

DISSOLVED-SOLIDS CONCENTRATIONS AND
LOADS IN FLORIDA SURFACE WATERSBy
Joel E. Dysart and Donald A. GoolsbyPrepared by the
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INTRODUCTION

Historical dissolved-solids data were analyzed to evaluate their areal distribution and to compute the loads transported by major rivers, canals and springs in the State of Florida. The concentration of dissolved solids is a measure of the amount of inorganic and organic material in solution, and, therefore, it is one of the most common and useful measurements of water quality. The concentration of dissolved solids is of major importance for any water used for public consumption or for agricultural purposes. This atlas is designed to provide interested persons and agencies with a summary of dissolved-solids data from about 1,000 sampling sites in major rivers, canals and springs in Florida.

Material transported by streams is either dissolved or suspended. The load carried by surface water has been used to estimate rates of denudation of the land surface by erosion (Dole and Stabler, 1969; Livingstone, 1963; Judson and Ritter, 1964; Cunniff and others, 1973). However, Judson and Ritter (1964, p. 339) emphasized that the dissolved load may be greater than the suspended load under certain conditions of climate and rock type. The region of the United States delineated by them as the "South Atlantic and Eastern Gulf of Mexico," which includes Florida, had an estimated dissolved-solids load of 175 (T/mi²)/yr, whereas the suspended-solids load was 139 (T/mi²)/yr.

Much of the material transported by surface water has a destination in large bodies of water such as the Atlantic Ocean and the Gulf of Mexico. Here, the accretion of solid material carried in suspension can build vast deposits, such as deltas, which will alter the configuration of the coastline. The dissolved material, along with streamflow, governs the salinity balance of estuarine water and is a major source of nutrient material for estuarine and marine organisms. The concentrations, nature, and loads of dissolved material are therefore of interest to marine scientists, hydrologists, and pollution control officials.

NATURE AND SOURCE OF DISSOLVED SOLIDS

In Florida surface water, the dissolved solids consist mainly of bicarbonates, chlorides, and sulfates of calcium, magnesium, sodium, and, in lesser amounts, potassium. The dominant ions and water types in Florida surface water have been discussed by Kaufman (1972). The water also contains carbonate, phosphate, and nitrogen compounds and dissolved organic material, as well as trace amounts of iron, manganese and other substances. However, these latter compounds are not usually principal constituents of the dissolved solids.

The nature and concentrations of the dissolved species are influenced by many interrelated factors: the climate, type of rocks and soils which the water contacts, vegetation, biological activities, adsorption-desorption processes, chemical concentration of the rainfall, and ground-water inflow. Input from industrial and municipal effluents and agricultural runoff also affect the characteristics of the dissolved material.

PROCEDURE AND TECHNIQUES

Dissolved-solids concentrations in most Florida surface water can be estimated reliably by multiplying specific conductance by factors ranging from 0.55 to 0.75 (Slack and Kaufman, 1973). Examples of dissolved solids-specific conductance relations for the St. Johns River near Cocoa, Fla., (station 17) and the Suwannee River at Branford, Fla., (station 7) are shown in figure 1. Dissolved-solids concentrations shown on the large map were determined by multiplying the mean specific conductance at each station by a factor of 0.65. Approximately 20,000 specific conductance measurements made at about 1,000 stations between 1960 and 1975 were used in constructing the map.

The average annual dissolved-solids loads were computed for 57 sampling stations shown, representing the major streams, canals and springs in the state. The load calculations were based on actual laboratory measurements of dissolved-solids residue at 180° Celsius (Brown and others, 1970). Each station had at least 5 years of daily discharge data and a minimum of four dissolved-solids analyses annually for at least 5 years. Dissolved-solids loads contributed by springs were also considered, but the dissolved-solids and discharge values are less variable and consequently the criteria for selection of springs were not as rigid as those for streams and canals.

The average annual dissolved-solids loads were computed for each station from a regression analysis of daily dissolved-solids loads versus daily discharge. Daily dissolved-solids loads, the dependent variable, were computed as the product of dissolved-solids concentration, daily discharge in ft³/s, and 0.0027, a conversion factor. Log-log plots of daily dissolved-solids loads versus daily discharge and the computed least-squares regression line for two stations are shown in figure 2. A regression equation of the following form was developed for each station:

$\log(\text{dissolved-solids load in tons/day}) = (b \times \log Q) + \log a$
where Q is the daily discharge, a is the intercept, and b is the slope of the regression line. Annual dissolved-solids loads at the average discharge rates for the period of record were computed by substituting the average daily discharge into the regression equations and multiplying the resulting load by 365. Annual loads discharged at the mouth of the major basins were estimated from loads at upstream stations using differences in drainage areas to estimate additional inflow below the gaged site. The annual loads for the major streams and canals are shown on the large map.

RESULTS

Concentrations

The estimated average concentrations of dissolved solids in milligrams per liter for Florida surface waters are shown on the map. The minimum average concentration, 41 mg/l, is at the Yellow River at Milligan in Okaloosa County (station 2); the maximum average concentration, 1,490 mg/l, is at Homosassa Springs in Citrus County (station 15).

Average dissolved-solids concentrations in surface water are generally less than 200 mg/l in central and western Florida. Concentrations generally were greater than 200 mg/l in the St. Johns River basin and in subbasins south of Lake Okeechobee. Estimates of average concentrations for stations in the St. Johns River basin ranged from 140 to 830 mg/l and at three stations average concentrations exceeded 500 mg/l.

The dissolved-solids concentration in water from Florida's springs is highly variable with Rainbow Springs and Homosassa Springs representing the extremes (table 1). Concentrations in individual springs, however, exhibit only minor variations with respect to time of sampling.

The minimum estimated average dissolved-solids concentration in water from canals sampled regularly in south Florida is 238 mg/l for station 24 on the Tamiami Canal in Dade County. The maximum estimated concentration, 798 mg/l, is for Main Canal at Vero Beach in Indian River County (station 18). Concentrations are also high (> 500 mg/l) in the agricultural area south of Lake Okeechobee. The highest dissolved-solids concentrations in canal waters in south Florida occur primarily in drainage from wetlands used for agricultural purposes.

Loads

Estimates of dissolved-solids loads, in millions of tons per year, discharging from Florida surface water into the Gulf of Mexico and the Atlantic Ocean are shown on the map. The average annual load discharging into these two bodies of water is about 13 million tons; of this, 6 million tons is delivered to the gulf and 7 million tons to the ocean. The bulk of the load, 66 percent, is delivered by the St. Johns River (5.6 million tons), Apalachicola River (1.6 million tons), and the Suwannee River (1.4 million tons); the combined load of all other rivers represents 17 percent (2.2 million tons) of the annual load.

Because load is a function of both flow and dissolved-solids concentration, changes in either or both parameters would be reflected in the load calculation. Load, flow, concentrations, and annual load per square mile of drainage area are shown on table 2 for selected stations. The load delivered by the Apalachicola River is high primarily as a result of the high volume of streamflow; but the water is low in dissolved-solids concentration. The Suwannee River has much less volume of flow than the Apalachicola, but it has a higher average dissolved-solids concentration, resulting in a high load. The St. Johns River with both high flow volume and high dissolved-solids concentrations generates the greatest load. The loads calculated for the other stations shown in table 2 are relatively low by comparison, but also show the relation to flow volume and concentration.

In order to compare rates of denudation of basins of different size, yields, in tons per square mile per year, were calculated. Table 2 shows that the rates of denudation vary from about 60 to 140 tons per square mile per year for representative rivers and canals in Florida. The St. Johns River is atypical—the 4- to 10-fold larger yields are probably due to the dissolved-solids contributions of Silver Springs and leakage to the river of highly mineralized water from the aquifers underlying most of the basin (Snell and Anderson, 1970, p. 10).

Loads carried by springs were computed only for springs contributing substantially to rivers considered for this map. Of such springs, Blue Springs adds about 135,000 tons to the annual load of the St. Johns River, Silver Springs about 210,000 tons per year to the Oklawaha River, Ichauway Springs about 140,000 tons per year to the Suwannee River, and Wakulla Springs about 60,000 tons per year to the St. Marks River (table 1).

Canals are the main conduits for dissolved-solids discharge for south Florida. The total load discharged by the canals to the ocean and the gulf is estimated to be 2,190,000 tons per year or 17 percent of statewide annual load. The St. Lucie Canal of Martin County (station 20) and the Caloosahatchee River in Lee County (station 23) discharge about 470,000 and 550,000 tons annually. The Peace-River is a controlled river and, in this report, is considered to be a canal.

SUMMARY

Dissolved-solids concentrations in Florida surface waters show considerable statewide variation. Concentrations are highest in the canal system of south Florida, the St. Johns River basin, and most major springs. Other Florida surface waters have concentrations of less than 200 mg/l.

About sixty-six percent of the annual dissolved-solids load is carried to the Gulf of Mexico and Atlantic Ocean by the St. Johns, Apalachicola, and Suwannee Rivers. About seventeen percent of the annual load is carried by canals and 17 percent by the smaller rivers.

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TABLE 1.—Dissolved-solids concentrations and loads for selected springs of Florida.

Map no.	Spring	Average load, tons per year	Average discharge (ft ³ /s)	Average concentration (mg/l)
5	Wakulla Springs	60,000	390	158
8	Ichauway Springs	140,000	361	175
10	Rainbow Springs	80,000	763	91
11	Silver Springs	210,000	820	260
13	Blue Springs	135,000	162	827
15	Homosassa Springs	175,000	106 ^a	1,490
16	Weekiwachee Springs	30,000	176	169

^aComputed discharge for main spring only.

TABLE 2.—Dissolved-solids concentrations and loads for selected rivers and canals in Florida.

Map no.	Station	Average load, tons per year	Average discharge (ft ³ /s)	Average concentration (mg/l)	Yield, tons per square mile per year
1	Escambia River near Century	370,000	6,033	66	96 (104) ^a
3	Choctawhatchee River at Caryville	270,000	5,328	54	76
4	Apalachicola River at Chattahoochee	1,200,000	22,100	58	70 (64)
5	Withlacoochee River near Pinetta	130,000	1,645	139	61
7	Suwannee River at Branford	980,000	6,920	161	126
9	St. Marys River near Macclenny	40,000	689	69	64
12	St. Johns River near DeLand	1,900,000	3,212	643	614 (583)
14	Withlacoochee River near Holder	190,000	1,146	181	104
19	Kissimmee River near Okeechobee	150,000	2,188	92	Indeterminate
20	St. Lucie Canal near Stuart	470,000	1,105	439	Indeterminate
21	Peace River at Arcadia	190,000	1,212	208	138
22	Myakka River near Sarasota	20,000	260	93	93
24	Tamiami Canal near Miami	50,000	252	238	Indeterminate

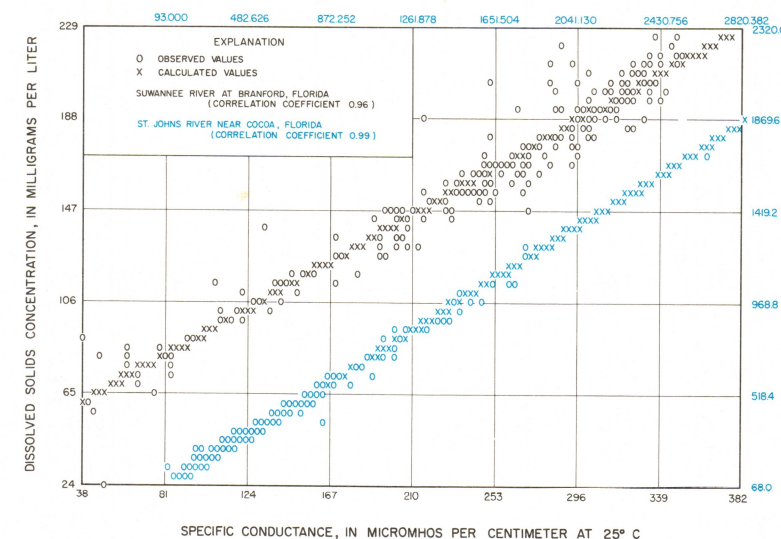
^aData in parentheses computed from Leifeste (1974).

Figure 1.—Relation between dissolved-solids load and specific conductance for the St. Johns River near Cocoa, Fla. (station 17) and the Suwannee River at Branford, Fla. (station 7).

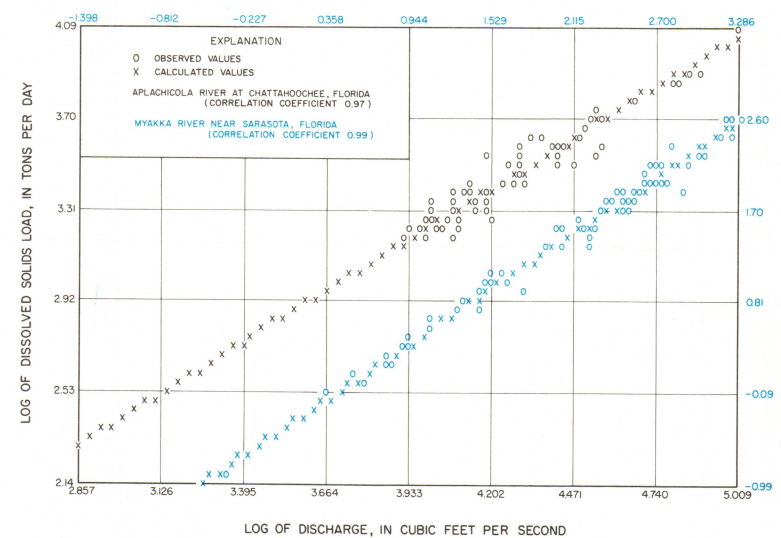
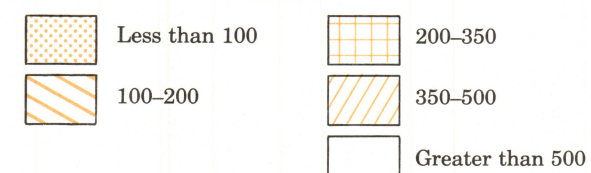
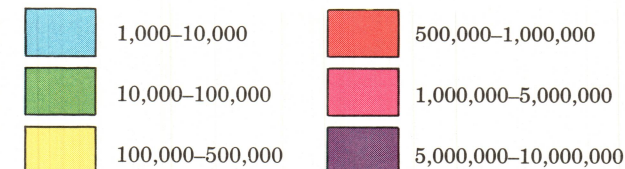


Figure 2.—Relation between dissolved-solids load and stream-flow for the Apalachicola River at Chattahoochee, Fla. (station 4) and the Myakka River near Sarasota (station 22).

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EXPLANATION

ESTIMATED AVERAGE CONCENTRATIONS
OF DISSOLVED SOLIDS, IN MILLIGRAMS
PER LITREAVERAGE LOAD OF DISSOLVED SOLIDS,
IN TONS PER YEARESTIMATED DISSOLVED SOLIDS, IN MILLIONS
OF TONS PER YEAR, DISCHARGED TO GULF
OF MEXICO OR ATLANTIC OCEANWATER QUALITY DATA STATIONS
Numbered Stations Referenced in Text, Tables, or Figures
● 2 STREAM OR CANAL
● 16 SPRING

0 10 20 30 40 50 MILES