PREPARED IN COOPERATION WITH THE
CITY OF CAPE CORAL, LEE COUNTY,
AND THE FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

WATER-RESOURCES INVESTIGATIONS REPORT 93-4057
SHEET 1 OF 2

Russell, G.M., and Kane, R.L., 1995, Bathymetry, freshwater flow, and specific conductance of Matlacha Pass, southwestern Florida

INTRODUCTION

The Matlacha Pass estuary, a State of Florida aquatic preserve, is bounded by Pine Island to the west, Cape Coral to the east, Charlotte Harbor to the north, and the Caloosahatchee River to the south (fig. 1). The estuary is important for its aesthetic value; used for recreational boating, sport and commercial fishing, tourism, and residential development; and is a nursery for fish and invertebrates.

Historically, freshwater runoff from Cape Coral entered Matlacha Pass estuary as sheetflow. As development occurred on Cape Coral, canals were designed and constructed to collect the freshwater runoff and distribute it as sheetflow through two spreader canal systems into Matlacha Pass. Water managers have expressed concern that altering the freshwater runoff patterns into the pass could have a detrimental effect on salinity distribution which might adversely affect the aquatic system of the pass. Adequate data were not available to evaluate the freshwater flow, its movement, and mixing. The U.S. Geological Survey, in cooperation with the City of Cape Coral, Lee County, and the Florida Department of Environmental Protection, conducted a study from July 1989 to September 1992 to identify three hydrodynamic aspects for managing the estuary.

Purpose and Scope

This report presents bathymetry and information on the hydrodynamics of tidal flow, freshwater flow, and specific conductance in Matlacha Pass. Bathymetric contours were used to define the physical characteristics of Matlacha Pass, which control water movement and mixing. Specific conductance data, both recent and historical, were used to evaluate the distribution of freshwater flow, its movement, and mixing in Matlacha Pass.

Description of Study Area

The Matlacha Pass estuary is part of the connected inshore waters of the Charlotte Harbor estuary in southwestern Florida. The Charlotte Harbor estuarine complex is composed of Charlotte Harbor, the Caloosahatchee River, and their associated coastal lagoons and rivers including Matlacha Pass (figs. 2 and 3). Charlotte Harbor began forming about 5,000 years ago when a rise in sea level caused inundation of the lower flood plains of these rivers. Sediments were deposited as deltas and barrier islands began to form. As the flow from the rivers shifted southward, Pine Island separated from the mainland. Sanibel Island (not shown), south of Pine Island, formed from the increased river sediments and closed the inlet to the south. A new inlet to the Gulf of Mexico opened, leaving the Matlacha Pass estuary (Herwitz, 1977).

Matlacha Pass is underlain by marine terrace deposits of the Pamlico Sand in Lee County. The Pamlico Sand is characterized as a light-gray to brown, fine- to medium-grained, quartz sand that contains many shells and variable concentrations of clay and silt (Boggess and others, 1981).

The bed topography of Matlacha Pass is relatively flat with the exception of the main channel. The pass is about 13 mi long and about 1.2 mi wide. To the north near the Peace River (not shown) and to the south near the Caloosahatchee River (fig. 3), Matlacha Pass is about 2 mi wide. South of the bridge at Matlacha (fig. 2), the pass narrows to less than 1 mi. The inland coves and bays along the shorelines of Pine Island and Cape Coral (figs. 2 and 3) average less than 2 ft in depth.

Oyster beds and foreshore flats (or sandbars) have developed along the sides of the channel (figs. 2 and 3). These flow obstructions tend to reduce the velocity and turbidity of the water, thereby promoting the colonizations of algae and providing a habitat for small fish and invertebrates (Harris and others, 1983).

The primary vegetative features within Matlacha Pass are the mangrove swamps along the shorelines of Cape Coral and Pine Island (figs. 2 and 3). Red mangroves (*Rhizophora mangle*) are near the shore and black mangroves (*Avicennia germinans*) are inland (Harris and others, 1983). The extensive root system of the mangroves prevents erosion and provides protection for fish nurseries. Seagrass beds are abundant in Matlacha Pass and provide food for herbivores and detritivores, shelter for small fish and crustaceans, and serve to stabilize sediments (Harris and others, 1983).

The climate in the Matlacha Pass area is subtropical and humid. The average annual air temperature at Page Field in Fort Myers, 3.5 mi east of Cape Coral, is 74 degrees Fahrenheit, and monthly averages range from 64 degrees Fahrenheit in January to 83 degrees Fahrenheit in August (National Oceanic and Atmospheric Administration, 1978-91). Freshwater discharge is dependent on rainfall, which is distributed unevenly throughout the year. About 60 percent (54 in.) of the average annual rainfall occurs during the wet season (June-September), mostly the result of localized convective storms.

Methods of Study

Bottom depth data were collected in Matlacha Pass by personnel of the U.S. Geological Survey using a boat equipped with an automatic positioning system and a recording depth sounder. The positioning system used microwaves to measure the distance between a transponder aboard the boat and two remote transponders at known coordinates. The angle between the boat and each remote transponder was required to be between 30 and 150 degrees. Therefore, the boat was within a circle described by the remote transponders with a radius equal to the distance between the remote transponders (Patterson and Logan, 1988). Coordinates for the boat were triangulated from distances between the transponder aboard the boat and the two transponders onshore. Because of these constraints, the transponders were moved along either shoreline to 16 locations.

Transects were run diagonally from shoreline to shoreline, when possible, and also down the main channel. Many of the shallow areas near shore are not navigable and were measured with a tape and weight to confirm depths. Boat coordinates, time, and mean water depth were recorded about every 30 to 60 seconds on a paper scroll. Continuous data from the recording fathometer were available for interpolation between recorded measurements. Depths were considered accurate within 0.5 ft, whereas the horizontal position was considered accurate within 100 ft. The combined margin of error for the depth contours was about 1.0 ft.

Five continuous tidal-stage recorders were used to make observations of the tidal stage every 15 minutes at Bokeelia, Indian Field, Matlacha, Parrots Perch, and Camelot Lock (figs. 2 and 3). Records from these stations were evaluated to determine time lag and changes in amplitude of tidal waves. Depth data were adjusted to sea level based on the tidal stage from the nearest recorders at the stations (figs. 4-8).

The average time lag varied at high and low tides between Bokeelia (in the northern end of Matlacha Pass) and Matlacha (in the middle of the pass) and between Matlacha and Parrots Perch (in the southern end of the pass). The average time lag was about 45 minutes between Bokeelia and Matlacha and between Matlacha and Parrots Perch during high tide. The average time lag was about 1 hour and 45 minutes between Bokeelia and Matlacha and about 1 hour between Matlacha and Parrots Perch during low tide.

The average range in tidal waves between the high and low tides throughout Matlacha Pass was about 1.62 ft. At Bokeelia, Matlacha, Parrots Perch, and Camelot Lock for the 1990-92 water years and at Indian Field for the 1991-92 water years, the average range in tidal waves between the high and low tides was: 1.77 ft at Bokeelia, 1.87 ft at Indian Field, 1.77 ft at Matlacha, 1.17 ft at Parrots Perch, and 1.52 ft at Camelot Lock. The small tidal average at Parrots Perch might have been because of dampening of wave action as this gage is located in protected waters.

Freshwater flow into Matlacha Pass was measured at streamflow-gaging stations on the major canals in Cape Coral (figs. 2 and 3). A stage-discharge relation was established for each canal. The daily mean discharge was computed from this relation.

Water samples were collected and specific conductance was measured at about 90 sites in the freshwater canals, spreader canal systems, and in Matlacha Pass during 1984 (La Rose and Sheftall, 1984). That extensive study provided an excellent data base for determining the distribution of freshwater flow into Matlacha Pass under wet- and dry-season conditions. Continuous monitoring for specific conductance was conducted about 2 ft below the surface and about 2 ft above the bottom in the main channel near State Road 78 (fig. 2).

A geographic information system (GIS) was developed to store, analyze, and plot spatial data for this study. From the bathymetric surveys, Universal Transverse Mercator coordinates, time, depth, and other information (such as location of sandbars and oyster beds) were stored in the GIS. The canal system, roads, sandbars, and mangroves of the pass were digitized from U.S. Geological Survey 1:24,000 scale topographic maps. Adjusted depth data were plotted on large-scale digitized maps, and depth contours were digitized into the GIS. Vegetative features and aerial photography were used to modify the depth contours in areas where depth data were unavailable.

BATHYMETRY

The bathymetric contours and the location of sandbars and oyster beds in northern and southern Matlacha Pass are shown in figures 2 and 3. Depths are more than 9 ft below sea level in the northern end of the pass near Charlotte Harbor (fig. 2). The deepest part of the channel in this area averages 8 ft or more and is relatively wide and unobstructed. Shallow-depth areas of about 2 ft are present along the mangrove shoreline of Cape Coral and Pine Island.

Depths in the main channel range from 4 to 14 ft below sea level and average about 8 ft (fig. 3). The channel is narrow and irregular with wide and shallow areas along the shorelines of Cape Coral and Pine Island. Many oyster beds are present, indicating freshwater-saltwater mixing zones between the Caloosahatchee River and the Gulf of Mexico. Variable velocities are also indicated by sandbar deposition outside the narrow channels. Sandbars and oyster beds in the southern end of the pass (fig. 3) can be exposed at low tide.

Velocities capable of maintaining channel depths greater than 5 ft (fig. 3) occur from San Carlos Bay to the southern end of Little Pine Island. In the middle of Matlacha Pass adjacent to Little Pine Island, depths average less than 4 ft across a wide section of the pass and about 2 ft along the mangrove shoreline (fig. 3). A tidal division occurs at State Road 78 near the center of Matlacha Pass, and tidal stages are affected more by tidal currents from upper Charlotte Harbor rather than from San Carlos Bay. This mixing or dampening of tidal stage lowers tidal velocities and promotes a deposition of sediment.

FRESHWATER FLOW

Estuaries are complex systems at the interface of oceanic and riverine environments. The mixing of freshwater runoff primarily from Cape Coral and incoming saltwater tides from San Carlos Bay and Charlotte Harbor (figs. 2 and 3) allows many species of animals and plants to flourish in the estuary. Freshwater runoff from Cape Coral is mainly because of canals that are designed to collect runoff and distribute it as sheetflow through two spreader canal systems into Matlacha Pass or from canals that discharge directly into the Caloosahatchee River.

The canals within the Cape Coral drainage basin are divided into two different drainage systems: the north Cape Coral spreader canal system (fig. 2) and the south Cape Coral spreader canal system (fig. 3). State Road 78, extending from Cape Coral in the east to the city of Matlacha, divides these two canal systems.

The north Cape Coral canal system has a drainage area of about 46 mi^2 east of State Road 765 and consists of four freshwater canals that discharge into spreader canals (fig. 2). This canal system, referred to as the north Cape Coral spreader canal system, is subject to tidal overtopping during extreme high tides and may contain brackish to salty water (1,301 to 28,800 µS/cm of specific conductance) at and near the canal bottoms. Several breeches in the north Cape Coral spreader canal system allow freshwater to discharge as point sources into the estuary.

The south Cape Coral spreader canal system has a drainage area of about 20 mi^2 upstream of the salinity weirs and consists of five canals (fig. 3). Four of these canals (not shown) discharge into the Caloosahatchee River. The Aries Canal, with an indeterminate drainage basin because of the extensive interconnection of canals and weir placement, discharges freshwater into Matlacha Pass (fig. 3).

Most of the freshwater flow into Matlacha Pass comes from the spreader canal systems during the wet season. Other sources of inflow are from direct rainfall into Matlacha Pass and freshwater runoff from Pine Island. For the 1990 water year, more than 67 percent of the total measured flow from the north Cape Coral spreader canal system and about 80 percent of the total measured flow from the south Cape Coral spreader canal system occurred during the wet season. Freshwater flow into Matlacha Pass from the north Cape Coral spreader canal system averaged 113 ft^3/s for the period October 1987 to September 1992 and 49.6 ft^3/s for the 1990 water year. Freshwater inflow from the Aries Canal of the south Cape Coral spreader canal system averaged 14.1 ft^3/s for the period October 1989 to September 1992 and 5.73 ft^3/s for the 1990 water year. Hydrographs showing daily mean discharge from the Aries Canal and the north Cape Coral spreader canal system are depicted in figures 9 and 10, respectively.

SPECIFIC CONDUCTANCE

Conductance is a measure of the ability of water to transmit an electrical current and is proportional to the amount of dissolved solids in the water; thus, the greater the conductance, the greater the salinity (Hem, 1985). Specific conductance is conductance standardized to 25 degrees Celsius. Specific conductance is used as an indicator of salinity (Giovannelli, 1980) in this report. Ranges of specific conductance shown in figures 11 and 12 were selected as convenient intervals to delineate the freshwater-saltwater interface. Specific conductance in freshwater ranges from 0 to 1,300 µS/cm, specific conductance in brackish water ranges from 1,301 to 28,800 µS/cm, and specific conductance in salty water is greater than 28,800 µS/cm.

Salinity distribution in Matlacha Pass based on specific conductance is characterized as well mixed. Salinity gradients change daily with tides and seasonally with the quantity of freshwater flow. Specific conductance ranged from less than 1,000 to 57,000 µS/cm throughout Matlacha Pass. Specific conductance at Matlacha ranged from 9,000 to 53,000 µS/cm 2 ft below the water surface (averaging 36,000 µS/cm) and from 19,000 to 57,000 µS/cm 2 ft above the bottom (averaging 40,000 µS/cm) for February to September 1992. Specific conductance 2 ft below the water surface and 2 ft above the bottom at Matlacha Pass and daily mean discharge from the north Cape Coral spreader canal system are shown in figure 13. Freshwater inflow from Cape Coral is minimal and specific conductance remains high during the dry season. Freshwater inflow increases and specific conductance decreases during the wet season (fig. 13).

Specific conductance for the northern part of Matlacha Pass during wet-season conditions (August 8, 1984) is shown in figure 11. Specific conductance ranged from 4,000 to 15,500 µS/cm at two breaks in the north Cape Coral spreader canal system near Matlacha where freshwater enters the pass. Specific conductance ranged from 15,000 to 20,800 µS/cm over a relatively large area of the north-central pass. Similar specific conductance patterns were detected for waters measured within the top 2 ft of water surface and waters measured at 10 ft below the surface or total depth if less than 10 ft. An area of canals between the Shadroe and Hermosa Canals does not receive sufficient freshwater inflow to flush the saline waters near the bottom (fig. 11). Specific conductance near the bottom of the canals remained between 1,300 and 4,000 µS/cm, even though waters near the surface were less than 1,300 µS/cm.

Specific conductance for the northern part of Matlacha Pass during dry-season conditions (May 11, 1984) is shown in figure 12. Specific conductance was greater than 28,000 µS/cm throughout the estuary, indicating well-mixed tidal waters. Freshwater flow into the estuary was minimal during the dry season. Specific conductance measurements within the brackish range were evident in the spreader canal systems and canals downstream of the control structures, indicating tidal overtopping of the north Cape Coral spreader canal system during the dry season.

SUMMARY

The Matlacha Pass estuary is part of the connected inshore waters of the Charlotte Harbor estuary in southwestern Florida. Bathymetry indicates depths in the main channel range from 4 to 14 feet below sea level. The channel averages about 8 feet deep in the northern end of the pass and about 5 feet deep in the southern end of the pass. In the middle of Matlacha Pass, depths average about 4 feet across a wide section of the pass and about 2 feet along the mangrove shoreline.

Surface-water runoff occurs primarily during the wet season (May-September), with most of the flow entering Matlacha Pass through two openings in the spreader canal system near Matlacha. Freshwater flow into the pass from the north Cape Coral spreader canal system averaged 113 cubic feet per second from October 1987 to September 1992. Freshwater inflow from the Aries Canal of the south Cape Coral spreader canal system averaged 14.1 cubic feet per second from October 1989 to September 1992.

Specific conductance ranged from less than 1,000 to 57,000 microsiemens per centimeter throughout Matlacha Pass. Specific conductance at Matlacha averaged 36,000 microsiemens per centimeter 2 feet below the water surface and 40,000 microsiemens per centimeter 2 feet above the bottom from February to September 1992. During the wet and dry seasons, specific conductance indicates that the primary mixing of tidal waters and freshwater inflow occurs in the mangroves along the shoreline.

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.029317	cubic meter per second

Temperature conversion between degrees Celsius (°C) and degrees Fahrenheit (°F):

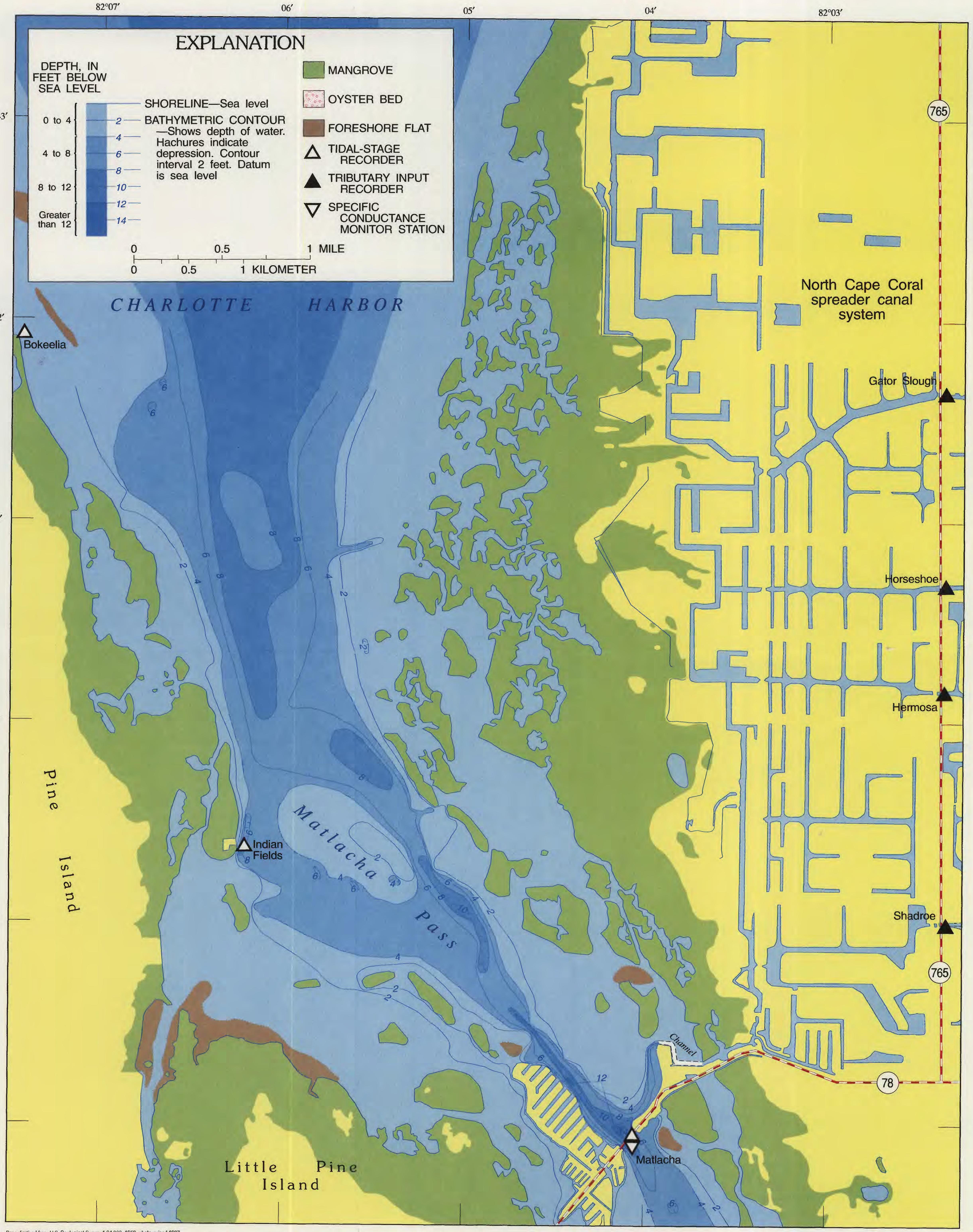
$$°C = 5/9\ (°F - 32)$$

$$°F = (9/5\ °C) + 32$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

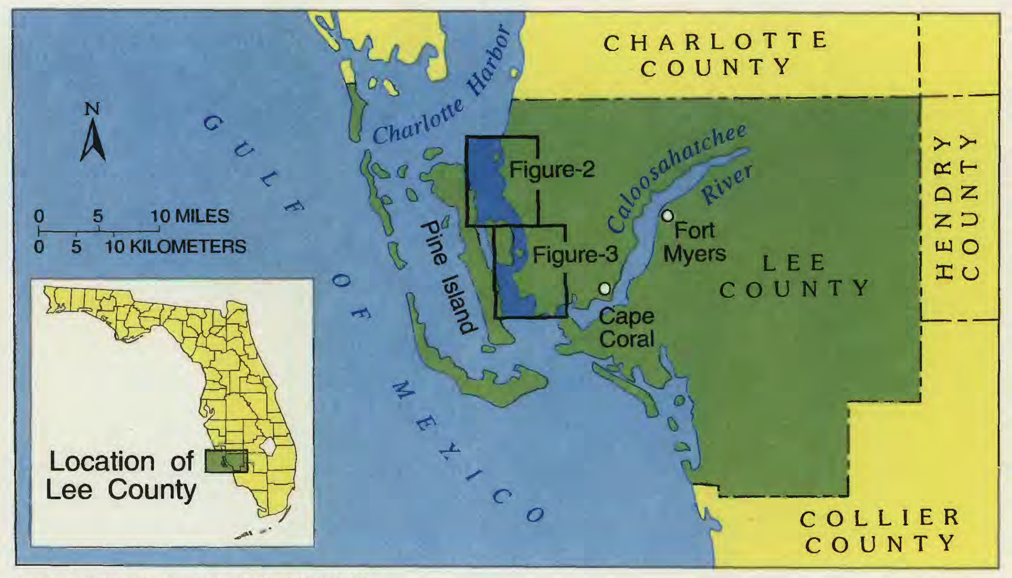
ADDITIONAL ABBREVIATIONS

GIS	Geographic Information System
µS/cm	microsiemens per centimeter at 25 degrees Celsius



Base digitized from U.S. Geological Survey 1:24,000, 1958, photorevised 1987
Universal Transverse Mercator projection
Zone 17

Figure 2. Bathymetric contours in northern Matlacha Pass, southwestern Florida.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard Parallels 29°30' and 45°30', central meridian -83°00'

Figure 1. Location of Lee County and figures 2 and 3.

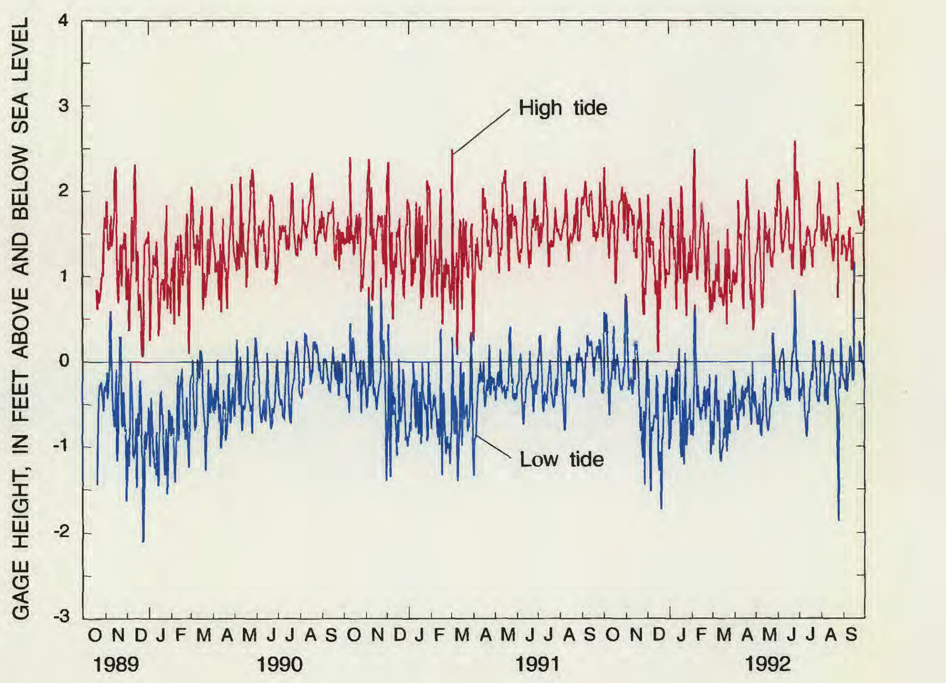


Figure 4. High and low tidal stage at Bokeelia.

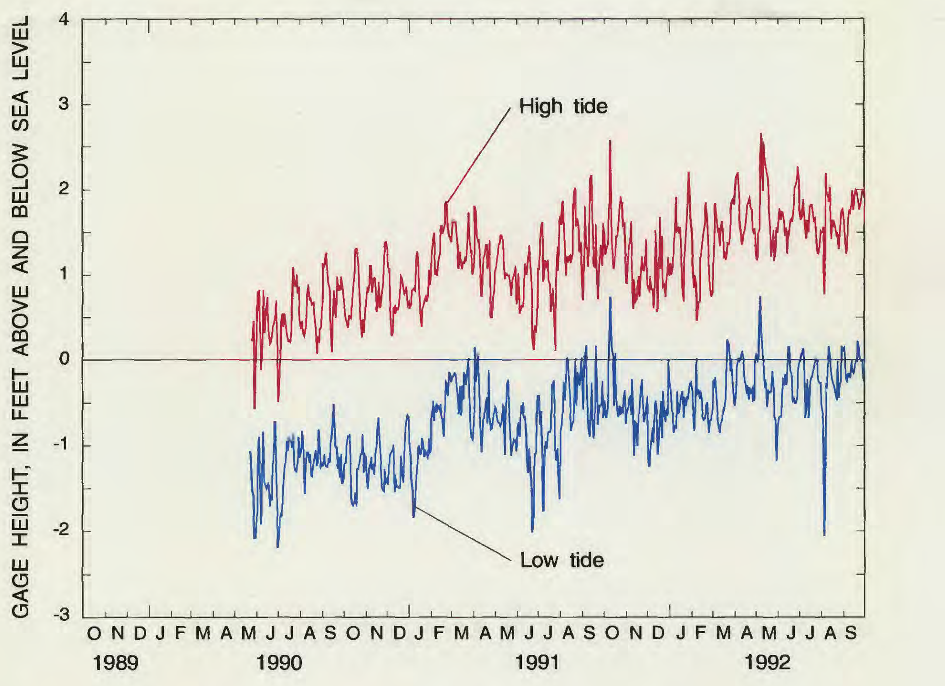


Figure 5. High and low tidal stage at Indian Field.

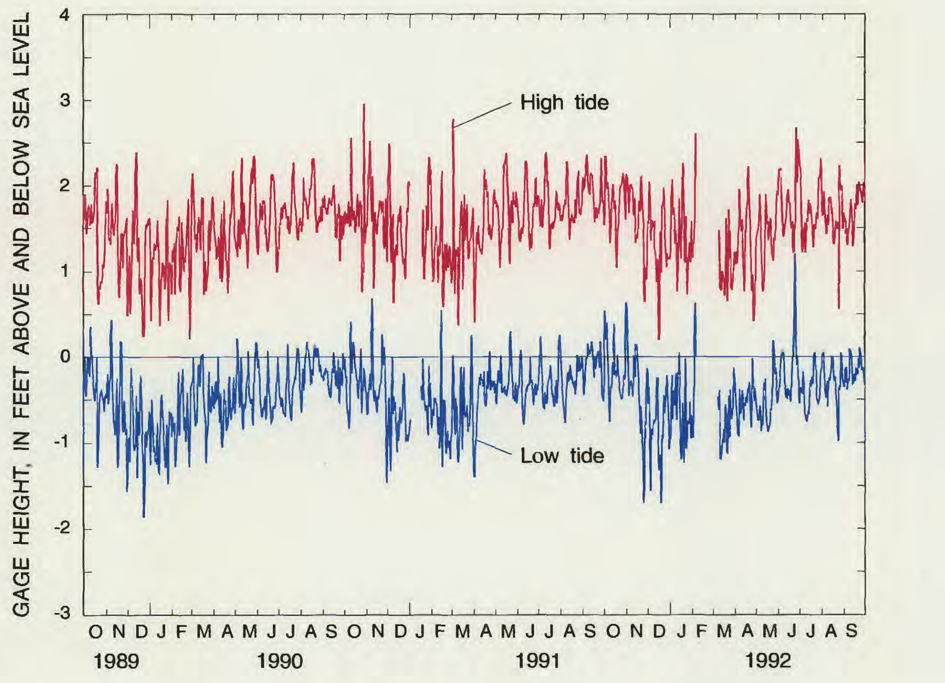


Figure 6. High and low tidal stage at Matlacha.

BATHYMETRY, FRESHWATER FLOW, AND SPECIFIC CONDUCTANCE OF MATLACHA PASS, SOUTHWESTERN FLORIDA

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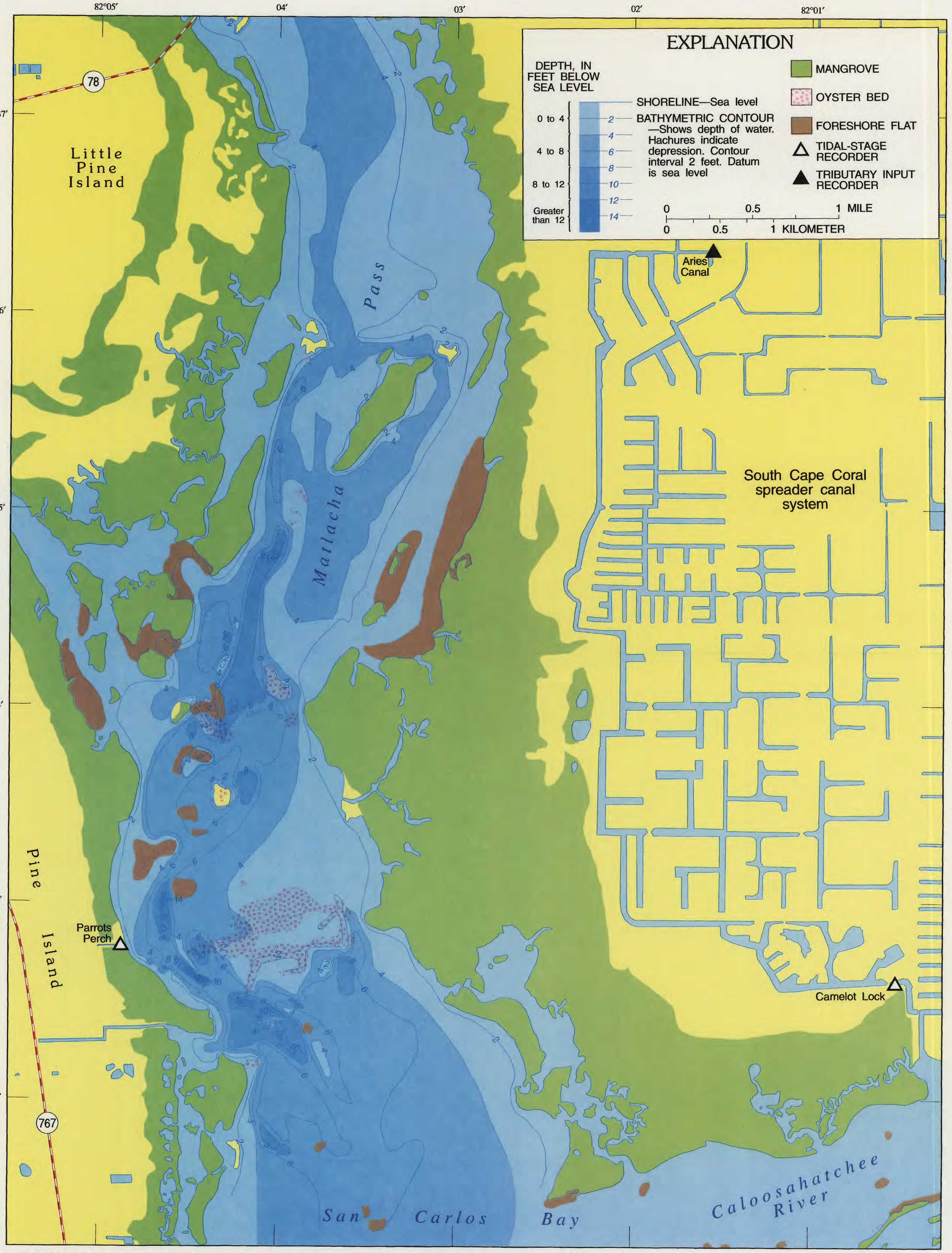

Figure 3. Bathymetric contours in southern Matlacha Pass, southwestern Florida.

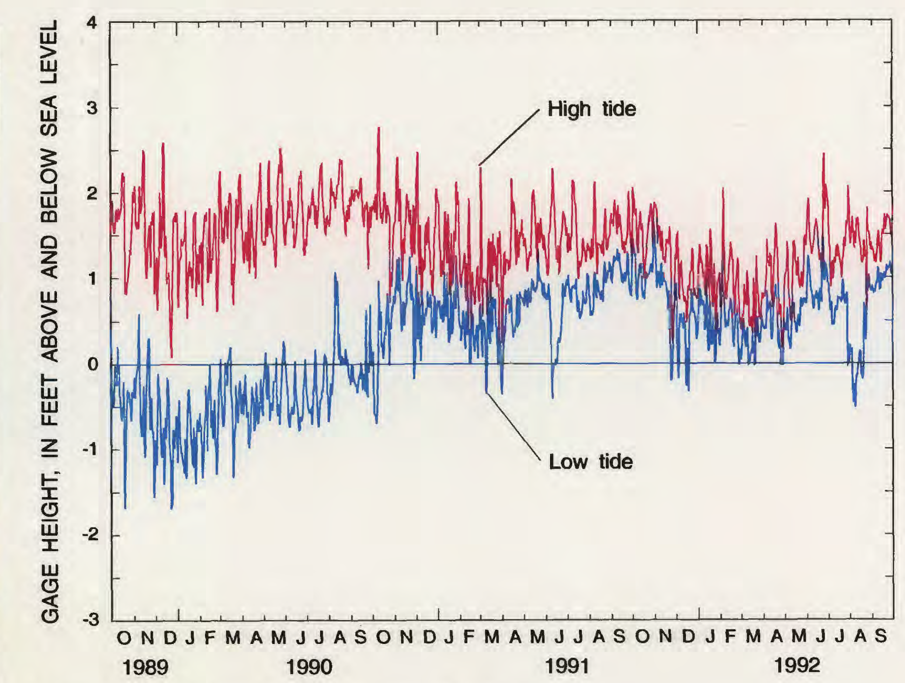

Figure 7. High and low tidal stage at Parrots Perch.

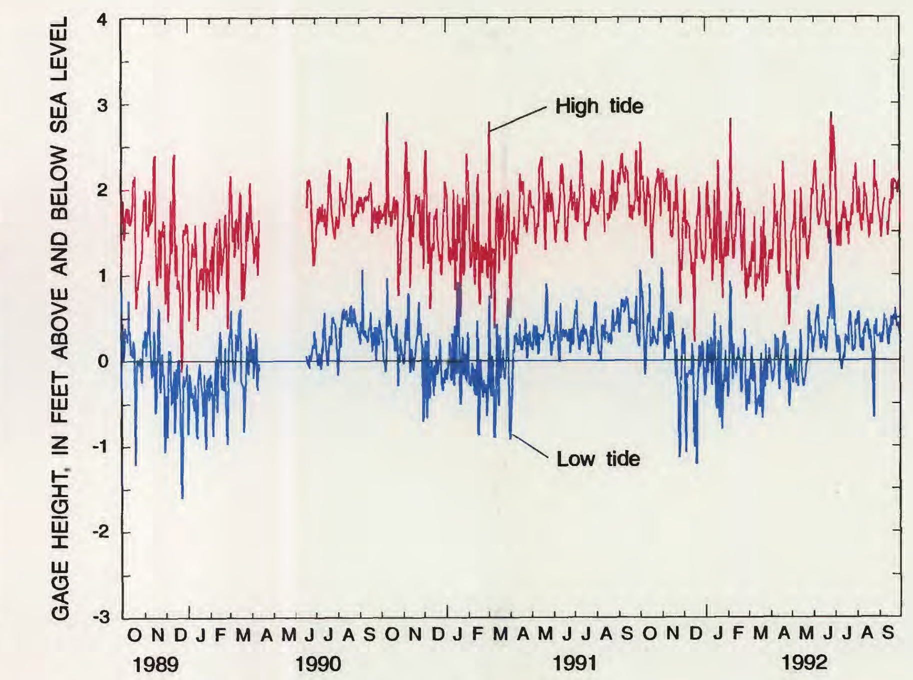

Figure 8. High and low tidal stage at Camelot Lock.

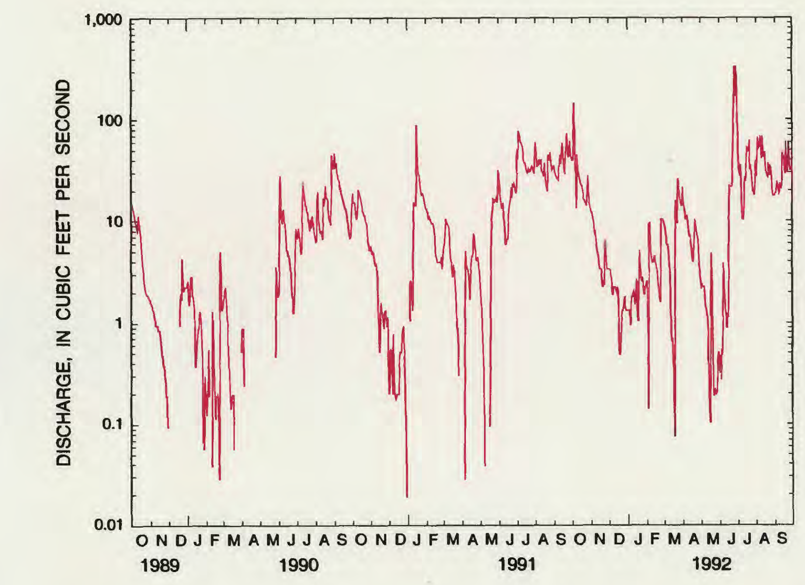

Figure 9. Daily mean discharge from the Aries Canal.

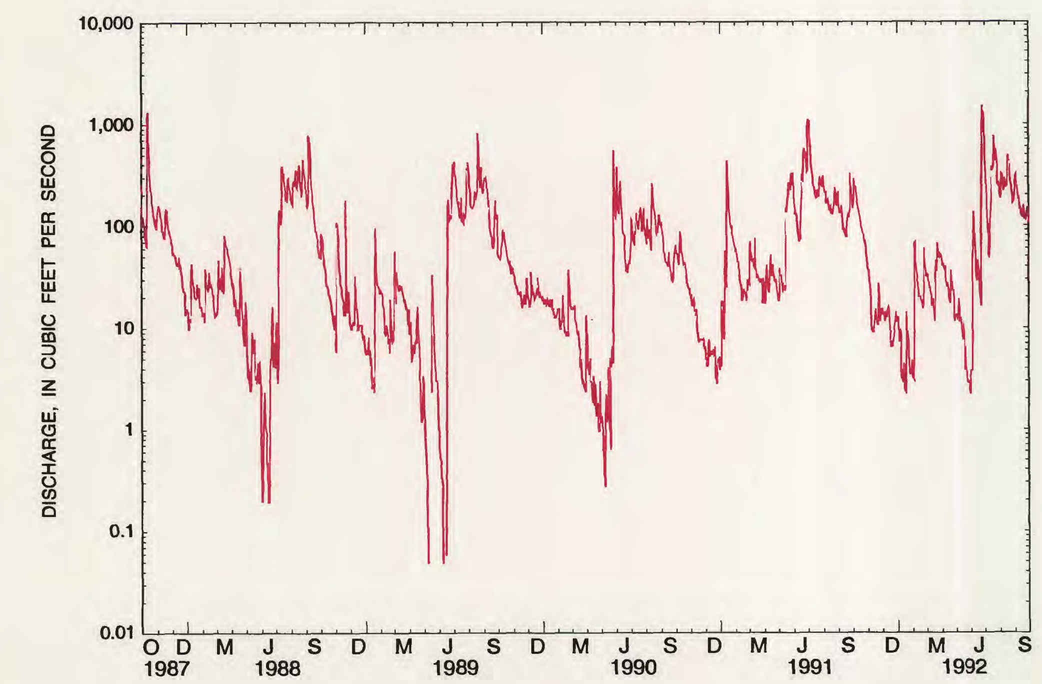

Figure 10. Daily mean discharge from the north Cape Coral spreader canal system (sum of daily mean discharge at Gator Slough, Horseshoe, Hermosa, and Shadroe).

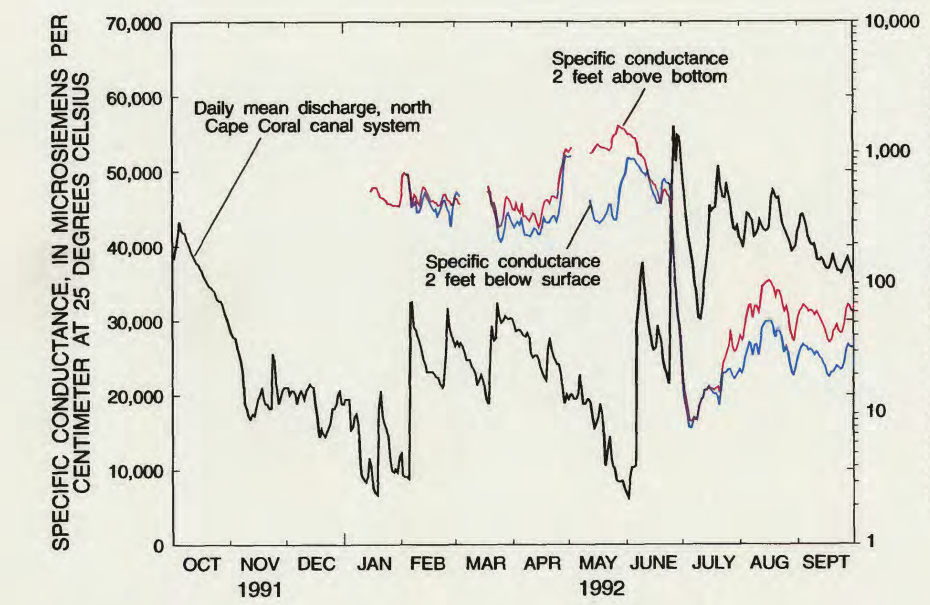

Figure 13. Specific conductance 2 feet below the surface and 2 feet above the bottom at Matlacha and daily mean discharge from the north Cape Coral spreader canal system.

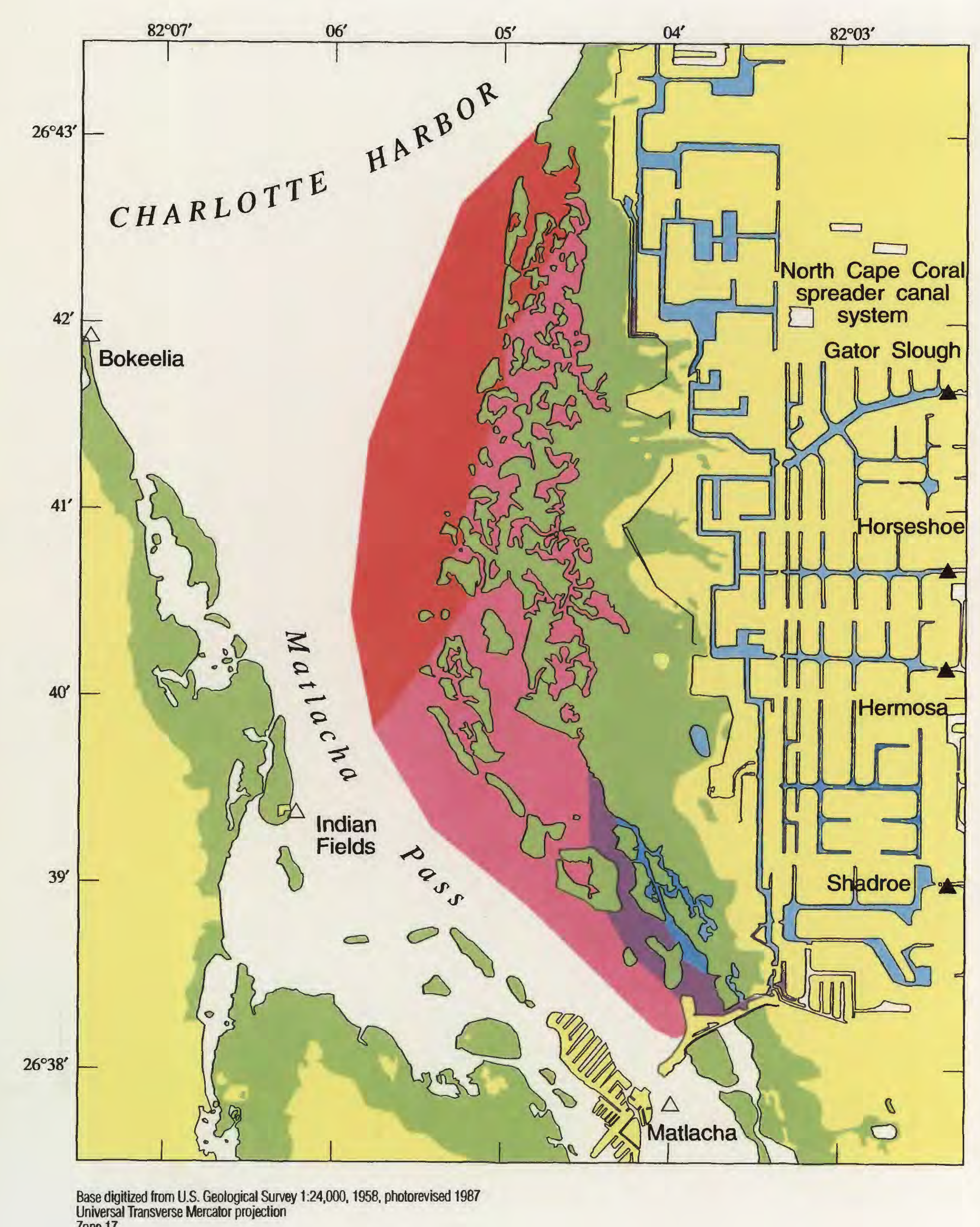

Figure 11. Specific conductance at 10 feet below the surface or near the bottom if depth is less than 10 feet, wet season of August 8, 1984.

EXPLANATION

SPECIFIC CONDUCTANCE, IN MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS

- 0 to 1,300
- 1,301 to 4,000
- 4,001 to 15,500
- 15,501 to 20,800
- 20,801 to 28,800
- Greater than 28,800

MANGROVE

TIDAL-STAGE RECORDER

TRIBUTARY INPUT RECORDER

0 1 MILE
0 1 KILOMETER

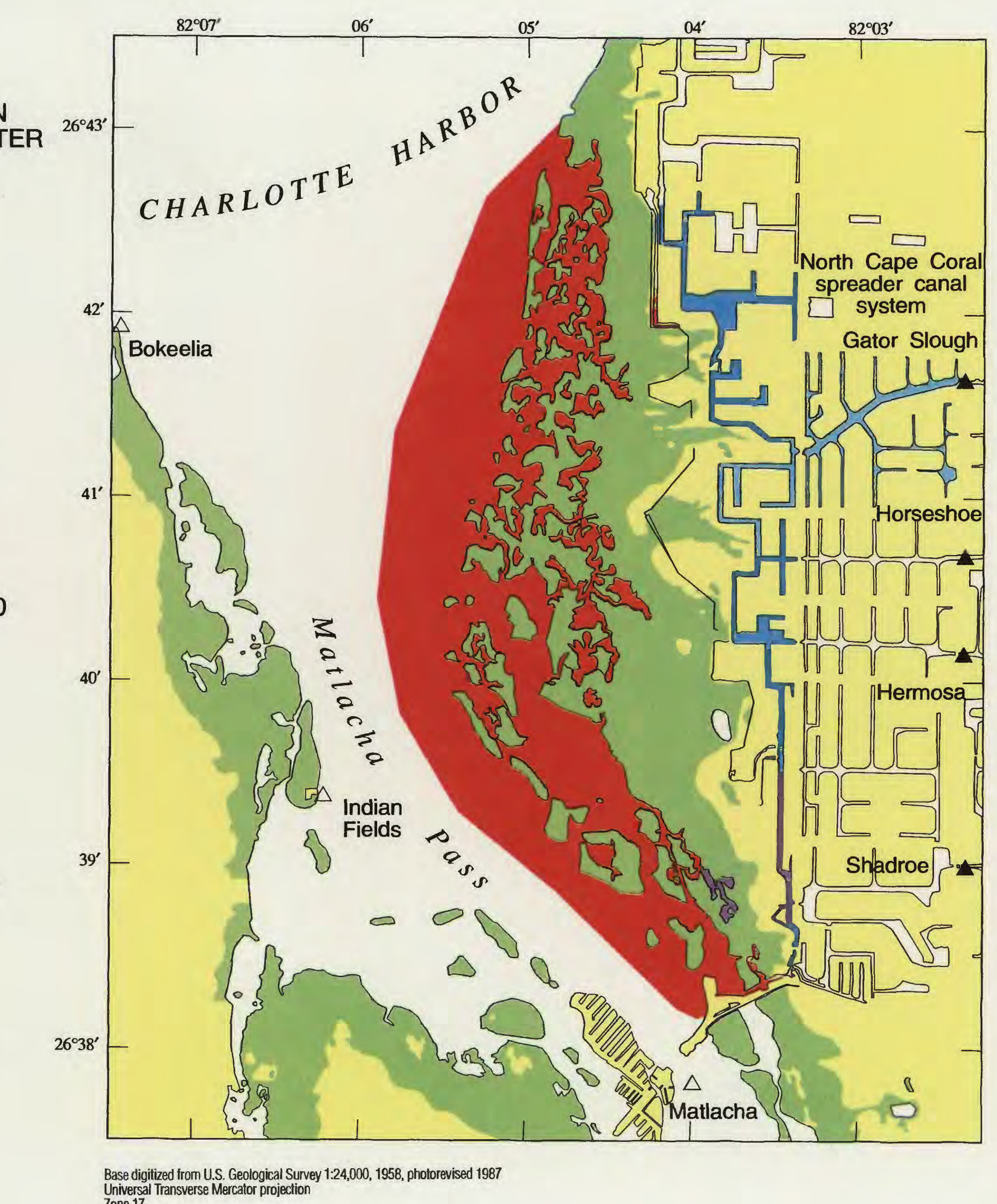

Figure 12. Specific conductance at 10 feet below the surface or near the bottom if depth is less than 10 feet, dry season of May 11, 1984.

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