976, the ICWW at mile 376 was slug injected with 5 gallons of 20 percent Rhodamine WT dye at low-slack tide. The subsequent high tide moved most of the dye up the Waccamaw River, but 5 percent or more moved to the null point at mile 375 and mixed with the "uncontaminated" water that had come from the opposite direction. On the falling tide, the dye from the Waccamaw River upstream from the small island (mile 375) became divided, part moving to the north and part to the south while much of that in the immediate area of the null point persisted and continued so for several tidal cycles. This clearly shows that if a solute, at low-slack tide, is located within the rising tidal excursion of the upstream Waccamaw River, it will by-pass the null point on the subsequent falling tide. The rising tidal excursion in this area is about 3 1/2 miles but this can be altered about 1 mile by abnormal tidal conditions.

Approximately 7 gallons of 20 percent Rhodamine WT dye was slug injected into the upstream Waccamaw River about 2 miles above the ICWW at high-slack tide Oct. 18, 1975. Since the ICWW channel changes relatively little for several miles above and below mile 375, a comparison of the relative concentrations of dye in the channel above and below mile 375 one day after injection indicated roughly the percentage of Waccamaw River flow which moved north toward Little River or south toward Bucksport. In this study, 66 percent of the dye concentration was found in the channel southward from mile 375 and 34 percent in the channel northward. The percentage of northward flow from the Waccamaw may increase if the Pee Dee flow through Bull Creek increases sufficiently to cause greater backwater conditions.

The time-of-travel of the dye in the northerly direction only, was determined at high-slack water on each succeeding day. These distances are listed below.

Day	Distance Traveled (miles)
1	4.0
2	4.7
3	3.8
4	4.3
5	6.2
6	4.9
7	4.5 (estimated)
8	2 (estimated; dye dispersal at Little River Inlet)

The 7th and 8th days are shown as estimates because the main body of the dye concentration had reached the Little River delta or Little River Inlet on earlier low tides. The average distance traveled per day was slightly more than 4 1/2 miles.

In a similar investigation made by the U.S. Environmental Protection Agency in November 1972, the distances of dye movement were about 50 percent greater -- primarily, because of higher freshwater inflow. However, an analysis of the results of both investigations indicates the downstream directional distance traveled on the outgoing tide is about equal to the total directional distance traveled in one tidal day and is about double the distance traveled on an incoming tide.

SALINITY CONDITIONS

The U.S. Naval Oceanographic Office defines salinity as "a measure of the quantity of dissolved salts in sea water. It is formally defined as the total amount of dissolved solids in sea water in parts per thousand by weight when all the carbonate has been converted to oxide, the bromide and iodide to chloride, and all organic matter is completely oxidized. These qualifications result from the chemical difficulty in drying the salts in seawater. In practice, salinity is not determined directly but is computed from chlorinity, electrical conductivity (specific conductance), refractive index, or some other property whose relationship to salinity is well established."

During this reconnaissance, periodic measurements of specific conductance were made for use in determining saltwater intrusion. Measurements were made at both high and low tide near the time of slack water. At each mile point where a measurement was made, specific conductance was determined from surface to bottom. Data obtained are given in table 4 and 5.

Effect of the Tide on the Saltwater Interface

The location of the saltwater interface in an estuary is controlled principally by tides and freshwater inflow. The interface moves up an estuary during flood (incoming) tide, and recedes during ebb (outgoing) tide. The distance traveled between high and low tides depends primarily on the height of the tide, the freshwater inflow, and the channel geometry of the estuary. Because of inertia, the mass of water will continue its upstream or downstream movement until slack water occurs a short time after high or low tides. The maximum intrusion of the saltwater interface occurs at high-slack tide, and the minimum intrusion occurs at low-slack tide. The higher the tide, the farther upstream the interface will move, if the freshwater inflow remains fairly constant.

Table 4. Field measurements of specific conductance (in micromhos per centimeter at 25°C) of the Intracoastal Waterway at high-slack tide (Depths in feet)

Sept. 10, 1975			Sept. 10, 1975			Sept. 10, 1975			Sept. 10, 1975			Sept. 10, 1975			Sept. 10, 1975			Sept. 10, 1975		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
343	1	49,000	345.6	1	47,000	347	1	33,000	350	1	10,500	352	1	1,000	353	1	410	354	1	200
	5	49,000		5	48,000		5	38,000		5	12,000		5	950		5	410		5	200
	10	49,000		10	48,000		10	40,000		10	12,500		10	1,050		10	400		10	195
	15	49,000		15	49,000		15	40,000		15	13,000		15	1,050		15	400		15	195
	18	49,000		20	49,000		20	40,000		19	13,000		19	1,050		20	400		25	195

Sept. 10, 1975			Sept. 10, 1975			Sept. 10, 1975			Sept. 10, 1975			Sept. 10, 1975			Oct. 2, 1975			Oct. 2, 1975		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
355	1	160	356	1	150	359	1	140	362	1	120	365	1	93	347	1	1,600	347.5	1	1,750
	5	160		5	150		5	135		5	120		5	93		5	9,000		5	3,000
	10	160		10	150		10	135		10	120		10	93		10	21,000		10	8,000
	15	160		15	150		15	135		15	120		15	93		12	24,000		15	17,000
	19	160		20	150		17	135		19	120					15	25,000		17	18,000
																16	25,000			

Oct. 2, 1975			Oct. 2, 1975			Oct. 2, 1975			Oct. 2, 1975			Oct. 2, 1975			Oct. 2, 1975			Oct. 2, 1975		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
348	1	400	348.5	1	150	349	1	140	350	1	100	352	1	92	354	1	90	362	1	75
	5	500		5	150		5	140		5	100		5	92		5	90		5	76
	10	1,500		10	150		10	140		10	100		10	92		10	90		10	76
	12	1,900		15	160		15	140		15	100		15	92		15	90		15	76
	15	2,400		16	160		17	140		17	100		17	92		17	90		17	78
	17	3,000																		

Oct. 24, 1975			Oct. 24, 1975			Oct. 24, 1975			Oct. 24, 1975			Oct. 24, 1975			Oct. 24, 1975			Oct. 24, 1975		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
342	1	49,000	343	1	49,000	344	1	38,000	345	1	26,000	346	1	13,000	347	1	8,000	348	1	7,000
	5	49,000		5	49,000		5	46,000		5	39,000		5	26,000		5	16,000		5	8,500
	10	49,000		10	49,000		10	48,000		10	45,000		10	35,000		10	22,000		10	10,000
	15	49,000								14	46,000		14	38,000		14	23,000		14	13,000

Table 4. Field measurements of specific conductance (in micromhos per centimeter at 25°C) of the Intracoastal Waterway at high-slack tide--continued
(Depths in feet)

Oct. 24, 1975			Oct. 24, 1975			Oct. 24, 1975			Oct. 24, 1975			Oct. 24, 1975			Oct. 24, 1975			Nov. 24, 1975		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
349	1	2,050	350	1	190	352	1	90	354	1	86	356	1	80	362	1	70	344	1	45,000
	5	2,200		5	190		5	95		5	86		5	81		5	70		5	49,000
	10	3,000		10	190		10	95		10	86		10	81		10	70		10	49,000
	15	3,400		14	190		14	95		14	86		14	82					14	49,000

Nov. 24, 1975			Nov. 24, 1975			Nov. 24, 1975			Nov. 24, 1975			Nov. 24, 1975			Nov. 24, 1975			Nov. 24, 1975		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
345	1	29,000	346	1	21,000	347	1	14,500	348	1	12,000	349	1	6,800	350	1	360	351	1	150
	5	42,000		5	29,000		5	22,000		5	12,000		5	7,200		5	425		5	160
	10	47,000		10	34,000		10	26,100		10	17,000		10	8,700		10	450		10	160
	15	47,000		18	34,000		15	26,500		15	18,800		15	9,300		15	450		15	160
	17	23,000								17	18,800		17	9,300		18	450		18	160

Nov. 24, 1975			Dec. 10, 1975			Dec. 10, 1975			Dec. 10, 1975			Dec. 10, 1975			Dec. 10, 1975			Dec. 10, 1975		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
352	1	120	342	1	50,000	343	1	39,000	344	1	28,000	346	1	6,000	347	1	4,600	348	1	6,000
	5	122		5	50,000		5	45,000		5	39,000		5	25,000		5	14,000		5	13,000
	10	122		10	50,000		10	46,000		10	44,000		10	36,000		10	31,000		10	23,000
	15	122																	15	24,000
	17	122																	18	24,000

Dec. 10, 1975			Dec. 10, 1975			Dec. 10, 1975			Jan. 21, 1976			Jan. 21, 1976			Jan. 21, 1976			Jan. 21, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
349	1	5,300	350	1	340	352	1	130	342	1	48,000	343	1	24,000	344	1	9,400	345	1	2,600
	5	6,900		5	360		5	130		5	49,000		5	48,000		5	39,000		5	21,000
	10	14,300		10	420		10	125		10	49,000		10	48,000		10	45,000		10	33,000
	15	14,500		15	440		15	130		15	49,000		15	48,000		15	47,000		15	35,000
	17	14,500		18	450					18	49,000								18	37,000

Table 4. Field measurements of specific conductance (in micromhos per centimeter at 25°C) of the Intracoastal Waterway at high-slack tide--continued
(Depths in feet)

Jan. 21, 1976			Jan. 21, 1976			Feb. 23, 1976			Feb. 23, 1976			Feb. 23, 1976			Feb. 23, 1976			Feb. 23, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
346	1	900	347	1	138	344	1	3,000	345	1	1,125	346	1	470	347	1	110	348	1	100
	5	1,325		5	140		5	21,000		5	2,600		5	620		5	130		5	110
	10	15,100		10	140		10	23,000		10	19,000		10	4,000		10	130		10	110
	15	17,200		15	140		15	28,000		15	20,000		15	5,100		15	130		15	110
	18	17,200		17	140					17	21,000		18	5,100					18	115

Feb. 23, 1976			Feb. 23, 1976			Mar. 31, 1976			Mar. 31, 1976			Mar. 31, 1976			Mar. 31, 1976			Mar. 31, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
349	1	100	350	1	87	342	1	45,000	343	1	37,000	344	1	12,000	345	1	4,200	346	1	1,850
	5	110		5	87		5	45,000		5	45,000		5	40,000		5	25,000		5	18,500
	10	120		10	87		10	45,000		10	45,000		10	45,000		10	34,000		10	24,000
	15	120		15	87		15	45,000		15	45,000		15	45,000		15	36,000		15	24,000

Mar. 31, 1976			Mar. 31, 1976			Mar. 31, 1976			Mar. 31, 1976			Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
347	1	870	348	1	140	349	1	110	350	1	95	344	1	32,000	345	1	29,000	346	1	19,500
	5	2,100		5	140		5	110		5	92		5	35,000		5	30,000		5	22,000
	10	9,500		10	140		10	110		10	92		10	38,000		10	33,000		10	28,000
	15	11,000		15	140		15	110		15	92		15	40,000		15	33,000		15	28,000
																20	34,000			

Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
347	1	11,000	348	1	12,800	349	1	7,700	350	1	2,300	351	1	870	352	1	260	353	1	158
	5	16,000		5	13,700		5	8,400		5	2,300		5	900		5	275		5	158
	10	21,000		10	14,300		10	10,200		10	2,450		10	900		10	275		10	158
	15	23,000		15	15,000		15	10,200		15	2,650		15	970		15	275		15	158
	18	24,000					17	10,300		18	2,650		17	970		17	275		17	158

Table 4. Field measurements of specific conductance (in micromhos per centimeter at 25°C) of the Intracoastal Waterway at high-slack tide--continued
(Depths in feet)

Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976			Apr. 28, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
354	1	148	355	1	138	357	1	122	360	1	114	365	1	95	370	1	70	377	1	71
	5	148		5	138		5	122		5	114		5	95		5	70		5	72
	10	148		10	138		10	122		10	114		10	95		10	70		10	72
	15	148		14	138		15	122		15	114		15	95		15	70		14	73
	16	148					16	122								18	70			

Jun. 8, 1976			Jun. 8, 1976			Jun. 8, 1976			Jun. 8, 1976			Jun. 8, 1976			Jun. 8, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
342	1	34,000	344	1	41,000	346	1	19,500	348	1	5,000	350	1	200	352	1	130
	5	34,000		5	42,000		5	29,000		5	7,100		5	210		5	130
	10	36,000		10	46,000		10	35,000		10	10,000		10	210		10	130
	15	39,000					13	38,000					15	210		15	130
	20	39,000											18	210		18	130

Table 5. Field measurements of specific conductance (in micromhos per centimeter at 25°C) of the Intracoastal Waterway at low-slack tide
(Depths in feet)

Nov. 26, 1975			Nov. 26, 1975			Nov. 26, 1975			Nov. 26, 1975			Nov. 26, 1975			Nov. 26, 1975			Nov. 26, 1975		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
342	1	25,000	343	1	17,000	344	1	12,800	345	1	5,300	346	1	640	347	1	170	348	1	112
	5	28,000		5	19,000		5	15,000		5	5,400		5	670		5	170		5	115
	10	31,000		10	24,000		10	21,000		10	5,800		10	780		10	170		10	115
	15	39,000		15	28,000		13	21,000		15	17,000		13	960		13	170		14	115
	20	40,000																		

Nov. 26, 1975			Nov. 26, 1975			Nov. 26, 1975			Feb. 24, 1976			Feb. 24, 1976			Feb. 24, 1976			Feb. 24, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
349	1	108	350	1	102	352	1	98	342	1	19,000	343	1	5,300	344	1	4,800	345	1	120
	5	107		5	102		5	98		5	19,000		5	6,200		5	7,800		5	120
	10	107		10	102		10	98		10	20,000		10	7,200		10	9,500		10	120
	13	107		15	102		13	103					15	7,400		15	9,500		13	120
													20	7,600						

Feb. 24, 1976			Mar. 30, 1976			Mar. 30, 1976			Mar. 30, 1976			Mar. 30, 1976			Mar. 30, 1976			Mar. 30, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
346	1	100	342	1	9,000	343	1	1,800	344	1	160	345	1	102	346	1	95	347	1	92
	5	105		5	13,000		5	2,500		5	165		5	102		5	95		5	92
	10	105		10	16,500		10	8,800		10	190		10	102		10	95		10	92
				15	33,000		15	8,800		15	230		15	102		15	95		15	92
										20	300									

Apr. 27, 1976			Apr. 27, 1976			Apr. 27, 1976			Apr. 27, 1976			Apr. 27, 1976			Apr. 27, 1976			Apr. 27, 1976		
Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.	Mile	Depth	Cond.
342	1	30,000	344	1	19,500	345	1	9,300	346	1	4,250	347	1	650	348	1	225	350	1	140
	5	33,000		5	20,000		5	9,900		5	4,300		5	700		5	225		5	140
	10	34,000		9	24,000		10	12,000		10	4,450		10	700		10	225		10	140
	15	37,000					12	13,000		12	4,500		15	2,000		14	225		15	140
	20	40,000																		

Effect of Freshwater Inflow on the Saltwater Interface

While a constant rate of freshwater inflow generally has minor effect on tidal excursion, a change in that rate has major effect on the location and shape of the interface. The amount of freshwater inflow to an estuary has a limiting effect on the saltwater intrusion: for any given tidal stage, the greater the freshwater inflow, the farther downstream the salt-water interface will be found. If there is appreciable freshwater inflow to an estuary, the saltwater interface becomes in effect, a saltwater wedge caused by the less-dense freshwater overriding the saltwater. The wedge is positioned so that its greatest upstream advance is along the bottom of the channel. In this stratified condition, the water in a vertical section has the least salt content at the surface and becomes progressively more salty with depth. When freshwater inflow is high, the trailing edge of the wedge may be a mile or more seaward from the leading edge with the water in the wedge area being quite stratified. During periods of low freshwater inflow, the wedge is almost nonexistent, and the saltwater interface may be replaced by a gradual transition taking place over several miles from fresh to saltwater, exhibiting little or no stratification.

Known fresh surface-water inflow to the ICWW in the study reach comes primarily from the Waccamaw River. The contribution from Socastee Creek and a few even smaller tributaries is negligable because of their small drainage areas. Much of the Pee Dee water enters the ICWW through Bull Creek which is only 4 miles south of Bucksport. All field investigations made during the study indicated that the Pee Dee River had no effect on the study area except possibly to cause backwater to the Waccamaw River. The amount of ground-water contribution to the ICWW has not been investigated and, at this time, is unknown; however, it is possible that it may be considerable.

The flow on the Waccamaw River is gaged at the U.S. Geological Survey's station 02110500 near Longs. The flow on the Pee Dee River at Bull Creek is a combination of three rivers which are gaged at Lynches River at Effingham, station 02132000; Pee Dee River at Peedee, station 02131000; and Little Pee Dee River at Galivants Ferry, station 02135000. These are noted on the map in Figure 3. The discharges for these gaging stations are in the Geological Survey's annual publications of surface-water records.

Correlation of saltwater intrusion with freshwater inflow

The probable location of the saltwater interface at high tide may be estimated by graphically correlating the locations of the greatest penetration of the interface with the concurrent freshwater inflows (see Figure 4). An arbitrary specific conductance value of 950 micromhos per centimeter has been used as the interface because it is equivalent to 250 milligrams per liter (mg/l) of chloride (the maximum amount recommended in the drinking water standards of the U.S. Public Health Service in 1962).

The freshwater component of Figure 4 is not only that from the Waccamaw River (which taken alone does not result in good alignment of points), but is combined with the total Pee Dee River flow. It is assumed here that the amount from the Waccamaw that flows northward is largely caused by backwater from the Pee Dee is proportional to the total Pee Dee and Waccamaw flow. The combined flow then, appears to be multiple of the actual northward flow; and, as such, would not, to any great extent, interfere with the alignment of plotted points in a graphic analysis as Figure 4. It should be pointed out that this correlation disregards a possible large ground-water contribution.

In the construction of Figure 4, to allow for time-of-travel from the several gaging stations to the study area and to dampen out of flow eccentricities, the combined flows were individually computed as follows: station

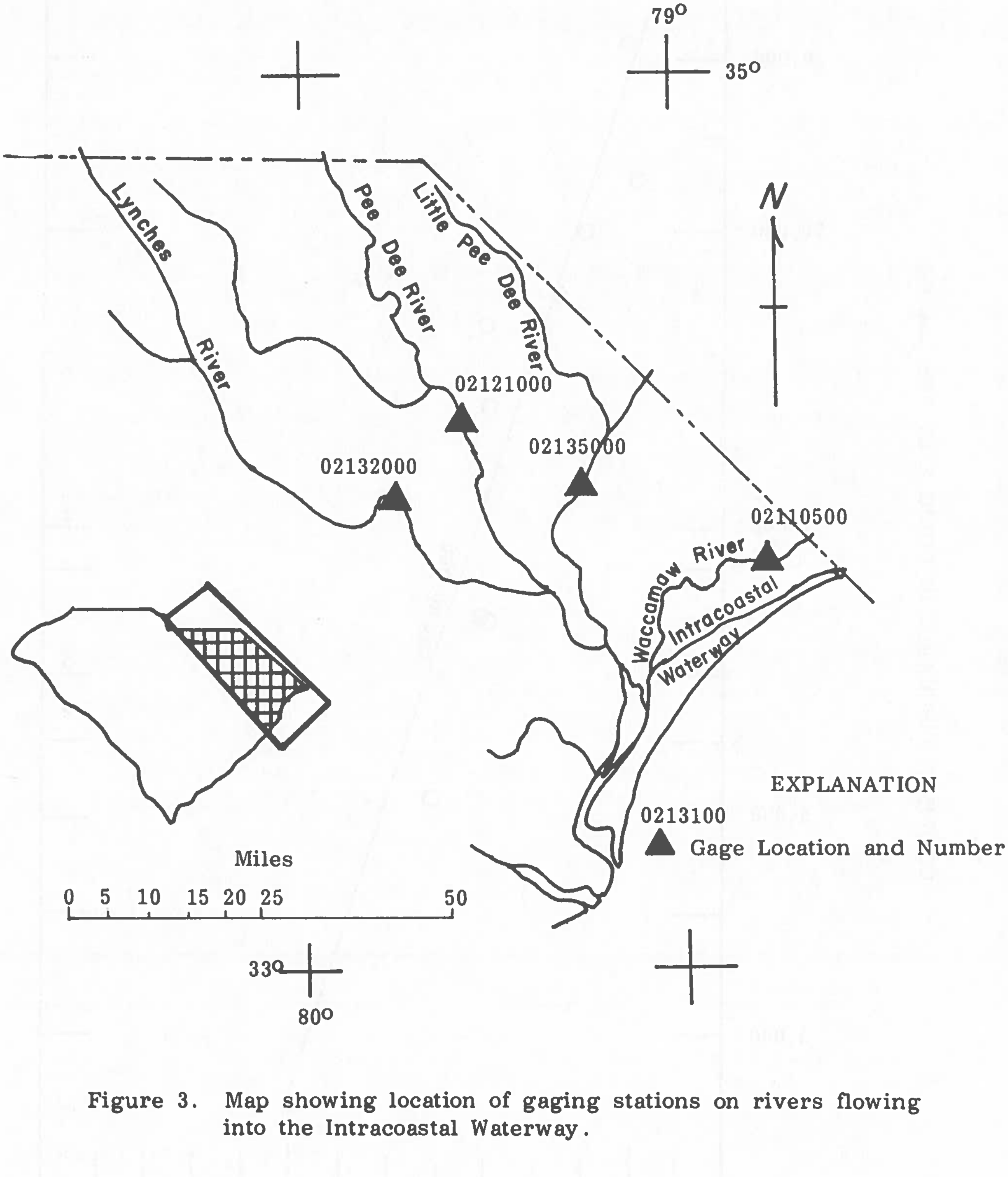

Figure 3. Map showing location of gaging stations on rivers flowing into the Intracoastal Waterway.

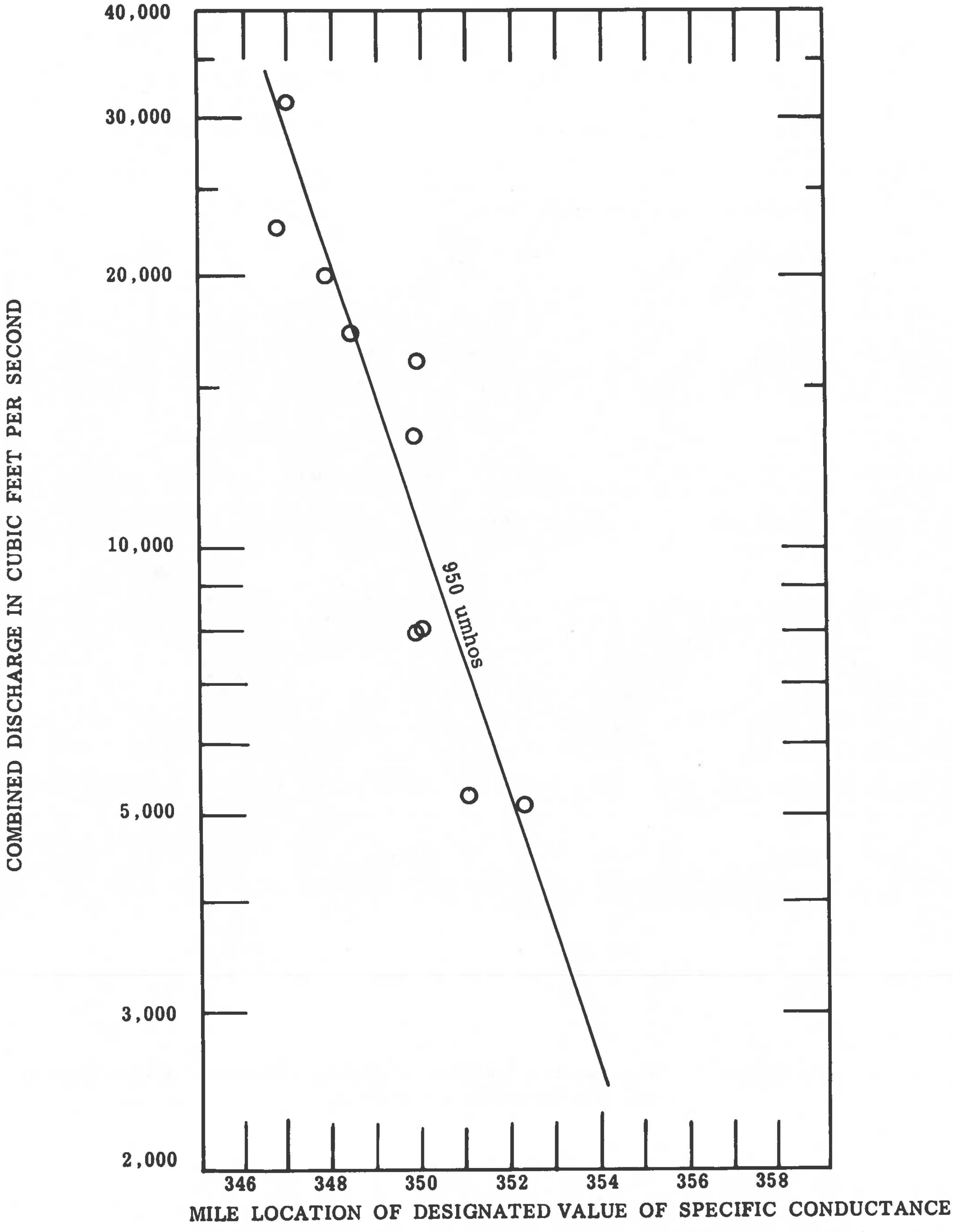

Figure 4. Location at high tide of the 950 micromho value of specific conductance per centimeter at 25°C versus combuned freshwater inflow.

02110500, the average of three consecutive days beginning 12 days before the plotted event; stations 02131000, and 0213500, the average of three consecutive days beginning nine (9) days before the plotted event.

In the same manner, the locations of other values for specific conductances may be made with reference to freshwater inflow (see figure 5). The narrow distance spread between the curves for 5,000 micromhos and 250 micromhos in figure 5 is also illustrated by figure 6 which shows the rapid increase in specific conductance, with regard to location, from freshwater to saltwater for both low and high freshwater inflows. The interface at high-slack tide changes position by only a few miles between low and high freshwater inflow, usually remaining within 6 to 10 miles of Little River Inlet. Figure 7 is included here for those who may desire to convert specific conductance to chloride or dissolved-solid concentration.

Since no statistical data have been compiled by the Survey on combined flows into the study area (as 7-day, 10-year low flow), no statement of probability will be made regarding the location of the interface during any particular statistical category of flow.

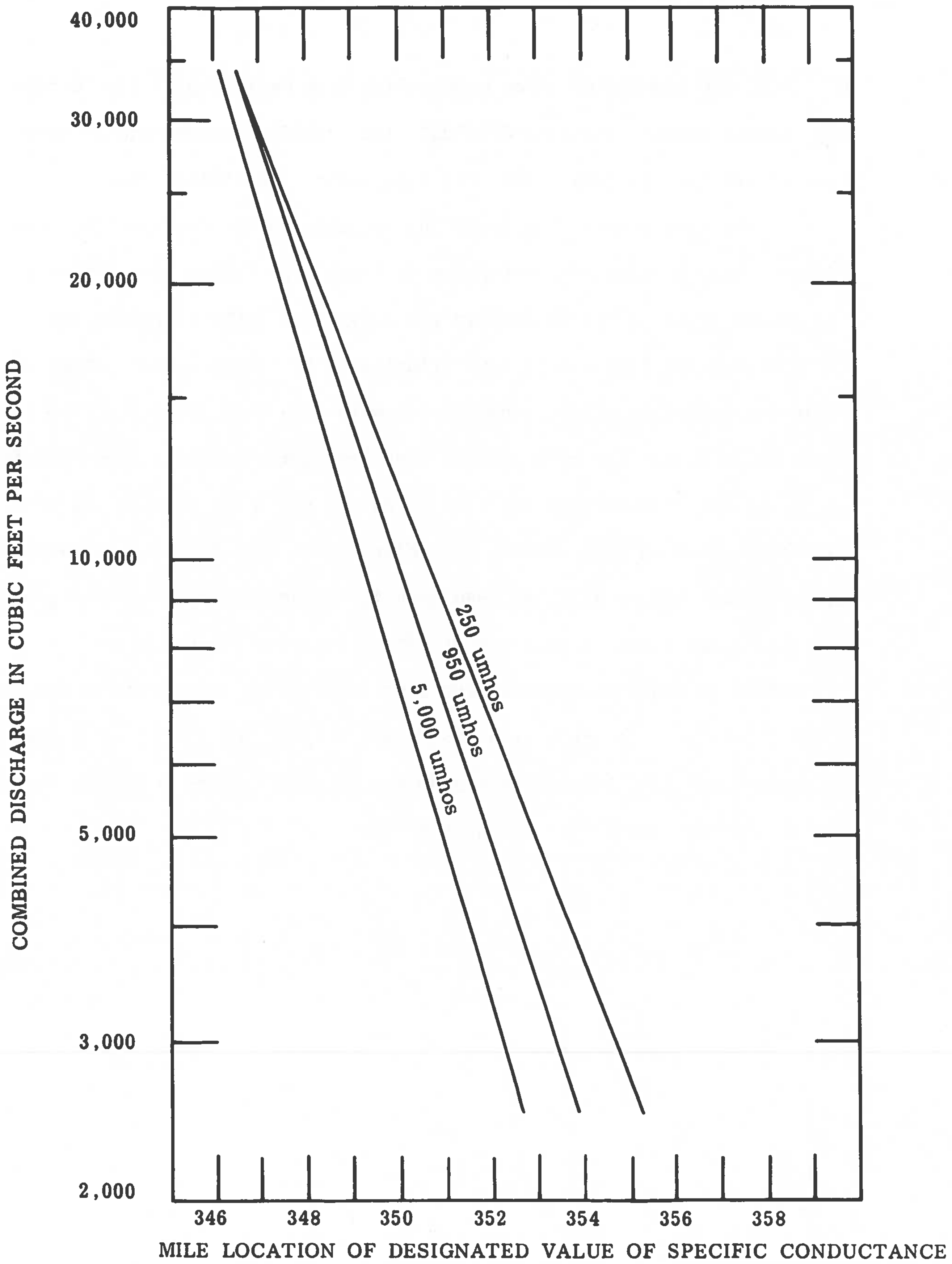

Figure 5. Location at high tide of selected values of specific conductance per centimeter at 25oC versus combined freshwater inflow.

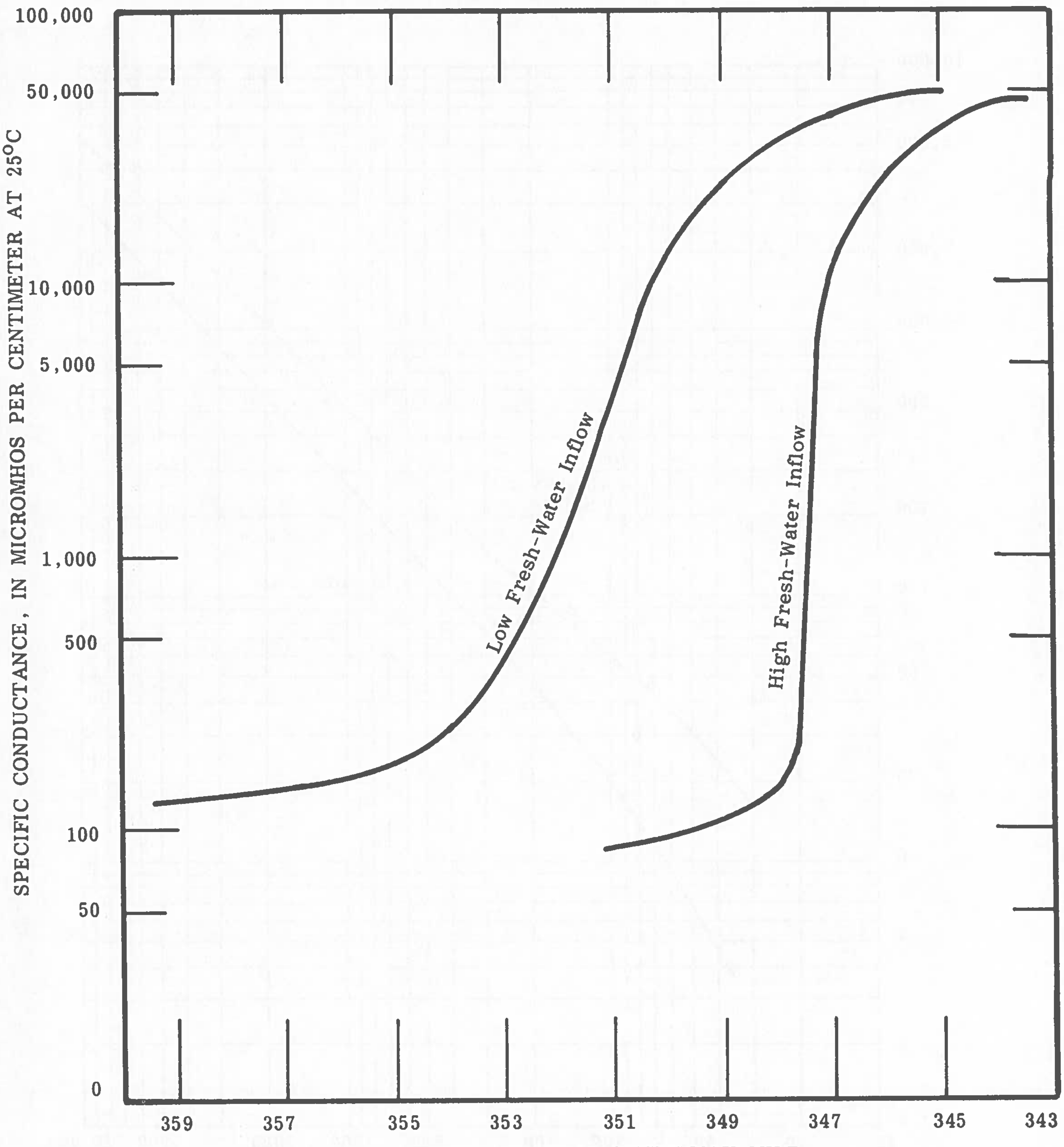

Figure 6. The change in specific conductance in the Intracoastal Waterway, with respect to location, from fresh to saltwater.

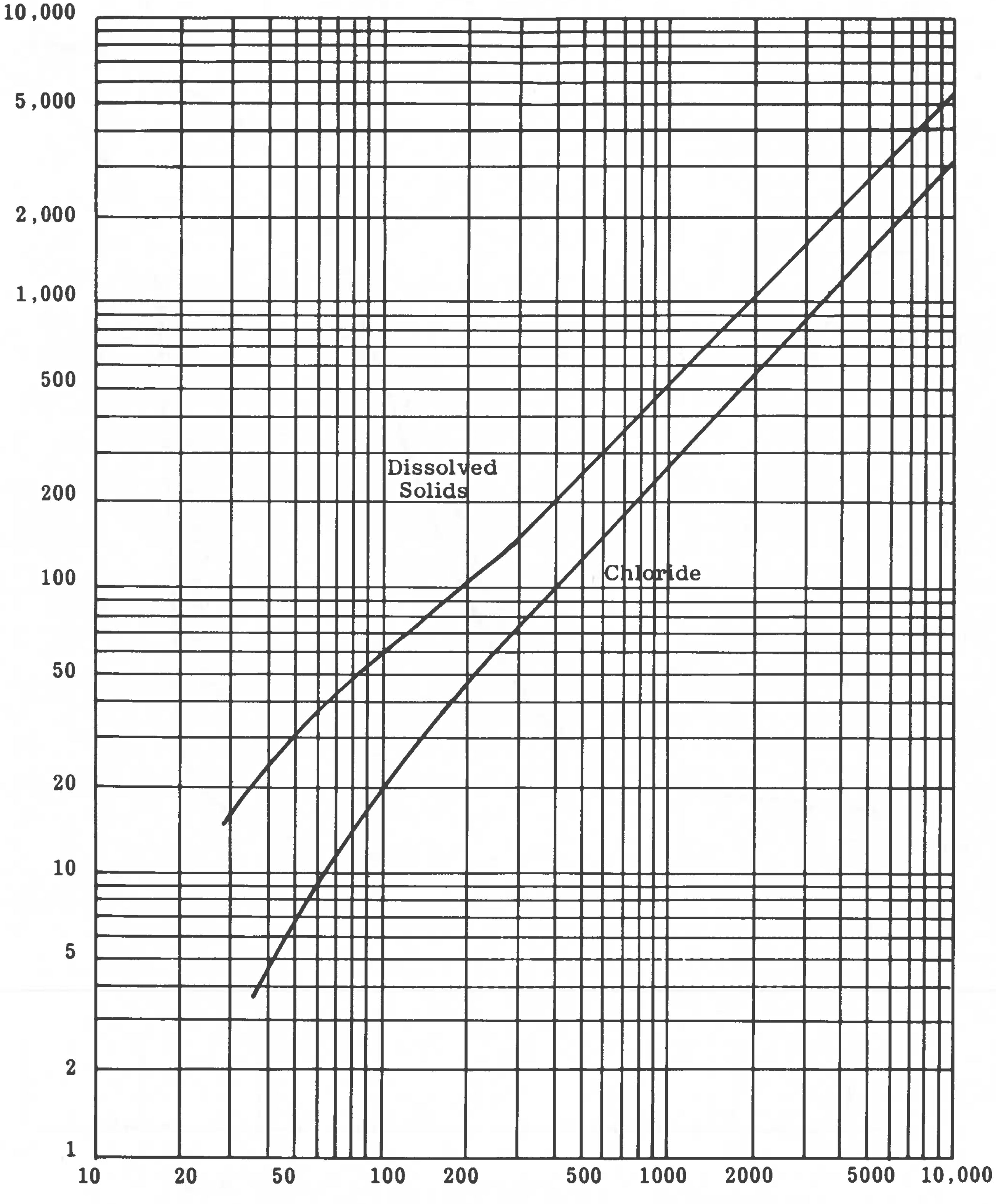

Figure 7. General relation of dissolved solids and chloride concentration to specific conductance.

CHEMICAL AND PHYSICAL CHARACTERISTICS OF WATER

General Water Quality

Table 6 compares the values of the standard constituents sampled at mile 347 and mile 365 on Jan. 21, 1976. At both sites only the iron content is higher than that recommended by the Public Health Service (1962) for domestic use. Additional constituents were not analyzed for nor were additional samples collected because of the limited nature of the reconnaissance.

Sediment Concentration, Color, Turbidity and Secchi Disc Transparency

On April 28, 1976 measurements of sediment concentration, color, turbidity, and Secchi disc transparency were made on the ICWW. These data are given in table 7. The color of water is due to both organic and inorganic ions in solution and its measure is based on the platinum-cobalt scale of Hazen (1892). Turbidity is caused by suspended material in water, and is determined by measuring the scattering and absorption of light by small suspended particles. The Geological Survey measures turbidity by comparisons to standard reference samples of suspensions of SiO . Secchi disc transparency is measured by lowering a white or white and black disc into water and noting the depth at which the white can no longer be dintinguished; thus, it provides a rough indication of the transmission of light through the water. The values of sediment concentration, color, and turbidity were low, as might be expected in a canal environment.

Bottom Sediments

The bottom sediments at miles 347 and 365 were tested once for PCB, PCN, herbicide, and pesticide contents. The results were negative with the exception of finding of a negligible 9.4 micrograms per kilogram (ug/kg) of DDD and 3.3 ug/kg of DDE at mile 365.

Table 6. Values of dissolved substances and physical properties of the Intracoastal Waterway at high tide Jan. 21, 1976 (Concentrations in mg/l, except as indicated).

	Mile 347	Mile 365
Alkalinity (as CaCO)	18	7
Silica (SiO)	6.5	6.4
Iron (Fe)	.38	.33
Calcium (Ca)	10	4.5
Magnesium (Mg)	1.6	.9
Sodium (Na)	11	5.5
Potassium (K)	1.1	.8
Bicarbonate (HCO)	22	9
Sulfate (SO)	18	8.8
Chloride (Cl)	18	9.0
Fluoride (F)	.3	.3
Nitrate (NO+NO)	.03	.04
Dissolved solids (residue at 180°)	73	41
Hardness Total	32	15
Noncarbonate hardness	14	8
Specific conductance (micromhos per centimeter at 25°C)	140	66
Manganese	2.0	0
Phosphate (asP)	.01	.00
Phosphate (ortho)	.03	.00

Table 7. Sediment concentration, turbidity, color, and Secchi Disc transparency at high-slack tide, April 28, 1976.

Mile	Sediment Concentration (mg/l)	Turbidity (mg/l)	Color (platinum-cobalt units)	Secchi Disc Transparency (feet)
344	32.8	7	3	1.8
347	35.2	6	6	1.8
350	26.6	13	3	1.3
352	18.3	6	4	1.5
354	9.6	5	4	1.8
358	9.9	5	4	2.0
365	16.0	9	4	1.7
370	17.5	4	4	2.2
375	4.2	2	3	2.1

Bottom sediments from the same locations were also tested for arsenic and metals. The results were inconsequential except for the high iron content. The results are listed below in micrograms per gram (ug/g).

	Mile 347	Mile 365
Arsenic	2	6
Cadmium	<10	<10
Cromium Total	<10	<10
Copper	<10	20
Iron	3,200	75,000
Lead	<10	<10
Manganese	40	60
Mercury	0.00	0.00
Nickel	<10	<10
Zinc	<10	20

Suitability of Water for Use

The suitability of a water for use depends largely on the chemical characteristics and physical properties of the water. Water suitable for one use may not be suitable for another, and thus water must be judged by criteria appropriate to the intended use. The degree to which a water fails to meet appropriate criteria usually determines the treatment required. If extensive treatment is necessary, use of a water supply may not be economically feasible.

Chemical-quality standards for water used for drinking and culinary purposes on interstate-commerce carriers have been established and recommended by the U.S. Public Health Service (1962). These standards have been endorsed by the American Water Works Association, and are commonly used to evaluate water intended for human consumption. Some of the maximum concentration limits of significance to the evaluation of water in the report area are, in mg/l: iron, 0.3; chloride, 250; and dissolved-solids concentration, 500. A maximum color of 15 units also has been recommended.

Hardness, in parts per million, has been classified in this investigation as follows: 60 or less, soft; 61-120, moderately hard; 121-180, hard; and 181 or more, very hard.

Using the above mentioned criteria, this reconnaissance indicates that the water in the ICWW above the saltwater interface probably is usually soft, generally of good quality, and suitable for domestic and general industrial use at all times, providing it is treated for iron when necessary.

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