DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

OPEN-FILE REPORT 84-804

QUALITY OF GROUND WATER USED FOR PUBLIC SUPPLY IN FLORIDA, 1983-84

By G.A. Irwin, Robert T. Kirkland, and Janet B. Pruitt

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INTRODUCTION

The Clean Water Act of 1977 identified numerous inorganic and organic chemical compounds and elements that are considered an environmental risk to the Nation's water resources. These substances are commonly referred to as "priority pollutants." Many of these priority pollutants are considered a great risk to human health and are regulated by established maximum contaminant levels (MCL) for safe drinking water (Florida Department of Environmental Regulation, 1984). However, little is known about the occurrence of many of these inorganic and organic priority pollutants in the ambient water of major aquifer systems in Florida.

The numerous communities throughout Florida that use ground water as a public supply present an excellent monitoring network for collecting background information on priority pollutants. This is because these public supplies are located throughout the State, are in the most populated areas, usually have continuous and often high pumpage, have ease of access for sampling, and have great health and economic significance.

Thus, from October 1983 through March 1984, the U.S. Geological Survey conducted a chemical sampling reconnaissance of ground water used for public supply for 91 communities throughout Florida. The purpose of this sampling reconnaissance was to initiate the collection of baseline data on the magnitude and distribution of priority pollutants and other chemical and physical variables in ground water throughout the State.

This reconnaissance was part of several project tasks initiated by the Florida Department of Environmental Regulation to develop guidelines and data bases for use in the design and implementation of a statewide ground-water monitoring network as mandated by the recent enactment of the "Water Quality Assurance Act of 1983."

The 91 community supplies sampled during the reconnaissance are shown in figure 1. These 91 supplies obtain water from the Floridan, surficial, intermediate, and sand-and-gravel aquifers. The sampling of community supplies that obtain water from the Biscayne aquifer was not within the scope of this project task. Information on the project task for the Biscayne aquifer is reported by Vincent (1984).

The sample for a community was usually collected at the water treatment plant. A sample from an individual well was preferred over that composited from several wells, but plant design often precluded the sampling of a single well.

The scope of the analytical coverage for the samples collected during the reconnaissance is given in table 1. Specifically, the analytical determinations indicated in table 1 were performed on each of the 91 community-supply samples, except the base/neutral and acid-extractable organic priority pollutants. Analyses for the base/neutral and acid-extractable compounds were performed only on samples of seven supplies, details of which are given in a following section. Parameter codes identify specific analytical methods as given in Skougstad and others (1979) and Wershaw and others (1983).

Site No.	Public supply	County	Aquifer
1	Altamonte Springs	Seminole	Floridan
2	Arcadia	De Soto	Intermediate
3	Auburndale	Polk	Floridan
4	Apalachicola	Franklin	Floridan
5	Apopka	Orange	Floridan
6	Bartow	Polk	Floridan
7	Blountstown	Calhoun	Floridan
8	Bonifay	Holmes	Floridan
9	Bonita Springs	Lee	Surficial
10	Boynton Beach	Palm Beach	Surficial
11	Brandon	Hillsborough	Floridan
12	Bristol	Liberty	Floridan
13	Bronson	Levy	Floridan
14	Brooksville	Hernando	Floridan
15	Bunnel	Flagler	Surficial
16	Bushnell	Sumter	Floridan
17	Cape Coral	Lee	Intermediate
18	Chipley	Washington	Floridan
19	Clearwater	Pinellas	Floridan
20	Cocoa	Brevard	Floridan
21	Crawfordville	Wakulla	Floridan
22	Crestview	Okaloosa	Floridan
23	Cross City	Dixie	Floridan
24	Dade City	Pasco	Floridan
25	Daytona Beach	Volusia	Floridan
26	Defuniak Springs	Walton	Floridan
27	Deland	Volusia	Floridan
28	Dunedin	Pinellas	Floridan
29	Edgewater	Volusia	Floridan
30	Englewood	Sarasota	Surficial
31	Fernandina Beach	Nassau	Floridan
32	Fort Myers	Lee	Surficial
33	Fort Myers Beach	Lee	Intermediate
34	Fort Pierce	St. Lucie	Surficial
35	Fort Walton Beach	Okaloosa	Floridan
36	Gainesville	Alachua	Floridan
37	Green Cove Springs	Clay	Floridan
38	Haines City	Polk	Floridan
39	Inverness	Citrus	Floridan
40	Jacksonville	Duval	Floridan
41	Jasper	Hamilton	Floridan
42	Jupiter	Palm Beach	Surficial
43	Kissimmee	Osceola	Floridan
44	La Belle	Hendry	Surficial
45	Lake Butler	Union	Floridan
46	Lake City	Columbia	Floridan
47	Lake Placid	Highlands	Floridan
48	Lake Wales	Polk	Floridan
49	Lakeland	Polk	Floridan
50	Lehigh Acres	Lee	Surficial
51	Live Oak	Suwannee	Floridan
52	Macclenny	Baker	Floridan
53	Madison	Madison	Floridan
54	Marianna	Jackson	Floridan
55	Mayo	Lafayette	Floridan
56	Milton	Santa Rosa	Sand-and-gravel
57	Monticello	Jefferson	Floridan
58	Moore Haven	Glades	Surficial
59	Naples	Collier	Surficial
60	Neptune Beach	Duval	Floridan
61	New Port Richey	Pasco	Floridan
62	Niceville	Okaloosa	Floridan
63	North Fort Myers	Lee	Surficial
64	Ocala	Marion	Floridan
65	Palatka	Putnam	Floridan
66	Pensacola	Escambia	Sand-and-gravel
67	Perry	Taylor	Floridan
68	Pine Island	Lee	Intermediate
69	Pinellas County	Pinellas	Floridan
70	Plant City	Hillsborough	Floridan
71	Port Orange	Volusia	Floridan
72	Sanford	Seminole	Floridan
73	Sanibel	Lee	Intermediate
74	Sarasota	Sarasota	Intermediate
75	Sebring	Highlands	Floridan
76	St. Augustine	St. Johns	Surficial
77	St. Petersburg	Pinellas	Floridan
78	Starke	Bradford	Floridan
79	Stuart	Martin	Surficial
80	Tallahassee	Leon	Floridan
81	Tarpon Springs	Pinellas	Floridan
82	Tavares	Lake	Floridan
83	Tequesta	Palm Beach	Surficial
84	Titusville	Brevard	Surficial
85	Trenton	Gilchrist	Floridan
86	Venice	Sarasota	Intermediate
87	Vero Beach	Indian River	Surficial
88	Vaushala	Hardee	Floridan
89	Wewahitchka	Gulf	Floridan
90	Winter Haven	Polk	Floridan
91	Winter Park	Orange	Floridan

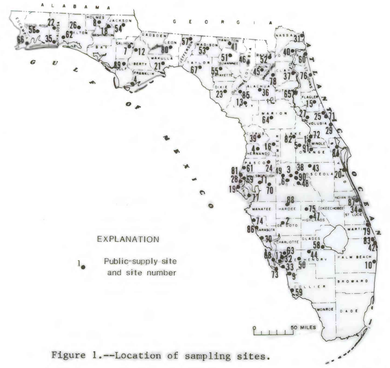


Figure 1.--Location of sampling sites.

Table 1. List of analytical determinations

[Maximum contaminant level : P, Primary Drinking Water Regulations; S, Secondary Drinking Water Regulations]

Volatile priority pollutants

Parameter code	Variable name	Maximum contaminant level, in µg/L
34030	Benzene	1P
32104	Bromoform	3P
32102	Carbon tetrachloride	3P
34301	Chlorobenzene	
34311	Chloroethane	
34576	2-Chloroethyl vinyl ether	
32106	Chloroform	
32105	Dibromochloromethane	
32101	Dichlorobromomethane	
34496	1,1-Dichloroethane	
32103	1,2-Dichloroethane	3P
34501	1,1-Dichloroethylene	
34546	1,2-trans-Dichloroethylene	
34561	1,2-Dichloropropane	
34561	1,3-Dichloropropane	
34371	Ethylbenzene	
34413	Methyl bromide	
34423	Methylene chloride	
34516	1,1,2,2-Tetrachloroethane	
34475	Tetrachloroethylene	3P
34010	Toluene	
34506	1,1,1-Trichloroethane	200P
34511	1,1,2-Trichloroethane	
39175	Vinyl chloride	1P
39180	Trichloroethylene	3P
LC798	Ethylene dibromide	.02P

Herbicide priority pollutants

Parameter code	Variable name	Maximum contaminant level, in µg/L
39730	2,4-D	100P
39760	Silvex	10P
39740	2,4,5-T	
82163	2,4-DP	

Trace metal priority pollutants

Parameter code	Variable name	Maximum contaminant level, in µg/L
01002	Arsenic	50P
01027	Cadmium	10P
01042	Copper	1,000P
71900	Mercury	2P
01077	Silver	50P
01007	Barium	1,000P
01034	Chromium	50P
01051	Lead	50P
01147	Selenium	10P

Base/neutral and acid-extractable priority pollutants

Parameter code	Variable name	Parameter code	Variable name
34205	Acenaphthene	34376	Fluoranthene
34200	Acenaphthylene	34381	Fluorene
34220	Anthracene	39700	Hexachlorobenzene
34526	Benz(a)anthracene	39702	Hexachlorobutadiene
34230	Benzo(b)fluoranthene	34386	Hexachlorocyclopentadiene
34242	Benzo(k)fluoranthene	34396	Hexachloroethane
34521	Benzo(g,h,i)perylene	34403	Ideno(1,2,3-cd)pyrene
34247	Benzo(a)pyrene	34408	Isophorone
34636	4-Bromophenyl phenyl ether	34696	Naphthalene
34292	Butylbenzyl phthalate	34447	Nitrobenzene
34278	Bis(2-chloroethoxy)methane	34438	N-Nitrosodimethylamine
34273	Bis(2-chloroethyl)ether	34428	N-Nitrosodi-n-propylamine
34283	Bis(2-chloroisopropyl)ether	34433	N-Nitrosodiphenylamine
34581	2-Chloronaphthalene	34461	Phenanthrene
34641	4-Chlorophenyl phenyl ether	34469	Pyrene
34320	Chrysene	34551	1,2,4-Trichlorobenzene
34556	Dibenzo(a,h)anthracene	34452	4-Chloro-3-methylphenol
34536	1,2-Dichlorobenzene	34586	2-Chlorophenol
34566	1,3-Dichlorobenzene	34601	2,4-Dichlorophenol
34571	1,4-Dichlorobenzene	34606	2,4-Dimethylphenol
34336	Diethylphthalate,	34657	4,6-Dinitro-2-methylphenol
34341	Dimethylphthalate	34616	2,4-Dinitrophenol
39110	Di-n-butyl phthalate	34591	2-Nitrophenol
34611	2,4-Dinitrotoluene	34646	4-Nitrophenol
34626	2,6-Dinitrotoluene	39032	Pentachlorophenol
34596	Di-n-octyl phthalate	34694	Phenol
39100	Bis(2-ethylhexyl) phthalate	34621	2,4,6-Trichlorophenol

Insecticide priority pollutants

Parameter code	Variable name	Maximum contaminant level, in µg/L
39330	Aldrin	
39350	Chlordane	
39360	p,p'-DDD	
39365	p,p'-DDE	
39370	p,p'-DDT	
39380	Dieldrin	
39388	Endosulfan	
39390	Endrin	0.2P
39034	Perthane	
39516	Gross polychlorinated biphenyls[1]	
39250	Gross polychlorinated naphthalenes[1]	
39410	Heptachlor	
39420	Heptachlor expoxide	
39340	Lindane	4.0P
39480	Methoxychlor	100P
39755	Mirex	
39400	Toxaphene	5.0P

[1]Industrial compounds.

Other inorganic chemical and physical variables

Parameter code	Variable name	Maximum contaminant level
90410	Alkalinity	
00915	Calcium	
00940	Chloride, mg/L	250S
00800	Color, Pt-Co units	15S
70300	Dissolved solids, mg/L	500S
00951	Fluoride, mg/L	1.4-2.4P
00925	Magnesium	
00630	Nitrate (as N), mg/L	10P
70507	Orthophosphorus	
00400	pH, units (minimum)	6.5
00935	Potassium	
00955	Silica	
00930	Sodium, mg/L	160P
00095	Specific conductance	
01080	Strontium	
00945	Sulfate, mg/L	250S

ABBREVIATIONS AND SYMBOLS

< = less than
MCL = maximum contaminant level
µg/L = micrograms per liter
mg/L = milligrams per liter
P = Primary Drinking Water Regulations
S = Secondary Drinking Water Regulations

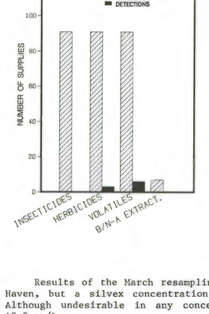
RESULTS

Insecticides, Herbicides, and Volatiles

Organic analyses of samples collected from the 91 community supplies indicated the presence of chlorophenoxy herbicides at three supplies, and volatile compounds at six supplies. No organochlorine insecticides were detected.

Respective compounds and concentrations were:

DISTRIBUTION OF ORGANIC PRIORITY POLLUTANTS



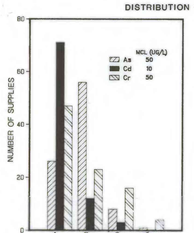
Community and site number	Compound	Concentration, in µg/L
Clearwater (19)	Methylene chloride	24
Edgewater (29)	Ethylene dibromide	.02
Fort Pierce (34)	2,4-D	.01
Macclenny (52)	Chloroform	8
	Dibromochloromethane	2
	Dichlorobromomethane	4
Moore Haven (58)	2,4-D	.09
North Fort Myers (63)	Toluene	4
Sanford (72)	Ethylene dibromide (EDB)	.15
St. Petersburg (77)	Chloroform	10
Winter Park (91)	Silvex	.02

These communities were resampled in March 1984 except for Sanford and Edgewater. Use of the supply well at Sanford had been discontinued prior to March 1984, and the trace EDB at Edgewater was not confirmed. The March resampling at St. Petersburg and Macclenny again indicated detectable concentrations of chloroform. The March sample for Clearwater indicated a trace of acetone (7.8 µg/L). Toluene was not detected in the March sample at North Fort Myers.

Results of the March resampling did not indicate the presence of 2,4-D at either Fort Pierce or Moore Haven, but a silvex concentration of 0.02 microgram per liter (µg/L) was again detected at Winter Park. Although undesirable in any concentration, this level of silvex is considerably less than the MCL of 10.0 µg/L.

For the seven sites (St. Petersburg, Clearwater, Fort Pierce, Moore Haven, Macclenny, North Fort Myers, and Winter Park) resampled in March, analyses were also made for base/neutral and acid-extractable compounds. No base/neutral and acid-extractable compounds were found greater than the 5 µg/L detection limit.

DISTRIBUTION OF ARSENIC (As) CADMIUM (Cd) AND CHROMIUM (Cr)

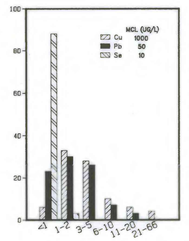


Trace Metals

Results of the reconnaissance sampling indicated that the concentrations of arsenic, cadmium, and chromium in the 91 community supplies were well below those required to meet Primary Drinking Water Regulations. Arsenic concentrations ranged from less than 1 µg/L (<1) to 2 µg/L in supplies for 82 communities, with a maximum concentration of 12 µg/L at Cross City (site 23). Cadmium was found in concentrations of <1 µg/L in supplies for 71 communities. The maximum concentration of cadmium was 4 µg/L in the supply for the city of Fernandina Beach (site 31). Concentrations of chromium ranged from <1 µg/L to 10 µg/L in 88 community supplies, with a maximum concentration of 25 µg/L in the supplies for both Monticello (site 57) and Bonifay (site 8).

Trace Metals--Continued

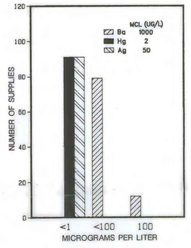
DISTRIBUTION OF COPPER (Cu) LEAD (Pb) AND SELENIUM (Se)



Concentrations of copper, lead, and selenium present in the ground-water supplies for 91 communities were less than the established MCL for safe drinking water. Trace concentrations of copper were found in most of the supplies with only six sites indicating concentrations of <1 µg/L. Copper ranged from 1 µg/L to slightly greater than 10 µg/L in 74 supplies, with 3 supplies above 25 µg/L. Lead concentrations in all 91 community supplies were considerably less than the Primary Drinking Water Regulation of 50 µg/L. The maximum concentration detected was 13 µg/L in the supply for the city of Pensacola and only two additional supplies had concentrations greater than 10 µg/L. Selenium concentrations in all 91 supplies were less than, or very near, the lower limit of detection of 1 µg/L.

Community and site number	Trace metal	Concentration, in µg/L
Macclenny (52)	Copper	39
Milton (56)	Lead	11
Niceville (62)	Lead	12
Pensacola (66)	Lead	13
Sarasota (74)	Copper	66
Tallahassee (80)	Copper	26

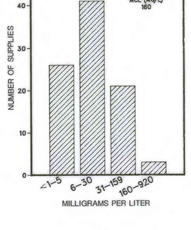
DISTRIBUTION OF BARIUM (Ba) MERCURY (Hg) AND SILVER (Ag)



Barium, mercury, and silver concentrations in all 91 community supplies were less than the MCL established for safe drinking water. At 79 supplies, the barium concentrations were less than the minimum analytical detection of 100 µg/L, and at 12 supplies a concentration of 100 µg/L was measured. The concentrations of both mercury and silver were <1 µg/L at all 91 community supplies.

Other Inorganic Chemical and Physical Variables

DISTRIBUTION OF SODIUM (Na)

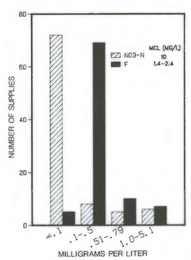


Concentrations of sodium were highly variable in ground water used for public supply. About 75 percent of the 91 community supplies had sodium concentrations ranging from <1 to 30 milligrams per liter (mg/L) and about 25 percent ranged from 31 to 920 mg/L. Only three supplies, however, contained sodium concentrations that exceeded the established MCL of 160 mg/L for safe drinking water. These supplies and concentrations were:

Community and site number	Concentration, in mg/L
Pine Island (68)	448
Sanibel (73)	920
Venice (86)	170

These supplies are from the intermediate aquifer located along the southwestern coast of Florida, and historically these ground-water supplies have required desalination prior to distribution for human consumption.

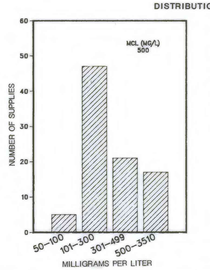
DISTRIBUTION OF NITRATE-NITROGEN (NO3-N) AND FLUORIDE (F)



Concentrations of nitrate-nitrogen in ground water from the 91 community supplies were generally less than 0.10 mg/L. Overall, 72 supplies had a nitrate concentration of <0.1 mg/L, with only 6 supplies containing concentrations of nitrate-nitrogen ranging from 1.0 to 5.1 mg/L. The greatest concentrations were measured in the supplies for the cities of Pensacola (site 66) 5.1 mg/L and Brandon (site 11) 4.2 mg/L. These concentrations, however, are only about 50 percent of the MCL of 10 mg/L established for safe drinking water.

The MCL for fluoride is based on the annual average maximum daily temperature. The maximum daily temperature in most parts of Florida exceeds 70°F, therefore, a fluoride concentration of about 1.8 mg/L and greater may be considered undesirable. Results of the reconnaissance indicated that 84 supplies had fluoride concentrations ranging from <0.1 to 0.99 mg/L, with only 7 supplies ranging from 1.0 to 2.6 mg/L. Three supplies had fluoride concentrations equal to or greater than 1.8 mg/L; the maximum fluoride concentration of 2.6 mg/L was detected in the supply for the city of Arcadia (site 2), and the supplies for the cities of Sanibel (site 73) and Venice (site 86) had respective concentrations of 1.8 and 1.9 mg/L.

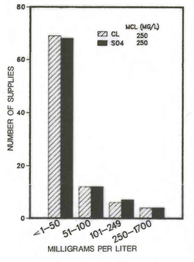
DISTRIBUTION OF DISSOLVED SOLIDS



The concentrations of dissolved solids in about 20 percent of the 91 supplies sampled during the reconnaissance exceeded the recommended MCL of 500 milligrams per liter (mg/L). Four supplies had concentrations greater than 1,000 mg/L. These supplies and concentrations were:

Community and site number	Concentration, in mg/L
Moore Haven (58)	1,110
Pine Island (68)	1,950
Trenton (85)	2,660
Sanibel (73)	3,510

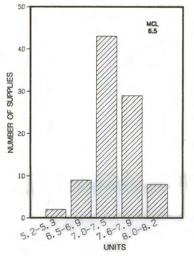
DISTRIBUTION OF CHLORIDE (Cl) AND SULFATE (SO4)



The distribution of chloride and sulfate in the 91 public supplies was quite similar. Concentrations of chloride ranged from <1 to 100 mg/L in 81 supplies and sulfate ranged from less than <1 to 100 mg/L in 80 supplies. Similarly, the MCL of 250 mg/L for both chloride and sulfate was exceeded in four supplies. The concentrations of chloride and sulfate by supply were:

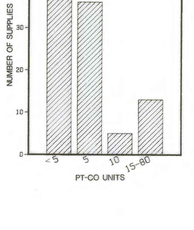
Community and site number	Chloride, in mg/L	Sulfate, in mg/L
Pine Island (68)	920	250
Sanibel (73)	1,700	380
Venice (86)	360	1,300
Moore Haven (58)	260	<250
Sarasota (74)	<250	320

DISTRIBUTION OF pH



The pH of most of the 91 community supplies ranged from 7.0 to 8.0 units and only 2 sites had pH values less than the minimum pH of 6.5 units established for safe drinking water. The supply for the city of Milton (site 56) had a pH of 5.3 and the city of Pensacola (site 66) had a pH of 5.2. Both supplies are from the sand-and-gravel aquifer system in northwest Florida.

DISTRIBUTION OF COLOR (Pt-Co)



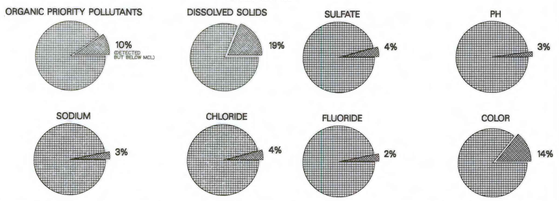
More than 50 percent of the 91 supplies indicated the presence of color. Of the total, 54 supplies had a detectable color of 5 platinum-cobalt (Pt-Co) units or greater, and 13 supplies had color in excess of the established MCL of 15 Pt-Co units. Virtually all of the supplies with color values of 15 Pt-Co units or greater were located in surficial aquifers. The maximum color detected was 80 Pt-Co units in the supply for the city of Moore Haven (site 58), and the supplies for both the cities of Fort Myers (site 32) and North Fort Myers (site 63) had a color of 60 Pt-Co units.

SUMMARY

From October 1983 through March 1984, a sampling reconnaissance was made of the untreated ground water used as public supply for 91 communities in Florida (see below). The analytical results of this reconnaissance indicated:

- Trace concentrations of pesticide and volatile organic priority pollutants were detected in the untreated ground-water supplies of nine communities. However, the concentrations of none of the organic compounds exceeded Florida's Drinking Water Regulations, except for ethylene dibromide at Sanford (site 72).
- Except for sodium and fluoride at three locations in southwest Florida, no supplies contained inorganic contaminants exceeding the Primary Drinking Water Regulations.
- In contrast, the concentrations of several inorganic variables established as Secondary Drinking Water Regulations were frequently exceeded. As shown below, dissolved solids and color most commonly exceeded secondary regulations, but several other variables also exceeded regulations in a few supplies.

PERCENT OF SUPPLIES WITH INORGANIC VARIABLES EXCEEDING THE MAXIMUM CONTAMINANT LEVEL (MCL) AND THE PERCENT OF SUPPLIES INDICATING ORGANIC PRIORITY POLLUTANTS



SELECTED REFERENCES

Florida Department of Environmental Regulation, 1984, Water quality standards: Chapter 17-22 in Florida Administrative Code.

Skougstad, M. W., Fishman, M. J., Friedman, L. C., Erdmann, D. E., and Duncan, S. S., eds., 1979, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter A1, 626 p.

U.S. Congress, 1977, 33 U.S. Code 466, Committee Print HR. 3199, Clean Water Act: Washington, D.C.

Vincent, J. R., 1984, South Florida drinking water investigation, Broward, Dade, and Palm Beach Counties: U.S. Environmental Protection Agency, EPA-330/1-84-001.

Wershaw, R. L., Fishman, M. J., Grabbe, R. R., Lowe, L. E., eds., 1983, Methods for the determination of organic substances in water and fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Laboratory Analysis, Chapter A3, Open-File Report 82-1004, 173 p.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Suite 3015
227 North Bronough Street
Tallahassee, Florida 32301

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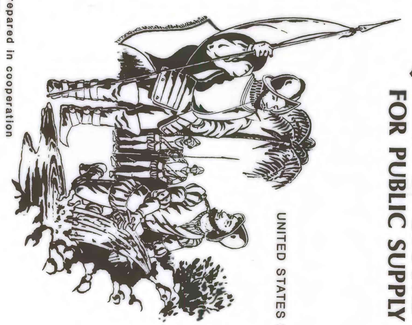

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