

# **Documentation of Hydrochemical-Facies Data and Ranges of Dissolved-Solids Concentrations for the Northern Atlantic Coastal Plain Aquifer System: New Jersey, Delaware, Maryland, Virginia, and North Carolina**

Supplement to Professional Paper 1404-L  
By HAROLD MEISLER and LEROY L. KNOBEL

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# CONTENTS

Abstract . . . . .	1
Introduction . . . . .	1
Description of the study area . . . . .	1
Location and extent . . . . .	1
Hydrogeology. . . . .	1
Data compilation and analysis . . . . .	3
Hydrochemical facies and ranges of dissolved-solids concentrations . . . . .	3
Data base . . . . .	4
Definition of hydrochemical facies . . . . .	4
Description of data table. . . . .	5
Selected references . . . . .	5

## ILLUSTRATIONS

Figure 1. Map showing location of the study area in the Atlantic Coastal Plain . . . . .	2
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## TABLES

Table 1. Water samples used for construction of hydrochemical facies maps and sections, Professional Paper 1404-L. . . . .	.Diskette
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## DISKETTE

(In pocket at back of report)

High-density, double-sided, double-track, 3-1/2-inch micro floppy disk with data file and text of report

## CONVERSION FACTORS AND ABBREVIATED UNITS

Multiply	By	To Obtain
foot (ft)	0.3048	meter
square mile (mi <sup>2</sup> )	2.590	square kilometer

Abbreviated units used in report: milliequivalent per liter (meq/L); milligram per liter (mg/L).

# DOCUMENTATION OF HYDROCHEMICAL-FACIES DATA AND RANGES OF DISSOLVED-SOLIDS CONCENTRATIONS FOR THE NORTHERN ATLANTIC COASTAL PLAIN AQUIFER SYSTEM: NEW JERSEY, DELAWARE, MARYLAND, VIRGINIA, AND NORTH CAROLINA

by Harold Meisler and LeRoy L. Knobel

## Abstract

Hydrochemical-facies data and ranges of dissolved-solids concentrations used to construct hydrochemical-facies maps and sections for U.S. Geological Survey Professional Paper 1404-L have not been previously published. In this report, the data are contained on a 3-1/2-inch high-density diskette in a file presented in American International Standard Code for Information Exchange (ASCII) format. The file requires about 0.2 megabyte of disk space on an IBM-compatible microcomputer using the MS-DOS operating system.

## INTRODUCTION

The geochemistry of the northern Atlantic Coastal Plain aquifer system was studied from 1979 to 1986 and hydrochemical facies maps covering New Jersey, Delaware, Maryland, Virginia, and North Carolina were prepared for 10 aquifers. The results of the geochemistry study are reported by Knobel and others (in press), however the hydrochemical-facies data and ranges of dissolved-solids concentrations used to construct the maps included in that report have not been previously published. The purpose of this report, which supplements the report by Knobel and others, is to document the data used to prepare the hydrochemical-facies maps.

## DESCRIPTION OF THE STUDY AREA

### Location and Extent

The northern Atlantic Coastal Plain covers an area of about 50,000 mi<sup>2</sup>, extending from the

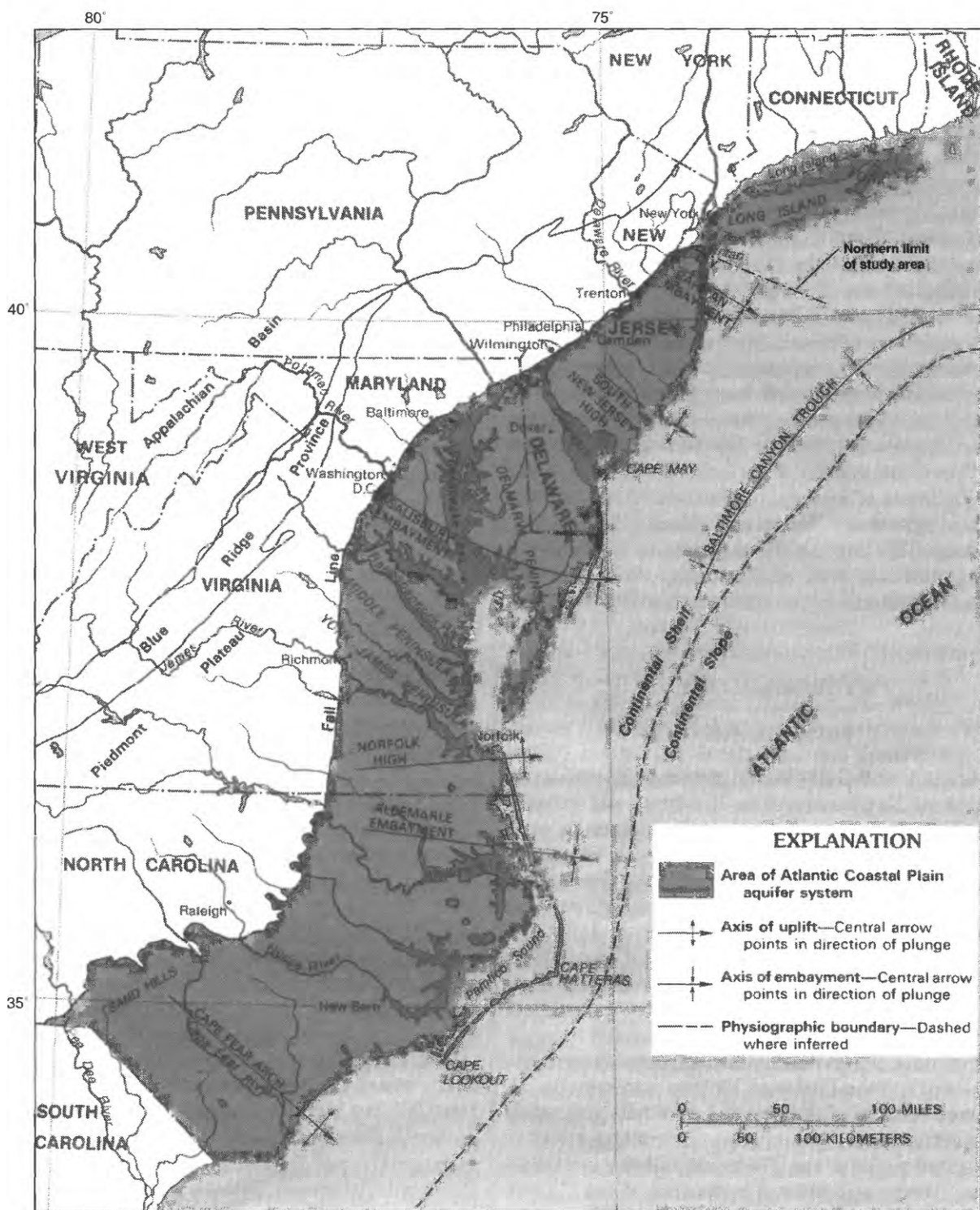
southern boundary of North Carolina north-eastward to Long Island Sound, New York. It is bounded on the west by the Fall Line—generally defined as the contact between Coastal Plain sedimentary deposits and older predominantly crystalline rocks—and on the east by the Atlantic Ocean (fig. 1). The Coastal Plain is underlain by a wedge-shaped body of primarily unconsolidated sediments that dip gently seaward. The wedge thickens from a feather edge at the Fall Line to 8,000 ft along the coast of Maryland and 10,000 ft at Cape Hatteras, North Carolina.

The sedimentary wedge extends offshore to the continental slope. The geochemistry of the offshore area has been discussed in previous reports (Meisler and others, 1984; Meisler, 1989) and is not considered in Knobel and others (in press). Similarly, the geochemistry of the coastal plain of Long Island, New York has been extensively studied (Pearson and Friedman, 1970; Ragone and others, 1976; Ragone, 1977; Katz and others, 1978; Kreitler and others, 1978; Porter and others, 1978; Flipse and others, 1984) and is not included in Knobel and others (in press). Thus, the study area considered in this report consists of the coastal plains of New Jersey, Delaware, Maryland, Virginia, and North Carolina (fig. 1).

### Hydrogeology

Sediments underlying the northern Atlantic Coastal Plain form a multilayered aquifer system containing interbedded lenses of sand, silt, clay, gravel, and limestone. In places, the sediments are cemented by authigenic minerals.

Trapp (1992, pl. 3) has divided the sedimentary sequence of the aquifer system into 11 regional aquifers separated by 9 confining units and shows the relations among regional aquifers, local hydrogeologic units, and geologic



Base enlarged from U.S. Geological Survey  
National Atlas, 1970, 1:7,500,000

Positions of structural features adapted from Uchupi (1968),  
Maher (1971), and Owens and Gohn (1985).

**Figure 1. Location of study area in the Atlantic Coastal Plain  
(Modified from Trapp and Meisler, 1992, fig. 1).**

formations. Also shown in Trapp (1992, pl. 3) are aquifer numbers used in a model of three-dimensional ground-water flow (Leahy and Martin, 1993). The basis for definition of the aquifers is continuity of permeability. The geographical and vertical distribution of aquifers and confining units is depicted by Knobel and others (in press) on a series of maps (pls. 2-6) and hydrogeologic sections (pls. 7-8), respectively. Also shown on these plates are the hydrochemical facies for each aquifer. Trapp (1992) gives a description of the regional aquifers and confining units.

### **Data Compilation and Analysis**

Knobel and others (in press) describes areal changes in ground-water chemistry at a large scale. A large amount of water-quality data that had been compiled for local studies and data programs and completed in cooperation with agencies of the individual States was the basis for describing these changes. These data have generally been stored in the U.S. Geological Survey's (USGS) National Water Data Storage and Retrieval System (WATSTORE). This system contains a computerized data base (Water-Quality File) for storing chemical data collected by Federal, State and local organizations (U.S. Geological Survey, 1975b). The data base is maintained by the USGS at its National Center in Reston, Virginia, and is accessible to the general public (U.S. Geological Survey, 1975a). Most of the data consists of results of partial analyses, such as chloride-concentration measurements and, therefore cannot be used for areal interpretations of aquifer geochemistry. If an analysis is complete (concentrations of all ionic species measured) and has no analytical error, the sum of the milliequivalents per liter of cations should be equal to the sum of the milliequivalents per liter of anions. In practice, it is not feasible to achieve this level of accuracy; however, the nearness to this standard is a good means of testing the acceptability of an analysis. Hem (1985, p. 164) suggests that the difference between the sum of the cations and the sum of the anions should not exceed 1 or 2 percent of the total of cations plus anions for waters where the total is equal to or greater than about 5 meq/L. If the total is less than

about 5 meq/L, the acceptance percentage should be increased. This standard is based on the assumption that all chemical species present in a sample have been accurately determined in the analysis. Because this is rarely the case, the acceptance levels for chemical analyses used in the present study were set at 5 percent when the total of cations plus anions was equal to or greater than 5 meq/L and 10 percent when the total of cations plus anions was less than 5 meq/L. For the purposes of this report, this test is designated "the 5-percent test" for cation-anion balance. Unless otherwise indicated, all analyses used in this report have passed the 5-percent test for cation-anion balance. As part of this study, more than 15,000 chemical analyses were retrieved from WATSTORE. Of these, approximately 3,600 passed the 5-percent test for cation-anion balance and were tabulated by Knobel (1985).

### **HYDROCHEMICAL FACIES AND RANGES OF DISSOLVED-SOLIDS CONCENTRATIONS**

Ground water in the Atlantic Coastal Plain from New Jersey to North Carolina has been classified into four hydrochemical facies—variable composition, calcium plus magnesium bicarbonate, sodium bicarbonate, and sodium chloride—and five ranges of dissolved-solids concentrations (0-250, 251-500, 501-1,000, 1,001-2,000, and greater than 2,000 mg/L). The hydrochemical facies are defined by the predominance (greater than 50 percent in units of milliequivalents per liter) of particular cations and anions. For example, the sodium bicarbonate hydrochemical facies is defined by water in which sodium makes up greater than 50 percent of total cations and bicarbonate makes up greater than 50 percent of total anions. This definition differs from the more detailed definition used by Back (1966, p. A13, table 2, and fig. 5). Distributions of both the hydrochemical facies and dissolved-solids concentrations are shown on maps for each of 10 regional aquifers (Knobel and others, in press, pls. 2-6). Hydrochemical facies also are shown on several hydrogeologic sections (Knobel and others, in press, pls. 7-8); the hydrogeologic units on the sections were delineated by Trapp

(1992). Hydrochemical facies and dissolved-solids concentrations in the surficial aquifer have not been depicted by Knobel and others (in press) because of their variability at a regional scale. The distributions of hydrochemical facies and dissolved-solids concentrations depicted by Knobel and others (in press) in plates 2-8 are generalized; individual analyses may differ from the predominant chemical character or range of dissolved-solids concentration.

## Data Base

The delineation of hydrochemical facies and dissolved-solids concentrations is based on 2,320 chemical analyses of water samples from 2,230 wells that tap 10 aquifers of the northern Atlantic Coastal Plain. The analyses are distributed by State as follows: New Jersey, 580 analyses from 536 wells; Delaware, 72 analyses from 65 wells; Maryland, 538 analyses from 532 wells; Virginia, 477 analyses from 462 wells; and North Carolina, 653 analyses from 635 wells. Aquifer designation for each analysis was determined by comparing the altitude of the screen setting in each well to the altitude of each aquifer as mapped by Trapp (1992).

The wells, along with well location, date of collection, hydrochemical facies, and dissolved-solids range are stored on a diskette, which is included in a pocket at the back of this report. Multiple samples from a single well are listed only if the multiple samples represent different hydrochemical facies or different categories of dissolved solids. All but 63 of the analyses have been tested for cation-anion balance and meet "the 5-percent test" described. Untested analyses, noted in the diskette, are from Bain (1970) and from the files of the North Carolina Department of Natural Resources and Community Development.

## Definition of Hydrochemical Facies

Water of variable composition.—Ground water in the areas depicted on the hydrochemical-facies maps as having variable composition either (1) has no predominant anion or cation, or (2) has a predominant cation or anion that differs from sample to sample so that no specific facies could

be mapped. Also, ground water in which sulfate is the predominant anion occurs within the area mapped as "variable composition" in several aquifers in New Jersey and Maryland. The dissolved-solids concentrations of variable-composition ground water are generally less than 250 mg/L, although concentrations in the range of 250 to 500 mg/L occur in southwestern New Jersey.

Bicarbonate water.—In the calcium plus magnesium bicarbonate water, calcium plus magnesium makes up greater than 50 percent of the cations (calcium generally predominates over magnesium), and bicarbonate makes up greater than 50 percent of the anions. This water generally occurs along the updip limit of the aquifers or downdip from water of variable composition. The dissolved-solids concentrations in ground water of this facies are generally less than 250 mg/L. Larger concentrations (generally 250-500 mg/L) are most common in North Carolina.

In the sodium bicarbonate water, sodium makes up greater than 50 percent of the cations, and bicarbonate makes up greater than 50 percent of the anions. This water generally occurs downdip from the calcium plus magnesium bicarbonate water. Dissolved-solids concentrations in the sodium bicarbonate water generally range up to about 1,000 mg/L, except in New Jersey, where they are generally less than 500 mg/L.

Sodium chloride water.—In the sodium chloride water, sodium makes up more than 50 percent of the cations, and chloride makes up more than 50 percent of the anions. This water generally occurs downdip from the sodium bicarbonate water. It is the dominant facies in the deepest, farthest downdip parts of the 10 aquifers. Dissolved-solids concentrations in ground water from North Carolina to Delaware generally are greater than 1,000 mg/L. Smaller concentrations occur locally, such as in the vicinity of the Cape Fear River and Albemarle Sound in North Carolina, on the York-James Peninsula in Virginia, and near the Delaware estuary in Delaware. In New Jersey, dissolved-solids concentrations generally are greater than 500 mg/L, but smaller concentrations occur near

the Delaware estuary and in the upper Chesapeake aquifer along the coast.

## DESCRIPTION OF DATA TABLE

Hydrochemical-facies designations and ranges of dissolved-solids concentrations listed in table 1 (diskette) were derived from chemical data tabulated by Knobel (1985). Additional chemical data, which have not passed the 5-percent test for cation-anion balance, were taken from Bain (1970) and the files of the North Carolina Department of Water Resources and Community Development in Raleigh, North Carolina. The following information also is included on table 1.

**Latitude and longitude.**—Table 1 contains latitudes and longitudes, in decimal format, for each sample site. The latitudes and longitudes are north and west, respectively. Because of the density of sample locations, all of the sites cannot be plotted on a sample-location map. Knobel (1985, pl. 1) superposed a gridded rectangle of latitude and longitude upon a map of the northern Atlantic Coastal Plain so that the reader can locate the sampling site for a chemical analysis. The method is explained in detail by Knobel (1985, p. 10).

**County codes.**—Codes in table 1 (diskette) are taken from the WATSTORE User's Guide (U.S. Geological Survey, 1975b).

**Local well identifiers.**—Sample sites listed in table 1 (diskette) contain local well names and numbers which are based on criteria established locally. These names are supplied for the convenience of readers familiar with the nomenclature of these well-identification systems.

**Collection date.**—The month, day, and year of sample collection.

**Facies, dissolved solids.**—The hydrochemical facies and range of dissolved solids are designated by a letter and number, respectively. The letters C, L, M, N, and S refer to the hydrochemical facies as follows: C, calcium and magnesium bicarbonate; L, sodium chloride; M, mixed—no predominant ion; N, sodium bicarbonate; S, sulfate. The number following the facies

designation refers to dissolved solids concentration as follows: 1, 0-250 mg/L; 2, 251-500 mg/L; 3, 501-1,000 mg/L; 4, 1,001-2,000 mg/L; 5, greater than 2,000 mg/L.

**Data file.**—The original data file was stored on an IBM-compatible microcomputer (operating under MS-DOS version). The file on the diskette is the same as the original file and is presented in the American International Standard Code for Information Interchange (ASCII) format.

The data file is on a high-density, double-sided, double-track micro floppy disk with a capacity of 1.44 megabytes. The file name is TABLE1.DAT. The file length is about 170,000 bytes and the record length is 80 characters.

## SELECTED REFERENCES

- Back, William, 1966, Hydrochemical facies and ground-water flow patterns in northern part of the Atlantic Coastal Plain: U.S. Geological Survey Professional Paper 498-A, 42 p.
- Bain, G.L., 1970, Geology and ground-water resources of New Hanover County, North Carolina: North Carolina Department of Water and Air Resources Ground-Water Bulletin 17, 79 p.
- Flipse, W.J., Jr., Katz, B.G., Lindner, J.B., and Markel, Richard, 1984, Sources of nitrate in ground water in a sewered housing development, Central Long Island, New York: Ground Water, v. 22, no. 4, p. 418-426.
- Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water (3d ed.): U.S. Geological Survey Water-Supply Paper 2254, 263 p.
- Katz, B.G., Ragone, S.E., and Lindner, J.B., 1978, Monthly fluctuations in the quality of ground water near the water table in Nassau and Suffolk Counties, Long Island, New York: U.S. Geological Survey Water-Resources Investigations 78-41, 38 p.
- Knobel, L.L., 1985, Ground-water-quality data for the Atlantic Coastal Plain: New Jersey, Delaware, Maryland, Virginia and North Carolina: U.S. Geological Survey Open-File Report 85-154, 84 p.



- Knobel, L.L., Chapelle, F.H., and Meisler, Harold, in press, Geochemistry of the northern Atlantic Coastal Plain aquifer system: U.S. Geological Survey Professional Paper 1404-L.
- Kreitler, C.W., Ragone, S.E., and Katz, B.G., 1978,  $N^{15}/N^{14}$  ratios of ground-water nitrate, Long Island, New York: *Ground Water*, v. 16, no. 6, p. 404-409.
- Leahy, P.P., and Martin, Mary, 1993, Geohydrology and simulation of ground-water flow in the northern Atlantic Coastal Plain: U.S. Geological Survey Professional Paper 1404-K, 81 p.
- Maier, J.C., 1971, Geologic framework and petroleum potential of the Atlantic Coastal Plain and Continental Shelf, with a section on Stratigraphy, by J.C. Maier and E.R. Applin: U.S. Geological Survey Professional Paper 659, 98 p.
- Meisler, Harold, 1989, The occurrence and geochemistry of salty ground water in the northern Atlantic Coastal Plain: U.S. Geological Survey Professional Paper 1404-D, 51 p.
- Meisler, Harold, Leahy, P.P., and Knobel, L.L., 1984, The effect of eustatic sea-level changes on saltwater-freshwater relations in the northern Atlantic Coastal Plain: U.S. Geological Survey Water-Supply Paper 2255, 28 p.
- Owens, J.P., and Gohn, G.S., 1985, Depositional history of the Cretaceous Series in the U.S. Atlantic Coastal Plain: Stratigraphy, paleoenvironments, and tectonic controls of sedimentation, in Poag, C.W., ed., *Geologic evaluation of the United States Atlantic margin*: New York, Van Nostrand-Reinhold, p. 25-86.
- Pearson, F.J., Jr., and Friedman, Irving, 1970, Sources of dissolved carbonate in an aquifer free of carbonate minerals: *Water Resources Research*, v. 6, no. 6, p. 1775-1781.
- Porter, K.S., Bouldin, D.R., Shoemaker, C.A., Baskin, L.B., Zaeh, D.H., Pacenka, Stephen, and Fricke, D.H., 1978, Nitrogen on Long Island: Sources and fate: Cornell University Cooperative Extension, Ithaca, New York, 186 p.
- Ragone, S.E., 1977, Geochemical effects of recharging the Magothy aquifer, Bay Park, New York, with tertiary-treated sewage: U. S. Geological Survey Professional Paper 751-D, 22 p.
- Ragone, S.E., Katz, B.G., Lindner, J.B., and Flipse, W.J., Jr., 1976, Chemical quality of ground water in Nassau and Suffolk Counties, Long Island, New York--1952 through 1976: U. S. Geological Survey Open-File Report 76-845, 92 p.
- Trapp, Henry, Jr., 1992, Hydrogeologic framework of the northern Atlantic Coastal Plain in parts of North Carolina, Virginia, Maryland, Delaware, New Jersey, and New York: U.S. Geological Survey Professional Paper 1404-G, 59 p.
- Trapp, Henry, Jr., and Meisler, Harold, 1992, The regional aquifer system underlying the northern Atlantic Coastal Plain in parts of North Carolina, Virginia, Maryland, Delaware, New Jersey, and New York--Summary: U.S. Geological Survey Professional Paper 1404-A, 33 p.
- Uchupi, Elazar, 1968, Atlantic Continental Shelf and Slope of the United States—Physiography: U.S. Geological Survey Professional Paper 529-C, 30 p.
- U.S. Geological Survey, 1975a, WATSTORE: U.S. Geological Survey's National Water Data Storage and Retrieval System: U.S. Geological Survey INF-74-23, 15 p.
- \_\_\_\_\_, 1975b, WATSTORE User's Guide, National Water Data Storage and Retrieval System, Volumes I, III, Appendix: U.S. Geological Survey Open-File Report 75-426.