WATER-TEMPERATURE DATA ACQUISITION ACTIVITIES IN THE UNITED STATES

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations 2-72

PREPARED BY OFFICE OF WATER DATA COORDINATION
IN COOPERATION WITH FEDERAL, STATE AND
LOCAL AGENCIES IN RESPONSE TO REQUIREMENTS OF
OFFICE OF MANAGEMENT AND BUDGET CIRCULAR A-67

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No.

4. Title and Subtitle

Water-Temperature Data Acquisition Activities in the United States

5. Report Date: November 1972

6.

7. Author(s): F. H. Pauszek

8. Performing Organization Rept. No. WRI 2-72

9. Performing Organization Name and Address

Office of Water Data Coordination
U. S. Geological Survey, WRD
2100 M Street, N.W., Room 102
Washington, D. C. 20242

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

Office of Water Data Coordination
U. S. Geological Survey, WRD
2100 M Street, N.W., Room 102
Washington, D. C. 20242

13. Type of Report & Period Covered: Final

14.

15. Supplementary Notes

16. Abstracts

Temperature is one of the basic parameters used in the evaluation of water quality because it influences the chemical and physical processes that take place in water and because it bears on the utility of water. Because of its importance, a large amount of temperatue data is collected by Federal and non-Federal agencies. In this report, information is furnished on: Federal and non-Federal agencies collecting such data; where the data were collected, that is, by States and by Water Resources Council regions; the number of stations on streams, lakes, reservoirs, canals, estuaries, drainges, springs, and well where temperature data were collected; and the frequency of measurement. The actual data are not presented. However, in the bibliography at the end of the report, 194 references are listed which contain temperature data on surface and ground waters.

17. Key Words and Document Analysis. 17a. Descriptors

Water temperature/ Data collections/ Water quality/ Surface waters/ Ground water/ Station/ Sites

17b. Identifiers/Open-Ended Terms

Office of Management and Budget Circular A-67/ Catalog of Information on Water Data/ Office of Water Data Coordination/ Water Resources Council/ Federal agencies/ Non-Federal agencies

17c. COSATI Field/Group Ø10, Ø7C

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Available from the National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Rd. Springfield, Virginia 22151	UNCLASSIFIED	54
	20. Security Class (This Page) UNCLASSIFIED	22. Price

WATER-TEMPERATURE DATA ACQUISITION ACTIVITIES IN THE UNITED STATES

By

F. H. Pauszek

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations 2-72

PREPARED BY OFFICE OF WATER DATA COORDINATION
IN COOPERATION WITH FEDERAL, STATE AND
LOCAL AGENCIES IN RESPONSE TO REQUIREMENTS OF
OFFICE OF MANAGEMENT AND BUDGET CIRCULAR A-67

1972

UNITED STATES DEPARTMENT OF THE INTERIOR
ROGERS C. B. MORTON, Secretary

Geological Survey
V. E. McKelvey, Director

FOR ADDITIONAL INFORMATION WRITE TO:

U. S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
OFFICE OF WATER DATA COORDINATION
RM 102 2100 M ST. N. W.
WASHINGTON, D. C. 20242

CONTENTS

ILLUSTRATIONS

CONTENTS

TABLES

CONTENTS

WATER-TEMPERATURE DATA ACQUISITION ACTIVITIES IN THE UNITED STATES

by F. H. Pauszek

Introduction

Along with the growing interest in water quality during the last decade, the need for data on all types of water-quality parameters has also increased. One parameter of particular interest, because of its many ramifications, is temperature. It influences many of the chemical and physical processes that take place in water. The solubility of gases--for example, oxygen and carbon dioxide--and the solution of mineral matter in water are functions of temperature. Such physical properties as density and viscosity vary with temperature. Oxidation of organic materials, as well as algal and bacterial growth, is promoted or retarded by favorable or unfavorable temperatures.

Further, temperature bears on the utility of water: as a source of public water supplies; for industrial use, particularly if the water is used for cooling; and in the field of recreation involving contact sports, fishing, and fish culture. In recent years, temperature changes resulting from inflow of heated industrial waste, particularly effluent from power generating plants, have increased the need for temperature data to determine the degree of change, its effect on ecology, and the effect of any remedial action. Thus, because of the many extensive and intensive effects, a large amount of temperature data is collected on surface and ground waters by many agencies throughout the country.

Moreover, because of its importance, there is a widespread interest in temperature even by those who are not active collectors of the data themselves. The industrialist, the manager, the public official, and others at one time or another may have need for temperature data and may well raise the questions: Who is collecting temperature data? What is the extent of the activity? Where are the data being collected? The purpose of this report is to answer these questions. The information in the report is confined to the activities of Federal and non-Federal agencies. It is based on information furnished to the

Office of Water Data Coordination, U.S. Geological Survey, and published in the "Catalog of Information on Water Data, Index to Water Quality Section, Edition 1970." This is one of four indexes, each of which is a separate section of the Catalog. Three of the indexes, "Index to Water-Quality Section," "Index to Surface-Water Section," and "Index to Ground-Water Stations," contain information on data acquired on a recurrent basis at specific locations for a period of 3 years or more. The fourth section, "Index to Areal Investigations and Miscellaneous Activities," is concerned with specific projects or shorter-term data activities that involve field or laboratory measurements or observations not included in any other section of the Catalog.

The Catalog is a record of activities throughout the country (and in some places along the international border between the United States and Canada) conducted by Federal and non-Federal agencies engaged in the acquisition of water data and who furnish such information for presentation in the Catalog. The Catalog itself is an outgrowth of an assignment to the Department of the Interior and in turn to the Geological Survey, by the Office of Management and Budget, through the medium of OMB Circular A-67. This Circular states in part that one of the assigned responsibilities will be maintenance of a "central catalog of information on . . . water data and on Federal activities being planned or conducted to acquire such data." As an extension of this activity, non-Federal agencies are solicited to participate in the program.

In this report, information is presented by means of tables and illustrations preceded by brief explanations. It includes the agencies collecting the data, the number of stations located on surface and ground waters where temperature measurements are made, the distribution of stations by States and by the 21 regions of the Water Resources Council (WRC) (a Federal agency created in accordance with the Water Resources Planning Act of 1965), and the frequency of measurements. Acquisition activities were not reported for those areas left blank on some illustrations. The report does not contain the actual temperature data. For this information, the particular agency, Federal or non-Federal, acquiring the data will have to be contacted. However, a bibliography at the end of this report lists 194 references which contain temperature data. Many of these references, especially the publications of the Geological Survey, may be available in major public and university libraries and libraries of Federal and non-Federal agencies.

Acknowledgments

The many Federal and non-Federal agencies which furnished information on water-temperature data acquisition for incorporation in the Catalog deserve special mention and they are listed in Tables 1 and 2. Without this information the report could not have been prepared. The codes shown in these two tables correspond to those utilized in the Catalog.

TABLE 1.--*Federal agencies reporting information on water-temperature data acquisition by State and Puerto Rico*

	DEPT. OF AGRICULTURE Forest Service	DEPT. OF THE ARMY Corps of Engineers	DEPT. OF COMMERCE National Marine Fisheries Service	DEPT. OF THE INTERIOR Bureau of Reclamation	Bureau of Sport Fisheries and Wildlife	Geological Survey	DEPT. OF THE NAVY Naval Facilities Eng. Command	ATOMIC ENERGY COMMISSION	ENVIRONMENTAL PROTECTION AGENCY	INTERNATIONAL BOUNDARY & WATER COMMISSION	TENNESSEE VALLEY AUTHORITY
Alabama		X				X					X
Alaska	X					X	X				
Arizona	X			X		X					
Arkansas		X			X	X			X		
California	X			X		X			X		
Colorado				X		X			X		
Connecticut						X			X		
Delaware						X					
Florida						X			X		
Georgia		X				X			X		X
Hawaii						X					
Idaho						X		X	X		
Illinois						X			X		
Indiana	X					X			X		
Iowa		X				X			X		
Kansas		X				X			X		
Kentucky		X				X		X	X		X
Louisiana		X				X					
Maine	X					X	X				
Maryland		X	X			X			X		
Massachusetts						X			X		
Michigan	X		X			X			X		
Minnesota	X					X			X		
Mississippi		X				X			X		
Missouri	X	X			X	X			X		
Montana		X				X			X		
Nebraska		X				X			X		
Nevada				X		X			X		
New Hampshire	X					X					
New Jersey		X				X			X		
New Mexico						X					
New York		X				X		X	X		
North Carolina						X					X
North Dakota		X			X	X			X		
Ohio		X				X		X	X		
Oklahoma		X				X	X		X		
Oregon	X	X	X	X		X			X		
Pennsylvania		X				X			X		
Rhode Island						X					
South Carolina		X				X		X	X		
South Dakota		X			X	X			X		
Tennessee		X				X		X			X
Texas		X				X			X	X	
Utah				X		X					
Vermont						X			X		
Virginia		X				X	X		X		
Washington	X	X	X	X		X	X	X	X		
West Virginia	X	X				X			X		
Wisconsin			X	X		X					
Wyoming						X		X			
Puerto Rico						X					

TABLE 2.--*Non-Federal agencies reporting information on water-temperature data acquisition activities and codes used in the Catalog of Information on Water Data*

ARIZONA
B01 Water Resources Research Center
B03 Arizona Game and Fish Dept.

ARKANSAS
B50 Arkansas State Dept. of Health
B51 Arkansas Game and Fish Dept.
B52 Ark. Pollution Control Commission

CALIFORNIA
C00 Calif. Dept. of Water Resources
C03 Alameda County Water District
C06 Calif. Water Quality Control Board

COLORADO
C50 Board of Water Commissioners, City & County of Denver
C52 Dept. of Public Utilities, City of Colorado Springs
C53 Boulder City-County Health Dept.
C54 Pueblo Board of Water Works

CONNECTICUT
D00 State Dept. of Health
D01 The Water Bureau of the Metropolitan District
D02 Bridgeport Hydraulic Co.

DELAWARE
D50 Delaware Geological Survey

DISTRICT OF COLUMBIA
D53 Dept. of Sanitary Engineering, Gov't of D. C.
D54 Dept. of Public Health, Gov't of D. C.

FLORIDA
E02 Manatee County Health Dept.

GEORGIA
E50 Savannah Dept. of Water & Sewage
E53 City of Gainesville Water Works
E54 City of Rome Water Works
E55 City of Griffin Water Works
E56 Macon Board of Water Commissioners
E57 Atlanta Water Works
E58 Columbus Water Works

IDAHO
F52 Idaho Dept. of Health

ILLINOIS
G00 Ill. Dept. of Public Health
G01 Metropolitan Sanitary District of Greater Chicago
G02 Ill. Dept. of Registration and Education

INDIANA
G50 Indiana State Board of Health

IOWA
H01 Director of Lakeside Laboratory, University of Iowa
H02 Des Moines Water Works
H03 Ottumwa Water Works
H04 Dept. of Civil Engineering, University of Iowa
H05 Iowa Dept. of Preventive Medicine and Environmental Health
H07 Fort Dodge Dept. of Municipal Utilities
H08 Council Bluffs Water Works

KANSAS
H50 Kansas State Dept. of Health
H53 Topeka Water Dept.
H54 Kansas Forestry, Fish and Game Commission

KENTUCKY
I01 Ky. State Dept. of Health, Water Pollution Control Commission
I02 Louisville Water Co.

LOUISIANA
I50 Rapides Parish Water Works District No. 3
I53 Jefferson Water Works District No. 2
I54 Lafourche Water Works District No. 1
I55 East Jefferson Water Works District No. 1
I56 New Orleans Sewerage & Water Board
I57 Bossier City Water Plant
I58 Monroe Water Treatment Plant
I59 La. Wild Life & Fisheries Commission
I60 City of Shreveport Dept. of Water Utilities

MARYLAND
D51 Baltimore County Health Dept.
D52 City of Baltimore Dept. of Public Works

MICHIGAN
K50 Michigan Water Resources Commission

TABLE 2.--*Non-Federal agencies reporting information on water-temperature data acquisition activities and codes used in the Catalog of Information on Water Data*--Continued

MINNESOTA
L03 Otter Tail Power Co.
L06 City of Duluth Water, Gas & Sewage Treatment Dept.
L08 Blandin Paper Co.
L10 Minneapolis-St. Paul Sanitary District
L11 Minn. Pollution Control Agency

MISSISSIPPI
L50 City of Vicksburg Water Treatment Plant
L51 City of Jackson Water Works
L53 City of Meridian Water & Sewer Dept.
L54 City of Columbus Light & Water Dept.

MISSOURI
M01 Kansas City Sanitary Sewer District
M02 Univ. of Mo. at Rolla
M03 Metropolitan St. Louis Sewer District

MONTANA
M50 Montana Fish and Game Dept.

NEBRASKA
N01 Nebraska Dept. of Health
N02 Omaha Metropolitan Utilities District

NEVADA
N50 Nevada Dept. of Health, Welfare and Rehabilitation

NEW JERSEY
O50 Passaic Valley Water Commission
O55 N. J. State Dept. of Health

NEW YORK
P50 N. Y. State Dept. of Health

NORTH CAROLINA
Q00 N. C. State Board of Health
Q01 N. C. Dept. of Water & Air Resources

NORTH DAKOTA
Q50 N. Dak. Game and Fish Dept.
Q51 N. Dak. State Dept. of Health
Q52 Minot Water Treatment Plant
Q53 City of Bismarck Water Dept.
Q54 City of Dickinson Water Treatment
Q55 Grand Forks Water Treatment Plant

OHIO
R01 The Miami Conservancy District
R02 Ohio River Valley Water Sanitation Commission
R03 Ohio Dept. of Health

OKLAHOMA
R50 Okla. State Dept. of Health

OREGON
S01 Ore. State Game Commission
S04 Fish Commission of Ore.

PENNSYLVANIA
S50 Pa. Dept. of Health

SOUTH CAROLINA
T51 Greenville Water Works
T52 Spartanburg Water Works

TENNESSEE
U50 Tenn. Game & Fish Commission
U51 Tenn. Dept. of Public Health
U52 Cleveland Water System
U53 City Water Co. of Chattanooga
U54 Bristol Water Plant
U57 Water Resources Research Center

UTAH
V50 Utah State Health Dept.
V52 Utah Division of Fish & Game
V53 Salt Lake County Water Conservancy District
V54 Salt Lake City Water Supply & Waterworks
V58 Utah Geological and Mineralogical Survey

WASHINGTON
X01 Skagit County PUD No. 1
X02 Chelen County PUD No. 1
X03 College of Fisheries, Univ. of Washington
X05 Dept. of Zoology, Univ. of Wash.
X06 City of Bremerton Water Dept.
X09 Tacoma Dept. of Public Utilities

WEST VIRGINIA
X50 W. Va. Dept. of Natural Resources
X51 W. Va. Dept. of Health

WISCONSIN
Y00 Wis. Dept. of Natural Resources

WYOMING
Y51 Sheridan Water Dept.
Y53 Water Resources Research Institute

WATER-TEMPERATURE DATA ACQUISITION ACTIVITIES

Surface Waters

The widespread interest in water temperature is reflected in the number of water-quality stations where temperature measurements were made. Figure 1 shows the distribution and density of stations on surface waters (streams, lakes, reservoirs, estuaries, canals, and drains). Of the total number of 9,404 stations reported in the index to water-quality section of the Catalog (1970 edition), temperature data were collected at 7,525 surface-water stations--about 80 percent of the total. A breakdown of these stations shows that 5,969 were on streams, 963 were on lakes and reservoirs, 333 on estuaries, and 260 on canals and drains.

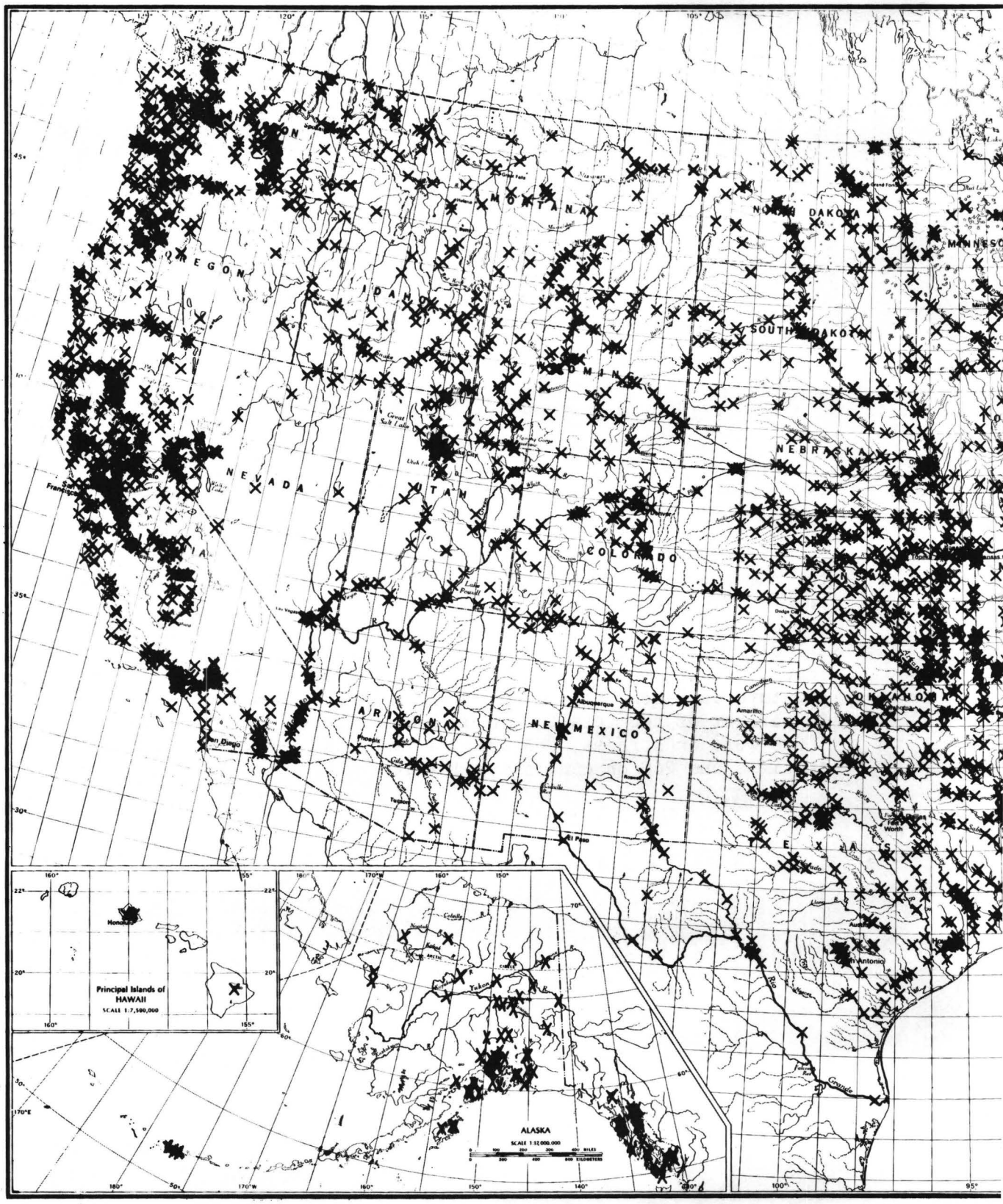


FIGURE 1.--*Map of the United States showing the distribution and density of water-quality stations on surface waters where temperature measurements were made*

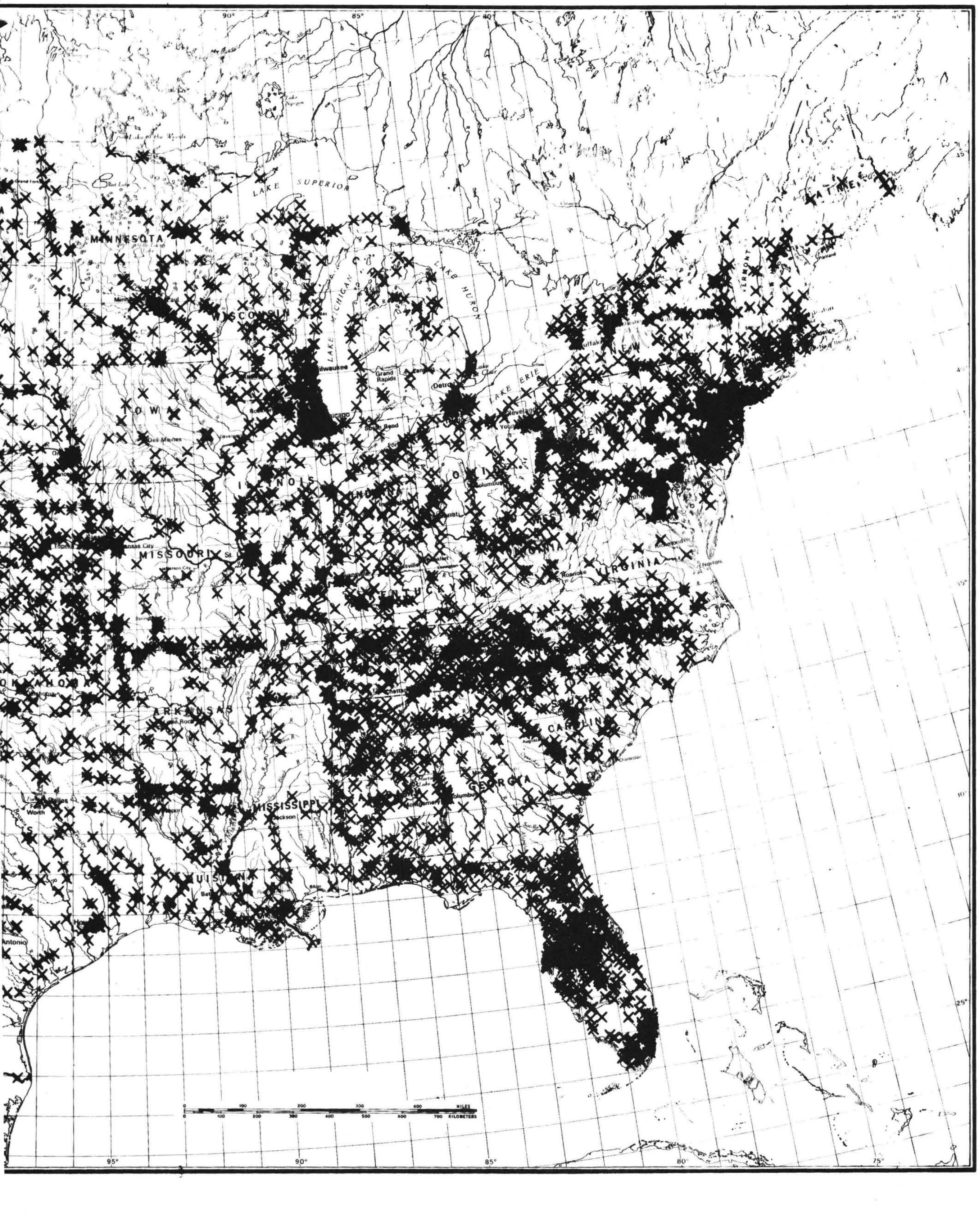

LAKE SUPERIOR
MINNESOTA
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
Milwaukee
Grand Rapids
Detroit
Chicago
South Bend
Des Moines
MISSOURI
Kansas City
Columbus
Roanoke
VIRGINIA
Norfolk
MISSISSIPPI
Jackson
GEORGIA
CAROLINA
Charleston
Fort Worth
Antonio
MILES
KILOMETERS
90°
85°
80°
75°
95°
25°

Figure 2 shows the number of active stations on surface waters in each of the States and Puerto Rico where temperature measurements were being made as of January 1, 1970. In addition, temperature data were collected at stations located in Canada (along rivers connecting the Great Lakes), in the Ryukyu Islands, Guam, Midway Island, and U.S. foreign installations.

A total of 7,525 stations was reported in operation in the States and on the islands. Of these, 4,573 stations were operated by Federal agencies; non-Federal agencies collected data at 2,952 stations. Although in nine of the States and in Puerto Rico (as shown in fig. 2) temperature data were collected by Federal agencies only, many of the stations, especially those reported by the U.S. Geological Survey, in these and other States were operated jointly in cooperation with non-Federal agencies.

The number of stations varied from State to State, although the concentration was greater in the eastern part of the country than in the west. In States east of the Mississippi River, temperature measurements were made at 4,004 stations. Of these, 38 percent were located in States bordering the Great Lakes, a highly industrialized area. West of the Mississippi River there were 3,281 stations of which 1,454 (44 percent) were located in the coastal States--Washington, Oregon, California, and Louisiana. The remainder (1,827 stations) were distributed among the remaining 17 States west of the Mississippi River. In the island possessions and U.S. foreign installations, the distribution of stations was: 22 on the Ryukyu Islands, one on Guam, and one station at a U.S. foreign installation.

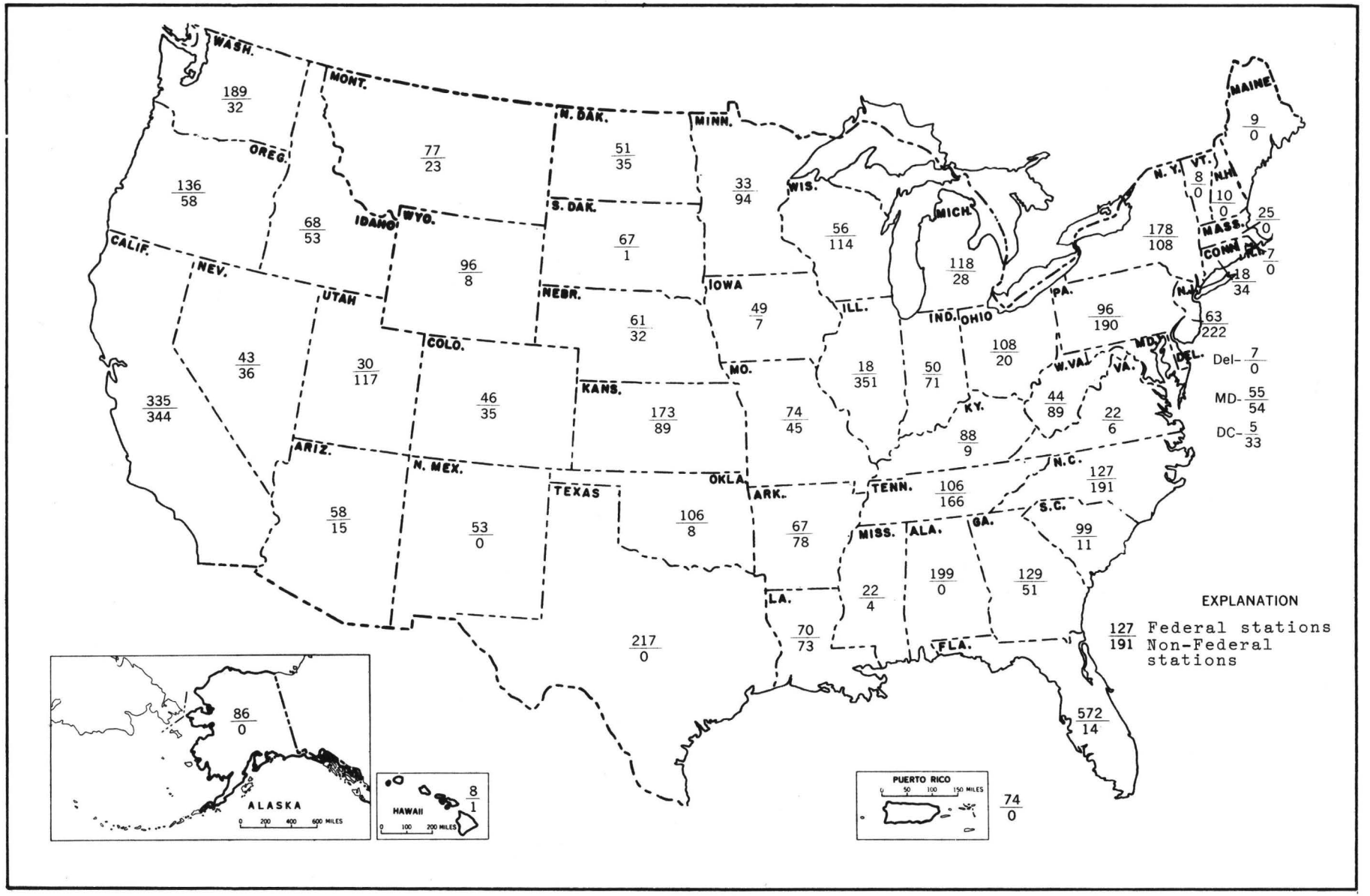
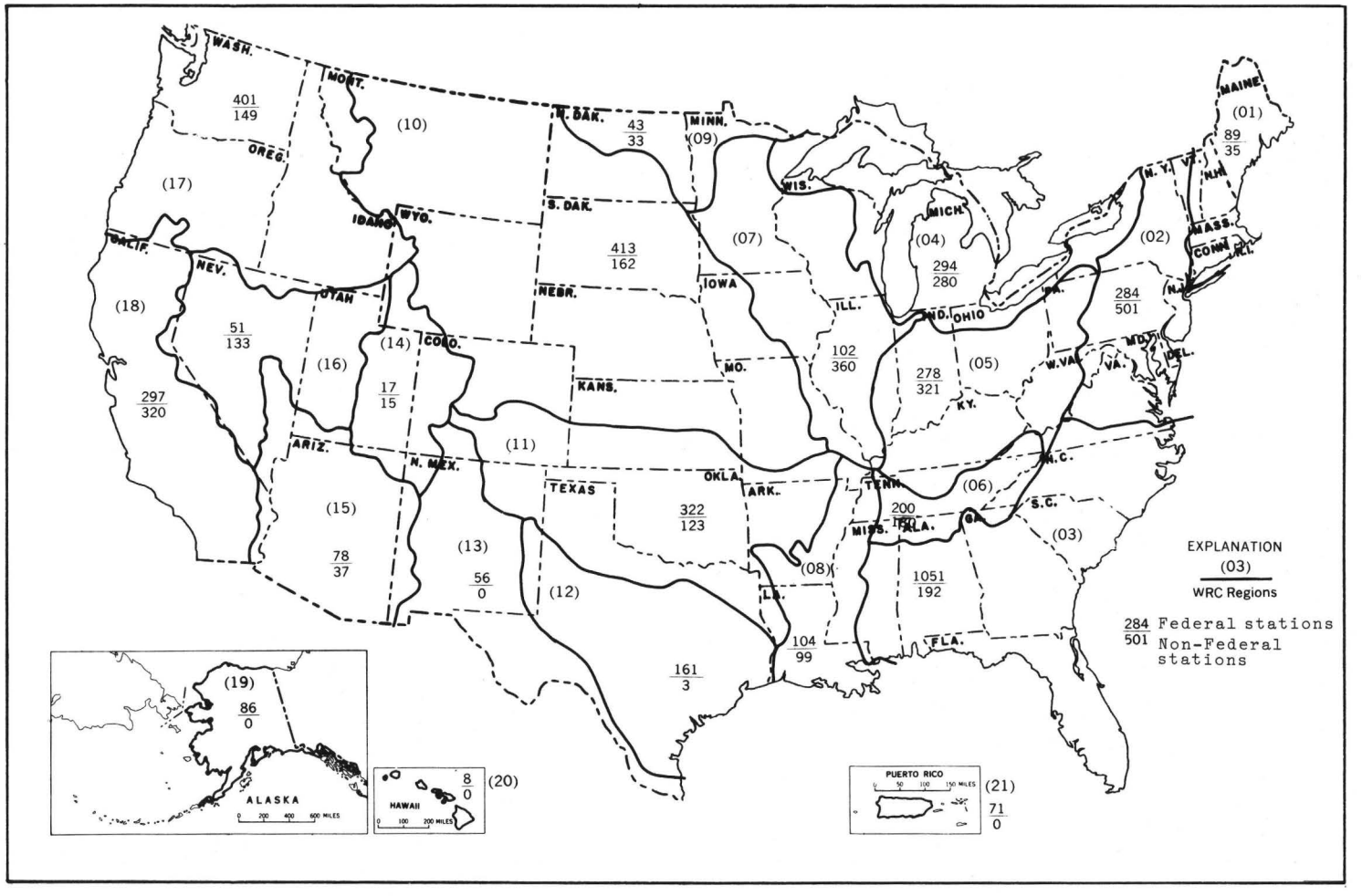


FIGURE 2.--*Map of the United States and Puerto Rico showing the number of active water-quality stations on surface waters where temperature measurements were made.*

Whereas figure 2 shows the distribution of stations by States, figure 3 gives the distribution of water-quality stations on surface waters in the 21 regions established by the Water Resources Council. Temperature measurements were made at 7,409 stations, about 80 percent of the total number of 9,244 stations in the 21 regions. Federal agencies operated 4,466 and non-Federal agencies operated 2,943 stations.

In the preceding section the general picture of temperature-collecting activities on surface waters has been presented. In the material to follow, a breakdown will be made by source, i.e., streams, lakes, reservoirs, estuaries, canals, drains, and ground water; by agency collecting the temperature data; and by frequency of measurement.



WRC Regions

(01) New England Region
(02) Middle Atlantic Region
(03) South Atlantic- Gulf Region
(04) Great Lakes Region
(05) Ohio Region
(06) Tennessee Region
(07) Upper Mississippi Region
(08) Lower Mississippi Region
(09) Souris-Red-Rainy Region
(10) Missouri Region
(11) Arkansas-White-Red Region
(12) Texas-Gulf Region
(13) Rio Grande Region
(14) Upper Colorado Region
(15) Lower Colorado Region
(16) Great Basin Region
(17) Columbia-North Pacific Region
(18) California-South Pacific Region
(19) Alaska Region
(20) Hawaii Region
(21) Puerto Rico Region

FIGURE 3.---*Number of active stations on surface waters by Water Resources Council regions where temperature data were collected*

O/L MAP

Streams, Lakes, and Reservoirs

Figure 4 shows the number of active stations on streams and lakes and reservoirs (grouped together) in each of the States, Puerto Rico, and the District of Columbia where temperature data were collected. Of the 7,239 water-quality stations on streams, temperature data were collected at 5,925 stations, 82 percent of the total. In addition, 25 stations were in Canada, 18 stations were located in the Ryukyu Islands, and one at a U.S. foreign installation.

On lakes and reservoirs, temperature measurements were made at 963 stations, 69 percent of the total 1,389 stations on these sources. Twenty-two of these stations were in Canada, four were located on the Ryukyu Islands, and one on Guam. Totals include stations operated by both Federal and non-Federal agencies.

Table 3 gives the names of the Federal agencies and non-Federal agencies (grouped together), and the number of stations on streams and lakes and reservoirs where temperature data were collected. Ten Federal agencies and 82 non-Federal agencies collected temperature data on streams. Eleven Federal agencies and 52 non-Federal agencies collected temperature data on lakes and reservoirs.

TABLE 3.--*Number of active water-quality stations operated by Federal and non-Federal agencies on streams and lakes and reservoirs where temperature measurements were made*

	Streams	Lakes and Reservoirs
Atomic Energy Commission	38	4
Bureau of Reclamation	40	39
Bureau of Sport Fisheries and Wildlife	0	32
Corps of Engineers	175	91
Environmental Protection Agency	218	111
Forest Service	31	2
Geological Survey	2924	206
International Boundary and Water Commission	13	0
Marine Corps	0	2
National Marine Fisheries Service	37	8
Naval Facilities Engineering Command	1	9
Tennessee Valley Authority	57	83
Subtotal	3534	587
Non-Federal agencies	2435	376
Total	5969	963

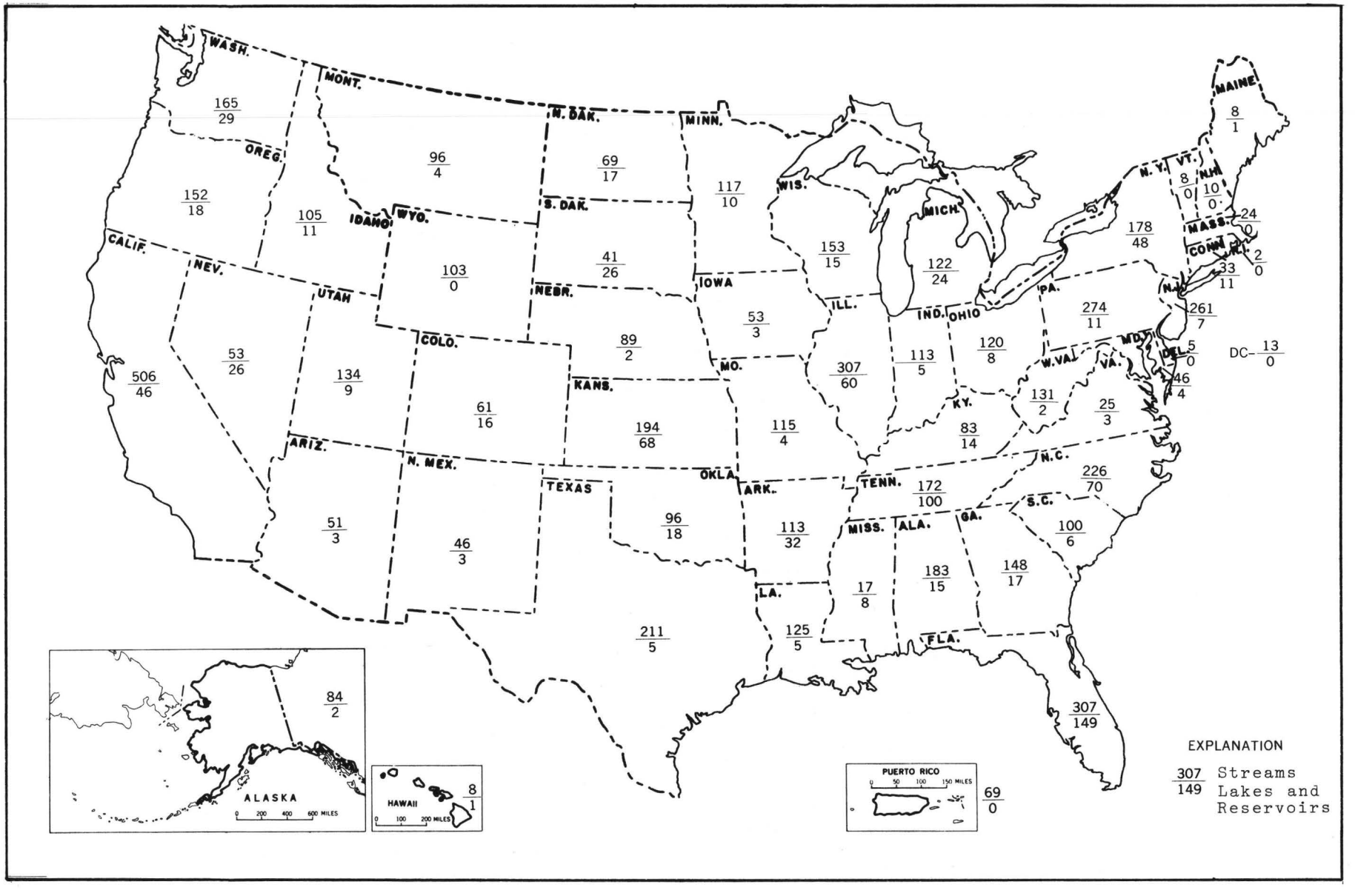


FIGURE 4.--*Number of active stations on streams and lakes and reservoirs where temperature measurements were made*

Frequency of measurement becomes an important factor in water-temperature data acquisition depending, of course, on the thermal conditions and the time requirement for the information. As shown in figure 5, monthly and quarterly measurements were made more often than at any other frequency. At about 41 percent of the stations, measurement was on a monthly basis, and about 22 percent on a quarterly basis. Continuous temperature measurements were made at 731 stations. Thirty-nine percent of these stations were located in three western States--Washington, Oregon, and California. In the East, about the same number of stations (operating continuously) were distributed among 25 States. Of the 936 monthly stations located east of the Mississippi River, 545 were located in States bordering the Great Lakes. Of the 999 monthly stations located west of the Mississippi River, 331 were in States bordering the Mississippi River. California had the greatest number of stations. Most of the annual stations were located in Florida. Weekly measurements were made at 296 stations; 141 were located in the eastern States, 143 in the western States, and 12 in Canada.

In addition to the frequencies of measurements discussed above, a number of other frequencies are reported in the Catalog. Ninety stations were reported as operating on a seasonal basis, for example, during the irrigation season, low flow season, or some other period of the year best suited to fill that type of need. Fifty seasonal stations were in California, 16 in Michigan, and the remainder in eight other States.

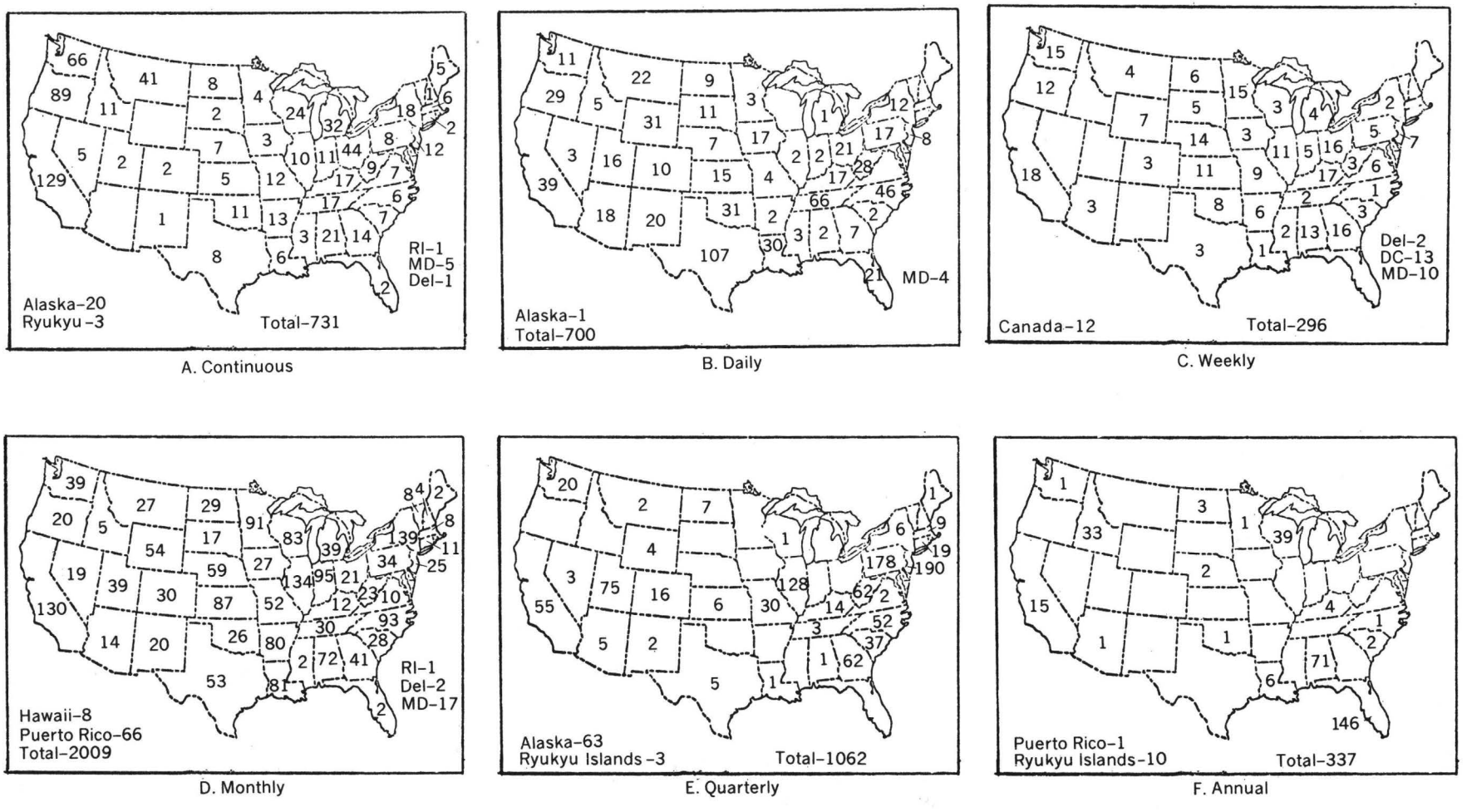


FIGURE 5.--*Number of active stations on streams and frequency of temperature measurement*

At many stations, the frequency of temperature measurement was reported as "other periodic," that is, recurring measurements made at intervals greater than annual. Since a substantial number of stations (636) were so classified, the locations and number of stations are shown on figure 6. Two stations were operated on an irregular basis and for 105 stations no frequencies were reported.

Table 4 lists the Federal agencies and non-Federal agencies (grouped together) collecting temperature data on streams, the number of stations operated, and frequency of measurement.

FIGURE 6.--*Number of water-quality stations on streams where temperature measurements were made at intervals greater than annual*

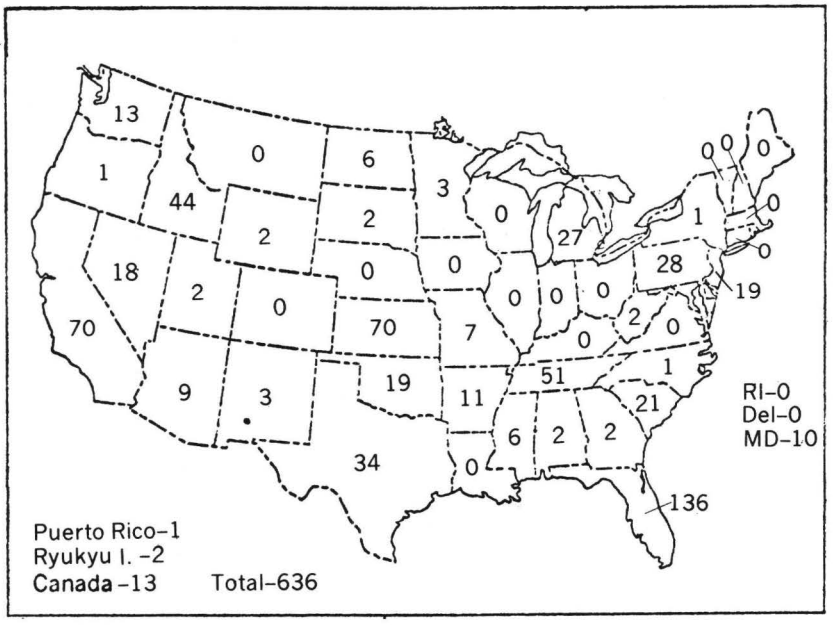
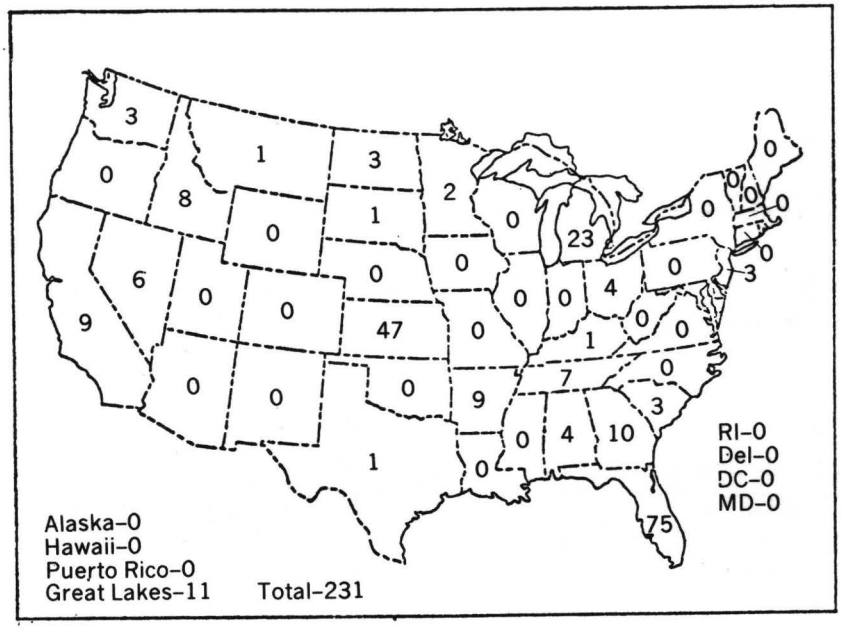


TABLE 4.--*Federal and non-Federal agencies collecting temperature data on streams, number of stations operated, and frequency of measurement*

AGENCY	Frequency										
	Continuous	Daily	Weekly	Monthly	Quarterly	Annual	Seasonal	Other Periodic	Irregular	Unknown	Total
Atomic Energy Commission	9	3	4	12	1	--	9	--	--	--	38
Bureau of Reclamation	--	--	3	22	3	3	--	7	--	2	40
Corps of Engineers	13	30	44	56	--	--	--	32	--	--	175
Environmental Protection Agency	10	--	70	76	1	--	--	44	--	17	218
Forest Service	16	--	1	1	5	--	7	1	--	--	31
Geological Survey	556	466	40	893	289	278	5	352	2	43	2924
International Boundary and Water Commission	7	1	--	--	5	--	--	--	--	--	13
National Marine Fisheries Service	--	--	--	19	--	--	18	--	--	--	37
Naval Facilities Engineering Command	--	--	--	1	--	--	--	--	--	--	1
Tennessee Valley Authority	22	--	12	16	4	--	--	--	--	3	57
Federal Agency Subtotal	633	500	174	1096	308	281	39	436	2	65	3535
Non-Federal Agency Subtotal	98	200	122	914	754	56	51	200	--	40	2435
Grand Total	731	700	296	2010	1062	337	90	636	2	105	5969

As for streams, the frequency of temperature measurement on lakes and reservoirs ranged from continuous to "other periodic," that is, at intervals greater than annual. The latter frequency was reported for 231 stations--122 of these were located in Kansas and Florida, and 11 in Canada (fig. 7). More frequent temperature measurements were reported for 692 stations. Figure 8 shows the distribution of these stations on the basis of frequency. In addition, seasonal temperature measurements were made at 20 stations in Kansas, three in California, and one in Iowa. For 20 stations on lakes and reservoirs, no frequencies were reported.

FIGURE 7.--*Number of active water-quality stations on lakes and reservoirs where temperature measurements were made at intervals greater than annual*



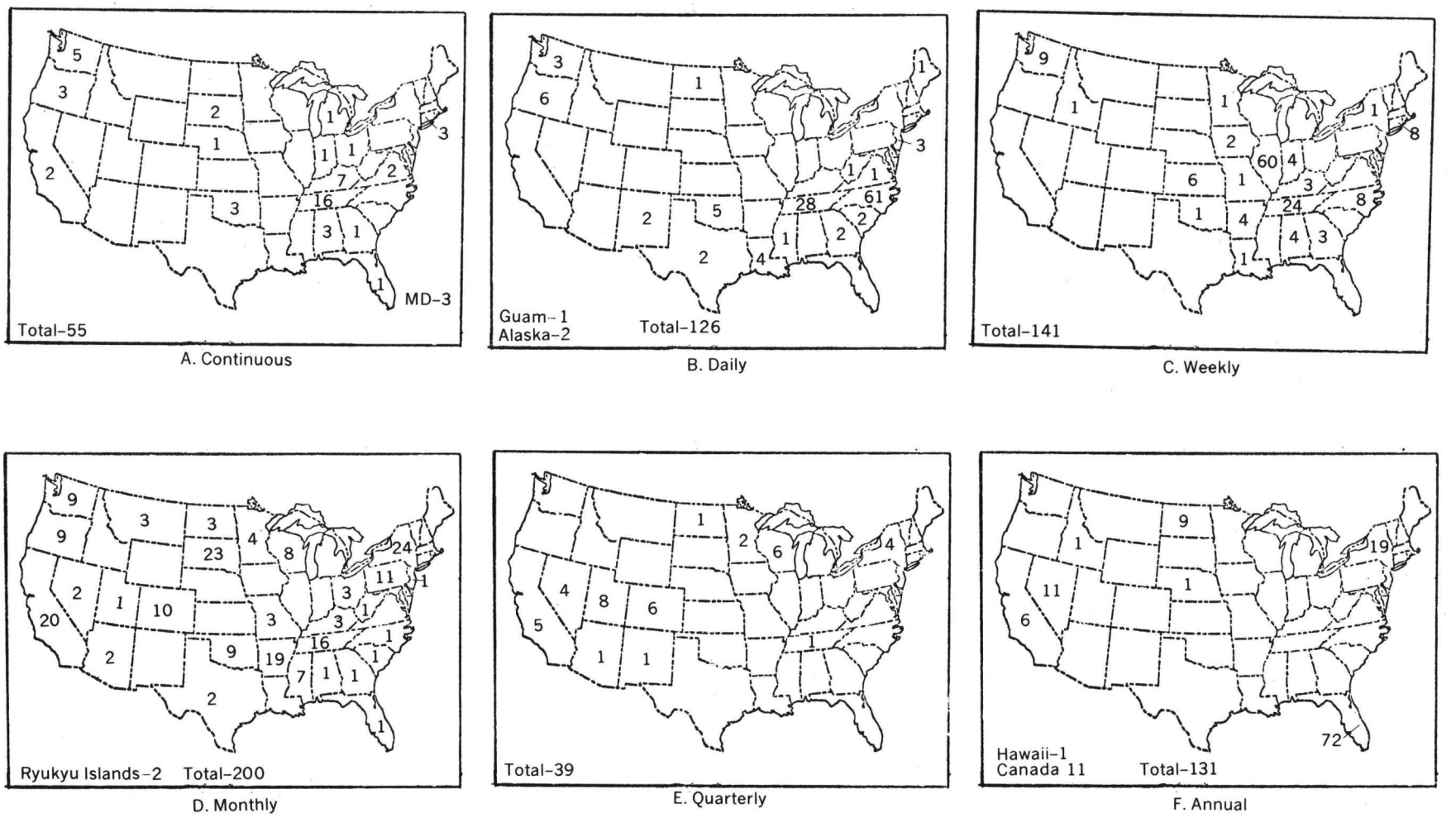


FIGURE 8.--*Number of active water-quality stations on lakes and reservoirs and frequency of temperature measurement*

As shown in Table 5, about 1-1/2 times as many stations were operated on lakes and reservoirs by Federal than by non-Federal agencies. However, the frequency of measurement varied. At 25 percent of the stations operated by Federal agencies, temperature measurements were made at monthly intervals; at 22 percent they were made weekly, daily, and continuously. At about the same number of stations, measurements were made annually or less frequently. At 65 percent of the stations operated by non-Federal agencies, temperature measurements were made monthly or more frequently, mostly weekly and daily. Annual and less frequent measurements were made at a smaller number of stations.

TABLE 5.--*Federal and non-Federal agencies collecting temperature data on lakes and reservoirs, number of stations, and frequency of measurement*

AGENCY	Frequency										Total
	Continuous	Daily	Weekly	Monthly	Quarterly	Annual	Seasonal	Other Periodic	Irregular	Unknown	
Atomic Energy Commission	2	--	--	1	--	--	1	--	--	--	4
Bureau of Reclamation	--	--	--	18	7	12	--	1	--	1	39
Corps of Engineers	8	9	18	38	--	--	--	18	--	--	91
Environmental Protection Agency	3	--	8	10	5	30	--	49	--	6	111
Forest Service	--	--	--	--	2	--	--	--	--	--	2
Geological Survey	9	7	--	20	3	83	3	81	--	--	206
Marine Corps	--	--	--	--	--	--	--	--	--	2	2
National Marine Fisheries	1	--	--	7	--	--	--	--	--	--	8
Naval Facilities Engineering Command	--	6	1	2	--	--	--	--	--	--	9
Sport Fisheries and Wildlife	--	--	--	32	--	--	--	--	--	--	32
Tennessee Valley Authority	26	--	33	17	1	--	--	--	--	6	83
Federal Agency Subtotal	49	22	60	145	18	125	4	149	--	15	587
Non-Federal Agency Subtotal	6	104	81	55	21	6	16	83	--	5	376
Grand Total	55	126	141	200	39	131	20	232	--	20	963

Estuaries

Of the remaining surface waters to be considered, the largest number of water-quality stations was located on estuaries. There is a growing interest in the quality of estuaries and estuarine areas because they bear on the marine ecology and the utility of waterways for recreation, transportation, and industry. Temperature measurements were made at 333 stations (fig. 9). As to frequency, temperature measurements were made monthly or quarterly at 241 stations and more frequently at 70 stations (fig. 10). At one station, the Geological Survey made one annual measurement. The California Water Quality Control Board made seasonal measurements at two stations. At 19 stations, temperature measurements were made at intervals greater than annual.

Table 6 lists the agencies collecting temperature data on estuaries, number of stations, and State or area of operation.

FIGURE 9.--*Number of active stations on estuaries where temperature measurements were made*

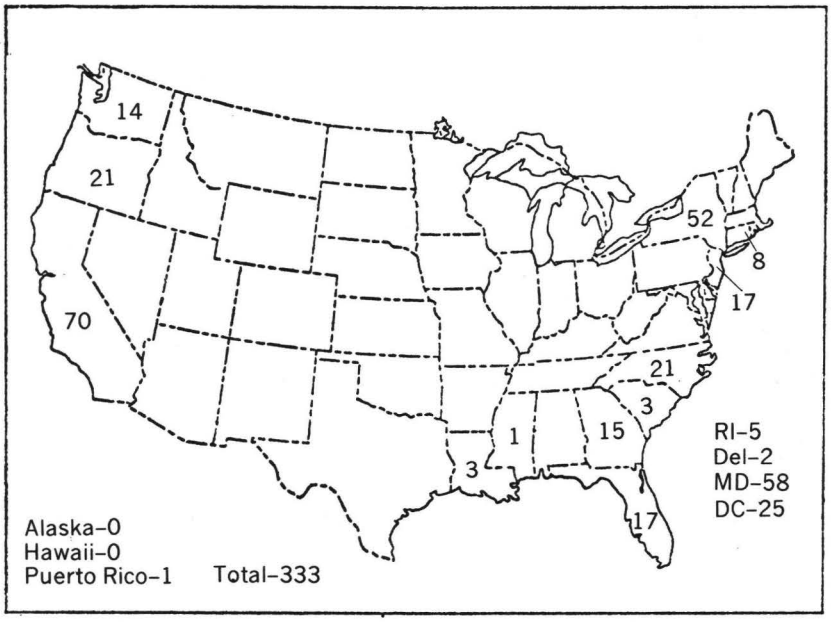


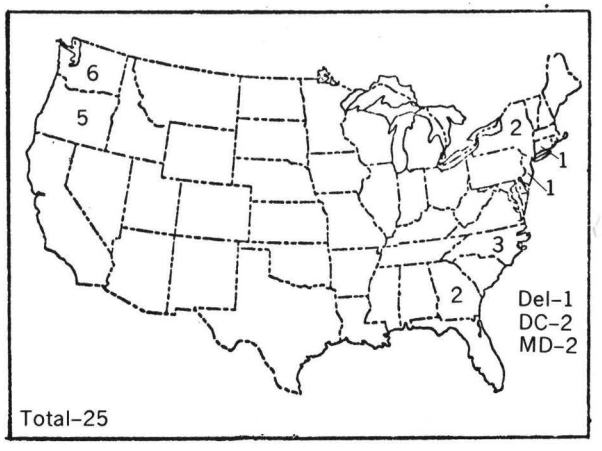
TABLE 6.--*Agency, number of temperature stations on estuaries, and State or area of operation*

PART A--Federal Agencies

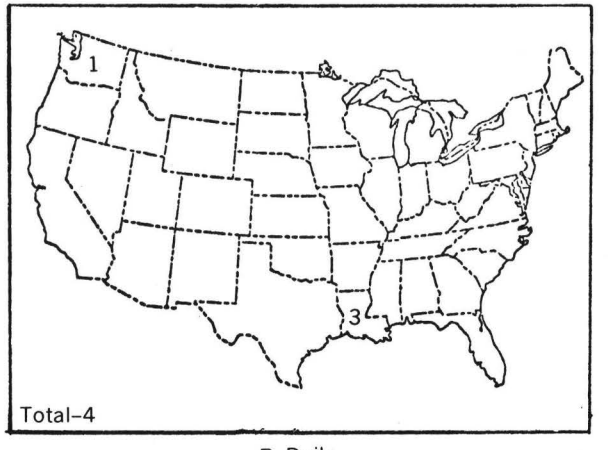
Agency	State and Number of Stations	Total
Bureau of Reclamation	California----56	56
Corps of Engineers	Georgia-------14 Louisiana------3 New Jersey-----3 New York-------4	24
Environmental Protection Agency	District of Columbia-----5 Georgia--------1 Maryland------13 New Jersey----14 New York------35 Oregon---------2	70
Geological Survey	Connecticut----1 Delaware-------2 Florida--------4 Maryland-------1 Mississippi----1 New York-------1 N. Carolina---21 Oregon---------4 Rhode Island---5 S. Carolina----3 Washington-----7 Puerto Rico----1	51
National Marine Fisheries Service	Maryland-------1 Oregon--------12 Washington-----7	20
		GRAND TOTAL 221

PART B--Non-Federal Agencies

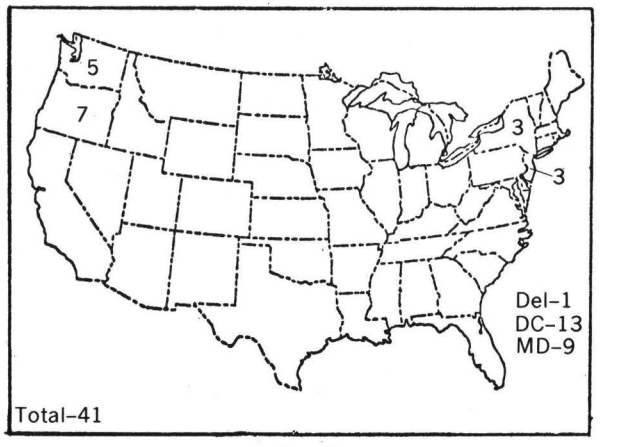
Agency	State and Number of Stations	Total
Dept. of Water Resources Water Quality Control Board	California-----3 California----11	14
State Dept. of Health	Connecticut----7	7
Dept. of Sanitary Eng.	District of Columbia----20	20
Baltimore County Health Dept. Dept. of Sanitary Eng. (DC)	Maryland------34 Maryland-------9	43
State Dept. of Health	New York------12	12
Fish Commission	Oregon---------3	3
Manatee County Health Dept.	Florida-------13	13
		GRAND TOTAL 112



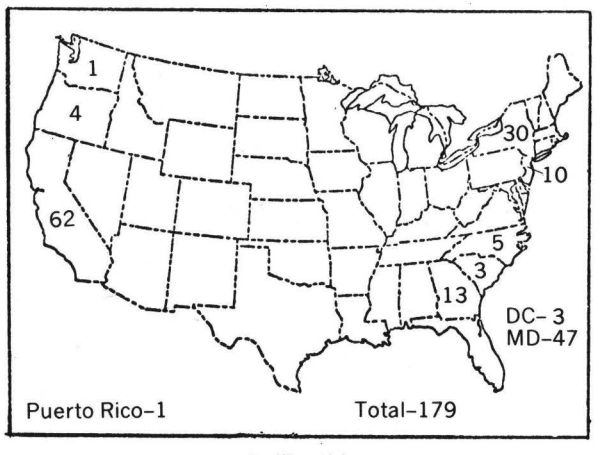
A. Continuous



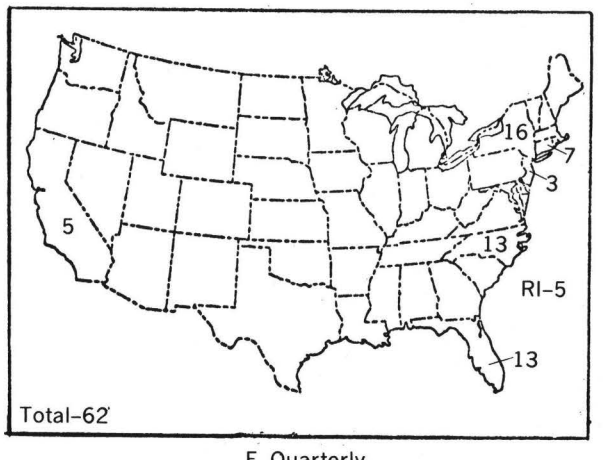
B. Daily



C. Weekly



D. Monthly



E. Quarterly

FIGURE 10.--*Number of stations on estuaries and frequency of temperature measurement*

Canals and Drains

About 4 percent of the 7,409 temperature stations on surface waters are located on canals and drains. Canals and drains are grouped together because both are manmade and their basic use is conveyance of water. Although the terms are sometimes used synonymously, canals have a wider use: transportation of water for public and industrial supply, irrigation, connecting bodies of water, and marine transportation. Drains are used for drainage, irrigation, and storm runoff.

Figure 11 shows the number of active water-quality stations on canals and drains where temperature measurements were made. Of the 260 stations shown, 204 are on canals and 56 on drains.

Table 7 gives the names of agencies collecting temperature data on canals and drains and the number of stations on each source.

FIGURE 11.--*Number of active water-quality stations on canals and drains where temperature measurements were made*

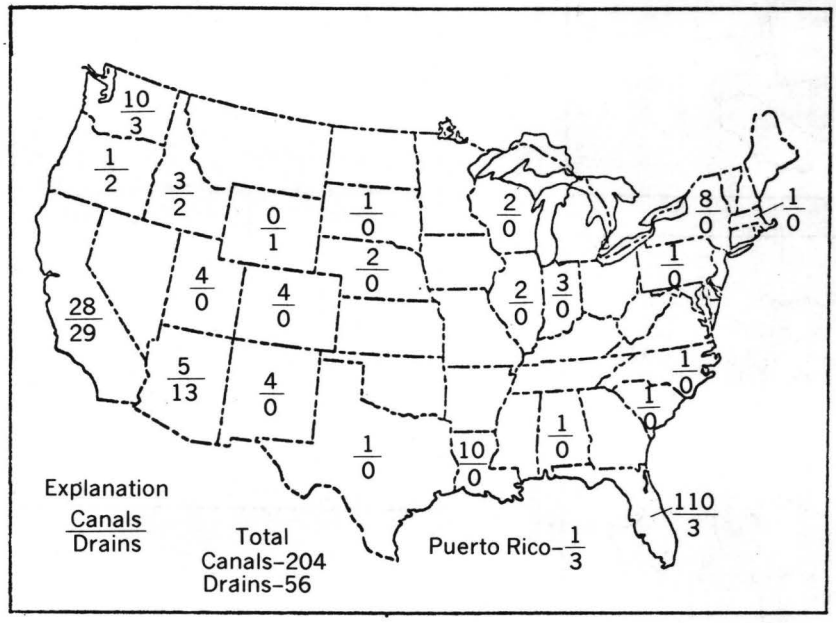


TABLE 7.--*Agencies collecting temperature data on canals and drains and number of stations*

Agency	No. of Stations		
	Canals	Drains	Total
Bureau of Reclamation	28	24	52
Corps of Engineers	12	--	12
Environmental Protection Agency	6	--	6
Geological Survey	132	27	159
International Boundary and Water Commission	1	--	1
Subtotal (Federal)	179	51	230
California, Dept. of Water Resources	8	5	13
Colorado, Board of Water Commissioners, City and County of Denver	1	--	1
Idaho, Dept. of Health	1	--	1
Illinois, Dept. of Health	2	--	2
New York, Dept. of Health	4	--	4
North Carolina, Board of Health	1	--	1
Oregon, Fish Commission	1	--	1
Pennsylvania, Dept. of Health	1	--	1
Utah, Health Dept.	4	--	4
Wisconsin, Dept. of Natural Resources	2	--	2
Subtotal (Non-Federal)	25	5	30
Grand Total	204	56	260

Figure 12 shows the number of stations and frequency of temperature measurements on canals and drains. In addition to those frequencies shown, measurements were made at intervals greater than annual at 77 stations on canals and at five stations on drains.

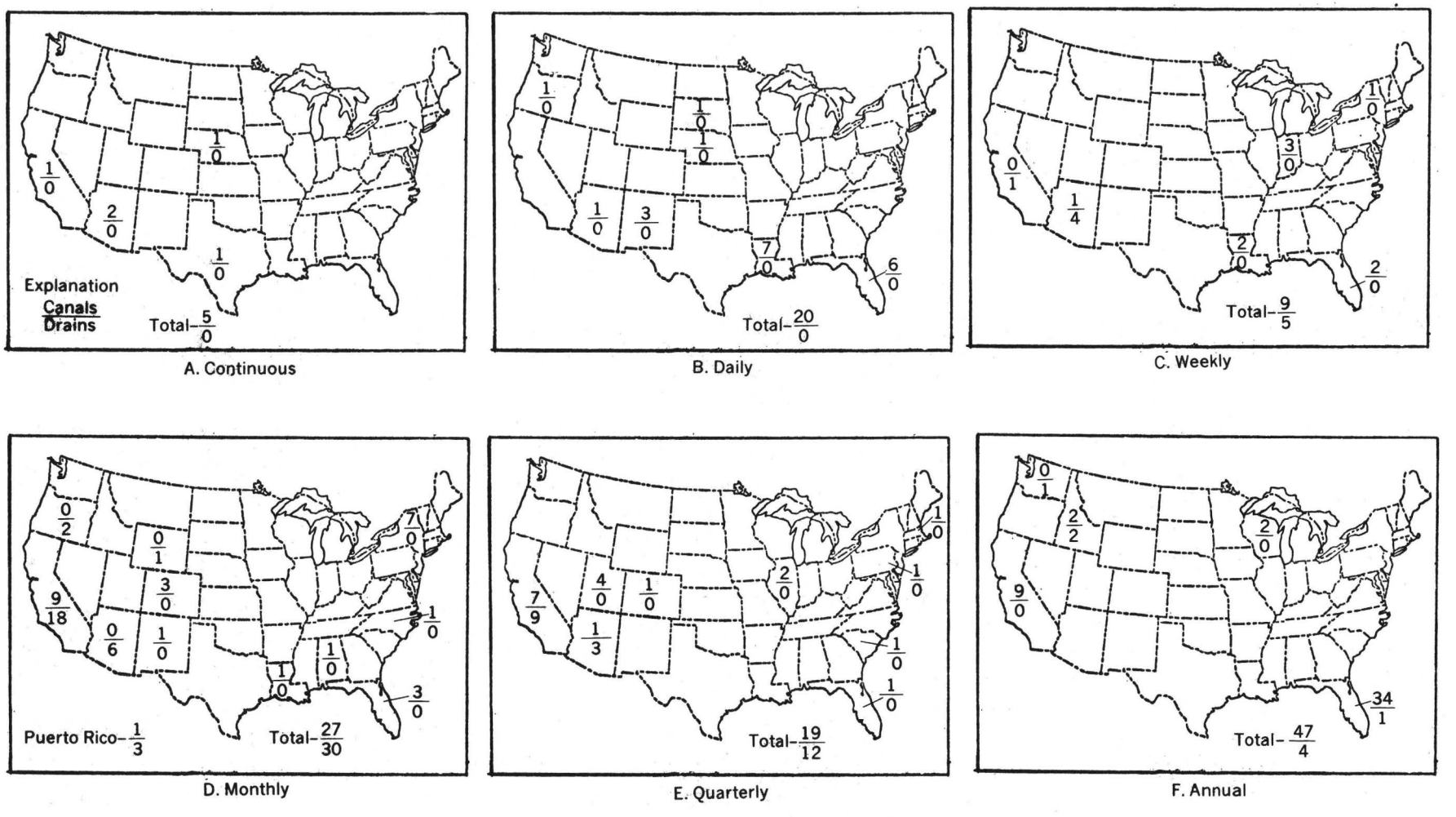


FIGURE 12.--*Number of stations and frequency of temperature measurements on canals and drains*

Ground Waters

As reported in the Catalog, long-term water-quality data were obtained at 5,280 ground-water sources (5,105 wells and 175 springs). Of this total, temperature measurements were made on 3,390 wells and 130 springs, 67 percent of the total number of long-term water-quality stations.

Figure 13 shows the number of active stations in each of the States and Puerto Rico where temperature measurements were made on springs and wells. In addition, 16 stations were located on Guam; one on Midway; and four in the Ryukyu Islands. No temperature data were collected on springs and wells in 12 States and Puerto Rico. In three States temperature data were collected only on springs; and in 23 States temperature data were collected only on wells. In 12 States temperature data were collected on both springs and wells.

Table 8 shows the Federal agencies and non-Federal agencies (grouped together) and the number of temperature stations operated on springs and wells. Five Federal agencies and 22 non-Federal agencies collected temperature data on springs and wells.

TABLE 8.--*Agencies and number of active temperature stations on springs and wells*

Agency	Number of Stations	
	Springs	Wells
Atomic Energy Commission	--	301
Bureau of Reclamation	--	8
Geological Survey	44	1519
Naval Facilities Engineering Command	--	85
Public Health Service	3	--
Subtotal (Federal)	47	1913
Non-Federal agencies	83	1387
Total	130	3300

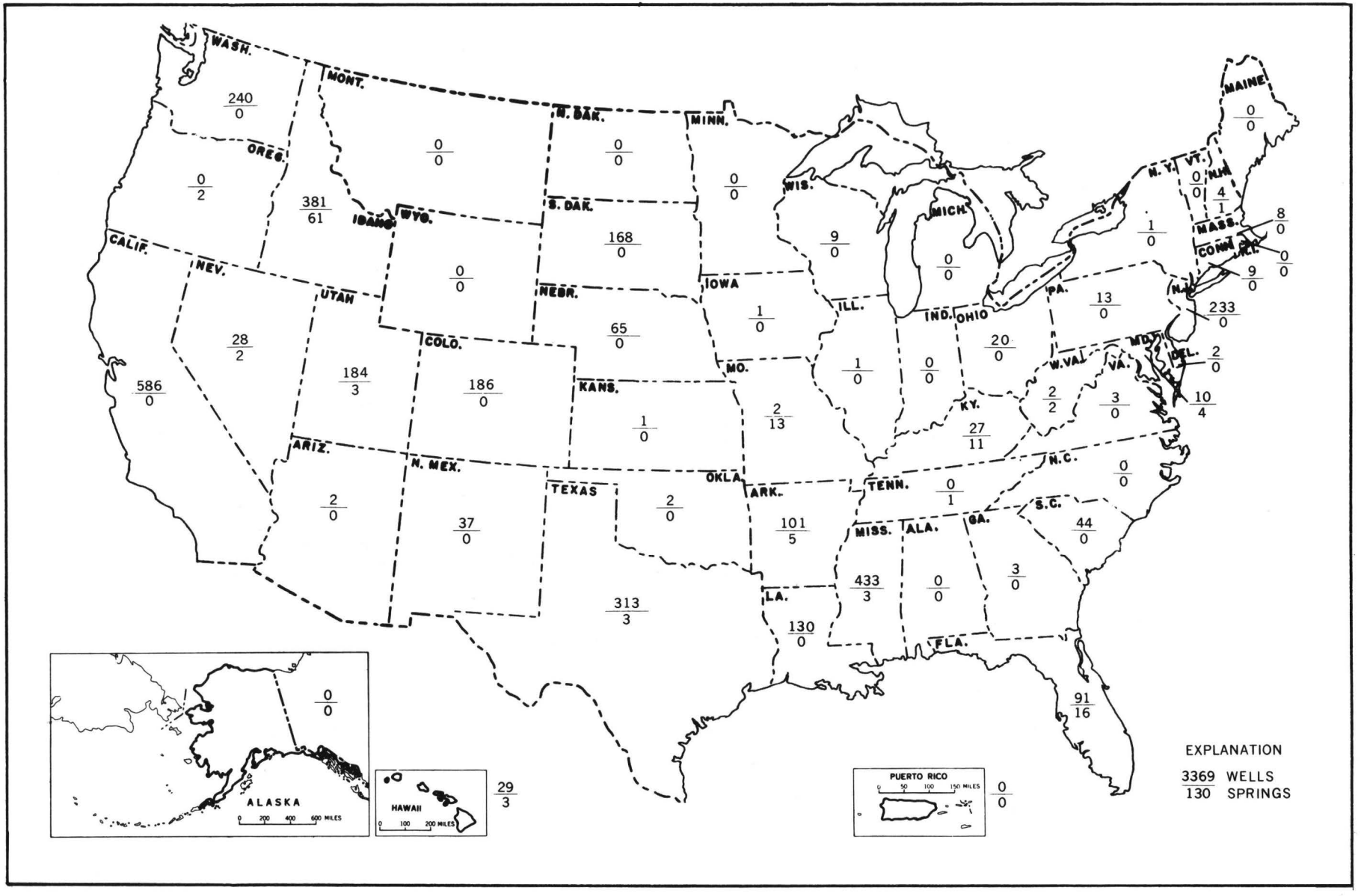
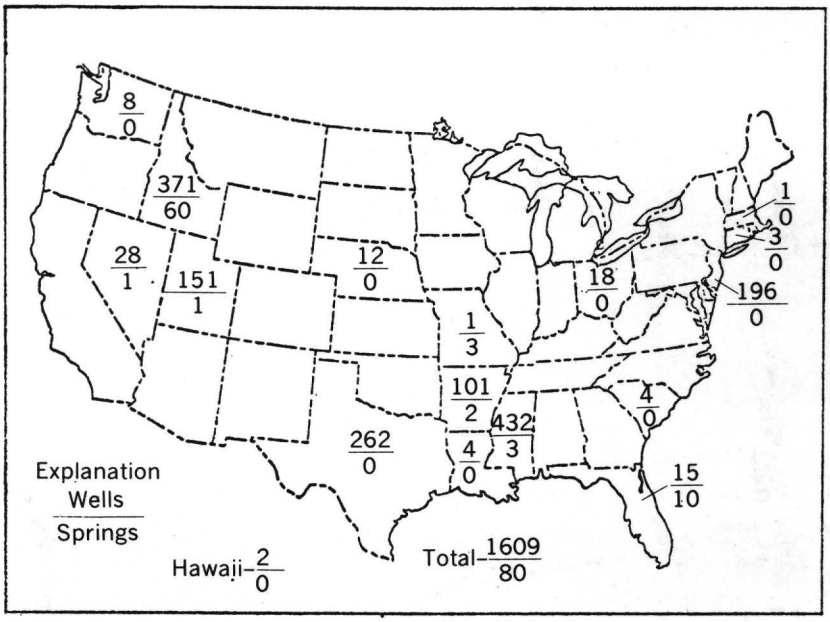


FIGURE 13.--*Number of active stations on springs and wells where temperature measurements were made*

At more than 85 percent of the stations on springs and wells, temperature measurements were made annually or even less frequently. Apparently the temperature of these ground waters changed very little and did not warrant more frequent measurement (figs. 14 and 15). At 46 stations temperature measurements were made seasonally and at one station the measurement was reported as irregular. No information on frequency was reported for 23 stations.

FIGURE 14.--*Number of temperature stations on springs and wells where measurements were made at intervals greater than annual*



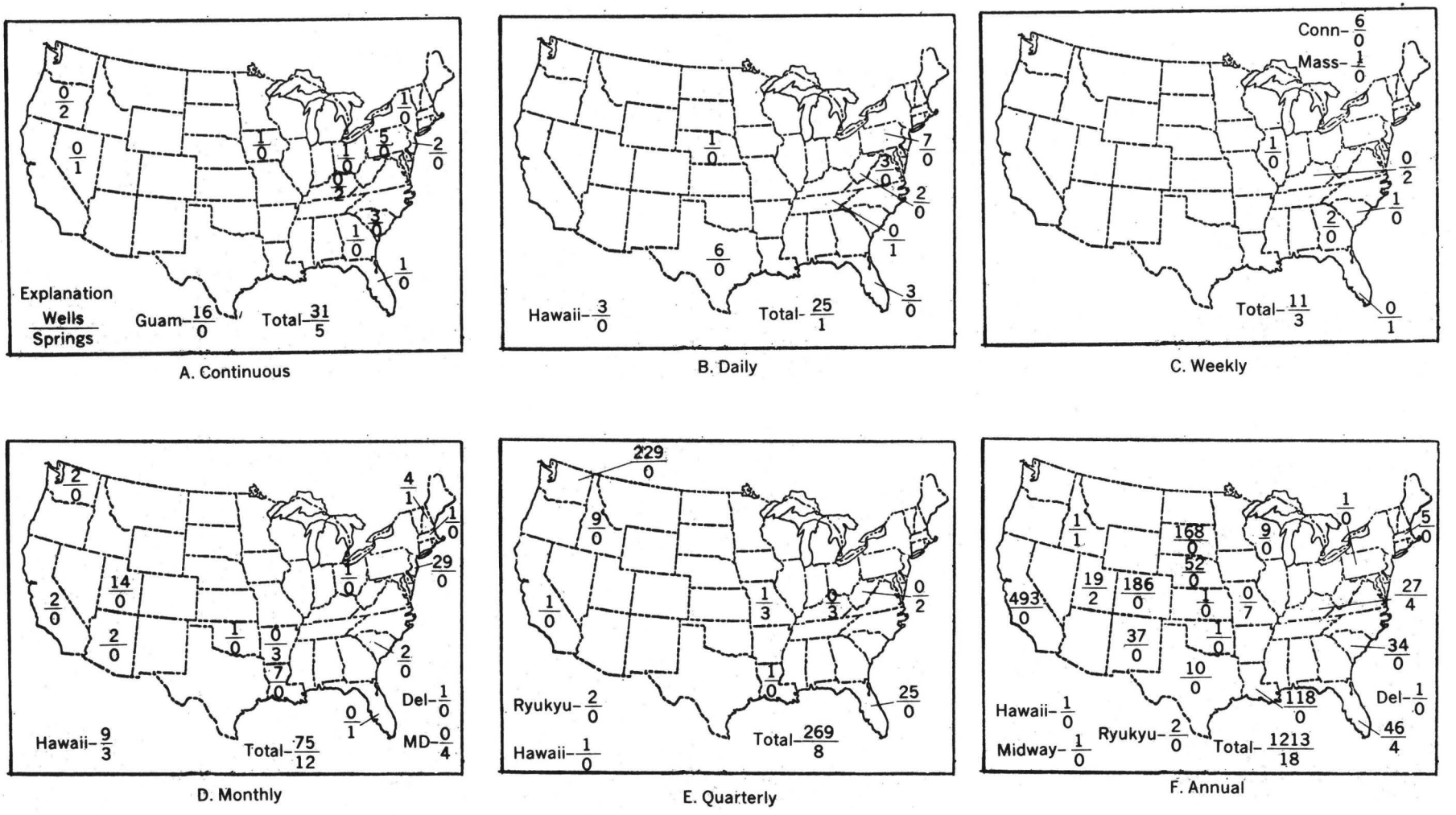


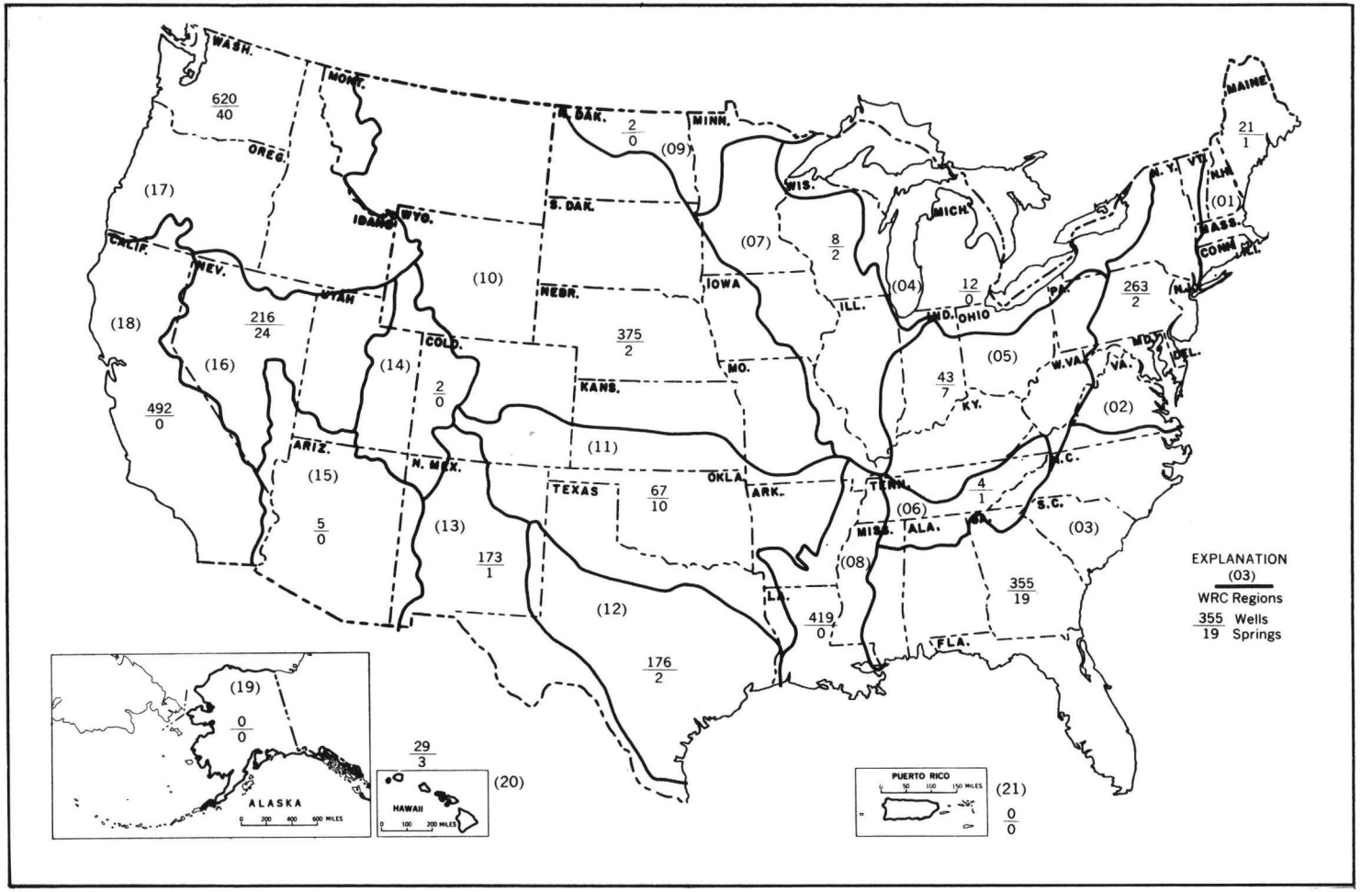
FIGURE 15.--*Number of temperature stations on springs and wells and frequency of measurement*

In the 21 Water Resources Council regions, temperature was measured on 3,282 wells and 114 springs (fig. 16). The largest number of stations was in the Columbia-North Pacific Region (17) (620 springs and 40 wells). In the California-South Pacific Region (18) temperature data were collected at 492 wells, and in the Lower Mississippi Region (08) at 419 wells. No long-term stations were located on springs in these latter two regions. In the South Atlantic-Gulf Region (03) data were obtained at 355 wells and 79 springs. Fewer stations were operated in other regions.

Three Federal agencies collected temperature data at 1,912 wells. The U.S. Geological Survey measured temperature at 1,519 wells; the Atomic Energy Commission at 301; and the Naval Facilities Engineering Command at 92 wells. Non-Federal agencies collected temperature data at 1,370 wells.

The Geological Survey collected temperature data on 45 springs and non-Federal agencies reported temperature data collection on 69 springs.

At 86 percent of the stations on wells, temperature measurements were made annually or less frequently. The same frequencies were reported for 82 percent of the stations on springs.



WRC Regions

(01) New England Region
(02) Middle Atlantic Region
(03) South Atlantic- Gulf Region
(04) Great Lakes Region
(05) Ohio Region
(06) Tennessee Region
(07) Upper Mississippi Region
(08) Lower Mississippi Region
(09) Souris-Red-Rainy Region
(10) Missouri Region
(11) Arkansas-White-Red Region
(12) Texas-Gulf Region
(13) Rio Grande Region
(14) Upper Colorado Region
(15) Lower Colorado Region
(16) Great Basin Region
(17) Columbia-North Pacific Region
(18) California-South Pacific Region
(19) Alaska Region
(20) Hawaii Region
(21) Puerto Rico Region

FIGURE 16.--*Number of active stations on wells and springs in Water Resources Council regions where temperature measurements were made*

SELECTED BIBLIOGRAPHY

Aagaard, F. C., 1969, Temperature of surface waters in Montana: Montana Fish and Game Dept., 613 p.

Adolphson, D. G., and Leroux, E. F., 1968, Temperature variations of deep flowing wells in South Dakota: U.S. Geol. Survey Prof. Paper 600-D, p. D60-D62.

Avrett, J. R., and Carroon, L. E., 1964, Temperature of Alabama streams: Alabama Geol. Survey Inf. Ser. 35, 165 p.

Ayer, G. R., and Pauszek, F. H., 1968, Streams in Dutchess County, N.Y., their flow characteristics and water quality in relation to water problems: New York Water Resources Comm. Bull. 63, 105 p.

Bednar, G. A., and others, 1968, Analysis of water quality of the Mahoning River in Ohio: U.S. Geol. Survey Water-Supply Paper 1859-C, 6 p.

Biesecker, J. E., and others, 1968, Water resources of the Schuylkill River basin: Pennsylvania Dept. Forests and Waters, Water Resources Bull. 3, 198 p.

Billingsley, G. A., and others, 1957, Water resources of the Neuse River basin, North Carolina: U.S. Geol. Survey Water-Supply Paper 1414, 89 p.

Blakey, J. F., 1966, Temperature of surface waters in the conterminous United States: U.S. Geol. Survey Hydrol. Inv. Atlas HA-235.

Burd, R. S., 1969, Water quality standards for temperature in Engineering Aspects of Thermal Pollution: Federal Pollution Control Adm., Office of Program Planning and Devel., chap. 3, p. 72-77.

Burford, A. E., and Minke, J. G., 1964, Thermal springs at Berkeley Springs, West Virginia: Acad. Sci. Proc., v. 36, p. 113-117.

California Department of Water Resources, 1964, Quality of ground waters in California 1961-62, Part 1--Northern and central California: California Dept. Water Resources Bull. 66-62, pt. 1, 429 p.

_____1968, Hydrologic data, 1966, vol. 2--Northeastern California: California Dept. Water Resources Bull. 130-66, 63 p.

Castenholz, R. W., 1967, Environmental requirements of thermophilic blue-green algae in Oregon Univ. Dept. of Biology Symposium environmental requirements of blue-green algae: Federal Water Pollution Control Adm., p. 55-79.

Cervione, M. A., and others, 1968, Hydrogeologic data for the lower Thames and southeastern coastal river basins: Connecticut Water Resources Bull. 16, 65 p.

Choi, Yu-Leuk, 1970, Temperature variations in deep reservoirs: Jour. Hydraulics Div., ASCE Proc., v. 96, no. HY10, p. 2154-2158.

Colby, B. R., and Scott, C. H., 1965, Effects of water temperature on the discharge of bed material: U.S. Geol. Survey Prof. Paper 462-G, 25 p.

Collings, M. R., and others, 1968, Water resources of the Millers River basin, north-central Massachusetts and south-central New Hampshire: U.S. Geol. Survey Hydrol. Inv. Atlas HA-293.

Collins, M. R., 1969, Temperature analysis of a stream: U.S. Geol. Survey Prof. Paper 650-B, p. B174-B179.

Collins, R. S., and others, 1963, Water atlas of the United States, 2d ed.: Water Inf. Center, pl. 16, map.

Collins, W. D., 1925, Temperature of water available for industrial use in the United States: U.S. Geol. Survey Water-Supply Paper 520, p. 97-101.

Cory, R. L., and Nauman, J. W., 1967, Temperature and water quality conditions for the period July 1963 to December 1965, Patuxent estuary, Maryland: U.S. Geol. Survey open-file report, 72 p.

_____1971, Water quality at Patuxent River bridge, Maryland, January 1968 through November 1969: U.S. Geol. Survey open-file report, 31 p.

Cummings, T. R., 1964, Chemical character of surface waters of Oklahoma 1958-59: Oklahoma Water Resources Board Bull. 20, 133 p.

Dendy, J. S., 1946, Water temperature and spring fishing, Norris Reservoir, Tennessee: Jour. Tennessee Acad. Sci., v. 21, p. 89-93.

Duncan, A. C. [1971?], Chemical quality of surface waters of Louisiana, 1959-63: Louisiana Dept. Public Works Basic Records Rept. 2, 137 p.

Durfor, C. N., and Keighton, W. B., 1954, Chemical characteristics of Delaware River water Trenton, New Jersey to Marcus Hook, Pennsylvania: U.S. Geol. Survey Water-Supply Paper 1262, 173 p.

Estes, R. D., and Cumming, K. B., 1969, Some water-quality aspects of the upper Roanoke River basin with special emphasis on temperature: Virginia Polytech. Inst., Water Resources Research Center, 44 p., apps. A-K.

Feulner, A. J., and Schupp, R. G., 1964, Temperature and chemical quality of water from a well drilled through permafrost near Bethel, Alaska: U.S. Geol. Survey Prof. Paper 501-D, p. D144-D146.

Franco, J. J., 1968, Effects of water temperature on bed-load movement: Jour. Waterways and Harbors Div., Am. Soc. Civil Engineers Proc., v. 94, NOWW3, PAP 6083, p. 343-352.

Garza, Sergio, 1964, Chemical analyses of water from observation wells in the Edwards and associated limestones, San Antonio, Texas, 1963: Texas Water Comm. and City of San Antonio, Bull. 4, 15 p.

Geurin, J. W., 1951, Chemical composition of Arkansas surface waters 1949: Arkansas Univ., Inst. Sci. and Technol., 46 p.

_____1952, Chemical composition of Arkansas surface waters, 1950: Arkansas Univ., Inst. Sci. and Technol., 103 p.

Geurin, J. W., and Jeffery, H. G., 1957, Chemical quality of surface waters of Arkansas, 1945-55, a summary: Arkansas Univ., Eng. Expt. Sta. Bull. 25, 79 p.

Golden, H. G., 1959, Temperature observations of Mississippi streams: Mississippi Board Water Commissioners Bull. 59-1, 67 p.

Hahl, D. C., and Ratzlaff, K. W., 1970, Chemical and physical characteristics of water in estuaries of Texas, September 1967-September 1968: Texas Water Devel. Board Rept. 117, 91 p.

Hansen, A. J., Jr., 1968, Availability of ground water in the Blondville Quadrangle, Jackson Purchase Region, Kentucky: U.S. Geol. Survey Hydrol. Inv. Atlas HA-184.

Harmeson, R. H., and Schnepper, V. M., 1965, Temperature of surface waters in Illinois: Illinois Water Survey Rept. of Inv., 45 p.

Illinois State Sanitary Board, and Department of Public Health, 1967, Compilation of data for 1966: Illinois Water Quality Network, 109 p.

Iowa Geological Survey, 1955, Quality of surface waters of Iowa 1886-1954: Iowa Geol. Survey Water-Supply Bull. 5, 351 p.

Jeppson, R. W., and others, 1968, Hydrologic atlas of Utah: Logan, Utah Water Research Lab. Rept. PRWG 35-1, 306 p.

Kansas State Board of Health, 1958, Chemical quality of surface waters in the Kansas River unit, 1892-1958: Kansas Div. Sanitation, 138 p.

Keighton, W. B., 1965, Delaware River water quality Bristol to Marcus Hook, Pennsylvania, August 1949 to December 1963: U.S. Geol. Survey Water-Supply Paper 1809-0, 57 p.

Kipple, F. P., 1968, Water records of Puerto Rico, 1958-63: U.S. Geol. Survey open-file report, 353 p.

Lamar, W. L., and others, 1955, Quality of surface waters of Kentucky 1951-55: Kentucky Agr. and Indus. Devel. Board, 210 p.

Lamar, W. L. and Schroeder, M. E., 1951, Chemical character of surface waters of Ohio 1946-50: Ohio Water Div. Bull. 23, 100 p.

Larson, T. E., and Larson, B. O., 1957, Quality of surface waters in Illinois: Illinois Water Survey Bull. 45, 135 p.

McCarren, E. F., 1964, Chemical quality of surface water in the West Branch Susquehanna River basin, Pennsylvania: U.S. Geol. Survey Water-Supply Paper 1779-C, 40 p.

McCarthy, L. T., Jr., and Keighton, W. B., 1964, Quality of Delaware River water at Trenton, New Jersey: U.S. Geol. Survey Water-Supply Paper 779-X, 51 p.

Michigan Water Resources Commission, 1963, Water quality monitoring program, 1963: Michigan Water Resources Comm., Water Quality Records, 69 p.

Mitten, H. T., and others, 1968, Chemical quality of surface waters in Devils Lake basin, North Dakota, 1952-60: U.S. Geol. Survey Water-Supply Paper 1859-B, 42 p.

Moore, A. M., 1967, Correlation and analysis of water-temperature data for Oregon streams: U.S. Geol. Survey Water-Supply Paper 1819-K, 53 p.

_____1968, Water temperature in the lower Columbia River: U.S. Geol. Survey Cir. 551, 45 p.

Murphy, J. J., 1955, Chemical character of surface waters in Oklahoma 1952-53: Oklahoma Planning and Resources Board Bull. 11, 128 p.

Nece, R. E., 1967, Stream temperature study North Fork, Snoquaimie River, Washington: Washington Univ., Civil Eng. Dept. Tech. Rept. 23, 49 p.

Noble, V. E., 1967, Temperature structure of Lake Michigan: Michigan Univ., Great Lakes Research Div. Spec. Rept. 30, p. 340-356.

Norvitch, R. F., and others, 1968, Hydrology and water resources of the Housatonic River basin, Mass.: U.S. Geol. Survey Hydrol. Inv. Atlas HA-281.

Parker, G. G., Ferguson, G. E., and others, 1955, Water resources of southeastern Florida: U.S. Geol. Survey Water-Supply Paper 1255, 965 p.

Parker, G. G., Hely, A. G., and others, 1964, Water resources of the Delaware River basin: U.S. Geol. Survey Prof. Paper 381, 200 p.

Pauszek, F. H., 1951, Chemical character of surface waters of South Carolina 1945-50: South Carolina Research Planning and Devel. Board Bull. 16H, 46 p.

_____1952, Chemical character of surface waters of North Carolina 1950-51: North Carolina Div. Water Resources and Eng. Bull. 52, v. 7, 59 p.

_____1959, Chemical quality of surface waters in the Allegheny, Genesee, and Susquehanna River basins, New York 1953-56: New York Commerce Dept. Bull. 3, 94 p.

_____[no date], Chemical and physical quality of water resources in Connecticut 1955-58--Progress Report: Connecticut Water Resources Bull. 1, 79 p.

Pauszek, F. H., and Edmonds, R. J., 1965, A preliminary appraisal of water quality in the Housatonic River basin in Connecticut 1965: Connecticut Water Resources Bull. 6, 70 p.

Pauszek, F. H., and Harris, K. F., 1951, Chemical character of surface waters of North Carolina 1949-1950: North Carolina Div. Water Resources and Eng. Bull. 52, v. 6, 56 p.

Pauszek, F. H., and Joyner, B. F., 1949, Chemical character of surface waters of North Carolina, 1947-48: North Carolina Div. Water Resources and Eng. Bull. 52, v. 4, 31 p.

Peirce, L. B., 1964, Reservoir temperatures in north-central Alabama: Alabama Geol. Survey Bull. 82, 103 p.

Phibbs, E. J., Jr., 1964, Chemical and physical character of surface waters of North Carolina 1961-62: North Carolina Div. Stream Sanitation and Hydrol. Bull. 1, v. 5, 192 p.

Plebuch, R. O., 1962, Ground-water temperatures in the coastal plain of Arkansas: Arkansas Geol. and Conserv. Comm., Water Resources Summary 2, 2 p., 3 figs.

Pluhowski, E. J., 1968, Urbanization and its effect on the temperature of Long Island streams: U.S. Geol. Survey open-file report, 277 p.

_____1970, Hydrology of the Upper Malad River basin, southeastern Idaho: U.S. Geol. Survey Water-Supply Paper 1888, p. 75-77.

Pluhowski, E. J., and Kantrowitz, I. H., 1963, Influence of land-surface conditions on ground-water temperature in southwestern Suffolk County, Long Island, New York: U.S. Geol. Survey Prof. Paper 475-B, p. B186-B188.

Randall, A. D., and others, 1966, Water resources inventory of Connecticut. Part 1, Quinebaug River basin: Connecticut Water Resources Bull. 8, 102 p.

Raphael, J. M., 1962, Prediction of temperature in rivers and reservoirs: Berkeley, California Univ., Jour. Power Div., Am. Soc. Civil Engineers Proc., v. 88, no. PO2, p. 157-181.

Schroeder, M. E., and Kapustka, S. F., 1957, Chemical and physical character of surface waters of Virginia 1951-54: Virginia Div. Water Resources Bull. 21, 199 p.

Smith, R. E., 1961, Records and water-level measurements of selected wells and chemical analysis of ground water, East Shore area, Davis, Weber, and Box Elder Counties, Utah: Utah State Engineer's Office Basic Data Rept. 1, 35 p.

Still, Robert, and others, 1963, Surface temperature and salinity observations at shore stations in the Oregon Coast for 1962: Oregon State Univ., Dept. Oceanography Data Rept. 11, 15 p.

Taylor, C. T., 1964, Chemical quality of Missouri surface water: Missouri Water Pollution Board, Dept. Public Health and Welfare, 28 p.

Tennessee Stream Pollution Control Board, 1966, Water quality of Tennessee surface streams: Tennessee Dept. Public Health, 122 p.

_____1967, Water quality of Tennessee surface streams: Tennessee Dept. Public Health, 78 p.

Thomas, J. D., and Heidel, S. G., 1969, Chemical and physical character of municipal water supplies in Maryland: Maryland Geol. Survey Inv. Rept. 9, 52 p.

Thomas, M. P., and others, 1967, Water resources inventory of Connecticut, Part 2, Shetucket River basin: Connecticut Water Resources Bull. 11, 96 p.

Thomas, W. H., 1970, Summary of data on temperature of streams in North Carolina, 1943-67: U.S. Geol. Survey Water-Supply Paper 1895-A, 39 p.

Trainer, F. W., 1968, Temperature profiles in water wells as indicators of bedrock fractures: U.S. Geol. Survey Prof. Paper 600-B, p. B210-B214.

U. S. Department of Commerce, 1968, Surface water temperature and density, 3rd ed.: Coast and Geod. Survey Pub. XXXI-I.

U. S. Department of the Interior, 1969, Temperature effects, pt. vi, F of Quality of water Colorado River basin, Progress Report: U.S. Dept. Interior, p. 62-65.

U. S. Geological Survey, Quality of water of the United States, annual reports as water-supply papers, see table, below, p. 47.

_____, released annually, Water resources data, pt. 2, Water quality records (separate book for each State): U.S. Geol. Survey, Water Resources Div.

Waddell, K. M., 1970, Quality of surface water in the Bear River basin, Utah, Wyoming, and Idaho: Utah Div. Water Rights, Utah Basic-Data Release 18, 65 p.

Whetstone, G. W., and McAvoy, R. L., 1952, Chemical character of surface waters of Virginia: Virginia Water Resources Devel. Div. Bull. 11, 38 p.

Whitaker, G. L., 1971, Periodic water- and air-temperature records for Utah streams, 1966-70: Utah Dept. Natural Resources, Water Rights Div., Basic-Data Release 22 (open file), 423 p.

Williams, O. O., 1968, Reservoir effect in downstream water temperatures in the upper Delaware River basin: U.S. Geol. Survey Prof. Paper 600-B, p. B195-B199.

Woodward, T. H., 1970, Summary of data on temperature of streams in North Carolina, 1943-67: U.S. Geol. Survey Water-Supply Paper 189A, 39 p.

List of Reports on Quality of Surface Waters of the United States
Published as U.S. Geological Survey Water-Supply Papers
(Water-Supply Paper numbers shown in table) 1/

Report Year	Volume Complete	Parts 1-2	Parts 1-4	Parts 3-4	Parts 5-6	Parts 7-8	Parts 9-11	Parts 9-14	Parts 12-15	Parts 12-16	Alaska
1941	942										
1942	950										
1943	970										
1944	1022										
1945	1030										
1946	1050										
1947	1102										
1948			1132			1133					
1949			1162			1163					
1950			1186		1187	1188		1189			1466
1951			1197		1198	1199		1200			1466
1952			1250		1251	1252		1253			1466
1953			1290		1291	1292		1293			1466
1954			1350		1351	1352		1353			1486
1955			1400		1401	1402		1403			1486
1956			1450		1451	1452		1453			1486
1957			1520		1521	1522		1523			1500
1958			1571		1572	1573		1574			1570
1959		1641		1642	1643	1644		1645			1640
1960		1741		1742	1743	1744		1745			1720
1961		1881		1882	1883	1884		1885			1953
1962		1941		1942	1943	1944		1945			1953
1963		1947		1948	1949	1950		1951			1953
1964		1954		1955	1956	1957	1958		1959		
1965		1961		1962	1963	1964	1965			1966	
1966		1991		1992	1993	1994	1995				
1967		2011		2012	2013	2014	2015			2016	

PARTS 1 AND 2--North Atlantic Slope Basins and South Atlantic Slope and Eastern Gulf of Mexico Basins
PARTS 3 AND 4--Ohio River Basin and St. Lawrence River Basin
PARTS 5 AND 6--Hudson Bay and Upper Mississippi River Basins and Missouri River Basin
PARTS 7-8--Lower Mississippi River Basin and Western Gulf of Mexico Basin
PARTS 9 AND 11--Colorado River Basin to Pacific Slope Basins in California
PARTS 9-14--Colorado River Basin to Pacific Slope Basins in Oregon and Lower Columbia River Basin
PARTS 12-15--Pacific Slope Basins in Washington and Upper Columbia River Basin to Alaska
PARTS 12-16--Pacific Slope Basins in Washington and Upper Columbia River Basin to Hawaii and other Pacific areas

1/ Water-Supply Papers for 1968, 1969, and 1970 are in press.

GPO 940-517