623SERBSF10,635

623SERBSF10,635

Site Name (Subject):	UNION CAMP CORPORATION
Site ID (Document ID):	NCD003216959
Document Name (DocType):	Preliminary Assessment/Site Inspection (PA/SI)
Report Segment:	
Description:	Phase II Screening Site Inspection: References
Date of Document:	11/1/1991
Date Received:	
Box: *Enter SF and # with no spaces*	SF10,635
Access Level:	PUBLIC
Division:	WASTE MANAGEMENT
Section:	SUPERFUND
Program (Document Group):	SERB (SERB)
Document Category:	FACILITY

Print Report for Record | **Go to New Blank Record** | **Go to New Record - (default to last record values)** | **Delete Record**

STATE OF NORTH CAROLINA

Department of Environment, Health, and Natural Resources
Division of Solid Waste Management
Superfund Section

Union Camp Corporation - Jamestown
NCD 003216959

Phase II
Screening Site Inspection
References

November 1991

By:

Greenhorne & O'Mara, Inc.

LIST OF REFERENCES FOR UNION CAMP CORPORATION - JAMESTOWN, NORTH CAROLINA
EPA REFERENCE ID NUMBER NCD003216959

CERCLA

1. Potential Hazardous Waste Site Preliminary Assessment (EPA Form 2070-12) for the Union Camp Corporation. Filed by Jack Butler, North Carolina Department of Human Resources. December 20, 1985.

2. Evans, Richard, R. (Union Camp Corp.) 1982. Letter to North Carolina Department of Human Resources, Division of Health Services, RE: Request for RCRA Part A withdrawal. April 23.

3. RCRA Part A Application (EPA Forms 3510-1 and 3510-3) for the Union Camp Corporation, Jamestown, Guilford County. Submitted by J.H. Neal, Vice President, Union Camp Corp. November 7, 1980.

4. Strickland, O.W. (Solid and Hazardous Waste Branch) 1982. Letter to Richard Evans (Union Camp Corporation), RE: RCRA Status change. May 10.

5. Lawson, Keith (Solid and Hazardous Waste Branch) 1985. Letter to Richard Evans (Union Camp Corporation), RE: RCRA status change. January 29.

6. U.S. Geological Survey, 7.5 minute series Topographic Quadrangle Maps of North Carolina: High Point West 1969 (photorevised 1987), High Point East 1950 (photorevised 1982), Kernersville 1969 (photorevised 1987), Greensboro 1951 (photorevised 1968), Pleasant Garden 1970 (photorevised 1982).

7. Greenhorne & O'Mara, Inc. 1991. Field Notes. Site visit to the Union Camp Corporation site, June 11.

8. NUS Corporation Field Logbook No. F4-1926 for Union Camp Corporation, TDD No. F4-8911-70. Documentation of facility reconnaissance, January 5, 1990.

9. U.S. Department of Commerce, National Climatic Data Center, Climatic Atlas of the United States, Asheville, NC.

10. U.S. Government Printing Office. Rainfall Frequency Atlas of the United States. Technical Paper No. 40, U.S. Department of Commerce, Washington, DC. 1963.

11. North Carolina Geological Survey. 1985. Geologic Map of North Carolina, North Carolina Department of Conservation and Community Development, Division of Land Resources, Raleigh, N.C.

12. Brown, Philip M. 1988. Preliminary Explanatory Text for the 1985 Geologic Map of North Carolina, Contractual Report 88-1 by the North Carolina Geological Survey, November 4, 1985.

13. Mundorff, M.J., Geology and Groundwater in the Greensboro Area, North Carolina, Bulletin Number 55 (Raleigh: USGS, 1948).

14. U.S. Dept. of Agriculture, Soil Conservation Service, Soil Survey of Guilford County, North Carolina, December 1977.

15. Floyd Edwin, O. and Richard R. Peace, An Appraisal of the Groundwater Resources of the Upper Cape Fear River Basin North Carolina, Groundwater Bulletin Number 20 (USGS and the North Carolina Office of Water and Air Resources, 1974).

16. Daniel, Charles C. and N. Bonar Sharpless, Groundwater Supply Potential and Procedures for Well-Site Selection, Upper Fear River Basin (USGS, 1983).

17. Spangenberg, Rachel (G&O). 1991. Population calculations for the Union Camp - Jamestown site, NCD 003216959. November 19.

18. Frezell, John (Town Manager, Jamestown, North Carolina), 1989. Telecommunications with Eric Corbin (NUS Corporation), RE: Water Sources of Jamestown, North Carolina. April 24.

19. DeRosa, Pat (NCDEHNR). 1991. Letter to Technical Staff, RE: U.S. Census Bureau 1990 Population Data. September 16.

20. NUS Corporation, Phase I Screening Site Inspection for Union Camp Corporation, Jamestown, Guilford County, North Carolina. August 3, 1990.

21. U.S. Fish and Wildlife Service, Endangered and Threatened Species of the Southeastern United States (Atlanta, Georgia, 1988).

22. North Carolina Natural Heritage Program Element List for Guilford County, printout dated June 30, 1989.

23. DeRosa, Pat (NCDHR) 1989. Memorandum to Superfund Branch Staff, RE: Critical Habitats of Federally Listed Endangered Species in North Carolina. May 18.

24. U.S. Environmental Protection Agency, Environmental Services Division, Environmental Compliance Branch Standard Operation Procedures and Quality Assurance Manual. Athens, Georgia, February 1, 1991.

25. U.S. Environmental Protection Agency, Office of Drinking Water, Drinking Water Regulations and Health Advisories. November 1990.

26. Huff, Christopher (G&O). 1992. Telecon with NC Environmental Management Division, Groundwater Section RE: Wellhead Protection Areas. January 31.

REFERENCE 1

Reference 1

North Carolina Department of Human Resources
Division of Health Services
P.O. Box 2091 • Raleigh, North Carolina 27602-2091

James G. Martin, Governor
Phillip J. Kirk, Jr., Secretary

Ronald H. Levine, M.D., M.P.H.
State Health Director

20 December 1985

Ms. Denise Bland
EPA NC CERCLA Project Officer
Air and Hazardous Material Division
345 Courtland Street, N.E.
Atlanta, GA 30365

SUBJECT: Preliminary Assessment Report
Union Camp Corporation NC D003216959
Ragsdale Road
Jamestown, NC 27282

Dear Ms. Bland:

Enclosed please find the Preliminary Assessment report for the subject site. This priority is based on review of available data.

The Union Camp plant in Jamestown was built in 1946 by Highland Container Company. Highland Container merged with Union Camp in December 1959.

Corrigated shipping containers have been manufactured in this plant since 1946. In this process cardboard cartons are cut out, glued together, and printed. In the past the inks that were used contained metals such as lead and chromium. Utilization of an ink with low lead content was begun in about 1978 or 1979. The basic glue used is made in 660 gallon batches and contains about 1,000 lb. of corn starch and about 30 lb. of caustic soda to suppress the gel temperature of the glue. A water proof glue is also produced by adding approximately 50 to 60 lbs. of a water proofing agent to the basic glue formulation. This water proofing agent is called amerez resin and contains a small amount of formaldehyde, presumably as a preservative. In the past about a cup or two of formaldehyde was also used in the basic glue formulation as a preservative, however, the use of formaldehyde was discontinued in about 1975.

The wastes from this process result from washing down this glue and ink from machinery. This wash water is discharged to the Jamestown sewage treatment system without pretreatment. Approximately 1,000 to 1,500 gallons/day of waste water is generated. Occasionally glue containing an excess of starch will solidify before it can be used. This off spec. glue is disposed of in the city landfill as a non-hazardous solid waste.

A small amount of 1,1,1-trichloroethane is used to clean machinery and in removing pads from the printers. All of this is lost by evaporation during use. The used rags are reused after off site laundrying.

Approximately 2 gallons of oil suspected to contain PCB's from an old switch box was disposed of approximately 3 years ago as a hazardous waste. Number 6 fuel oil also reportedly has been spilled on site and contaminated a nearby stream on at least 2 occasions in the past. The first fuel oil spill resulted from a broken pipe and the second spill resulted from a leaking underground storage tank. These fuel oil spills occurred approximately 3 or 4 years ago, were reported to state environmental officials at the time, and reportedly have been cleaned up. The plant presently uses natural gas, however, number 6 fuel oil is used as an alternative fuel.

Water from a 182 ft. deep well on the site is used to wash down the corrigation equipment. The plant is also served by city water which is used for drinking, boilers, and to wash the flexographic printing equipment.

There are no records or reports of past hazardous waste disposal or spills, other than the fuel oil spills, in the past. Because of the age of the facility and unknown past waste disposal practices a low priority is assigned.

On 19 December 1985, this Preliminary Assessment was reviewed by CERCLA Unit personnel and by the following representatives from the North Carolina Department of Natural Resources and Community Development, Division of Environmental Management: Fay Sweat, Groundwater Section and Glen Ross, Air Quality Section.

If you have any questions, please call me at (919) 733-2178.

Sincerely,

Jack Butler

Jack Butler, Environmental Engineer
Solid and Hazardous Waste Management Branch
Environmental Health Section

JB/tb/0214b

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 1 - SITE INFORMATION AND ASSESSMENT

EPA

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D003216959

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site)	02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER				
Union Camp Corp.	Ragsdale Road				
03 CITY	**04 STATE**	**05 ZIP CODE**	**06 COUNTY**	**07 COUNTY CODE**	**08 CONG DIST**
Jamestown	NC	27282	Guilford	41	6

09 COORDINATES LATITUDE	LONGITUDE
35° 59' 30"	79° 56' 15"

10 DIRECTIONS TO SITE (Starting from nearest public road)

The site is on US 29A/70A about 0.5 or 0.6 miles east of the High Point City Park. Access the plant from Dillon Road which crosses the RR tracks from US 29A/70A.

III. RESPONSIBLE PARTIES

01 OWNER (If known)	02 STREET (Business, mailing, residential)			
Union Camp	1600 Valley Road			
03 CITY	**04 STATE**	**05 ZIP CODE**	**06 TELEPHONE NUMBER**	
Wayne	NJ	07470	(201) 628-2000	
07 OPERATOR (If known and different from owner)	**08 STREET** (Business, mailing, residential)			
Union Camp Corp.	P.O. Box 759			
09 CITY	**10 STATE**	**11 ZIP CODE**	**12 TELEPHONE NUMBER**	
Jamestown	NC	27282	(919) 454-1151	

13 TYPE OF OWNERSHIP (Check one)

☒ A. PRIVATE ☐ B. FEDERAL: _____ (Agency name) ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL

☐ F. OTHER: _____ (Specify) ☐ G. UNKNOWN

14 OWNER/OPERATOR NOTIFICATION ON FILE (Check all that apply)

☒ A. RCRA 3001 DATE RECEIVED: 11 / 19 / 80 (MONTH DAY YEAR) ☐ B. UNCONTROLLED WASTE SITE (CERCLA 103 c) DATE RECEIVED: ___ / ___ / ___ (MONTH DAY YEAR) ☐ C. NONE

IV. CHARACTERIZATION OF POTENTIAL HAZARD

01 ON SITE INSPECTION

☐ YES DATE ___ / ___ / ___ (MONTH DAY YEAR)

☒ NO

BY (Check all that apply)

☐ A. EPA ☐ B. EPA CONTRACTOR ☐ C. STATE ☐ D. OTHER CONTRACTOR

☐ E. LOCAL HEALTH OFFICIAL ☐ F. OTHER: _____ (Specify)

CONTRACTOR NAME(S): _____

02 SITE STATUS (Check one)	03 YEARS OF OPERATION		
☐ A. ACTIVE ☒ B. INACTIVE ☐ C. UNKNOWN	1946 (BEGINNING YEAR)	Present (ENDING YEAR)	☐ UNKNOWN

04 DESCRIPTION OF SUBSTANCES POSSIBLY PRESENT, KNOWN, OR ALLEGED

Manufacture corrigated shipping containers. Mix glue and ink on site. Equipment wash down and off spec. glue are sources of waste. Glue is non-hazardous solid. Ink containing lead and chromium used until about 1978.

05 DESCRIPTION OF POTENTIAL HAZARD TO ENVIRONMENT AND/OR POPULATION

Wash water to city sewer. No pretreatment. No on-site disposal. City water for drinking; 182 ft. well for wash. Past spill of #6 fuel oil from leaking underground storage tank.

V. PRIORITY ASSESSMENT

01 PRIORITY FOR INSPECTION (Check one. If high or medium is checked, complete Part 2 - Waste Information and Part 3 - Description of Hazardous Conditions and Incidents)

☐ A. HIGH (Inspection required promptly) ☐ B. MEDIUM (Inspection required) ☒ C. LOW (Inspect on time available basis) ☐ D. NONE (No further action needed, complete current disposition form)

VI. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF (Agency/Organization)	03 TELEPHONE NUMBER
Bill Thompson	Union Camp - Moorestown, Tenn.	(615) 581-8650

04 PERSON RESPONSIBLE FOR ASSESSMENT	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NUMBER	08 DATE
Jack Butler/Pat DeRosa	NC DHR/DHS	SHW Mgmt. Br.	(919) 733-2178	12 / 03 / 85 (MONTH DAY YEAR)

EPA FORM 2070-12 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216959

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 [X] A. GROUNDWATER CONTAMINATION — 02 [X] OBSERVED (DATE: ~1981 & 1982) ☐ POTENTIAL [X] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: Unknown — 04 NARRATIVE DESCRIPTION

#6 fuel oil spilled from ruptured pipe and leaking underground storage tank on 2 occasions in the past. Spills reported to state and reportedly cleaned up.

01 [X] B. SURFACE WATER CONTAMINATION — 02 [X] OBSERVED (DATE: ~1981 & 1982) ☐ POTENTIAL [X] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

Spills discussed under groundwater contamination reportedly contaminated off site stream.

01 ☐ C. CONTAMINATION OF AIR — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

01 ☐ D. FIRE/EXPLOSIVE CONDITIONS — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

01 ☐ E. DIRECT CONTACT — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

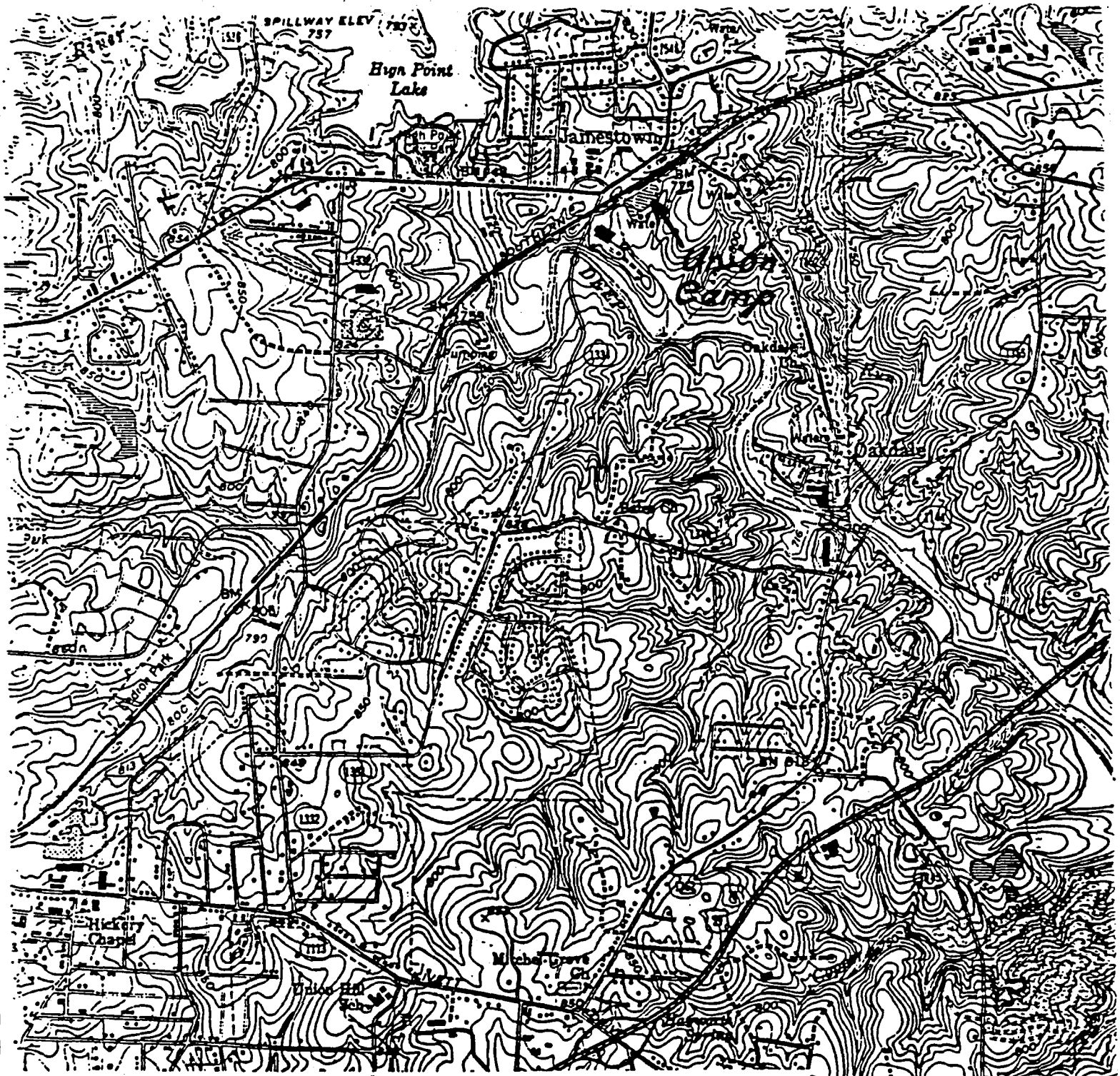
01 [X] F. CONTAMINATION OF SOIL — 02 [X] OBSERVED (DATE: ~1981 & 1982) ☐ POTENTIAL [X] ALLEGED
03 AREA POTENTIALLY AFFECTED: Unknown (Acres) — 04 NARRATIVE DESCRIPTION

As discussed above.

01 ☐ G. DRINKING WATER CONTAMINATION — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

01 ☐ H. WORKER EXPOSURE/INJURY — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 WORKERS POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

01 ☐ I. POPULATION EXPOSURE/INJURY — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION



SCALE 1:24000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

ROAD CLASSIFICATION

Heavy-duty ——— Light-duty — — —

Medium-duty ——— Unimproved dirt - - - -

Interstate Route U.S. Route State

HIGH POINT EAST QUADRANGLE

NORTH CAROLINA

7.5 MINUTE SERIES (TOPOGRAPHIC)

MN GN

5½° 98 MILS 0°37' 11 MILS

UTM GRID AND 1982 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

HIGH POINT EAST, N

N3552.5—W7952.5/7.5

1950

PHOTOREVISED 1982

DMA 5055 IV NW-SERIES V842

REFERENCE 2

Reference 2





CONTAINER DIVISION P.O. DRAWER 759 JAMESTOWN, NC 27282 TELEPHONE (919) 454-1151

April 23, 1982

NC Department of Human Resources
Division of Health Services
Environmental Health Section
Solid & Hazardous Waste Management Branch
PO Box 2091
Raleigh, NC 27602

Dear Sir:

Our corrugated box plant in Jamestown, NC submitted a Part A Hazardous Waste Permit Application in November, 1980 as a storage facility in accordance with RCRA regulations. We obtained EPA I.D. #NCD003216959. At that time the hazardous waste consisted of flexographic ink washwater and sludge which contained small amounts of lead and chromium pigments. These wastes may have exceeded the limits for these metals in the EP toxicity test.

Since that time the inks have been changed to eliminate these pigments and further testing demonstrates that the washwater and sludge is clearly not a hazardous waste by RCRA definition. We are also notifying the US EPA Region IV Office in Atlanta, GA.

We wish to withdraw our Hazardous Waste Permit Application for this facility based on the above change in our operation. Any hazardous waste in storage will be disposed in accordance with North Carolina and EPA regulations for such disposal. Please advise if any other action is required.

Very truly yours,

Richard R. Evans
Plant General Manger

RRE:lp

REFERENCE 3

Please print or type in the unshaded areas only
(fill—in areas are spaced for elite type, i.e., 12 characters/inch).

Form Approved OMB No. 158-R0175

FORM 1 GENERAL

EPA

U. S. ENVIRONMENTAL PROTECTION AGENCY

GENERAL INFORMATION

Consolidated Permits Program

(Read the "General Instructions" before starting.)

I. EPA I.D. NUMBER: F NCD003216959

LABEL ITEMS

I. EPA I.D. NUMBER

II. FACILITY NAME

III. FACILITY MAILING ADDRESS

IV. FACILITY LOCATION

PLEASE

Reference 3

GENERAL INSTRUCTIONS

If a preprinted label has been provided, affix it in the designated space. Review the information carefully; if any of it is incorrect, cross through it and enter the correct data in the appropriate fill—in area below. Also, if any of the preprinted data is absent (the area to the left of the label space lists the information that should appear), please provide it in the proper fill—in area(s) below. If the label is complete and correct, you need not complete items I, III, IV, and VI (except VI-B which must be completed regardless). Complete all items if no label has been provided. Refer to the instructions for detailed item descriptions and for the legal authorizations under which this data is collected.

II. POLLUTANT CHARACTERISTICS

INSTRUCTIONS: Complete A through J to determine whether you need to submit any permit application forms to the EPA. If you answer "yes" to any questions, you must submit this form and the supplemental form listed in the parenthesis following the question. Mark "X" in the box in the third column if the supplemental form is attached. If you answer "no" to each question, you need not submit any of these forms. You may answer "no" if your activity is excluded from permit requirements; see Section C of the instructions. See also, Section D of the instructions for definitions of terms.

SPECIFIC QUESTIONS	MARK 'X' YES	NO	ATTACHED	SPECIFIC QUESTIONS	MARK 'X' YES	NO
A. Is this facility a publicly owned treatment works which results in a discharge to waters of the U.S.? (FORM 2A)		X		B. Does or will this facility (either existing or proposed) include a concentrated animal feeding operation or aquatic animal production facility which results in a discharge to waters of the U.S.? (FORM 2B)		X
C. Is this a facility which currently results in discharges to waters of the U.S. other than those described in A or B above? (FORM 2C)		X		D. Is this a proposed facility (other than those described in A or B above) which will result in a discharge to waters of the U.S.? (FORM 2D)		X
E. Does or will this facility treat, store, or dispose of hazardous wastes? (FORM 3)	X		X	F. Do you or will you inject at this facility industrial or municipal effluent below the lowermost stratum containing, within one quarter mile of the well bore, underground sources of drinking water? (FORM 4)		X
G. Do you or will you inject at this facility any produced water or other fluids which are brought to the surface in connection with conventional oil or natural gas production, inject fluids used for enhanced recovery of oil or natural gas, or inject fluids for storage of liquid hydrocarbons? (FORM 4)		X		H. Do you or will you inject at this facility fluids for special processes such as mining of sulfur by the Frasch process, solution mining of minerals, in situ combustion of fossil fuels, or recovery of geothermal energy? (FORM 4)		X
I. Is this facility a proposed stationary source which is one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act, and may affect or be located in an attainment area? (FORM 5)		X		J. Is this facility a proposed stationary source which is NOT one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act, and may affect or be located in an attainment area? (FORM 5)		X

III. NAME OF FACILITY

1 SKIP UNION CAMP CORP

IV. FACILITY CONTACT

A. NAME & TITLE (last, first, & title)	B. PHONE (area code & no.)
2 EVANS RICHARD GEN MGR	919 454 1151

V. FACILITY MAILING ADDRESS

A. STREET OR P.O. BOX	
3 BOX 759	

B. CITY OR TOWN	C. STATE	D. ZIP CODE
4 JAMESTOWN	NC	27282

VI. FACILITY LOCATION

A. STREET, ROUTE NO. OR OTHER SPECIFIC IDENTIFIER	
5 RAGSDALE ROAD	

B. COUNTY NAME			
GUILFORD			
C. CITY OR TOWN	D. STATE	E. ZIP CODE	F. COUNTY CODE (if known)

SIC CODES (4-digit, in order of priority)

A. FIRST		B. SECOND	
2653	Paper Converting	7	

C. THIRD		D. FOURTH	
		7	

VIII. OPERATOR INFORMATION

A. NAME	B. Is the name listed in Item VIII-A also the owner?
UNION CAMP CORP	[X] YES [ ] NO

C. STATUS OF OPERATOR (Enter the appropriate letter into the answer box; if "Other", specify.)
F = FEDERAL M = PUBLIC (other than federal or state)
S = STATE O = OTHER (specify)
P = PRIVATE

C.	(specify)	D. PHONE (area code & no.)
P		A 201 628 9000

E. STREET OR P.O. BOX
1600 VALLEY ROAD

F. CITY OR TOWN	G. STATE	H. ZIP CODE	IX. INDIAN LAND
WAYNE	NJ	07470	Is the facility located on Indian lands? [ ] YES [X] NO

X. EXISTING ENVIRONMENTAL PERMITS

A. NPDES (Discharges to Surface Water)
N

D. PSD (Air Emissions from Proposed Sources)

G. UIC (Underground Injection of Fluids)
9U

J. OTHER (specify)

(specify)

B. RCRA (Hazardous Waste)
9R

E. OTHER (specify)

(specify)

XI. MAP

Attach to this application a topographic map of the area extending to at least one mile beyond property boundaries. The map must show the outline of the facility, the location of each of its existing and proposed intake and discharge structures, each of its hazardous waste treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers and other surface water bodies in the map area. See instructions for precise requirements.

XII. NATURE OF BUSINESS (provide a brief description)

Manufacturer of paperboard Packaging

XIII. CERTIFICATION (see instructions)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in the application, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME & OFFICIAL TITLE (type or print)	B. SIGNATURE	C. DATE SIGNED
J. H. NEALE, VICE PRES. & GENERAL MGR.	J. H. Neale	11/7/80

COMMENTS FOR OFFICIAL USE ONLY

(Fill—in areas are spaced for elite type, i.e., 12 characters/inch).

Form Approved OMB No. 158-S80004

FORM 3 RCRA

US ENVIRONMENTAL PROTECTION AGENCY

HAZARDOUS WASTE PERMIT APPLICATION

Consolidated Permits Program

(This information is required under Section 3005 of RCRA.)

I. EPA I.D. NUMBER: F W C S 0 0 3 2 1 6 9 5 5

FOR OFFICIAL USE ONLY

APPLICATION APPROVED	DATE RECEIVED (yr., mo., & day)	COMMENTS

II. FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below (mark one box only) to indicate whether this is the first application you are submitting for your facili revised application. If this is your first application and you already know your facility's EPA I.D. Number, or if this is a revised application, enter your fac EPA I.D. Number in Item I above.

A. FIRST APPLICATION (Place an "X" below and provide the appropriate date.)

[X] 1. EXISTING FACILITY (See instructions for definition of "existing" facility. Complete Item below.)

[ ] 2. NEW FACILITY (Complete Item belo

FOR EXISTING FACILITIES: PROVIDE THE DATE (yr., mo., & day) OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED (use the boxes to the left).

C	YR.	MO.	DAY
8	8 0	1 0	2 9

FOR NEW FACI PROVIDE THE (yr., mo., & day) TION BEGAN O EXPECTED TO

B. REVISED APPLICATION (Place an "X" below and complete Item I above.)

[ ] 1. FACILITY HAS INTERIM STATUS

[ ] 2. FACILITY HAS A RCRA PERMIT

III. PROCESSES—CODES AND DESIGN CAPACITIES

A. PROCESS CODE — Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provid entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below describe the process (including its design capacity) in the space provided on the form (Item III-C).

B. PROCESS DESIGN CAPACITY — For each code entered in column A, enter the capacity of the process.

1. AMOUNT — Enter the amount.

2. UNIT OF MEASURE — For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Storage:		
CONTAINER (barrel, drum, etc.)	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D79	GALLONS OR LITERS
LANDFILL	D80	ACRE-FEET (the volume that would cover one acre to a depth of one foot) OR HECTARE-METER
LAND APPLICATION	D81	ACRES OR HECTARES
OCEAN DISPOSAL	D82	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D83	GALLONS OR LITERS
Treatment:		
TANK	T00	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T01	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T02	TONS PER HOUR OR METRIC TONS PER HOUR OR GALLONS PER HOUR OR LITERS PER HOUR
OTHER (Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided, Item III-C.)	T03	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	CODE	UNIT OF MEASURE	CODE	UNIT OF MEASURE
GALLONS	G	LITERS PER DAY	V	ACRE-FEET
LITERS	L	TONS PER HOUR	D	HECTARE-METER
CUBIC YARDS	Y	METRIC TONS PER HOUR	W	ACRES
CUBIC METERS	C	GALLONS PER HOUR	E	HECTARES
GALLONS PER DAY	U	LITERS PER HOUR	H	

EXAMPLE FOR COMPLETING ITEM III (shown in line numbers X-1 and X-2 below): A facility has two storage tanks; one tank can hold 200 gallons a other can hold 400 gallons. The facility also has an incinerator that can burn up to 20 gallons per hour.

C D U P

LINE NUMBER	A. PROCESS CODE (From list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT (specify)	B. PROCESS DESIGN CAPACITY 2. UNIT OF MEASURE (enter code)	FOR OFFICIAL USE ONLY	LINE NUMBER	A. PROCESS CODE (From list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT	B. PROCESS DESIGN CAPACITY 2. UNIT OF MEASURE (enter code)
X-1	S 0 2	600	G		5			
X-2	T 0 3	20	E		6			
1	S 0 1	100	G		7			
2					8			
3					9			

III. PROCESSES (continued)

C. SPACE FOR ADDITIONAL PROCESS CODES O[illegible]OR DESCRIBING OTHER PROCESSES (code "T[illegible]. FOR EACH PROCESS ENTERED HERE INCLUDE DESIGN CAPACITY.

IV. DESCRIPTION OF HAZARDOUS WASTES

EPA HAZARDOUS WASTE NUMBER — Enter the four-digit number from 40 CFR, Subpart D for each listed hazardous waste you will handle. If you handle hazardous wastes which are not listed in 40 CFR, Subpart D, enter the four-digit number(s) from 40 CFR, Subpart C that describes the characteristics and/or the toxic contaminants of those hazardous wastes.

ESTIMATED ANNUAL QUANTITY — For each listed waste entered in column A estimate the quantity of that waste that will be handled on an annual basis. For each characteristic or toxic contaminant entered in column A estimate the total annual quantity of all the non-listed waste(s) that will be handled which possess that characteristic or contaminant.

UNIT OF MEASURE — For each quantity entered in column B enter the unit of measure code. Units of measure which must be used and the appropriate codes are:

ENGLISH UNIT OF MEASURE	CODE	METRIC UNIT OF MEASURE	CODE
POUNDS	P	KILOGRAMS	K
TONS	T	METRIC TONS	M

If facility records use any other unit of measure for quantity, the units of measure must be converted into one of the required units of measure, taking into account the appropriate density or specific gravity of the waste.

PROCESSES

1. PROCESS CODES —
For listed hazardous wastes: For each listed hazardous waste entered in column A, select the code(s) from the list of process codes contained in Item I to indicate how the waste will be stored, treated, and/or disposed of at the facility.
For non-listed hazardous wastes: For each characteristic or toxic contaminant entered in column A, select the code(s) from the list of process codes contained in Item I to indicate all the processes that will be used to store, treat, and/or dispose of all the non-listed hazardous wastes that possess that characteristic or toxic contaminant.
Note: Four spaces are provided for entering process codes. If more are needed: (1) Enter the first three as described above; (2) Enter "000" in the extreme right box of Item IV-D(1); and (3) Enter in the space provided on page 4, the line number and the additional code(s).

2. PROCESS DESCRIPTION — If a code is not listed for a process that will be used, describe the process in the space provided on the form.

NOTE: HAZARDOUS WASTES DESCRIBED BY MORE THAN ONE EPA HAZARDOUS WASTE NUMBER — Hazardous wastes that can be described by more than one EPA Hazardous Waste Number shall be described on the form as follows:

1. Select one of the EPA Hazardous Waste Numbers and enter it in column A. On the same line complete columns B, C, and D by estimating the total annual quantity of the waste and describing all the processes to be used to treat, store, and/or dispose of the waste.
2. In column A of the next line enter the other EPA Hazardous Waste Number that can be used to describe the waste. In column D(2) on that line enter "included with above" and make no other entries on that line.
3. Repeat step 2 for each other EPA Hazardous Waste Number that can be used to describe the hazardous waste.

EXAMPLE FOR COMPLETING ITEM IV (shown in line numbers X-1, X-2, X-3, and X-4 below) — A facility will treat and dispose of an estimated 900 pounds per year of chrome shavings from leather tanning and finishing operation. In addition, the facility will treat and dispose of three non-listed wastes. Two wastes are corrosive only and there will be an estimated 200 pounds per year of each waste. The other waste is corrosive and ignitable and there will be an estimated 100 pounds per year of that waste. Treatment will be in an incinerator and disposal will be in a landfill.

LINE NO.	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES: 1. PROCESS CODES (enter)	2. PROCESS DESCRIPTION (If a code is not entered in D(1))
X-1	K 0 5 4	900	P	T 0 3 D 8 0	
X-2	D 0 0 2	400	P	T 0 3 D 8 0	
X-3	D 0 0 1	100	P	T 0 3 D 8 0	
[illegible]	D 0 0 2				included with above

Continued from page 2.

NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

Form Approved OMB No. 158-S80004

EPA I.D. NUMBER (enter from page 1)

W | 1 | 1

FOR OFFICIAL USE ONLY

W | DUP | 2 | DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

LINE NO.	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (If a code is not entered in D(1))
1	D008	750,000	P	S01	
2	D007				INCLUDED WITH ABOVE
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					

IV. DESCRIPTION OF HAZARDOUS WASTE (continued)

E. USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM ITEM D(1) ON PA[illegible].

EPA I.D. NO. (enter from page 1)

6

V. FACILITY DRAWING

All existing facilities must include in the space provided on page 5 a scale drawing of the facility (see instructions for more detail).

VI. PHOTOGRAPHS

All existing facilities must include photographs (aerial or ground—level) that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas (see instructions for more detail).

VII. FACILITY GEOGRAPHIC LOCATION

LATITUDE (degrees, minutes, & seconds)	LONGITUDE (degrees, minutes, & seconds)
35 59 57	79 56 7

VIII. FACILITY OWNER

☒ A. If the facility owner is also the facility operator as listed in Section VIII on Form 1, "General Information", place an "X" in the box to the left and skip to Section IX below.

☐ B. If the facility owner is not the facility operator as listed in Section VIII on Form 1, complete the following items:

1. NAME OF FACILITY'S LEGAL OWNER	2. PHONE NO. (area code & r

3. STREET OR P.O. BOX	4. CITY OR TOWN	5. ST.	6. ZIP CODE
	G		

IX. OWNER CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME (print or type)	B. SIGNATURE	C. DATE SIGNED
J. H. NEALE	J. H. Neale	11/3/80

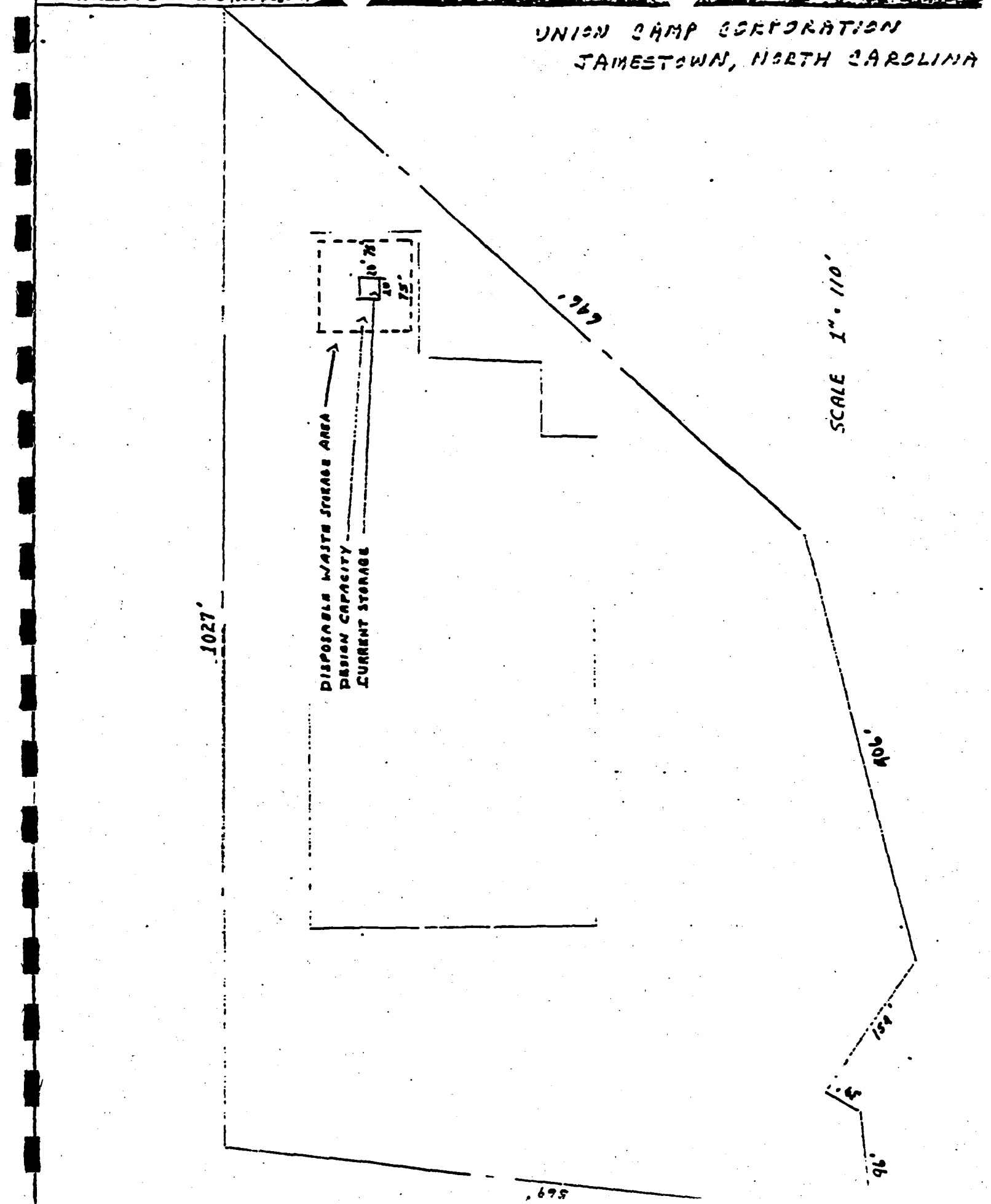
X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME (print or type)	B. SIGNATURE	C. DATE SIGNED

V. FACILITY DRAWING *(see page 4)*

UNION CAMP CORPORATION
JAMESTOWN, NORTH CAROLINA



REFERENCE 4

Reference 4

Ronald H. Levine, M.D., M.P.H.
STATE HEALTH DIRECTOR

DIVISION OF HEALTH SERVICES
P.O. Box 2091
Raleigh, N.C. 27602-2091

CONT. TECH.
MAY 14 1982

2

Mr. Richard R. Evans
Union Camp Corporation
P.O. Drawer
Jamestown, NC 27282

Re: Facility ID No. NCD003216959

Dear Mr. Evans:

Based on information supplied by you we have processed and accepted at the State level your request for the facility identified with the above ID number to receive the indicated change in classification under RCRA:

Add As	Delete As	
☐	☒	generator
☐	☐	transporter
☐	☐	treater
☐	☒	storer
☐	☐	disposer
☐	☐	small generator

We are advising EPA of the change in your status. Please notify us if there is any further change in your operations which would again affect your status. Your EPA ID NO. is ☐ is not ☒ being cancelled.

Cordially,

O. W. Strickland, Head
Solid & Hazardous Waste Management Branch
Environmental Health Section

OWS

cc: John Herrmann
EPA Region IV
Emil Breckling

DHS Form 3048 3/82
Solid & Haz. Waste Mgt. Branch

REFERENCE 5

Reference 5

Ronald H. Levine, M.D., M.P.H.
STATE HEALTH DIRECTOR

DIVISION OF HEALTH SER'
P.O. Box 2091
Raleigh, N.C. 27602-2091

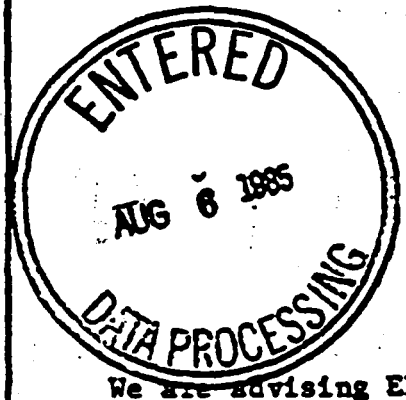
Date: January 29, 1985

Mr. Richard R. Evans
Union Camp Corporation
Post Office Drawer 759
Jamestown, NC 27282

RE: Facility ID No. NCD 003216959

Dear Mr. Evans:

Based on information supplied by you, we have processed and have accepted at the State level your request for the facility identified with the above ID number to receive the indicated change in classification under RCRA.



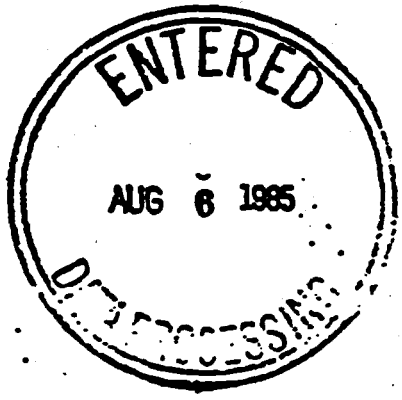
Add As	Delete As	
___	___	generator
___	___	transporter
___	X	small generator

We are advising EPA of the change in your status. Please notify us if there is any further change in your operations which would again affect your status. Your EPA ID Number is x is not ___ being cancelled.

Sincerely,

Keith Lawson

Keith Lawson
Environmental Chemist
Environmental Health Section



KL/jad

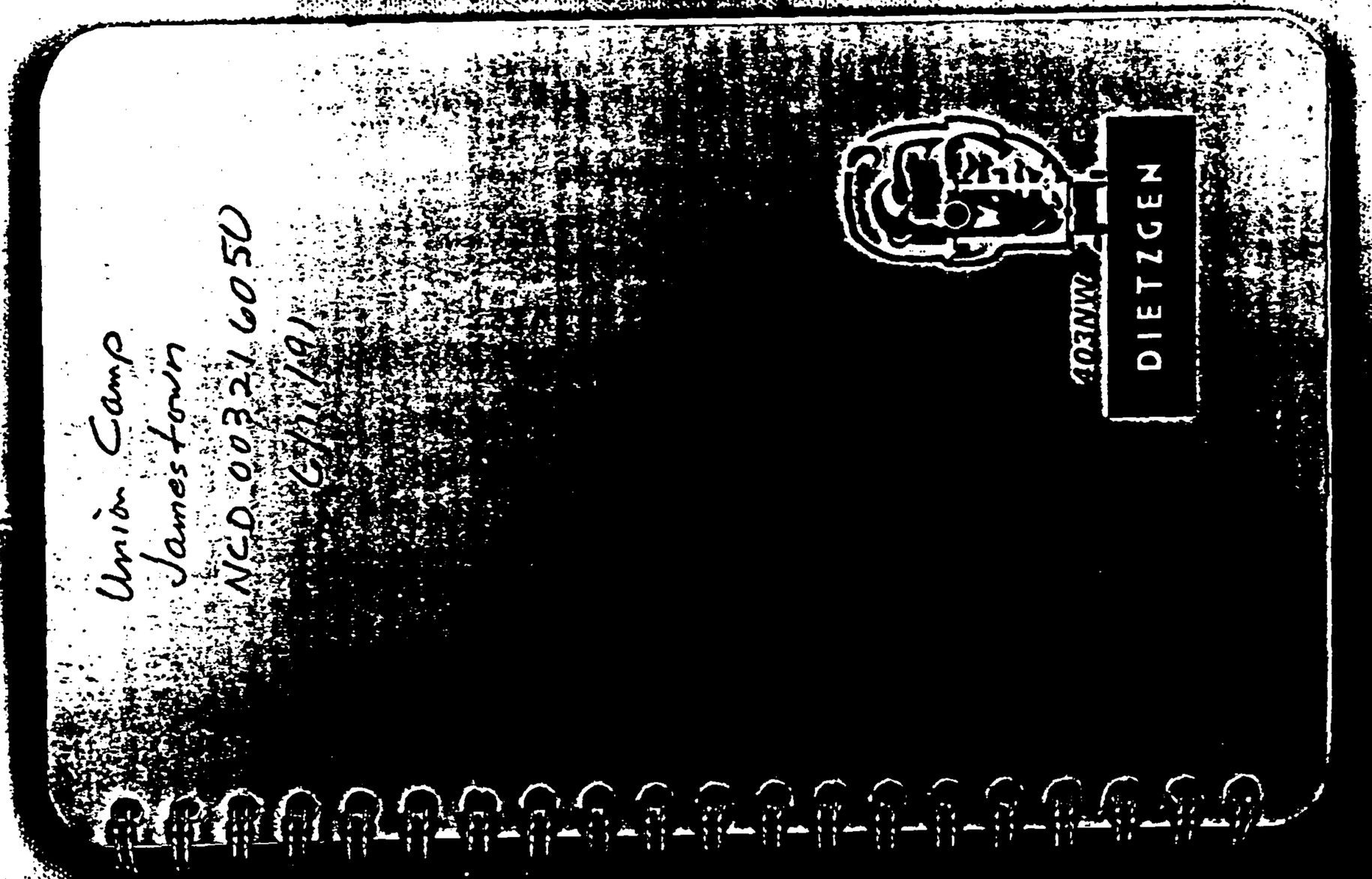
cc: Doug McCurry
EPA Region IV
Emil Breckling
Joe Deakins
Guilford Co. Health Dept.

DHS Form 3048 1/85

REFERENCE 6

SEE FIGURE 3 IN APPENDIX A

REFERENCE 7


DIETZGEN
103NW
Union Camp
Jamestown
NCD 003216050
CHI 191

1947 Construction
Union Camp purchased in
1959 - partial owner
in 1948.

PCB's were drained from
a transformer by Mr.
Thompson & disposed of
properly.

SS02

Soil: reddish clayey sand

GW01

Depth 130'

	Top	Bottom
Temp	18.3°	~~18~~ CNH 17.0°
C/T	0.666	0.660

GW01 - Sample taken from onsite well. Well was purged with submersible electric pump for 1 hour

NCD 003216050

UNION CAMP

JAMESTOWN, NC

6-11-91

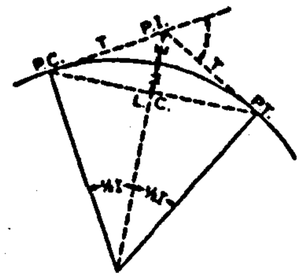


403NW

DIETZGEN

CURVE AND REDUCTION TABLES

Published by Eugene Dietzgen Co.



CURVE FORMULAS

1. Radius : $R=\frac{50}{\sin D/2}$
2. Degree of Curve: $D=100\frac{I}{L}$. Also, $\sin D/2=\frac{50}{R}$
3. Tangent : $T=R\tan \frac{1}{2} I$. Also, $T=\frac{T \text{ for } 1^\circ \text{ curve}}{D}+C.$
4. Length of Curve: $L=100\frac{I}{D}$
5. Long Chord : $L.C.=2R\sin \frac{1}{2} I.$
6. Middle Ordinate: $M=R(1-\cos \frac{1}{2} I)$
7. External : $E=\frac{R}{\cos \frac{1}{2} I}-R.$ Also, $E=T\tan \frac{1}{4} I.$

EXPLANATION AND USE OF TABLES

Given P.I. Sta. 83+40.7, I=45° 20′ and D=6°30′ find:

Stations—P.C.=P.I.−T. $T=\frac{T \text{ for } 1^\circ \text{ Curve}}{D}+$ C. From Tables V and VI $T=\frac{2392.8}{6.5}+.197=368.32=3+68.32$. Sta. P. C.=83+40.7−(3+68.32)=79+72.38. P. T.=P. C.+L, and $L=100\frac{I}{D}=100\frac{45.33}{6.5}=697.38$ Therefore, P. T.=(79+72.38)+(6+97.38)=86+69.76.

Offsets—Tangent offsets vary (approximately) directly with D and with the square of the distance. From Table III Tangent Offset for 100 feet=5.660 feet. Distance =80−Sta. P. C.=27.62. Hence offset $=5.66\times\left(\frac{27.62}{100}\right)^2=.432$ ft. Also, square of any distance, divided by twice the radius equals (approximately) the distance from tangent to curve. Thus $(27.62)^2\div(2\times881.95)=.432$ ft.

Deflections—Deflection angle=½ D for 100 ft., ¼ D for 50 ft., etc. For "X" ft. Deflection Angle (in minutes) $=.3\times X\times D$. For Sta. 80 of above curve Deflection Angle $=.3\times27.62\times6.5=53.86'$. Also Deflection Angle=dfl. for 1 ft. from Table III $\times X=1.95\times27.62=53.86'$. For Sta. 181 Deflection Angle $=53.86'+\frac{6^\circ 30'}{2}=4^\circ 8.86'$.

Externals—From Table V for 1° curve, with central angle of 45° 20′, E=479.6. Therefore, for 6° 30′ curve, $E=\frac{479.6}{6.5}+$ Correction from Table VI=7.378+.039=7.417.

NCD003216050

UNION CAMP

JAMESTOWN, NC

6-11-91

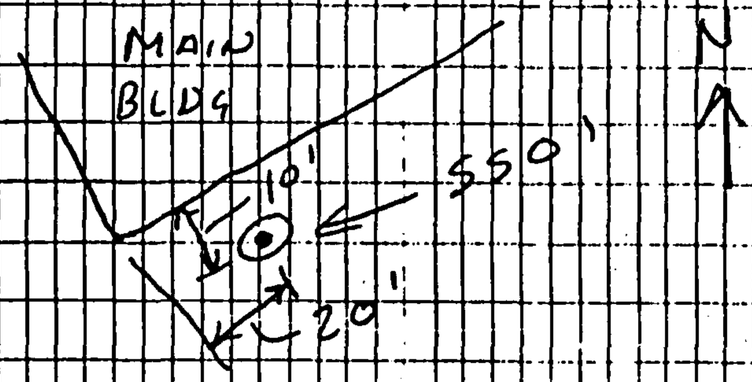
BILLY	DIXON	G40
JERRY	JOHNSON	G40
CHRIS	HUFF	G40
HARVEY	ALLEN	NCDENR

0800- ENTERED SITE & MET WITH REPRESETATIVES OF UNION CAMP

UC SS01 10:30

CONTROL SOIL SAMPLE (GRAB) (DUPLICATE)

SAMPLE WAS COLLECTED APPROX 20 FT. N.E. OF SOUTHERNMOST CORNER OF MAIN BLDG AND APPROX. 10 FT S.E. OF FACE OF BLDG AT A DEPTH OF 1 FT TO 3 FT BELOW GROUND 6-11-91 ~~SURFACE~~ SURFACE. SOIL WAS DARK TAN SAND W/ LITTLE CLAY.

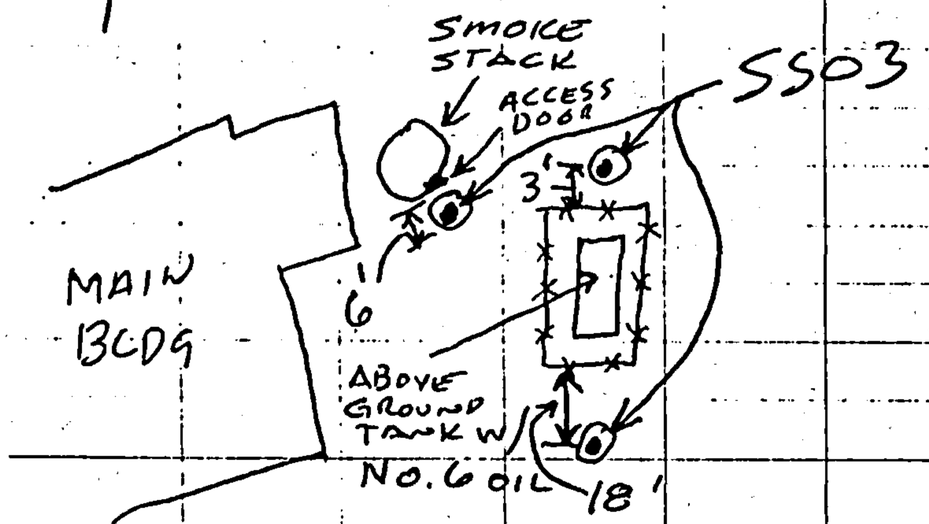


6-11-91

UC SS03 11:45

COMPOSITE SOIL SAMPLE COLLECTED NEAR NORTHEAST END OF MAIN BLDG IN THE VICINITY OF THE No. 6 OIL STORAGE TANK (ABOVE GROUND) AND THE SMOKE STACK. THIS SAMPLE WAS COLLECTED FROM 3 HOLES AS SHOWN IN THE SKETCH BELOW FROM A DEPTH OF APPROX. 1 FT. BELOW THE GROUND SURFACE. SOIL WAS GENERALLY DARK TAN SAND WITH LITTLE CLAY

N



Union Camp, Corp

Jamestown

NCD 003 216 959

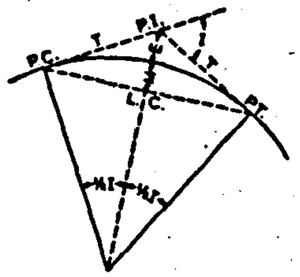


403NW

DIETZGEN

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2. Degree of Curve: $D=100\frac{I}{L}$. Also, $\sin D/2=\frac{50}{R}$
3. Tangent : $T=R\tan \frac{1}{2} I$. Also, $T=\frac{T \text{ for } 1° \text{ curve}}{D}+C.$
4. Length of Curve: $L=100\frac{I}{D}$
5. Long Chord : $L.C.=2R\sin \frac{1}{2} I.$
6. Middle Ordinate: $M=R(1-\cos \frac{1}{2} I)$
7. External : $E=\frac{R}{\cos \frac{1}{2} I}-R.$ Also, $E=T\tan \frac{1}{4} I.$

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Stations—P.C.=P.I.−T. $T=\frac{T \text{ for } 1° \text{ Curve}}{D}+$ C. From Tables V and VI $T=\frac{2302.8}{6.5}+.197=368.32=3+68.32$. Sta. P. C.=83+40.7−(3+68.32)=79+72.38. P. T.=P. C.+L, and $L=100\frac{I}{D}=100\frac{45.33}{6.5}=697.38$ Therefore, P. T.=(79+72.38)+(6+97.38)=86+69.76.

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Deflections—Deflection angle=½ D for 100 ft., ¼ D for 50 ft., etc. For "X" ft. Deflection Angle (in minutes) $=.3\times X\times D$. For Sta. 80 of above curve Deflection Angle $=.3\times27.62\times6.5=53.86'$. Also Deflection Angle=dfl. for 1 ft. from Table III $\times X=1.95\times27.62=53.86'$. For Sta. 181 Deflection Angle $=53.86'+\frac{6°\,30'}{2}=4°\,8.86'$.

Externals—From Table V for 1° curve, with central angle of 45° 20′, E=479.6. Therefore, for 6° 30′ curve, $E=\frac{479.6}{6.5}+$ Correction from Table VI=7.378+.039=7.417.

Start Time of GW02 - 1015

Background VO - 1 PPM

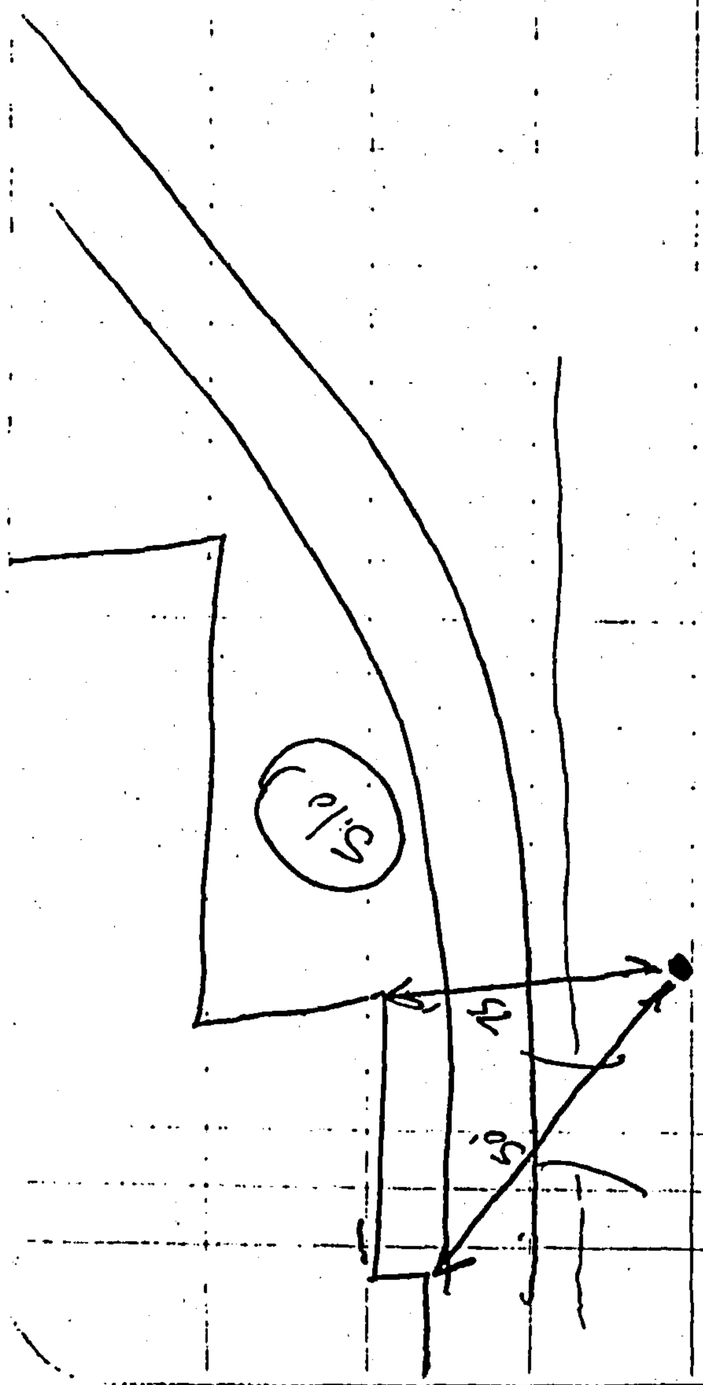
GW02 VO - 0.8 PPM

0"-6"		Lt Brown Top Soil
6"-24"		Lt. Brown Sandy Clay
24"-30"		Lt. Grey Clay with Trace of Sand
30"-42"	42"	Wet Brown/Grey Sandy Clay
42"-60"		Wet Grey Clay with Sand
60"-66"		Dark Grey Clay

	Top	Bottom
Temp	19.1°	17.7
CHT	0.820	0.820

Finished 6W02 st 12.15

Left Side 1400



REFERENCE 8

"Rite in the Rain"

Reference 8

ALL-WEATHER

LEVEL

Notebook No. 311

F4-1926

Union Camp Corp

F4-8911-70

Jamestown, Guilford Co., N.C.

Pltr.: Bryan F. Williams

NCP618

LOGBOOK REQUIREMENTS
REVISED - NOVEMBER 29, 1988

NOTE: ALL LANGUAGE SHOULD BE FACTUAL AND OBJECTIVE

1. Record on front cover of the Logbook: TDD No., Site Name, Site Location, Project Manager.
2. All entries are made using ink. Draw a single line through errors. Initial and date corrections.
3. Statement of Work Plan, Study Plan, and Safety Plan discussion and distribution to field team with team members' signatures.
4. Record weather conditions and general site information.
5. Sign and date each page. Project Manager is to review and sign off on each logbook daily.
6. Document all calibration and pre-operational checks of equipment. Provide serial numbers of equipment used onsite.
7. Provide reference to Sampling Field Sheets for detailed sampling information.
8. Describe sampling locations <u>in detail</u> and document all changes from project planning documents.
9. Provide a site sketch with sample locations and photo locations.
10. Maintain photo log by completing the stamped information at the end of the logbook.
11. If no site representative is on hand to accept the receipt for samples, an entry to that effect must be placed in the logbook.
12. Record I.D. numbers of COC and receipt for sample forms used. Also record numbers of destroyed documents.
13. Complete SMO information in the space provided.

All entries in this book will be made by Bryan Williams. Each page used will be initialled by the project manager and dated. All mistakes will be crossed out with one stroke and initialled. All members of the reconnaissance team have read and understand the workplan.

As understanding of the above:

Bryan Williams: Bryan G. Williams

Margaret Graves: Margaret D. Graves

John McKeown: John S. McKeown

1/5/90 TSJr

Note: All water information applicable to this site and others studied on this recon will be found in logbook No. F4-1914, for Guardsman Chemicals TDD No. F4-8912-02

0930 Reconned the facility - drove into parking lot and back out. A School is located kitty-corner across the RR tracks. Site is wooded south to the river, w/ a house between.

All foliage in the area appeared healthy, and there were no

1/5/90 TSJr

noticable odors around the site.

The facility is backed by a Chemical Company and bordered by RR tracks. A water tower is onsite.

facility is not fenced, but not easily accessable.

weather sunny & pleasant, ≈65°F

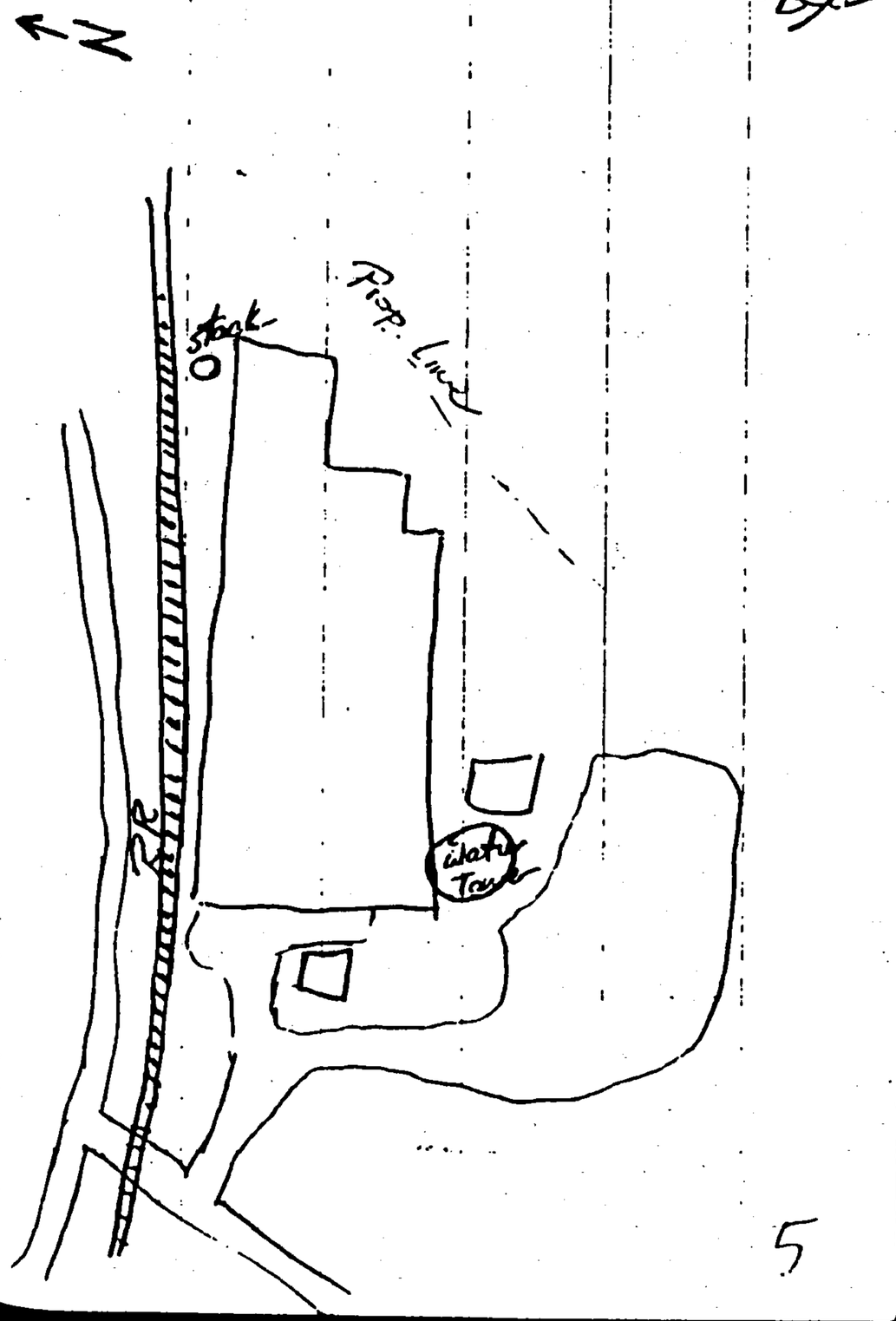
1120 Drove Down Dillon Rd and found houses to be on private wells. Spoke w/ Ms. Jospo Skean, of

1 1/5/90 BGW

3425 Dillon Rd.
She said they had a shallow 40 ft well until Oct 88, then redrilled to 140 ft. because of poor yield. She said almost everybody else had redrilled as well.

Bryan J Williams

1/5/90 BGW



5

REFERENCE 9



CLIMATIC ATLAS OF THE UNITED STATES

Reference 9

U.S. DEPARTMENT OF COMMERCE . Environmental Science Services Administration . Environmental Data Service



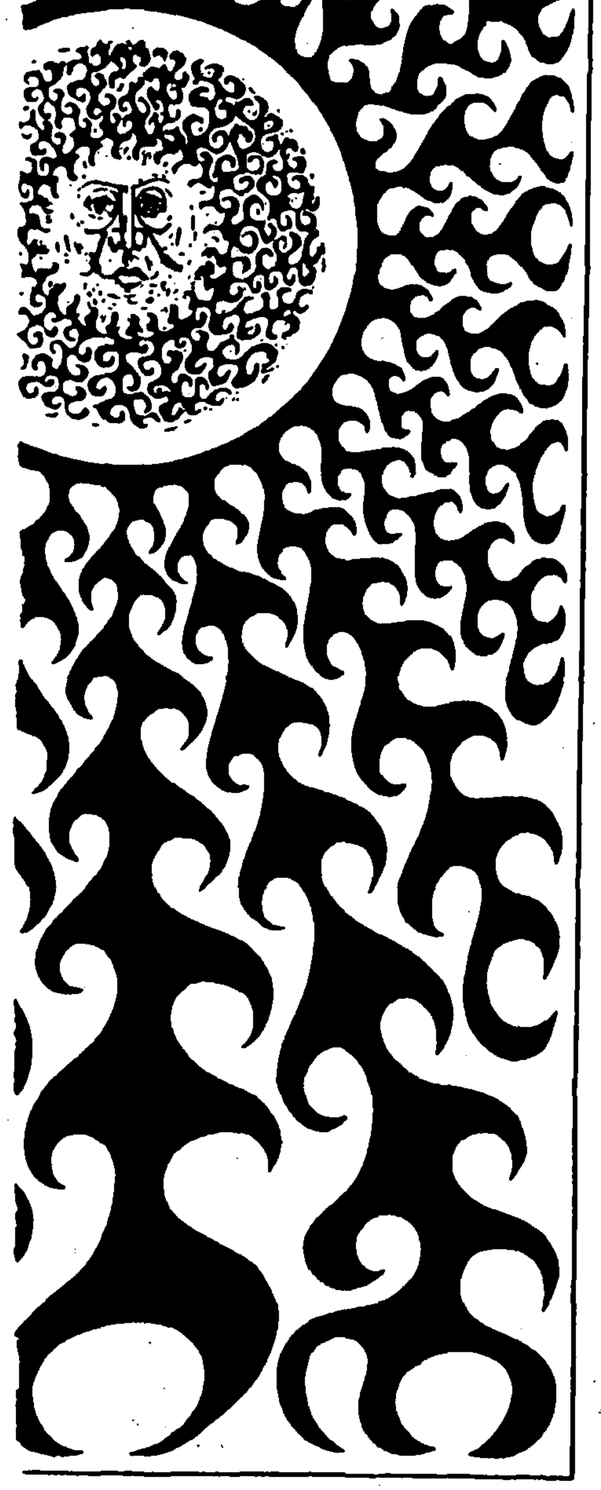
U.S. DEPARTMENT OF COMMERCE
C. R. Smith, Secretary

ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
Robert M. White, Administrator

ENVIRONMENTAL DATA SERVICE
Woodrow C. Jacobs, Director

JUNE 1968

REPRINTED BY THE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
1983



PREFACE

The purpose of this atlas is to depict the climate of the United States in terms of the distribution and variation of constituent climatic elements. Climate has a profound, often controlling, effect upon the life, mood, health, and activity of all of us.

Climate may be considered the collective state of the earth's atmosphere at a specific place for a long period of time (usually several decades). The short-term variations of the state of the atmosphere are called "weather." Weather is the product of the interaction of numerous natural elements; the long term statistical valuations of these various elements collectively define the climate. For many planning, engineering, and scheduling purposes it is more important to know the climate of a certain city, State, resort area, etc., than to know what the weather happens to be there today.

The Climatic Maps of the United States present in uniform format a series of analyses showing the national distribution of mean, normal, and/or extreme values of temperature, precipitation, wind, barometric pressure, relative humidity, dewpoint, sunshine, sky cover, heating degree days, solar radiation, and evaporation. The map projection has been standardized to allow accurate comparison and correlation of the various climatic elements and their patterns.

The individual analyses were originally prepared to meet the demand for climatic information from commercial, industrial, agricultural, research, and educational institutions, as well as from the general public. Each sheet, or set of sheets, was made available as soon as printed. Now the entire set - a total of 40 large sheets containing 271 climatic maps and 15 tables - has been collected and bound into this comprehensive atlas. (Individual sheets and sets may still be purchased separately).

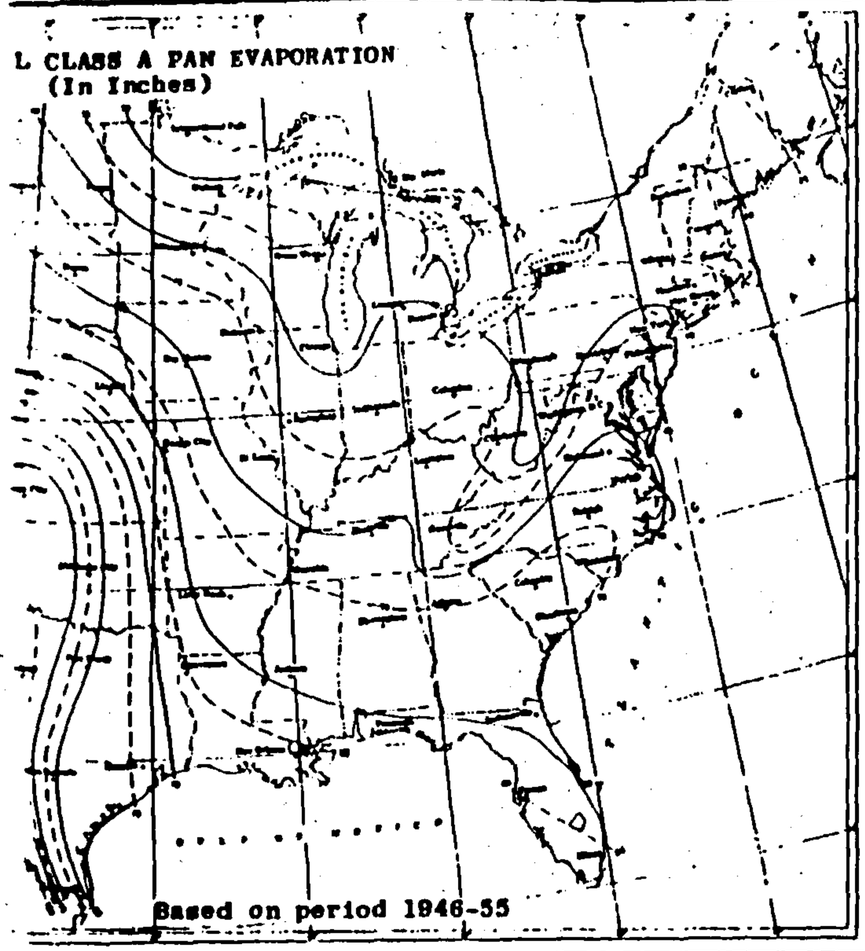
It should be remembered that these analyses are not forecasts of temperature, precipitation, etc., but rather reflect collective atmospheric conditions that occurred over periods of years; often observed conditions for any given day, week, month - or even year - will differ sharply from those indicated in the analyses.

The climatic maps in this atlas were prepared primarily by John L. Baldwin, Chief of the Domestic Climatology Branch of the Environmental Data Service, ESSA, an agency of the U.S. Department of Commerce, with some map contributions from the Hydrologic Services Division and the former Solar Radiation Section of the Weather Bureau. Appreciation is due Dr. Helmut E. Landsberg, former Director of the Environmental Data Service, and to the National Academy of Science Advisory Committee on Climatology for advice and guidance.

CONTENTS

	page
Normal Daily Maximum, Minimum, Average, Range and Extremes of Temperature (°F), Monthly	1
Mean Annual Number of Days Maximum Temperature 90°F and Above	25
Mean Number of Days Maximum Temperature 90°F and Above, Monthly and Annual	26
Mean Annual Number of Days Minimum Temperature 32°F and Below	27
Mean Number of Days Minimum Temperature 32°F and Below, Monthly and Annual	28
Mean Date of Last 32°F Temperature in Spring	29
Mean Date of First 32°F Temperature in Autumn	30
Mean Length of Freeze-Free Period (Days)	31
Mean Length of Period Between Selected Freezing Temperatures in Spring and Autumn and Mean Freeze Dates	32
Normal Total Heating Degree Days, Monthly and Annual	33
Normal Total Precipitation (Inches), Monthly and Annual	37
Mean Total Precipitation (Inches) by State Climatic Division, Monthly and Annual	45
State Climatic Divisions	50
Mean Annual Precipitation in Millions of Gallons of Water Per Square Mile by State Climatic Divisions	51
Mean Annual Precipitation in Millions of Gallons of Water Per Capita by State Climatic Divisions	52
Mean Total Snowfall (Inches)	53
Mean Monthly Total Snowfall (Inches), For Selected Stations	54
Mean Number of Days with 0.01 Inch or More of Precipitation, Monthly and Annual	55
Mean Dewpoint Temperature (°F), Monthly and Annual	57
Maximum Persisting 12-Hour 1000-mb Dewpoint Temperature (°F), Monthly and Record	59
Mean Relative Humidity (%), Monthly and Annual	61
Pan and Lake Evaporation	63
Mean Percentage of Possible Sunshine, Monthly and Annual	65
Mean Total Hours of Sunshine, Monthly and Annual	67
Mean Daily Solar Radiation, Monthly and Annual	69
Mean Sky Cover, Sunrise to Sunset, Monthly and Annual	71
Prevailing Direction, Mean Speed (m.p.h.), and Fastest Mile of Wind, Monthly and Annual	73
Surface Wind Roses, Monthly and Annual; Resultant Surface Winds, Midseasonal	75
Normal Sea-Level Pressures, Monthly and Annual	79

MEAN PAN AND LAKE EVAPORATION



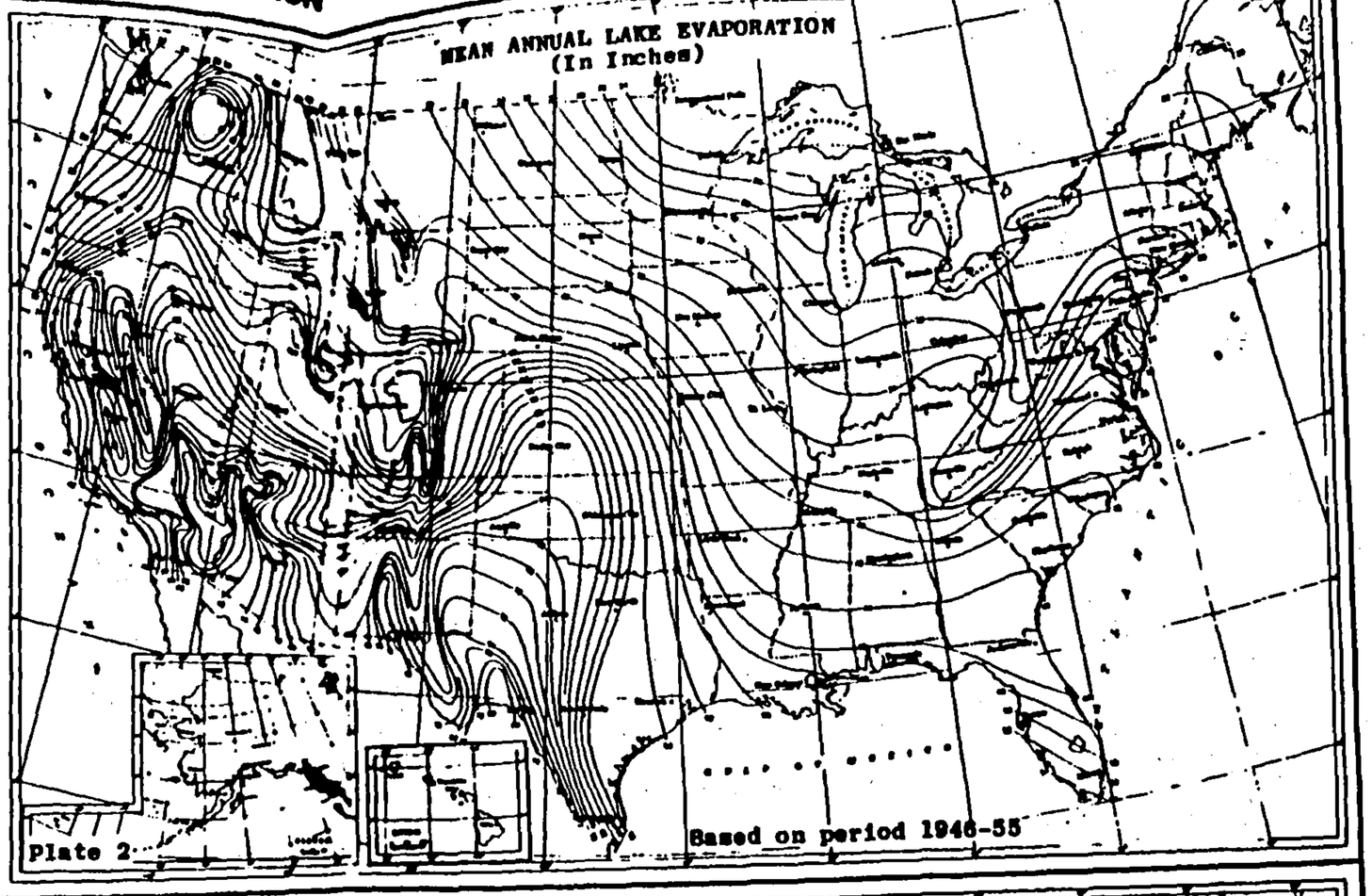
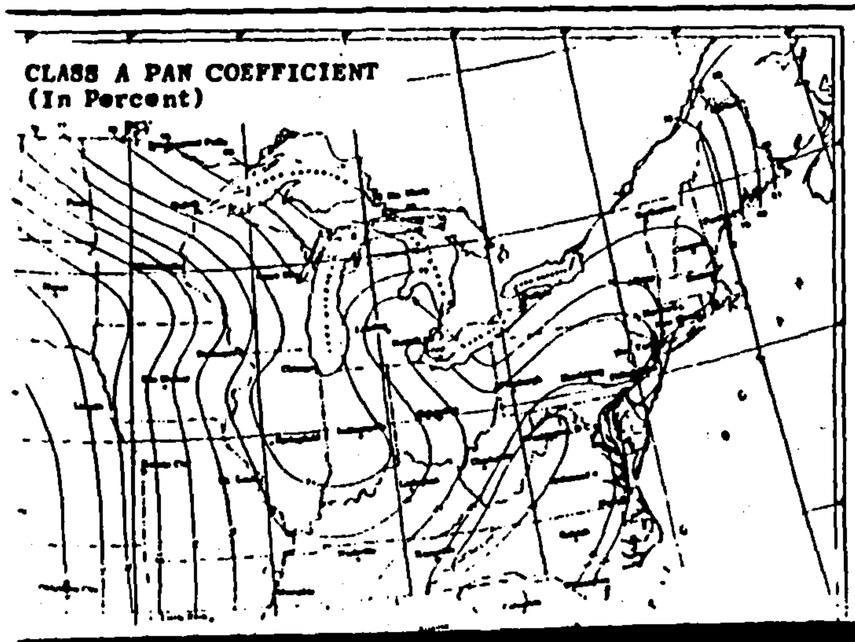
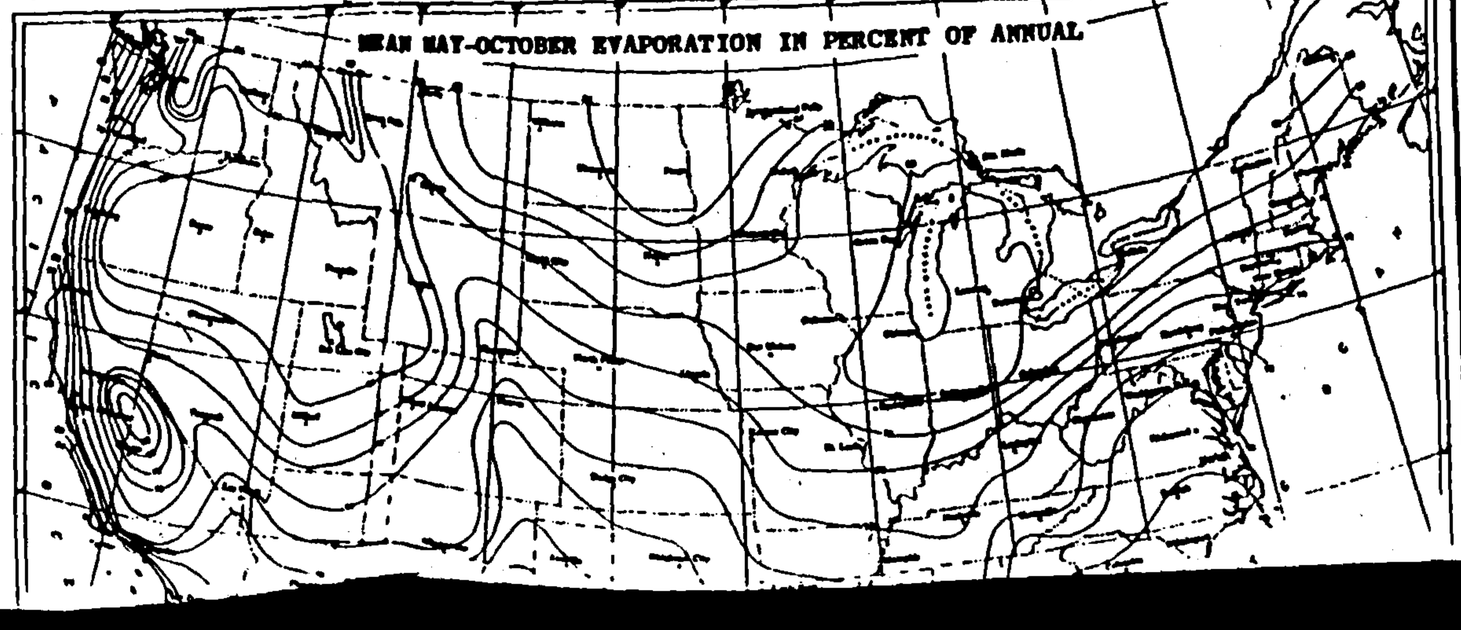


Plate 2

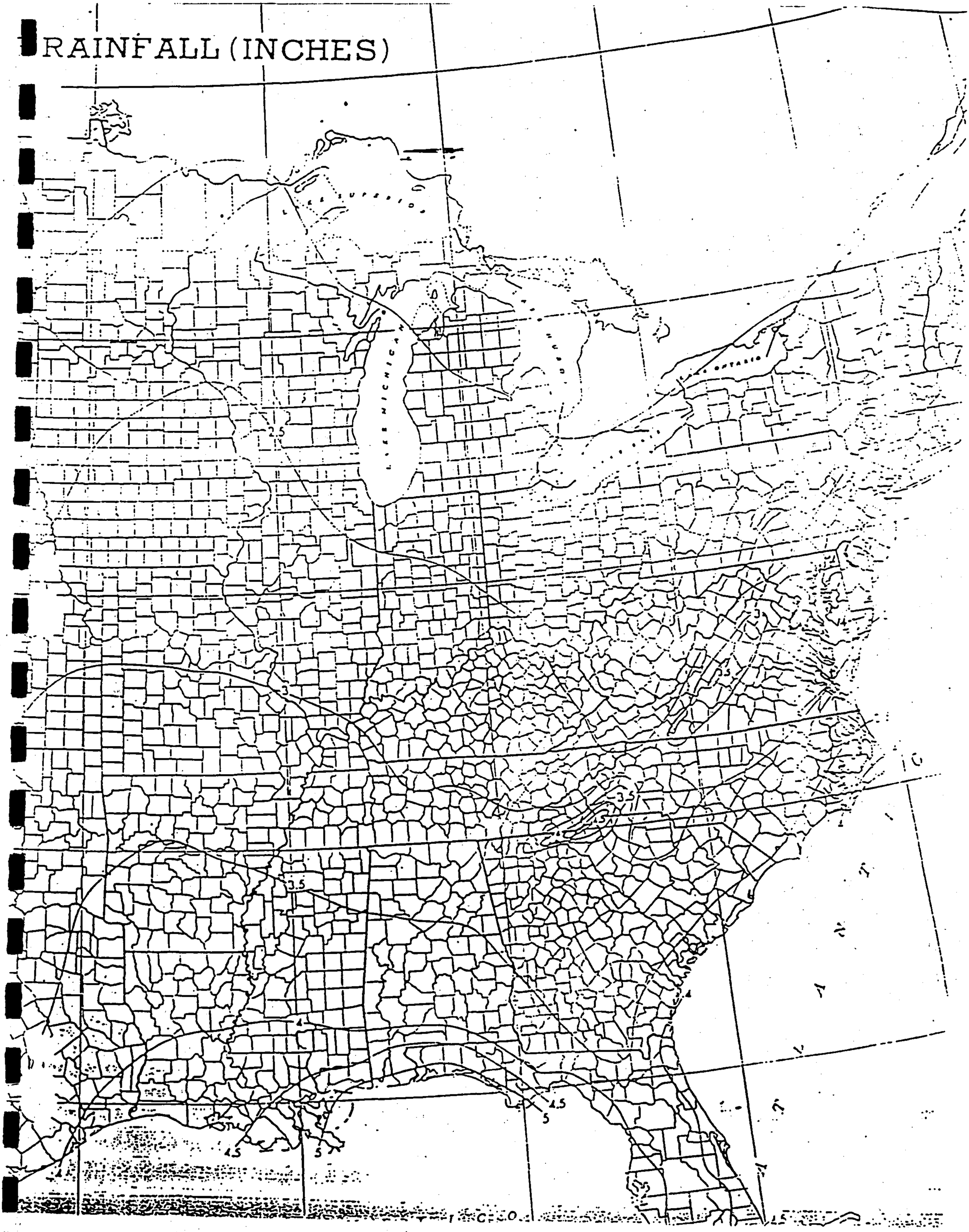


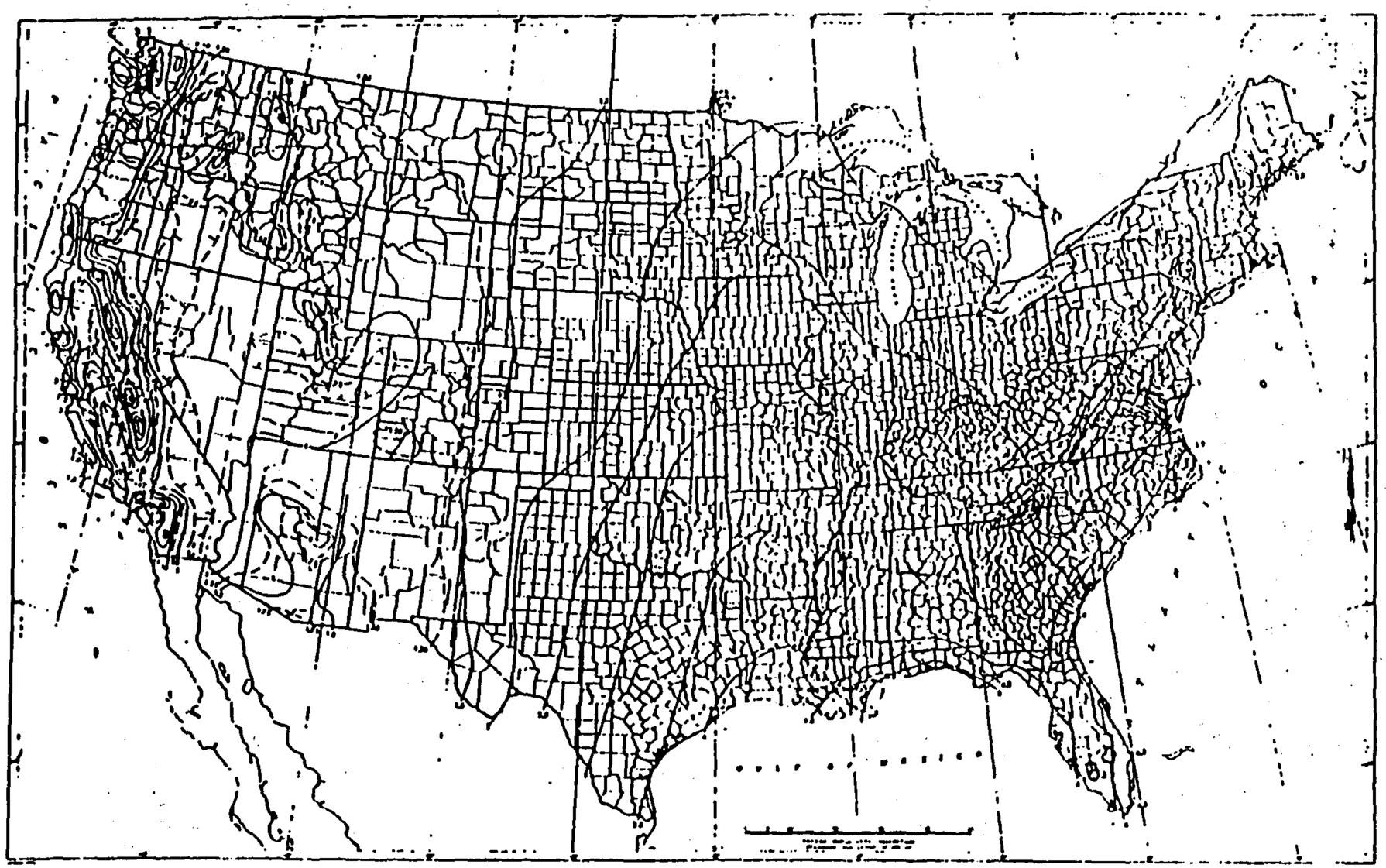


REFERENCE 10

Rainfall Frequency Atlas of the United States, Technical Paper No. 40, US Department of Commerce, US Government Printing Office, Washington, DC, 1963.

RAINFALL (INCHES)

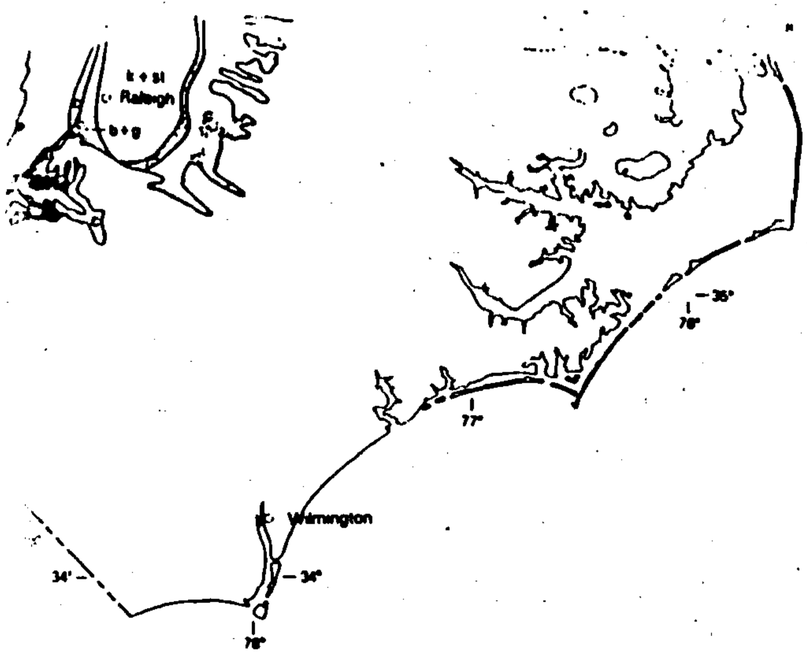




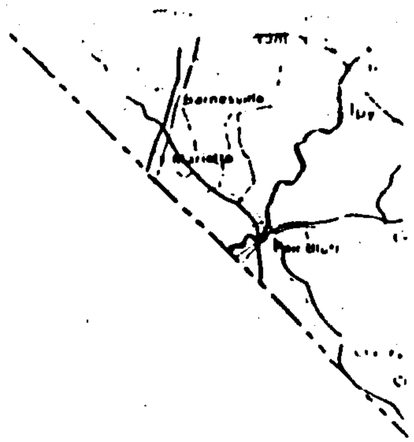
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FIGURE 8
1-YEAR 24-HOUR RAINFALL
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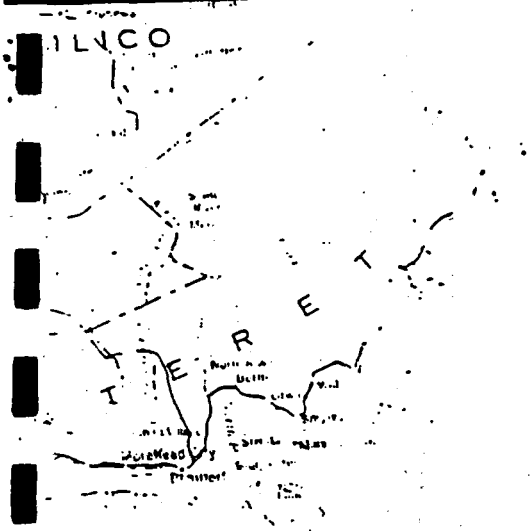
GEOLOGIC MAP OF NORTH CAROLINA

1985

Scale 1:500,000
1 inch equals approximately 8 miles

10 0 10 20 30 40 Miles
10 0 10 20 30 40 50 Kilometres

Reference 11



DEPARTMENT OF NATURAL RESOURCES AND COMMUNITY DEVELOPMENT
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RTH CAROLINA

TIN, GOVERNOR

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mphibolite.

and flowrock

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des hypabyssal

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CAROLINA SLATE BELT

METAMORPHIC ROCKS

€Zy — YADKIN FORMATION — Metamorphosed graywacke, volcanic sandstone, and *siltstone*; interbedded with mafic and intermediate metavolcanic flows and tuffs

€Zmd — METAMUDSTONE AND META-ARGILLITE — Thin to thick bedded; bedding plane and axial-planar cleavage common; interbedded with metasandstone, metaconglomerate, and metavolcanic rock
- $CZmd_3$ - Floyd Church Formation
- $CZmd_2$ - Cid Formation
- $CZmd_1$ - Tillery Formation

} (southwest of Asheboro)

€Zmv — MAFIC METAVOLCANIC ROCK — Metamorphosed basaltic flows and tuffs, dark green to black; interbedded with felsic and intermediate metavolcanic rock and metamudstone
- $CZmv_1$ - Cid Formation (southwest of Asheboro)

€Zfv — FELSIC METAVOLCANIC ROCK — Metamorphosed dacitic to rhyolitic flows and tuffs, light gray to greenish gray; interbedded with mafic and intermediate metavolcanic rock, meta-argillite, and metamudstone
- $CZfv_2$ - Cid Formation (southwest of Asheboro)
- $CZfv_1$ - Uwharrie Formation (at Asheboro and to south)

€Ziv — INTERMEDIATE METAVOLCANIC ROCK — Metamorphosed andesitic tuffs and flows, medium to dark grayish green; minor felsic and mafic metavolcanic rock

€Zv — METAVOLCANIC ROCK — Interbedded felsic to mafic tuffs and flowrock

€Zve — METAVOLCANIC-EPICLASTIC ROCK — Metamorphosed argillite, mudstone, volcanic sandstone, conglomerate, and volcanic rock

€Zc — VOLCANIC METACONGLOMERATE — Includes metagraywacke and metamudstone

€Zph — PHYLLITE AND SCHIST — Locally laminated and pyritic; includes phyllonite, sheared fine-grained metasediment, and metavolcanic rock. In Lilesville granite aureole, includes hornfels ($€Zph_1$), and biotite gneiss and schist (€Zbg)

INTRUSIVE ROCKS

Jd — DIABASE — Dikes, gray to black

PPg — GRANITIC ROCK (Pennsylvanian to Permian, 265-325 my; 11) — Megacrystic to equigranular. Lilesville granite

Pgb — PEE DEE GABBRO (Pennsylvanian, 314 my; 21) — Dark gray to black, medium to fine grained, massive

PzZq — METAMORPHOSED QUARTZ DIORITE — Foliated to massive

PzZg — METAMORPHOSED GABBRO AND DIORITE — Foliated to massive

PzZu — METAMORPHOSED MAFIC ROCK — Metagabbro, metadiorite, and mafic plutonic-volcanic complexes

META-ULTRAMAFIC ROCK — Metamorphosed dunite and peridotite; serpentinite, soapstone, and other altered ultramafic rock. Only larger bodies shown

€Zg — METAMORPHOSED GRANITIC ROCK (Late Proterozoic to late Cambrian, 520-650 my; 3,21,9,23,28,15) — Megacrystic, well foliated; locally contains hornblende. Chapel Hill, Chatham, Farrington, Meadow Flats,

AMPHIB
inclu
layer

€Zbg — BIOTITE
place
and

€Zms — MICA S.
clud
gneis

€Zig — INJECT
and

€Zfg — FELSIC
mica

€Zlg — LINEAT
mus
tion

€Zph — PHYLL
shea

Jr — RHYOL
crys
clay

Jd — DIABA

PPg — GRAN
cry

PPmg — FOLIA
270
Wis

PzZu — META

META
ser
bo

€Zg — META
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DAN RI

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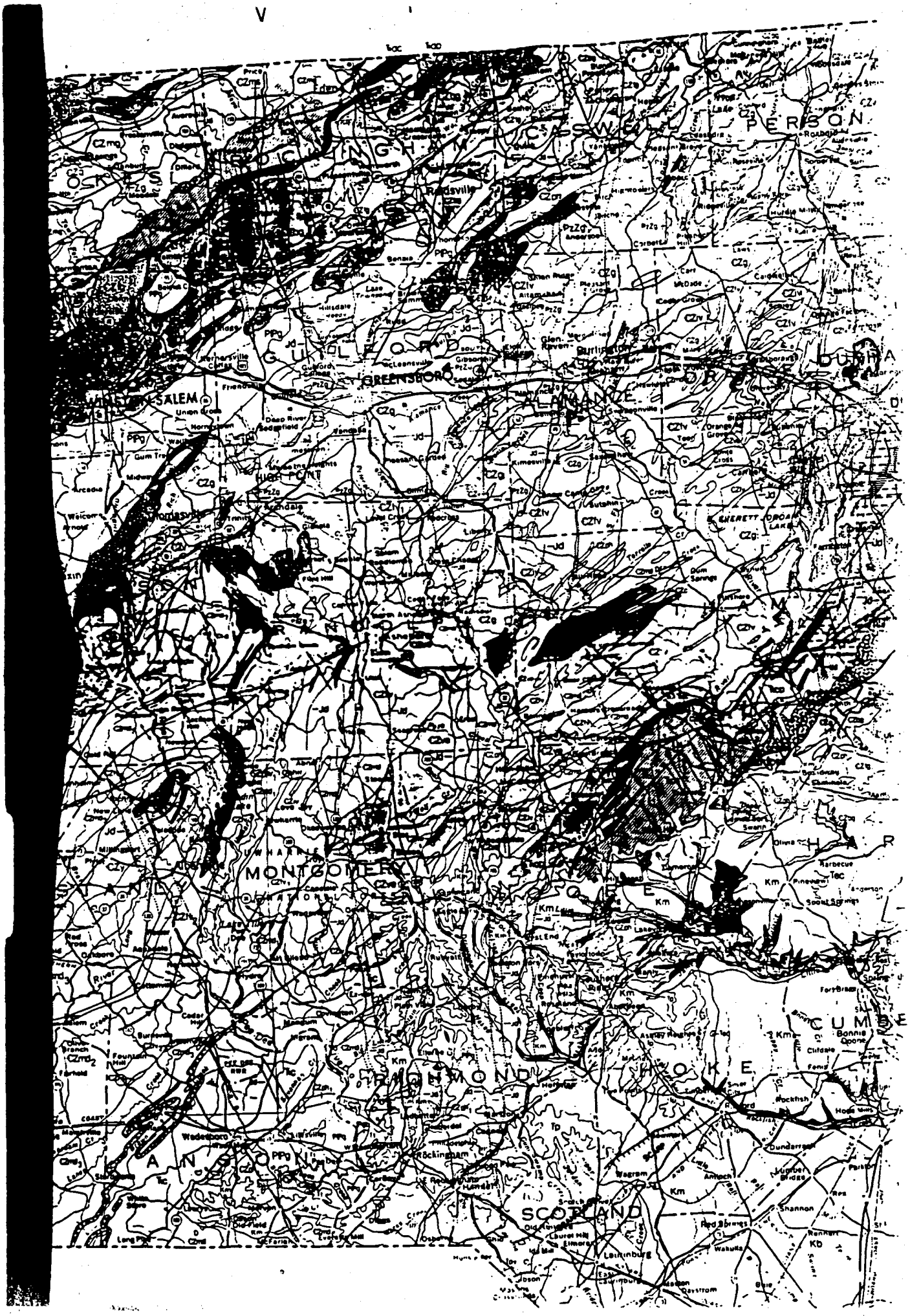
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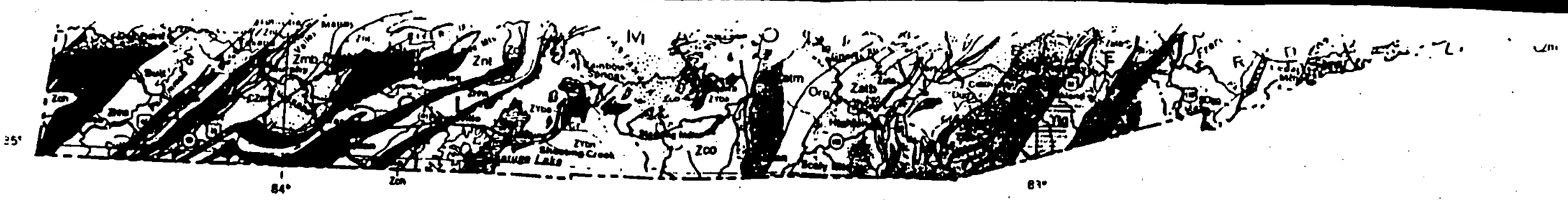
C

Elrod

Jacob

Lumberton

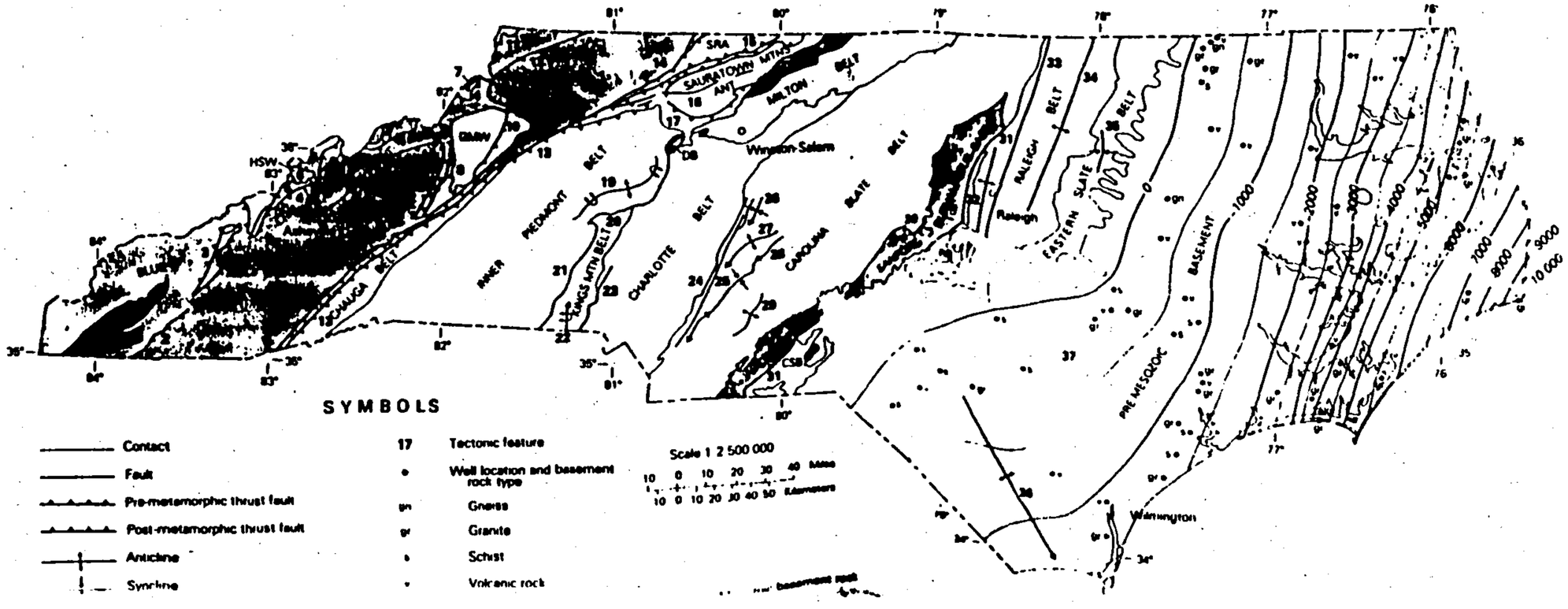

PERSON
CASWELL
ROCKINGHAM
GUILFORD
GREENSBORO
RANDOLPH
DURHAM
ORANGE
CHATHAM
LEE
MONTGOMERY
MOORE
RICHMOND
SCOTLAND
HOKE
CUMBERLAND
ANSON
Reidsville
WINSTON-SALEM
HIGH POINT
Thomasville
Lexington
Asheboro
Wadesboro
Rockingham
Laurinburg
Fayetteville



G E O R G I A

EXPLANATION

- MURPHY BELT
- HSW — HOT SPRINGS WINDOW
- GMW — GRANDFATHER MOUNTAIN WINDOW
- SRA — SMITH RIVER ALLOCHTHON
- BLUE RIDGE BELT
- CHAUGA BELT
- INNER PIEDMONT BELT
- KINGS MOUNTAIN BELT
- SAURATOWN MOUNTAINS ANTICLINORIUM
- CHARLOTTE BELT
- MILTON BELT
- CSB — CAROLINA SLATE BELT
- TRIASSIC BASINS
  - DURHAM, SANFORD } SUB-BASINS
  - WADESBORO BASIN
  - DAN RIVER BASIN (DRB)
  - DAVIE BASIN (DB)
- RB — RALEIGH BELT
- EASTERN SLATE BELT



SYMBOLS

- Contact
- Fault
- Pre-metamorphic thrust fault
- Post-metamorphic thrust fault
- Anticline
- Syncline
- 17 — Tectonic feature
- Well location and basement rock type
  - gn — Gneiss
  - gr — Granite
  - s — Schist
  - v — Volcanic rock

Scale 1 2 500 000

10 0 10 20 30 40 Miles

10 0 10 20 30 40 50 Kilometers

REFERENCE 12

Refernce 12

PRELIMINARY EXPLANATORY TEXT FOR THE 1985 GEOLOGIC MAP OF NORTH CAROLINA

Contractual Report 88-1

by

The North Carolina Geological Survey

November 4,1988

the eastern side of the Charlotte Belt but extending slightly into the Carolina Slate Belt in the vicinity of Randolph County. In this area, the unit is not described in great detail in the published literature. Goldsmith and others (1988) described a unit with almost identical contacts as metavolcanic rocks, undivided, including mafic, intermediate, and felsic volcanic rocks. North of Rocky River and west of the Gold Hill fault zone Stromquist and Henderson (1985) mapped several units that together have contacts corresponding to the metavolcanic rock (CZv) unit. They describe the material as being deeply weathered to soil and saprolite derived from the Cid and Millingport Formations.

CZbg BIOTITE GNEISS AND SCHIST

See Inner Piedmont belt, Chauga belt, Smith River allochthon, and Sauratown Mountains anticlinorium.

CZfg FELSIC MICA GNEISS

Carpenter (1982) and Wilson (1975) mapped units in the Milton belt and Parker (1979) mapped a unit in the Raleigh belt that were compiled into this State Map unit. The unit is predominantly a fine- to medium-grained, commonly equigranular gneiss. The chief minerals are quartz, feldspar, muscovite, and biotite. In Raleigh belt, the unit includes graphitic zones (Parker, 1979). In both belts the felsic gneiss is interlayered with other rock types such as biotite and hornblende gneiss and schist (Parker, 1979; Carpenter, 1982).

CZbf FINE-GRAINED BIOTITE GNEISS

See Kings Mountain belt.

CZg METAMORPHOSED GRANITIC ROCK

This unit is predominantly medium to coarse-grained, equigranular to porphyritic quartz monzonite and granodiorite with lesser amounts of granite, tonalite, and quartz diorite. The rock is massive to well-foliated with common shearing and recrystallization. The replacement of original minerals by minerals of low-rank metamorphic assemblages is almost universal. The largest aerial extent of this unit is in the northern half of the Carolina Slate belt, from Person County to Davidson County. Here the unit consists of single intrusions and complex, multiple intrusions only a few of which are described in detail such as the Roxboro pluton (Glover and Sinha, 1973; Wilson, 1975). Intrusions belonging to this State Map unit also occur in the Charlotte belt, Raleigh belt, and Eastern Slate belt.

Individual intrusions or complexes described in the literature include the Chapel Hill (Hayes, 1962), Farrington (Wagner, 1965), Meadow Flats (Mann and others, 1965), Moriah (McConnell, 1974), Parks Crossroads (Tingle, 1982), Fountain (Mauger and others, 1987), Oxford (Hadley, 1973), and Buckhorn (Parker, 1979) plutons. The description of the unit as a whole is based on detailed descriptions of these individual plutons which comprise a minority of the total surface area of the unit and one reconnaissance description (Carpenter, 1982) of the majority (Person County to Davidson County) of the unit.

REFERENCE 13

DEPARTMENT O) DEVELOPMENT

DIVISION OF MINERAL RESOURCES

JASPER L. STUCKEY, STATE GEOLOGIST

BULLETIN NUMBER 55

Geology and Ground Water

IN THE

Greensboro Area, North Carolina

BY

M. J. MUNDORFF

PREPARED IN COOPERATION WITH THE GEOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF THE INTERIOR

RALEIGH

1948

CONTENTS

	Page
Abstract	viii
Introduction	1
Location of area and scope of the investigation	1
Acknowledgments	2
Geography	2
Introduction	2
Area and population	2
Agriculture and industry	2
Mineral resources	3
Climate	3
Precipitation	3
Temperature	4
Drainage	4
Physiography	4
Geology	7
Introduction	7
Summary of rock units and their water-bearing properties	8
Areal distribution and character of the rocks	7
Gneiss	7
Quartzite and schist	10
Greenstone schist	11
Sericite schist	12
Slates	12
Sheared granite	13
Diorite	15
Porphyritic granite	15
Triassic (Newark group)	16
Ground water	18
Source	18
Occurrence	18
The water table	19
Fluctuations of the water table	20
Records of water-level fluctuations in the Greensboro area	21
Utilization of ground water	23
Dug wells	23
Bored wells	24
Drilled wells	24

CONTENTS—CONTINUED

	Page
Factors to be considered in selecting a well site	25
Rock texture	26
Cleavage and schistosity	26
Bedding planes	26
Joints and fractures	26
Quartz veins	26
Dikes	26
Completion and testing of drilled wells	27
The rock units and their water-bearing properties	28
Introduction	28
Relative water-bearing properties of the rock units	28
Effect of topographic location	30
Relation of depth of well to yield	32
Gneiss	32
Quartzite and schist	35
Greenstone schist	37
Sericite schist	39
Slate	40
Sheared granite	42
Diorite	45
Porphyritic granite	46
Triassic (Newark group)	47
County descriptions	49
Introduction	49
Alamance County	50
Geography, physiography, and drainage	50
Geology	50
Ground water	51
Municipal supplies	53
Caswell County	62
Geography, physiography, and drainage	62
Geology	62
Ground water	63
Municipal supplies	64
Forsyth County	69
Geography, physiography, and drainage	69
Geology	69
Ground water	69
Municipal supplies	71

CONTENTS—CONTINUED

	Page
Guilford County	76
Geography, physiography, and drainage	76
Geology	77
Ground water	77
Municipal supplies	79
Rockingham County	90
Geography, physiography, and drainage	90
Geology	91
Ground water	92
Municipal supplies	93
Stokes County	100
Geography, physiography, and drainage	100
Geology	101
Ground water	102
Municipal supplies	104

ILLUSTRATIONS

Plate 1.	Geologic map of the Greensboro area, North Carolina	after 6
2.	Map of the Greensboro area, North Carolina, showing location of wells and springs listed in the report	after 49
3.	View illustrating the flatness of the upland surfaces, which are remnants of the uplifted and dissected peneplane	5
4.	View of the escarpment along the southeastern side of the Triassic basin at Madison	5
5.	Interbedded gneiss and schist in northwestern Forsyth County, three quarters of a mile east of Yadkin River on State Highway 67	9
6.	Sauratown Mountain from the south.	
7.	Sheared granite with inclusions of older gneiss, both cut by mafic dikes	14
8.	Close-up of the sheared granite	14
9.	A. Porphyritic granite intimately intruded into biotite gneiss and schist near Oak Ridge in Guilford County. B. Close-up showing coarse texture of the granite	16
10.	Drilling rigs used in the two principal methods of drilling wells in the Greensboro area: A. Cable tool (percussion) method. B. Core-drilling with chilled shot	24

ILLUSTRATIONS—CONTINUED

		Page
11.	Bedded gneiss in a quarry at Stacey, Rockingham County	35
12.	Slate containing quartz veins through the fractures of which ground water circulates	42
13.	Granite quarry in east edge of Winston-Salem	44
14.	Triassic arkosic sandstone and shale between Walnut Cove and Madison	47
Figure 1.	Index map of North Carolina showing the location of the Greensboro area and other places where ground-water investigations have been made	1
2.	Cross-section of the Triassic basin near Walnut Cove, showing the physiography and structure	6
3.	Diagram illustrating several types of rock interstices	19
4.	Diagrammatic section illustrating the relation of the water table to the topography	20
5.	Hydrographs of observation wells in the Greensboro area showing the height of water above the assumed datum near the end of each month	21
6.	Fluctuations of the water levels in two observation wells and cumulative departure from normal precipitation at nearby stations	22
7.	A. Average yield, per foot of well, of wells in the different rock units. B. Average yield, per foot of well, according to range in depth. C. Average yield, per foot of well, according to topographic location	28
8.	Average yield, per foo tof well, of wells in the different rock units, according to range in depth	33
9.	Average yield, per foot of well, of wells in the different rock units, according to topographic location	34

ABSTRACT

The Greensboro area is in the north-central Piedmont of North Carolina and includes Alamance, Caswell, Forsyth, Guilford, Rockingham, and Stokes Counties.

The area includes 2,975 square miles and had a population of 438,404 in 1940.

The area lies entirely within the Piedmont province, which is characterized by flat to rolling upland surfaces, separated by stream valleys, with a few scattered monadnock hills.

Except for a belt of sandstones and shales along Dan River, the area is underlain by igneous and metamorphic rocks, consisting chiefly of gneiss, schist, slate, and granite.

Wells drilled in greenstone schist have a considerably higher average yield than wells in any other rock unit. The average yield of municipal and industrial wells in this rock is 55 gallons a minute. In granite, gneiss, and the Triassic sandstones and shales, the average yield of municipal and industrial wells is 33 to 35 gallons a minute.

Topographic location has an important bearing on the amount of water yielded by wells. The average yield of wells drilled in draws and valleys is more than 3½ times greater than the average yield of wells drilled on hills. It is probable that draws and valleys mark the location of sheared and fractured zones in which the rocks are saturated with water, whereas hills occupy areas of massive, unbroken rock which contain, and will yield, relatively little water.

Wells drilled where the weathered mantle is thick generally yield larger supplies than those drilled where it is thin.

The yield per foot of well generally decreases with depth and beyond 250 feet drops quite sharply, indicating that it is usually not advisable to drill beyond that depth if the well has not obtained water when it reaches that depth.

Included in the report are a number of tables showing the relation of yield to type of rock, to topographic location, and to depth of wells. The report includes a chapter on the ground-water resources of each of the six counties with tables of well data, chemical analyses, and well logs.

GEOLOGY AND GROUND WATER IN THE GREENSBORO AREA, NORTH CAROLINA

INTRODUCTION

LOCATION OF AREA AND SCOPE OF THE INVESTIGATION

This report, the third of a series on the ground-water resources of the State, gives the results of an investigation of the ground-water resources in a part of the north-central Piedmont of North Carolina. The area consists of Alamance, Caswell, Forsyth, Guilford, Rockingham, and Stokes Counties.

The investigations on which the reports are based are being made through a continuing cooperative agreement between the North Carolina Department of Conservation and Development and the Geological Survey, U. S. Department of the Interior. The program is under the direction of Dr. J. L. Stuckey, State Geologist of North Carolina, and Dr. A. N. Sayre, Geologist in charge, Division of Ground Water, U. S. Geological Survey.

The first report, published as Bulletin 47 of the North Carolina Department of Conservation and Development, is a progress report giving general information on ground-water resources of the entire State, with particular emphasis on the Coastal Plain.

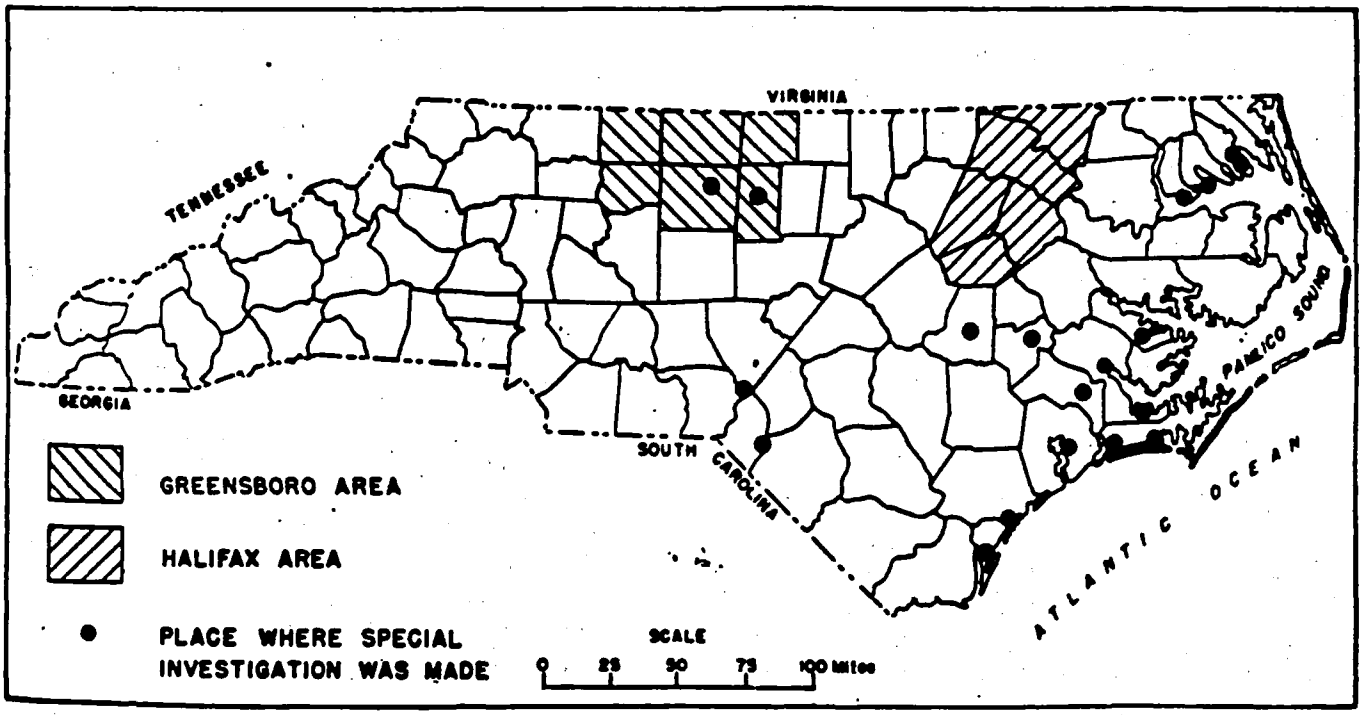


Fig. 1—Index map of North Carolina showing the location of the Greensboro area and other places where ground-water investigations have been made.

The second report, published as Bulletin 51, gives the results of an investigation of the ground-water resources of the Halifax area, including Edgecombe, Halifax, Nash, Northampton, and Wilson Counties.

Because of the many military establishments constructed in North Carolina during the war, most of which utilize ground water, a considerable amount of time has been devoted to special investigations and reports regarding ground-water supplies for military bases, war plants, and contiguous civilian housing areas. The index map (fig. 1) shows the areas in which investigations have been made.

The field work in the Greensboro area was done principally in the summers and autumns of 1942 and 1943 and consisted of obtaining data on about 1,300 wells, a number of springs, and the 23 municipal supplies, collecting samples of water, and noting the geologic and topographic setting of the wells. Information on the wells was obtained by interviewing well owners and operators and well drillers. A great deal of the information was given from memory and some of it, therefore, may be somewhat inaccurate.

During the course of the field work it was found that existing geologic maps were so generalized as to be wholly inadequate for use with the hydrologic data secured. Therefore, an additional 5 weeks were spent in the autumn of 1944 in mapping the geology on a reconnaissance scale. It should be emphasized that the geologic map (pl. 1) is based on these few weeks of field work plus notes made during the collection of hydrologic data in 1942 and 1943; and, in detail, the geology of the area is a great deal more complex than is shown by the map. Rocks of similar geologic and hydrologic characteristics have generally been mapped together. Also, some rocks of different kinds have been mapped together because they occur together in such a way that only mapping on a large scale, requiring a great deal of time, would permit their separation. The belt mapped as gneiss is a good example of this in that several types of gneiss and schist may alternate repeatedly in a short distance.

ACKNOWLEDGMENTS

Nearly all the chemical analyses were made by members of the Quality of Water Division, U. S. Geological Survey. The names of the analysts are given in the tables of analyses.

The writer wishes to acknowledge the courteous and generous assistance of the well owners, well drillers, school superintendents, superintendents of public water supplies, and many others. Without their aid the investigation could not have been successfully completed. Especial acknowledgment is due the well drillers, including the Carolina Drilling and Equipment Co., Danville Well Drilling Co., Heater Well Co., M. A. Holder, John Hopkins, W. B. Mayhew, J. A. Rich, F. L. Smith, J. Stafford, Sydnor Pump and Well Co., Virginia Machinery and Well Co., and Well Drillers Inc., who generously gave their time and effort in furnishing records of wells drilled by them.

GEOGRAPHY

INTRODUCTION

Area and population.—The Greensboro area is in the north-central part of the State, bordering the Virginia State line, and includes Alamance, Caswell, Forsyth, Guilford, Rockingham, and Stokes Counties, with a total area of 2,975 square miles. The location of the Greensboro area is shown in figure 1.

The area had a population of 438,404 in 1940, about 147 to the square mile, according to the U. S. Census Bureau report. There are 18 incorporated cities and towns with an aggregate population of 219,121, which is 50 percent of the total population of the area. Four cities, Burlington, Greensboro, High Point, and Reidsville, have a population of more than 10,000, and nine other cities and towns have a population of more than 1,000.

Agriculture and industry.—More than 79 percent of the area is included in farms, nearly half the total area of the farms, however, being woodland. The total value of the farm products in 1939, according to the 1940 census, was $20,599,677, tobacco accounting for slightly more than half the total. Other important products are livestock, dairy products, poultry and eggs, corn, wheat, hay, potatoes, and vegetables.

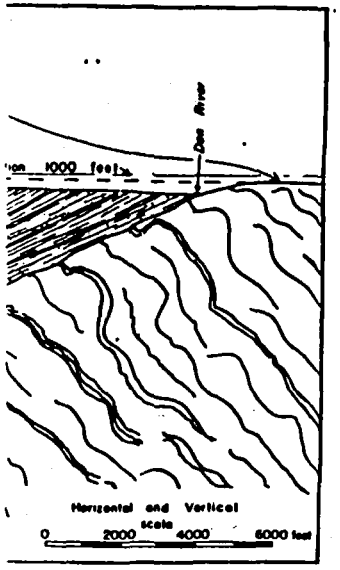
Manufacturing is the most important occupation in the area, with 67,607 wage earners being employed in 1939. The 1940 census report lists 526 manufacturing establishments in the Greensboro area. The total value added to that of the raw materials by the operations of these establishments in 1939, exclusive of the establishments in Forsyth and Rockingham Counties which are not reported, is more than $61,000,000. If these two counties were included, the total value added by manufacture probably would be well above $100,000,000. The textile industry, chiefly cotton, is the most important, employing about 65 percent of all factory workers. Tobacco manufacture, principally the manufacture of cigarettes, is next in importance, followed by furniture, food, chemicals, and lumber.

ance to erosion; and because the beds were developed on the more resistant has considerably modified the drainage f structural control is that of the Dan North Carolina-Virginia line, a distance ward into the northwestern corner of of Triassic sediments between Walnut northeastward to Danville, Virginia, ntact between the Triassic shales and s and schists is generally several hun- river flows. Dan River meanders con- st the metamorphic rocks to the south- he Triassic shales by the greater resist-

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lat areas of considerable extent. Drain- hese areas in contrast to the complex

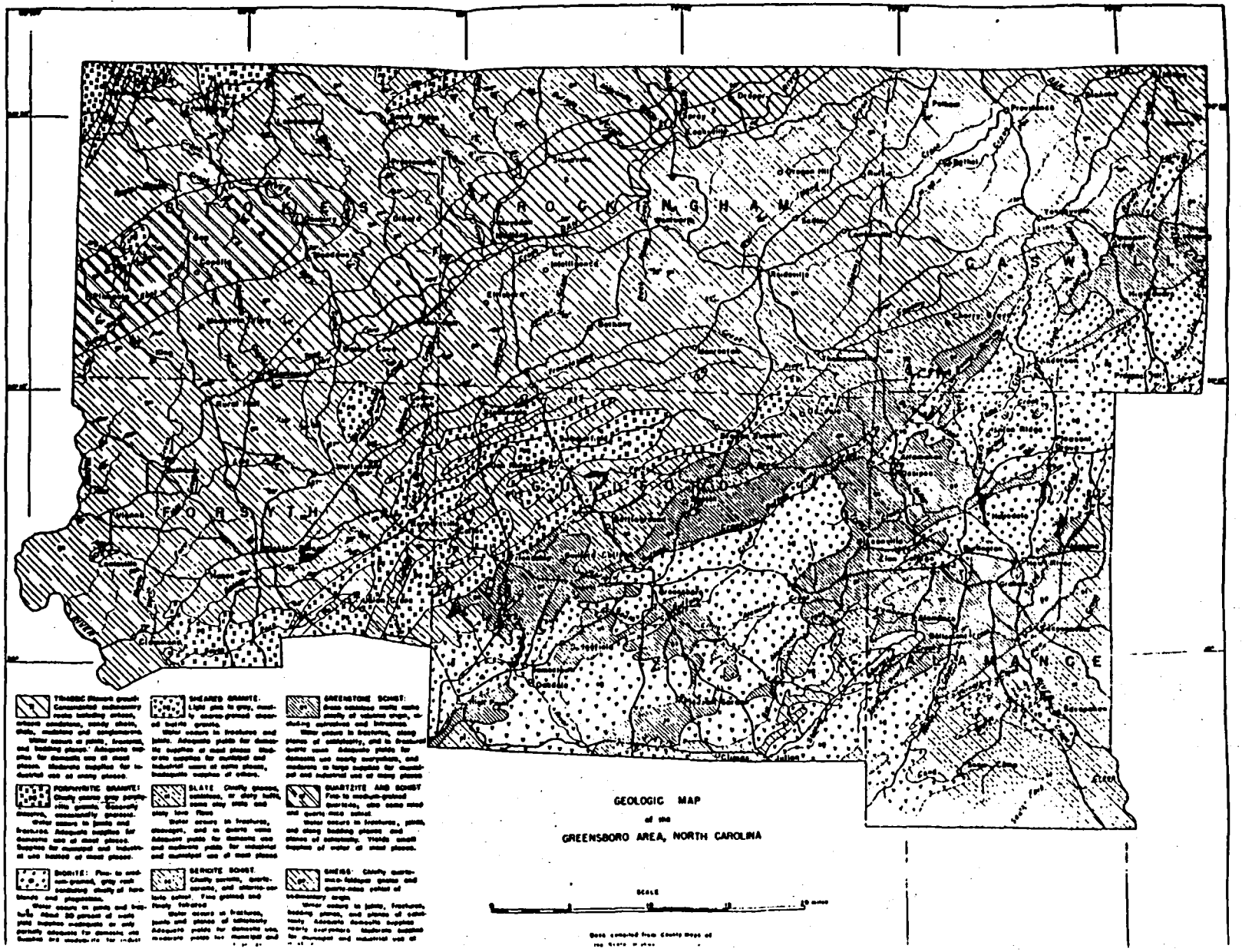
lissected and the topography is in the s, remnants of the peneplane are pre- This uniformity is illustrated in plate



he physiography and structure.

STATE BULLETIN 88, PLATE 1

UNITED STATES DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY
IN COOPERATION WITH
NORTH CAROLINA DEPARTMENT OF CONSERVATION AND DEVELOPMENT



Above-normal rainfall during 1935 and 1936 resulted in high ground-water levels in the spring in 1935, 1936, and 1937. However, the excess of rain did not prevent the water level from declining to near-normal levels in the autumn of each year. Below-normal rainfall in the winter and spring of 1938 prevented the normal winter and spring rise; and although about the normal amount of rain fell during the remainder of the year, the water level in the Lindale well reached record low stages. Because of the above-normal rainfall during the last part of 1938 at Haw River, the Governor Holt well did not decline to record lows. Rainfall and water levels in both wells were not far from normal in 1939 and 1940. Below-normal rainfall in nearly every month of 1941 and in January 1942 resulted in record low levels in both wells during the first part of February 1942. Approximately normal rainfall during February and March did not suffice to raise the water level of either well back to normal, evidently because of a very large deficiency in soil moisture. With approximately normal rainfall during the remainder of the year, both wells were at below-normal levels. However, the water level at the end of the year was not far below normal and evidently the soil-moisture deficiency was not large because the water level made its usual spring recovery in 1943 with normal or below-normal rainfall. Above-normal rainfall in 1944 built up the water table to a very favorable position at the end of 1944, although no record high was reached.

UTILIZATION OF GROUND WATER

Ground water in the Greensboro area is obtained from wells and springs. The different types of wells include dug, bored, and drilled wells.

Dug wells.—More domestic water supplies in the Greensboro area are obtained from dug wells than from any other type. Dug wells in the area range from a few feet to nearly 100 feet in depth. The hole is generally dug between 30 and 60 inches in diameter. When the well is curbed with terra cotta or concrete pipe, the inside diameter usually is 24 to 30 inches. The inside diameter of masonry- or rock-curbed wells and uncurbed wells generally is somewhat greater. Dug wells have certain advantages over other types of wells but also have certain disadvantages. Probably the most important consideration that leads to the choice of a dug well is that of cost. Generally this is the least expensive method of obtaining a water supply, with the possible exception of bored wells. Furthermore, many wells on farms and on the fringes of towns are dug by the owner in his spare time or in slack seasons, so that there is no cash outlay from digging. However, cost is not always in favor of the dug well, particularly where bedrock is encountered before a satisfactory supply is obtained. The cost of dug wells under such conditions has been reported at several places to have exceeded the cost of the average drilled well in the neighborhood. A second advantage of the dug well is the large storage capacity as compared particularly with the small-diameter drilled wells. A well 24 inches in diameter will contain nearly 24 gallons of water per foot of depth, as compared to 1½ gallons and 1/6 gallon per foot of depth for wells 6 inches and 2 inches in diameter, respectively. Thus, even though the yield of a well may be very low, a fairly large quantity of water can be withdrawn in a short time.

Dug wells have two important disadvantages. Usually the depth of water in a dug well is not great, either because of the difficulty involved in digging below the water table or because bedrock is encountered. In periods of drought, therefore, many dug wells go dry. A second disadvantage is that the water in these wells is much more susceptible to pollution or contamination by the entrance of impure surface water. A survey made in Pennsylvania in 1930 and 1931, during which 17,665 water supplies were examined for purity, showed that the supplies from 90 percent of the drilled wells were safe whereas less than 50 percent of the supplies from dug wells were safe[1].

The danger of contamination of dug wells can be decreased by observing certain precautions. All dug wells should be covered tightly to prevent direct entrance of contaminating material, either solid or liquid. The well should be cased or curbed with tile or concrete pipe or similar material and the joints should be cemented to a depth of at least a few feet below the water table, but in any event to a depth of at least 10 feet below the surface. The space between the walls and the curbing should be filled, above the water-bearing bed, with clay. The dug well should be located several hundred feet from any source of contamination and up the ground-water slope from any nearby source of contamination.

[1] Lohman, Stanley W., Ground water in northeastern Pennsylvania; Pennsylvania Topog. and Geol. Survey Bull. W4, p. 40, 1937.

ANALYSES OF GROUND WATER FROM FORSYTH COUNTY, NORTH CAROLINA

(Analysts: E. W. Lohr and M. S. Berry, U. S. Geological Survey. Numbers at heads of columns correspond to numbers in table of well data)

(parts per million)

	2	3	93	124	164
Silicia (SiO_2)	31	28	22	31	29
Iron (Fe)	.02	.02	.03	.03	.03
Calcium (Ca)	5.7	22	64	23	6.7
Magnesium (Mg)	3.1	8.0	24	7.4	3.0
Sodium and Potassium (Na+K)	14	7.2	67	7.0	1.3
Carbonate (CO_3)	0	0	0	0	0
Bicarbonate (HCO_3)	63	112	46	92	30
Sulfate (SO_4)	3.2	9.1	10	17	3.7
Chloride (Cl)	1.2	1.5	225	5	1.2
Fluoride (F)			.0	.5	
Nitrate (NO_3)	.0	.0	47	2.0	2.2
Dissolved solids	89	130	603	143	71
Total hardness as $CaCO_3$	27	88	258	88	29
Date of collection	May 21, 1943	May 20, 1943	Oct. 16, 1942	Oct. 13, 1942	May 19, 1943
Depth (feet)	130	350	714	308	110
Chief aquifer	Gneiss	Gneiss	Gneiss	Granite	Granite

GUILFORD COUNTY

(Area, 651 square miles; population, 153,916)

Geography, physiography, and drainage.—Guilford County, in the south-central part of the Greensboro area, is the largest of the six counties and has the largest population. It has four incorporated cities and towns and about 14 unincorporated towns and villages. Greensboro, located in the center of the county, is the largest city and county seat. High Point, the only other city, is in the extreme southwestern corner of the county. Greensboro is an important center of textile manufacturing and High Point also has a number of textile factories, although it is better known as a center of furniture manufacturing. There are a few factories in the smaller towns and villages, but the remainder of the county is dominantly agricultural. Guilford County has a good system of paved roads and railroads, most of which radiate from Greensboro.

Guilford County is in the Piedmont physiographic province. Its surface is formed by the uplifted and partially dissected peneplane of that province. The land surface near the larger streams is gently rolling, with a relief of 100 to 150 feet. The interstream areas are broad and generally quite flat. No large trunk streams flow through or near Guilford County and therefore there are no deep valleys. Because the base-level is higher, dissection has generally been less extensive than in other counties of the Greensboro area. Guilford County is underlain by rocks of several different types. Because some of these differ considerably in resistance to erosion, both the topography and the drainage pattern are greatly influenced by the geology. However, topographic maps have not been made of any part of the county, and the geology is complex and at many places obscure, so that the exact relation of the topography and drainage to the geology cannot always be ascertained. The outstanding feature is the northeastward trend of the ridges and streams. Apparently some of the streams flow along or near the contact between different kinds of rocks, whereas others flow in weaker rocks, the more resistant rocks forming interstream divides. The major exception to the northeastward trend of the streams is Deep River, which flows southeastward chiefly across diorite and granite, which are uniformly resistant.

Practically all of Guilford County is drained by the two main branches of the Cape Fear River system, Haw River and Deep River. About 75 percent of the county is drained by Haw River and its tributaries, the most important of which are Reedy Fork, Buffalo Creek, and Alamance Creek. Practically all of the remaining 25 percent is drained by Deep River, only a few square miles of the southwest corner of the county draining southward into Yadkin River.

Geology.—The geology of Guilford County apparently is more complex than that of any other county of the Greensboro area. Seven of the nine geologic units crop out in Guilford County and the areal distribution of most of them is quite irregular.

The gneiss unit crops out in several irregular belts extending northeastward across the northwestern corner of the county. These belts are separated by areas of porphyritic granite, which was intruded into the gneiss. The principal rocks of the gneiss unit are banded quartz-mica-feldspar gneiss and quartz-mica schist. They are chiefly of sedimentary origin, and although the rocks have been greatly changed by metamorphism at many places the bedding planes can still be distinguished. The granite has intimately intruded the gneiss so that the boundaries between the two units necessarily are greatly generalized.

The greenstone schist crops out in large, irregularly shaped areas in the southeastern two-thirds of the county. These areas are separated by areas of sheared granite. The greenstone schist consists of a green fine- to medium-grained basic schistose rocks, chiefly of volcanic origin. At most places the rock is highly schistose but at a few places it is coarser and fairly massive.

The sericite schist crops out in a belt extending northeastward across the county from a point near Guilford College. It is closely associated with the greenstone schist and may be a metamorphosed tuff or possibly a metamorphosed clay. The rock is greatly weathered, and usually the only recognizable minerals are quartz, sericite and iron oxide, the latter apparently an oxidation product of chlorite and hornblende.

The slate unit is limited to a narrow, highly irregular belt extending across the southeastern corner of the county and to a small patch in the south edge of High Point. The rocks are mostly tuffaceous slates but include some clay slates.

The sheared granite is exposed over about 50 percent of the southeastern half of the county, where it forms a fairly continuous area interrupted by large patches of greenstone and slate. The granite is generally a moderately coarse pink schistose and gneissic rock consisting chiefly of quartz, biotite, and feldspar. The granite has been considerably metamorphosed and intensely sheared. The outstanding feature of the granite is the schistose and slaty dikes, which are green in color and greatly resemble the greenstone schists.

Diorite crops out at a number of places but was mapped separately at only two places. The outcrops otherwise are too small or not well enough exposed to map separately. Places where diorite crops out but is not shown on the map include the vicinity of Sedgefield, Pleasant Garden, along State highway 62 between Climax and High Point, and an area about 6 miles north of High Point. The diorite is a medium- to coarse grained, dark-gray to greenish-gray rock consisting chiefly of plagioclase and hornblende. It generally is massive but at a few places is somewhat schistose.

The porphyritic granite outcrops in irregular, elongated patches across the northwestern corner of the county, where it is closely associated with the gneiss. In places the gneiss has been completely assimilated by the granite but in other places the gneiss has only been impregnated by emenations from the granitic magma. Because the granite has so intimately intruded the gneiss and because every gradation between true granite and true gneiss can be found, the map is necessarily greatly generalized.

The porphyritic granite is generally coarse-grained and medium gray, with large phenocrysts of feldspar. The ground mass consists of quartz, biotite, and feldspar. At most places the granite is entirely massive, but at some places the granite has some of the schistosity of the gneiss.

Ground water.—Nearly all domestic water supplies, many industrial supplies, and one of the three municipal water supplies are obtained from wells.

Dug wells are extensively used for domestic supplies in rural districts. Generally they are from about 15 to 50 feet deep and 2½ to 4 feet in diameter. Wells can generally be dug deep enough in gneiss and schist that they will not go dry even during a drought. However, at some places in granite, diorite, greenstone schist, and slate, the rock is so close to the surface that dug wells frequently go dry.

Bored wells are used considerably in suburban areas and are cheaply and easily constructed. They are bored by power-driven earth augers and cannot go below the completely weathered zone. For this reason, they are not always successful in rocks such as granite and diorite, where the water table at times declines below the weathered zone. Most bored wells are cased, and where they are properly constructed and of sufficient depth that they will not go dry, they are a satisfactory source of supply. Dug and bored wells

obtain their water from the weathered rock material at and just below the water table. For this reason, extra precautions must be observed to prevent contamination.

There are a large number of drilled wells in Guilford County. Records of more than 350 drilled wells are given in the tables of well data. Many of these were core-drilled with chilled shot and are 2 or 3 inches in diameter. There are many other core-drilled wells in Guilford County which do not appear in the table. Core-drilled wells have the advantages of all drilled wells and are cheaper than the larger percussion-drilled wells. However, although they are satisfactory for domestic wells, their small size makes them unsatisfactory for most industrial plants. About 7 or 8 gallons a minute is the maximum rate at which water can be removed from a 2-inch well by a deep-well pump. The average yield of 157 wells 2 inches in diameter in Guilford County is 6 gallons a minute and the average yield of 20 wells 3 inches in diameter is 10½ gallons a minute. These quantities are near the maximum amount that can be pumped from wells of that diameter and suggest that many of the wells would yield more than can be withdrawn from the well.

Most industrial, and public-supply wells are drilled with a percussion drill and are from 4 to 8 inches in diameter. The 6-inch well is by far the commonest. The larger-diameter wells encounter more fractures and cracks than small-diameter wells. Also, because a larger pump can be used, more water can be pumped from a large-diameter well than from a small-diameter well.

Drilled wells, both core-drilled and churn-drilled, have certain advantages over dug or bored wells. Because they are generally tightly cased and the water is obtained from crevices in the rock, they are much less liable to contamination. The depth of water in the well is generally large in comparison with the fluctuation of the water level, so that the yield decreases only slightly during a drought.

A summary of data on drilled wells 3 inches or more in diameter is given below:

TABLE 16—SUMMARY OF DATA ON WELLS IN GUILFORD COUNTY
(Drilled wells 3 inches or more in diameter)

ACCORDING TO ROCK TYPE

TYPE OF ROCK	Number of Wells	Average Depth (feet)	Yield (gallons a minute)			Percent of wells yielding less than 1 gallon a minute
			Range	Average	Per foot of Well	
Gneiss	90	123	1— 50	15.6	0.126	5.0
Greenstone schist	67	163	1—200	36.5	.223	3.0
Sericite schist	8	118	5— 30	11.1	.105	0
Slate	4	273	8— 13	10.3	.039	0
Sheared granite	54	175	0— 70	14.4	.082	13.0
Porphyritic granite	26	137	½— 30	10.9	.079	3.8
All wells	179	158	0—200	22.0	.139	6.1

ACCORDING TO TOPOGRAPHIC LOCATION

TOPOGRAPHIC LOCATION	Number of Wells	Average Depth (feet)	Yield (gallons a minute)			Percent of wells yielding less than 1 gallon a minute
			Range	Average	Per foot of Well	
Hill	41	203	0—100	15.5	0.076	24.4
Flat	44	170	0—200	22.2	.131	2.3
Slope	55	130	2—130	21.8	.168	0
Draw	16	125	2½— 75	22.8	.182	0
Valley	22	158	10—100	34.4	.218	0

REFERENCE 14

Reference 14

SOIL SURVEY OF

Guilford Cc rth Carolina



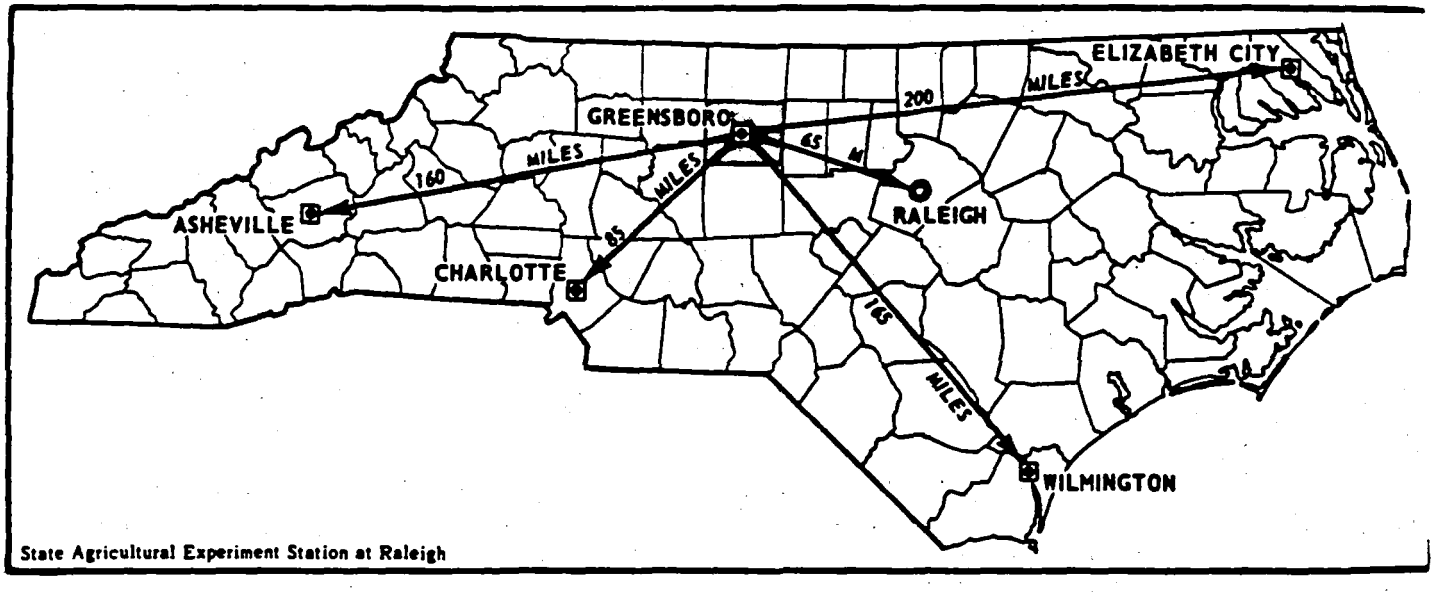
United States Department of Agriculture
Soil Conservation Service

In cooperation with
Board of Commissioners, Guilford County, North Carolina, and
North Carolina Agricultural Experiment Station

Contents

	Page
Index to soil mapping units	iv
Summary of tables	v
Foreword	vii
Introduction	1
General nature of the county	1
Climate	1
History	2
Cultural facilities	2
Industry and transportation	2
Water supply	3
Land use	3
How this survey was made	3
Soil map for general planning	4
1. Cecil-Madison association	4
2. Madison-Cecil association	5
3. Enon-Mecklenburg association	5
4. Wilkes-Enon association	5
5. Coronaca-Mecklenburg association	6
6. Appling-Vance-Helena association	6
7. Chewacla-Wehadkee-Congaree association	6
Soil maps for detailed planning	7
Soil descriptions and potentials	7
Planning the use and management of the soils	25
Crops and pasture	25
Yields per acre	26
Capability classification	27
Woodland management and productivity	27
Engineering	28
Building site development	29
Sanitary facilities	29
Construction materials	30
Water management	31
Recreation	32
Wildlife habitat	32
Soil properties	33
Engineering properties	34
Physical and chemical properties	34
Soil and water features	35
Soil test data	36
Classification of the soils	36
Soil series and morphology	36
Appling series	36
Cecil series	37
Chewacla series	37
Congaree series	38
Coronaca series	38
Enon series	38
Helena series	39
Iredell series	39
Madison series	39
Mecklenburg series	39
Sedgefield series	40
Vance series	40
Wehadkee series	41
Wilkes series	41
Classification	41
Formation of the soils	42
Climate	42
Plant and animal life	42
Relief	43
Time	43
Parent materials	43
Literature cited	44
Glossary	44
Tables	beginning 49

Issued December 1977



Location of Guilford County in North Carolina.

SOIL SURVEY OF GUILFORD COUNTY, NORTH CAROLINA

By Ronald B. Stephens

Soils surveyed by E. H. Karnowski, R. B. Stephens, Marcus R. Bostian, R. L. Howard, Roger J. Leab, and Michael L. Sherrill, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in cooperation with Board of Commissioners, Guilford County, North Carolina, and North Carolina Agricultural Experiment Station

Introduction

GUILFORD COUNTY is an agricultural, industrial, and urbanized county in north-central North Carolina (See map on facing page). It is bounded on the east by Alamance County, on the north by Rockingham County, on the west by Forsyth County, and on the south by Randolph County. The area of Guilford County is 415,940 acres. In 1970 the population was 288,590. The City of Greensboro is the county seat and is at the geographic center of the county.

Guilford County is in the Piedmont physiographic province. The county is generally rolling with moderately steep slopes along the drainageways.

Guilford County is rapidly growing into an industrial and urban county. Well diversified industry, government at all levels, educational institutions, wholesale and retail outlets, and transportation all contribute substantially to the economy of the county.

The northern part of the county is still primarily agricultural. Tobacco provides about 80 percent of the gross farm income from the major crops. Corn, hay, wheat, soybeans, oats, sweet potatoes, Irish potatoes, lespedeza seed, and cotton account for most of the remaining farm income. Beef and dairy livestock and poultry are also raised.

General Nature of the County

This section gives general facts about Guilford County. It briefly discusses climate, history, cultural facilities, industry and transportation, water supply, and land use.

Climate

Guilford County is hot and generally humid in summer because of its moist maritime air. Winter is moderately cold but short because the mountains to the west protect the county against many cold waves. Precipitation is quite evenly distributed throughout the year and is adequate for all crops.

Table 1 gives data on temperature and precipitation for the survey area, as recorded at Greensboro for the period 1951 to 1974. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on the length of the growing season.

In winter the average temperature is 40 degrees F, and the average daily low is 29 degrees. The lowest temperature on record, -1 degree, occurred at Greensboro on January 16, 1972. In summer the average temperature is 76 degrees, and the average daily high is 86 degrees. The highest temperature, 102 degrees, was recorded on June 27, 1954.

Growing degree days, shown in table 1, are equivalent to "heat units." Beginning in spring, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

Of the total annual precipitation, 22 inches, or 52 percent, usually fails during the period April through September, which includes the growing season for most crops. Two years in 10, the April-September rainfall is less than 19 inches. The heaviest 1-day rainfall during the period of record was 6.24 inches at Greensboro on October 15, 1954. Thunderstorms number about 47 each year, 29 of which occur in summer.

Average seasonal snowfall is 11 inches. The greatest snow depth at any one time during the period of record was 15 inches. On the average, 4 days have at least 1 inch of snow on the ground, but the number of days varies greatly from year to year.

The average relative humidity in midafternoon is about 55 percent. Humidity is higher at night in all seasons, and the average at dawn is about 85 percent. The percentage of possible sunshine is 64 percent in summer and 54 percent in winter. Prevailing winds are southwesterly. Average windspeed is highest, 9 miles per hour, in March.

In winter every few years heavy snow covers the ground for a few days to a week. Every few years in late summer or autumn, a tropical storm moving inland from

differences among the soils of Guilford County. Major differences among parent materials, such as differences in texture, can be observed in the field. Less distinct differences, such as differences in mineralogical composition, can be determined only by careful laboratory analysis.

The two broad classes of parent materials in Guilford County are residual materials and alluvium. Residual material is related to the underlying rock, from which it has weathered. Transported materials are related directly to the soils or rocks from which they were removed.

Guilford County is underlain by granite, diorite, slate, schist, and gneiss (*3*). Granite makes up about 48 percent of the underlying rock. Gneiss is found in the northwestern corner of the county and makes up about 15 percent. Schist underlies about 31 percent of the county. Minor amounts of diorite and slate make up the remaining underlying bedrock.

In Guilford County the parent materials of the residual soils derived primarily from acid and basic igneous and metamorphic rocks. The light-colored, acid rocks include granite, gneiss, and schist. Cecil and Appling soils formed in material derived from acid igneous and metamorphic rocks, as reflected in the low pH of these soils. In addition, the characteristics of the parent material have influenced the texture of these soils and of other more friable, coarser textured soils of this group. The dark-colored, basic rocks include diorite and gabbro. These rocks are the parent material of Iredell, Mecklenburg, and other soils of the county that are more plastic and finer in texture. The basic influence of the parent materials is reflected in the reaction of these soils: they are less acid than others in the county. A number of soils of Guilford County formed in mixed acid and basic rocks; for example, Coronaca, Helena, Sedgefield, and Wilkes soils. Greenstone schist makes up a large part of the mixed rocks. At various locations the mixture consists of weathered granitic rocks and dikes of basic, dark-colored rocks that intrude into the granite. These dikes vary considerably in width, and their sudden outcropping results in abrupt changes in kinds of soil. Many of the soils in such areas are mapped in the Helena-Sedgefield complex.

Transported parent materials are primarily alluvium and local alluvium, both of which may be young or old. Young alluvium has been deposited recently and consists of material that has been changed very little by the soil-forming processes. Old alluvium consists of material that has been deposited long enough for the soil-forming processes to change it in varying degrees. Local alluvium consists of soil material that has been transported short distances by water and has been deposited along small drainageways, in depressions, and at the foot of slopes. The principal soils that formed in alluvium along streams on flood plains are in the Congaree, Chewacla, and Wehadkee series.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim. An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single mapping unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Base saturation. The degree to which material having base exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bottom land. The normal flood plain of a stream, subject to frequent flooding.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coat, clay skin.

Coarse fragments. Mineral or rock particles up to 3 inches (2 millimeters to 7.5 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the bases of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures is difficult.

Complex, soil. A mapping unit of two or more kinds of soil occurring in such an intricate pattern that they cannot be shown separately on a soil map at the selected scale of mapping and publication.

Most areas of this soil are used for woodland. The rest are mainly used for pasture. Slope, surface runoff, erosion, slow permeability, and the high shrink-swell potential are the main limitations in the use and management of this soil.

This soil is unsuited to crops. It has low potential for hay and pasture plants.

This soil is unsuited to most urban and recreation uses.

There is a moderate potential for broadleaf and needleleaf trees. The dominant trees are Virginia pine, shortleaf pine, cedar, red oak, and white oak. The dominant understory species are dogwood and sourwood. Capability unit VIe-2; woodland group 4c.

Es—Enon complex, gullied. This complex is on points, shoulders, and sides of ridges. The mapped areas are 3 acres to more than 10 acres in size. Enon soils make up about half or slightly more than half of this complex. They are on elevated narrow ridges between gullies that have dissected these areas.

In most places the original surface layer of these Enon soils has been eroded and the present surface layer is made up of clay from the subsoil. In a few small places these Enon soils are not so eroded; in these places the surface layer is loam or fine sandy loam and the surface layer and subsoil are thinner than is described as representative of the Enon series.

Moderately deep to deep gullies make up 40 to 50 percent of the mapped areas. These gullies have exposed underlying parent material in many places; however, remnants of subsoil from the Enon soils remain on the sides of these gullies. Gravel, cobbles, or stones are in places.

This complex is well suited to trees or wildlife; however, trees or plants grow slowly unless the erosion is checked and the land is adequately fertilized and limed. Without proper treatment, this land is subject to accelerated erosion. Capability unit VIIe-2; woodland group not assigned.

EuB—Enon-Urban land complex, 2 to 10 percent slopes. This complex consists of areas of Enon soils and Urban land so small or so intricately mixed that is was not practical to map them separately. The complex consists of about 30 to 60 percent Enon soils and 30 to 60 percent Urban land.

Enon soils are well drained and are on side slopes and broad interstream divides. Typically, the surface layer is dark grayish brown fine sandy loam about 3 inches thick. The subsurface layer is yellowish brown fine sandy loam 5 inches thick. The subsoil is 25 inches thick; the upper part is light olive brown sandy clay loam, and the lower part is yellowish brown clay. The underlying material, to a depth of 75 inches, is mottled brownish yellow, black, and dark greenish gray loam.

Urban land part consists of areas where the original soil has been cut, filled, graded, paved, or otherwise changed to the extent that most soil properties have been so altered that a soil series is not recognized. These areas are used for shopping centers, factories, municipal buildings, apartment complexes, parking lots, or other uses where buildings are closely spaced or the soil is covered with pavement. Slope is generally modified to fit the needs of the site. The extent of site modification varies greatly. Many areas have had little disturbance, while many areas have been cut down or filled over.

Included in mapping are a few areas of Mecklenburg soils.

Determination of use and management of these areas generally requires onsite investigation. Not placed in interpretive groups.

HeC—Helena sandy loam, 6 to 10 percent slopes. This moderately well drained soil is on long, narrow side slopes on uplands. The mapped areas are generally 3 to 20 acres in size.

Typically, the surface layer is dark brown sandy loam about 7 inches thick. The subsoil is 31 inches thick; the upper part is mottled brownish yellow and reddish yellow clay, and the lower part is mottled brownish yellow, strong brown, and light gray clay loam. The underlying material, to a depth of 80 inches, is mottled strong brown and white clay loam.

Included with this soil in mapping are a few small areas of soils that have a loamy sand surface layer, a few small areas of soils that have a clay loam surface layer, a few areas of soils that have slopes of less than 6 percent or more than 10 percent, and a few small areas of soils that have gravel or cobbles on the surface. Also included are small areas of Appling, Enon, Iredell, Sedgefield, Vance, and Wilkes soils.

The organic-matter content of the surface layer is low. Permeability is slow, available water capacity is low, and the shrink-swell potential is high. Reaction of the subsoil is very strongly acid or strongly acid. Depth to rippable bedrock is more than 48 inches. The seasonal high water table is commonly at a depth of more than 5 feet, but because of a slowly permeable subsoil, a perched water table is at a depth of 1 foot to 2 1/2 feet in places during wet seasons.

Most areas of this soil are used for woodland. The rest are used for cultivated crops and for pasture. Slope, runoff, erosion, wetness, and the high shrink-swell potential are the main limitations in the use and management of this soil.

This soil has moderate potential for corn, sorghum, and small grain. Slope and wetness are the main limitations. Minimum tillage and crop residue management help to control runoff and erosion. Conservation practices such as maintaining sod in drainageways, constructing terraces and diversions, stripcropping, establishing field borders, contour farming, and using crop rotations that include close-growing crops also help to conserve soil and water. The potential for hay and pasture plants such as ladino clover, red clover, and sericea lespedeza is moderately high. Proper pasture management helps to ensure adequate protective cover, which reduces runoff and controls erosion.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS

[The symbol < means less than; > means greater then. The erosion tolerance factor (T) is for the entire profile. Absence of an entry means data were not available or were not estimated]

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Risk of corrosion		Erosion factors	
						Uncoated steel	Concrete	K	T
	In	In/hr	In/in	pH					
Appling:									
ApB, ApC----------	0-8	2.0-6.0	0.10-0.15	4.5-5.5	Low-------	Moderate------	Moderate-------	0.20	4
	8-53	0.6-2.0	0.15-0.17	4.5-5.5	Moderate	Moderate------	Moderate-------	0.24	
	53-72	---	---	---	----------	----------	----------	---	
Cecil:									
CcB, CcC, CcD-----	0-6	2.0-6.0	0.12-0.14	4.5-6.0	Low-------	Moderate------	Moderate-------	0.32	4
	6-52	0.6-2.0	0.13-0.15	4.5-5.5	Moderate	Moderate------	Moderate-------	0.28	
	52-85	---	---	---	----------	----------	----------	---	
CeB2, CeC2, [1]CfB--	0-6	0.6-2.0	0.13-0.15	4.5-6.0	Low-------	Moderate------	Moderate-------	0.32	3
	6-52	0.6-2.0	0.13-0.15	4.5-5.5	Moderate	Moderate------	Moderate-------	0.28	
	52-85	---	---	---	----------	----------	----------	---	
Dewacla:									
Ch----------	0-18	0.6-2.0	0.10-0.15	5.1-6.5	Low-------	High----------	Moderate-------	0.28	5
	18-50	0.6-2.0	0.12-0.20	5.1-6.5	Low-------	High----------	Moderate-------	0.28	
	50-70	0.6-2.0	0.15-0.24	5.1-6.5	Low-------	High----------	Moderate-------	---	
	70-90	---	---	---	----------	----------	----------	---	
Dongaree:									
Co----------	0-8	0.6-2.0	0.12-0.20	5.1-6.5	Low-------	Moderate------	Moderate-------	0.28	5
	8-49	0.6-2.0	0.12-0.20	5.1-6.5	Low-------	Moderate------	Moderate-------	0.28	
	49-80	---	---	---	----------	----------	----------	---	
Goldston:									
CrB, CrC, [1]CuB----	0-8	0.6-2.0	0.12-0.18	5.6-7.3	Low-------	Moderate------	Moderate-------	0.24	5
	8-95	0.6-2.0	0.12-0.16	5.6-7.3	Moderate	High----------	Moderate-------	0.24	
Union:									
EnB, EnC, EnD-----	0-8	2.0-6.0	0.11-0.15	5.1-6.5	Low-------	High----------	Moderate-------	0.37	4
	8-33	0.06-0.2	0.15-0.20	5.1-7.3	High------	High----------	Moderate-------	0.28	
	33-75	0.2-0.6	0.13-0.18	6.1-7.3	Moderate	High----------	Low----------	0.37	
EoB2, EoC2, EoD2, [1]Es, [1]EuB---------	0-8	0.6-2.0	0.15-0.20	5.1-6.5	Low-------	High----------	Moderate-------	0.37	2
	8-33	0.06-0.2	0.15-0.20	5.1-7.8	High------	High----------	Moderate-------	0.28	
	33-75	0.2-0.6	0.13-0.18	6.1-7.8	Moderate	High----------	Low----------	0.37	
Helena:									
[1]HbB:									
Helena part-----	0-7	2.0-6.0	0.10-0.12	4.5-6.5	Low-------	High----------	Moderate-------	0.37	3
	7-38	0.06-0.2	0.13-0.15	4.5-5.5	High------	High----------	High----------	0.32	
	38-80	---	---	---	----------	----------	----------	---	
Sedgefield part-	0-12	2.0-6.0	0.10-0.14	4.5-6.5	Low-------	High----------	Moderate-------	0.37	3
	12-16	0.06-0.2	0.14-0.18	4.5-6.5	High------	Low----------	Moderate-------	0.32	
	16-33	0.6-2.0	0.12-0.15	5.6-8.4	Moderate	Low----------	Low----------	0.32	
	33-48	---	---	---	----------	----------	----------	---	
HoC----------	0-7	2.0-6.0	0.10-0.12	4.5-6.5	Low-------	High----------	Moderate-------	0.37	3
	7-38	0.06-0.2	0.13-0.15	4.5-5.5	High------	High----------	High----------	0.32	
	38-80	---	---	---	----------	----------	----------	---	
Iredell:									
IrB----------	0-7	2.0-6.0	0.12-0.15	5.6-7.3	Low-------	Moderate------	Low----------	0.32	3
	7-24	0.06-0.2	0.16-0.22	5.6-7.3	Very high	High----------	Low----------	0.20	
	24-27	0.06-0.6	0.14-0.18	6.1-7.8	High------	High----------	Low----------	0.28	
	27	---	---	---	----------	----------	----------	---	
Mattaponi:									
MaB, MaC, MaD, MaE	0-5	2.0-6.0	0.11-0.15	4.5-6.0	Low-------	High----------	Moderate-------	0.28	4
	5-34	0.6-2.0	0.13-0.18	4.5-5.5	Low-------	High----------	Moderate-------	0.32	
	34-80	---	---	---	----------	----------	----------	---	

[1] See footnote at end of table.


(Joins sheet 32)
(Joins sheet 37)
(Joins sheet 44)
High Point Lake
water
Jamestown
MaC
MaE
McB2
McC2
CcB
MuB
MhB2
MhC2
EnB
EnC
EuB
EoB2
VuB
WkC
WkE
HhB
McD2
Ch
Scale 1:20000
5000 Feet

REFERENCE 15

AN APPRA TER RESOURCES

U BASIN

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JAMES E. HARRINGTON, SECRETARY

PREPARED COOPERATIVELY BY
UNITED STATES GEOLOGICAL SURVEY
AND THE
NORTH CAROLINA OFFICE OF WATER AND AIR RESOURCES
MAY 1974

AN APPRAISAL OF THE GROUND-WATER RESOURCES OF THE UPPER CAPE FEAR RIVER BASIN, NORTH CAROLINA

by

Edwin O. Floyd, U.S. Geological Survey

and

Richard Peace, N.C. Department of Natural and Economic Resources

INTRODUCTION

This report has been jointly prepared by the U.S. Geological Survey and the Division of Ground Water of the North Carolina Department of Natural and Economic Resources as a contribution to the interagency study of the water resources of the upper Cape Fear River basin. The report describes the occurrence, availability, chemical quality, and cost of development of the ground-water resources in the basin.

The authors wish to acknowledge the cooperation of Heater Well Company, Inc., McCall Brothers, Inc., and Bainbridge and Dance, Inc., in supplying estimates of well-drilling costs in the basin.

PURPOSE AND SCOPE

An adequate and dependable supply of good-quality water is a prime requisite to economic development of an area. The decision to use ground water or surface water as a source of supply should not be made until both sources are compared in terms of quantity, dependability, quality, and costs.

The purpose of this report is to supply information pertaining to the feasibility of using ground water as a source of supply in the upper Cape Fear River basin. Within the scope of this report, an appraisal of the ground-wate resources can be made by discussing, in general terms, the following basic questions:

Table 1.-- Population supplied with water from surface-water and ground-water sources in the counties lying entirely or partly in the upper Cape Fear River basin.

County	Population in 1970	Population served with		Percent using ground water
		Ground water	Surface water	
Alamance	96,362	46,562	49,800	48
Chatham	29,554	21,854	7,700	74
Caswell	19,055	17,555	1,500	92
Durham	132,681	32,681	100,000	25
Guilford	288,590	66,293	222,297	23
Harnett	49,667	34,017	15,650	68
Lee	30,467	17,967	12,500	59
Montgomery	19,267	13,767	5,500	71
Moore	39,048	27,468	11,580	70
Orange	57,707	24,207	33,500	42
Randolph	76,358	53,858	22,500	71
Rockingham	72,402	31,702	40,700	44
Wake	228,453	91,653	136,800	40
Totals	1,139,611	479,584	660,027	42

GROUND-WATER RESOURCES

Occurrence of Ground Water

The source of all water in the upper part of the Cape Fear River basin is precipitation, about 45 inches each year. Most of the precipitation runs overland to streams and is classed as "surface runoff." Another large part is returned to the atmosphere through evaporation and by transpiration of plants. Ten to 15 percent of the total amount percolates to the water table and becomes ground water. Beneath the water table, ground water is stored in and is transmitted through the openings in the rocks to points of discharge, such as wells and streams.

The rocks underlying the basin generally occur in two distinct zones. The uppermost zone is formed by weathering of the underlying bedrock. The residual material formed by weathering is referred to as saprolite. It usually consists of clay with lesser amounts of sand and large rock fragments. The thickness of saprolite in the upper Cape Fear River basin ranges from a few feet or less near rock outcrops to somewhat more than 100 feet. The average thickness on most hills and ridges is 30 feet.

Saprolite that has been eroded from the hills and transported to the stream valleys to form the flood plains is called alluvium, which may range in composition from clay to boulders. Its thickness is generally less than 20 feet.

The saprolite in the basin is underlain by unweathered bedrock. It consists of several different types of rock, most of which have similar hydrologic properties. The different rock types will be discussed in another section of this report.

The saprolite and fractured parts of the bedrock form the ground-water reservoir of the basin. The quantity of water that can be stored or transmitted by the saprolite-bedrock reservoir is dependent on the size, shape, and abundance of their contained openings. In the saprolite, ground water occurs in the pore spaces between particles. In bedrock, water occurs in the sheetlike openings developed along fractures in the rock.

The bedrock has been subjected to great stresses during its long geologic history and comprises a complex reservoir system. The degree of fracturing of the rocks resulting from these stresses varies greatly from place to place, ranging from very small, widely spaced fractures to zones of intensely broken rocks that are tens or hundreds of feet wide. Generally, bedrock fractures are only fractions of an inch in size and spaced a few inches to several feet apart. As a rule, the fractures decrease in number and size with depth. Data show that zones of significant fracturing extend to depths of more than 800 feet. The range of depth and degree of fracturing is not adequately known and considerable exploratory drilling will be necessary to ascertain the structure of the reservoir system.

One of the basic concepts of ground-water hydrology is that aquifers function both as a reservoir to store water and as a pipeline to transmit water. The quantity of water that can be stored depends on the porosity of the aquifer material. The ability to transmit water depends on the permeability and thickness of the aquifer material. The porosity usually is between 20 and 50 percent in saprolite whereas the porosity of bedrock is generally a fraction of 1 percent. The permeability of both materials generally is between 1 and 100 gpd (gallons per day) per square foot. Obviously, the water in storage in a unit volume of saprolite is many times greater than in an equal volume of bedrock. However, the thickness of the water-bearing zone in bedrock is generally several times greater than the thickness of the saturated part of the saprolite. In most cases it is useful to consider that the saprolite functions as the reservoir and that the bedrock functions as the pipeline.

Geologic Units

The occurrence of ground water in the upper Cape Fear River basin is influenced to a large extent by the local geology. The type and structure of the rocks have a strong influence on such factors as topography and the thickness of the saprolite.

LeGrand (1967) has shown that the yield of wells in the Piedmont region, which includes the upper Cape Fear River basin, is related to the topography at the well site and to the thickness of the saprolite. The highest-yielding wells are almost invariably located in topographically low areas, such as draws and stream valleys. The lowest-yielding wells are generally located near the tops of hills and ridges.

The differences in yield in different topographic situations apparently reflect the composite effect of several factors. Chief among these is the number and size of fractures in the bedrock. Valleys are believed to be located where fractures are most abundant, whereas the hills and ridges suggest the presence of relatively massive (unfractured) rock. Another factor is the tendency of the ground water to move toward valleys from the adjoining ridges, so that more water is available to pumping wells in valleys. A third factor, and one of the most important, is the infiltration of water from streams into the fractured rock when ground-water levels are lowered by pumping.

The thickness of saprolite is important because, as noted earlier, the saprolite functions as a reservoir. When fractured-rock wells are pumped, water slowly seeps downward from the saprolite into the fractures in the rock. Thus, the thicker the saprolite the larger the volume of water available for withdrawal. From what was said in the preceding paragraph about stream infiltration in valley areas, it is apparent that the thickness of saprolite is of greatest significance to the yield of wells in upland areas. In uplands underlain by 25 to 50 feet of saprolite, the sustained yield of wells may be double that of wells in uplands underlain by only 5 to 10 feet of saprolite.

Quantity of Available Ground Water

During extended dry periods the flow of streams in the basin is sustained by ground water discharging from the adjacent aquifers. The volume of ground water discharged to streams is an indication of the amount of water available for development from the ground-water reservoir.

Comprehensive quantitative studies of the amount of ground water available for development in the upper part of the Cape Fear River basin have not been made. However, based on studies in similar areas, it is estimated that the streamflow equaled or exceeded 70 percent of the time is a reliable indicator of the amount of ground water available.

Figure 3 shows areas of approximately-equal ground-water discharge, based on the flow of streams equaled or exceeded 70 percent of the time. The area encompassed by each coincides with the areas underlain by the three principal hydrologic units and represents the average rate of ground-water discharge to streams, in millions of gallons per day per square mile of

ground-water development, and after spending thousands of dollars in drilling wells they still do not have an adequate supply of water. However, the ground-water resources of the basin are adequate to meet demands many times larger than those presently being met. To minimize future problems, development of ground-water supplies for industries and municipalities should be carefully designed and managed by qualified professional personnel.

Pollution

Even though ground water is better protected from pollution than surface water, there are many places where pollutants are known to have found their way into the aquifers. With increased development of an area, there comes an increasing potential for pollution of the ground-water resource. Sanitary land fills are becoming more numerous and in each case provide almost direct connection between the refuse and the water table. Sewage, fertilizers, and industrial wastes are common agents of stream pollution, and, if unchecked, they may preclude the development of potentially large ground-water supplies from some of the stream valleys in the basin.

CONCLUSIONS

Large amounts of water are stored in the rocks underlying the upper part of the Cape Fear River basin. Dependable ground-water supplies can be developed from these rocks in all parts of the basin if the hydrologic conditions are properly evaluated and the wells and well fields are designed accordingly.

The chemical quality of the ground water in the basin is generally suitable for most uses. However, excessive concentrations of iron, hardness, and chloride occur in some local areas. Where necessary, the objectionable constituents can be effectively and economically reduced or removed by treatment of the water.

It is not within the scope of this report to provide exact data for development of water supplies at specific sites. However, with the available data, it is possible to predict, within acceptable limits, the general hydrologic conditions over a sizable area. Even in similar geologic and topographic situations, the hydrologic conditions can differ greatly within a short distance. For this reason, it is rarely possible to predict accurately the conditions at a specific site prior to actual on-site testing.

The different geologic, hydrologic, and economic conditions that had to be considered in appraising the ground-water resources of the basin make it necessary that certain generalized assumptions be made in estimating the costs of development. On these assumptions were based the estimated costs of construction and operation of hypothetical wells. These estimates are valid only for a comparison with estimates of costs of developing a supply from surface-water sources or from the different geologic units in the basin. Because of these assumptions, the estimates given are neither appropriate nor intended for use in detailed planning of a specific system. Planning and design of specific systems require geologic and hydrologic data from the actual project site and also the services of consulting ground-water hydrologists and qualified well-drilling contractors.

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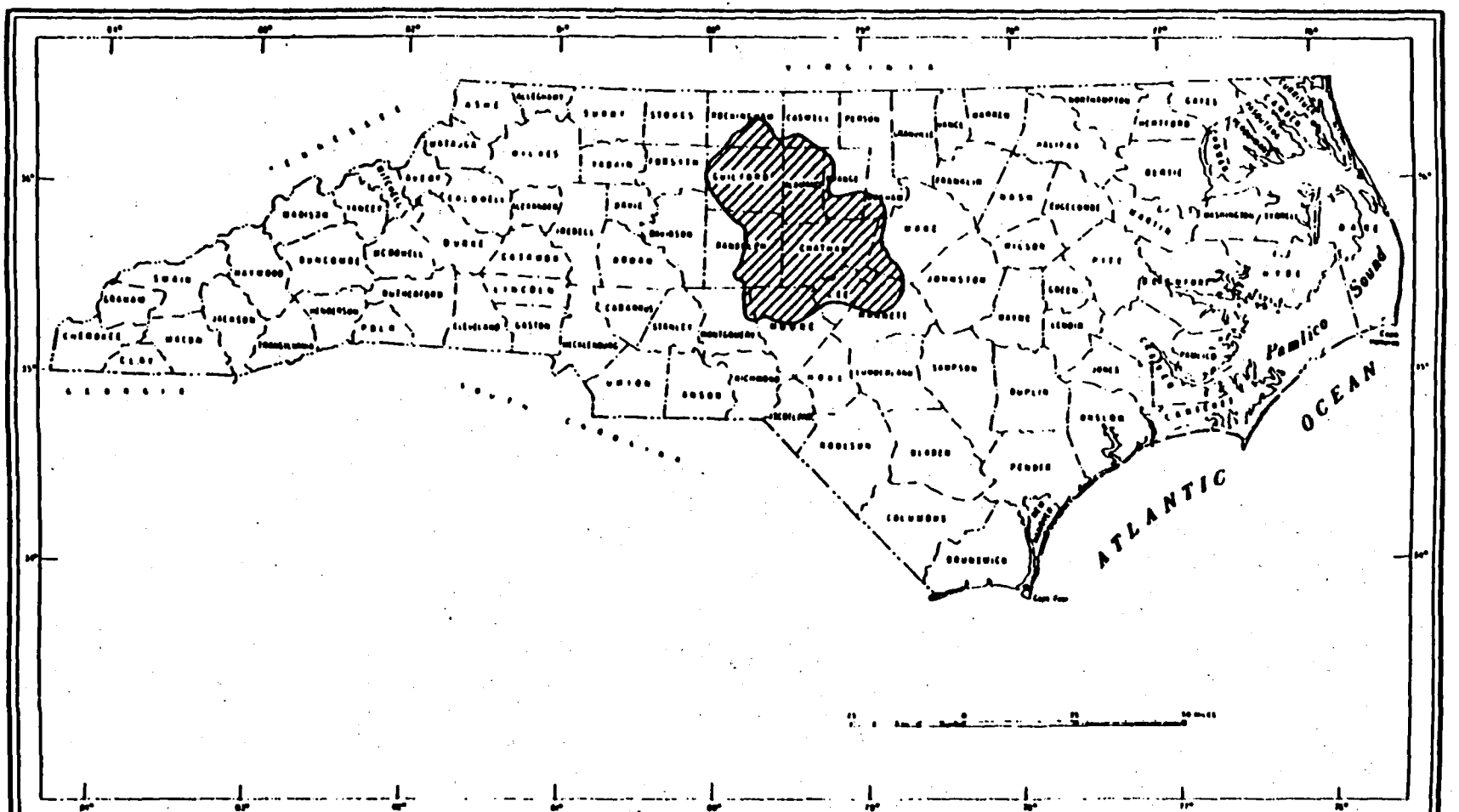
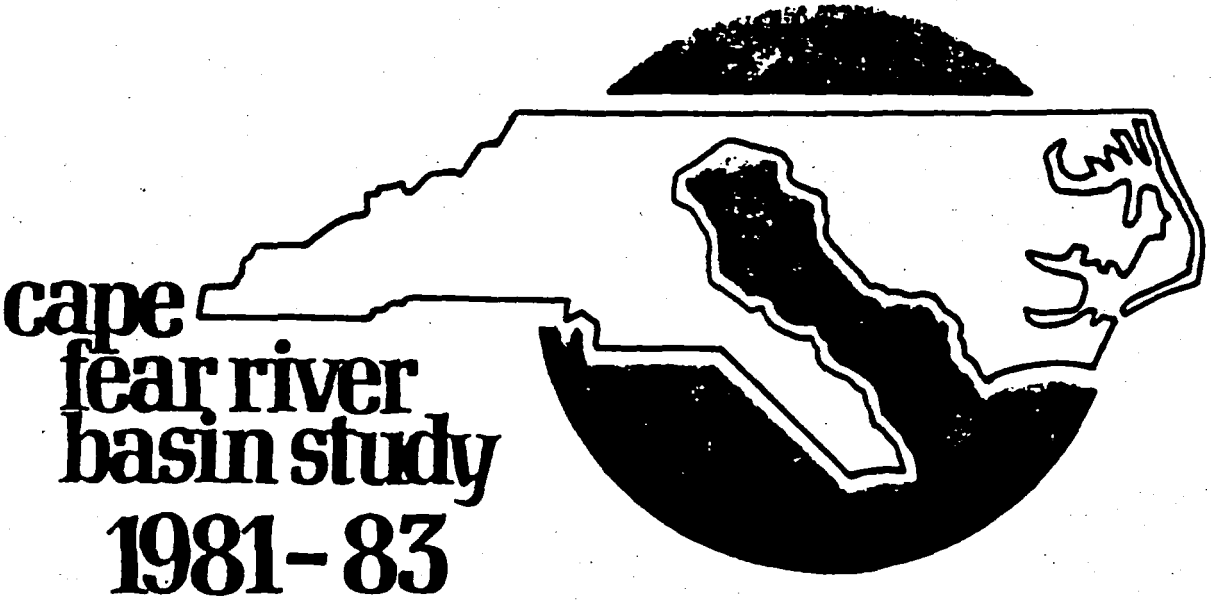


Figure 1. Map of North Carolina showing the location of the upper part of the Cape Fear River basin.

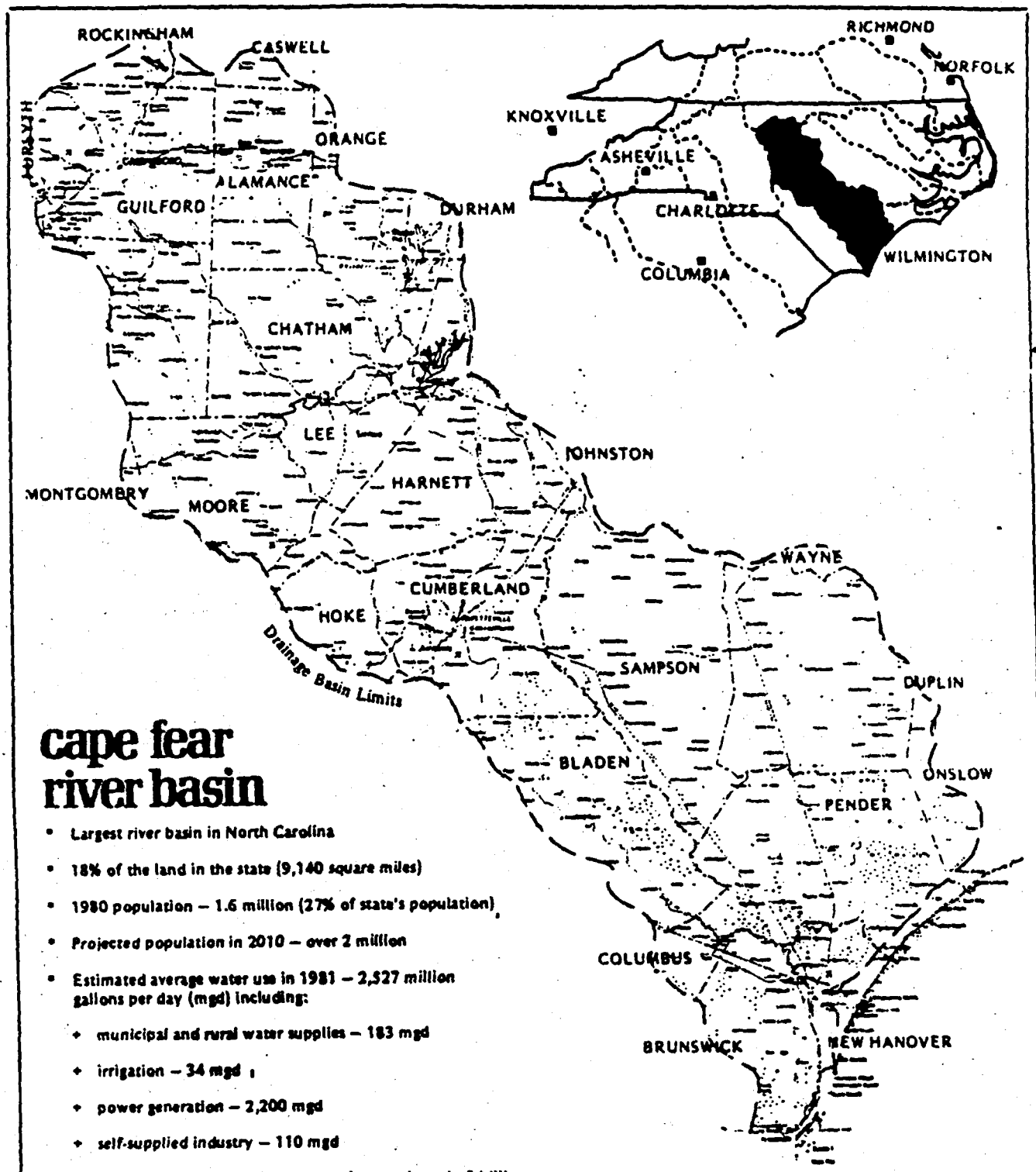
REFERENCE 16

GROUND-W / POTENTIAL AND PRC OR WELL-SITE SELECTION

UPPER CAPE FEAR RIVER BASIN



cape fear river basin study 1981-83



cape fear river basin

- Largest river basin in North Carolina
- 18% of the land in the state (9,140 square miles)
- 1980 population – 1.6 million (27% of state's population)
- Projected population in 2010 – over 2 million
- Estimated average water use in 1981 – 2,527 million gallons per day (mgd) including:
  - municipal and rural water supplies – 183 mgd
  - irrigation – 34 mgd
  - power generation – 2,200 mgd
  - self-supplied industry – 110 mgd
- Drainage contributes yearly average of approximately 6 billion gallons of fresh water per day to the Atlantic Ocean

scale: 1 inch = 22 miles

GROUND-WATER SUPPLY POTENTIAL
AND
PROCEDURES FOR WELL-SITE SELECTION
UPPER CAPE FEAR RIVER BASIN

CAPE FEAR RIVER BASIN STUDY

Sponsored by

North Carolina Department of Natural
Resources and Community Development
and
U. S. Water Resources Council

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P. O. Box 27687
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(919) 733-4064

October, 1983

CONTENTS

	Page
Abstract	1
Introduction	3
Purpose and scope	4
Cooperation and participation	5
Description of the study area	6
Geography	6
Geology	6
Climate	11
Geohydrology	12
Ground-water availability	16
Storage	16
Recharge	20
Well-site selection criteria	26
Geologic units	26
Fractures	30
Regolith thickness	37
The ideal well site	38
Testing of the site-selection criteria	42
Rock Creek test site	42
Greensboro-High Point Regional Airport test site	45
Pumping test	52
Data evaluation	54
Conclusions	57
Summary	59
References	62
Glossary	64
Acknowledgments	inside back cover

ILLUSTRATIONS

Page

Figure 1. Map showing the regional setting of the upper Cape Fear River basin study area in the Piedmont physiographic province of North Carolina..... 7

2. Geologic map of the upper Cape Fear River basin showing locations and yields of high-yield wells as of 1982..... 9

3. Sketch showing principal components of the ground-water system in the Piedmont and Blue Ridge provinces in North Carolina..... 13

4. Block diagram showing a conceptual view of the unsaturated zone (lifted up), the water-table surface, and the direction of ground-water flow for a typical area in the Piedmont and Blue Ridge provinces of North Carolina..... 15

5. Graph showing variation of porosity and specific yield of saprolite with depth at the Georgia Nuclear Laboratory in northeast Georgia..... 19

6. Map of the upper Cape Fear River basin and locations of streamflow and precipitation stations used in the water-budget analysis..... 21

7. Graphs showing variation of monthly mean ground-water discharge for three unregulated drainage basins in the upper Cape Fear River basin, 1971-1980..... 24

8. Bar graph showing number of high-yield wells per square mile by geologic unit in the upper Cape Fear River basin..... 29

9. Map views of typical drainage patterns and block diagrams of associated land forms in the upper Cape Fear River basin..... 32

GROUND-WATER SUPPLY POTENTIAL AND PROCEDURES FOR WELL-SITE SELECTION IN THE UPPER CAPE FEAR RIVER BASIN, NORTH CAROLINA

By

Charles C. Daniel III and N. Bonar Sharpless

ABSTRACT

Population growth and industrial development in the 1,750 square mile upper Cape Fear River basin of the central North Carolina Piedmont has been increasing, and current surface-water supplies are approaching limits of capacity. Thus, other water sources need to be considered as alternatives in planning for future water supplies. Ground water is one alternative source of supply. Ground water supplies nearly half the population in the Piedmont and Blue Ridge areas of North Carolina. Ground water is used at a rate of about 200 million gallons per day, yet it is a vastly underutilized resource and little used for large municipal and industrial sources of water.

This report describes the most favorable areas for high-yield wells (yields equal to or greater than 50 gal/min), estimates the total ground water availability both in storage and from recharge, and describes a site-selection procedure for wells that is based on bedrock lithology, geomorphic analysis to locate fractures, and reconnaissance mapping to locate areas of thick regolith and a high water table.

Ground water is stored in the regolith and in the underlying fractured bedrock. The regolith averages about 50 feet thick and contains approximately 1.5 billion gallons per square mile of potentially available water. Seasonally this value ranges from 1.3 to 1.7 billion gallons per square mile. Storage capacity in the fractured bedrock is low and decreases to nearly zero below a depth of about 400 feet. Precipitation data from National Weather Service stations

at Graham, Greensboro, and High Point averaged 45.9 inches per year for the period 1971 through 1980. About 19 percent of this amount infiltrates to the water table to recharge the ground-water system.

The mafic volcanics unit is the most productive bedrock aquifer, having nearly three times as many high-yield wells as the sheared granite, porphyritic granite, felsic volcanics, mica gneiss, and diorite. High-yield wells are absent in the mica schist and argillite units. The sheared granite, based on outcrop area and well yield, is the second best unit for wells.

High-yield wells are most often found in draws or narrow valleys where the well site is underlain by thick regolith and highly fractured bedrock, and has a high water table. Drainage patterns provide clues to the presence or absence of fractured bedrock.

Drilling of test wells demonstrated the usefulness of the site-selection criteria for locating, in selected geologic units, wells with above average yields that penetrated zones of highly fractured rock at sites with thick regolith and a high water table. A well completed in the sheared granite near Gibsonville yielded 18 gallons per minute, above average for the sheared granite unit. A production well drilled in the mafic volcanics near the Greensboro-High Point Regional Airport yielded 50 gallons per minute, nearly twice the average for the unit. That well was tested by continuous pumping for 62 hours at an average rate of 38.5 gallons per minute. Eighteen additional wells, 4 in bedrock and 14 in the regolith, were monitored during the test. The water table assumed the shape of an elliptical cone with the long axis approximately parallel to the strike of foliation in the bedrock. Nearly all the pumped water was derived from storage in the regolith.

INTRODUCTION

Additional water supplies will be needed in the upper Cape Fear River basin as population and industrial development continue to increase. Development of additional surface-water sources will be confronted by a number of problems, including: (1) reservoirs compete with farming, housing, and industrial development, for available land; (2) many of the best reservoir sites, those in deep, narrow valleys, are in use; (3) less suitable sites having wider, shallower valleys, will require more land area. Shallow reservoirs also tend to have more water-quality problems associated with biologic activity than deeper reservoirs; and, (4) increasing land and construction costs will make new reservoirs very expensive to build. Thus, other water sources need to be considered as alternatives in planning for future water supplies.

Ground water has many attractive features as a source of supply. Ground water in the Piedmont province has a relatively low cost of development (Cederstrom, 1973). Generally, ground water in Piedmont areas, such as the upper Cape Fear River basin, is of good chemical quality and requires little treatment. Because of the large quantity of water in storage, the ground-water system usually can sustain moderate yields during annual drought periods. Use of ground water generally permits other land use activities if they do not impede the infiltration of recharge or diminish water quality.

Ground water is an important but underutilized water-supply source in the Piedmont province and hydrogeologically similar Blue Ridge province of North Carolina. Data from a recent survey (Mann, 1978) show that 13 percent of the 132 public water supplies serving 500 or more customers in the Piedmont rely on ground water. In 1975, out of a total population of 3,950,000 in the Piedmont and Blue Ridge of North Carolina, two million people relied on ground water as a source of supply (Heath, 1978). Ground-water use was approximately 200 million gallons per day.

Results of studies in other areas of the Piedmont similar to the upper Cape Fear River basin suggest that the ground-water system may possibly support large yields. For example, many wells in the Georgia Piedmont produce more than 100 gal/min (gallons per minute) and some yield nearly 500 gal/min (David Swanson, Georgia Geological Survey, written comm., 1979). Similarly, Cederstrom (1972) found that yields of 100 to 300 gal/min are not uncommon for bedrock wells in the Piedmont and Blue Ridge provinces from Maine to Virginia.

Purpose and Scope

The primary purpose of this study was to evaluate ground water as a source of large supplies for the upper Cape Fear River basin. The occurrence and quantities of ground water available, both in storage and from recharge by precipitation, are described in this report along with improved techniques for developing the resource and locating sites to drill wells which will have a good probability of offering high sustained yields. This report discusses findings made from January 1982 to May 1983.

The most favorable conditions for ground-water development were identified in an analysis of existing records of high-yield wells (yields greater than 50 gal/min) and correlations between well yield and rock type, topographic position, distance from streams, and regolith thickness.

Ground-water storage was estimated from water-level records, estimates of regolith thickness, and hydrologic properties of core samples from the north Georgia Piedmont. An estimate of the maximum ground-water availability was determined in water-budget analyses for several streams in the upper Cape Fear River basin using continuous streamflow records and rainfall data collected between 1971 and 1980. Ground-water recharge was estimated by hydrograph separation.

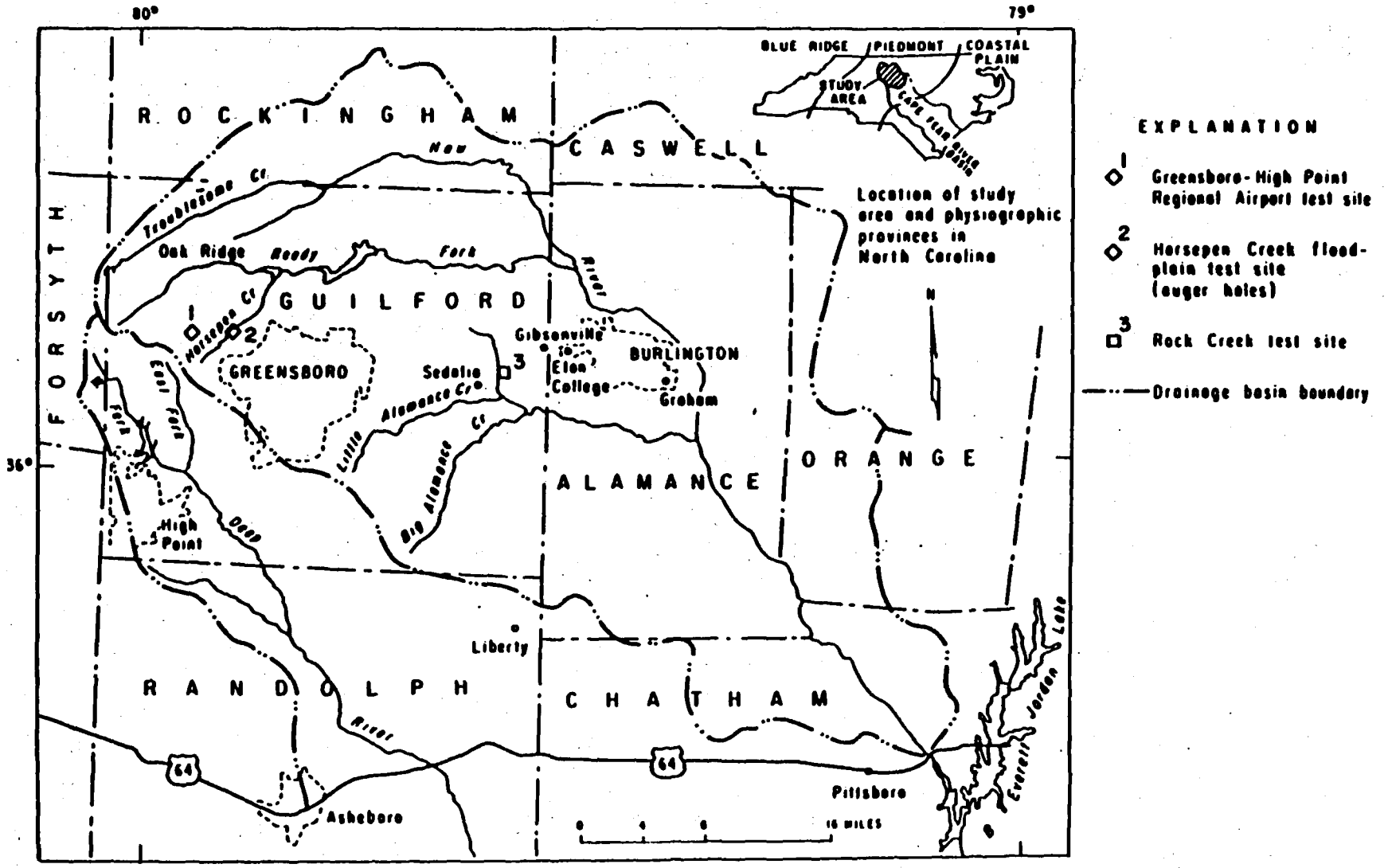


Figure 1.--Regional setting of the upper Cape Fear River basin study area in the Piedmont physiographic province of North Carolina.

Climate

The climate of the study area is temperate with distinct seasonal changes in weather. The coldest month is January with an average temperature of about 41 degrees Fahrenheit and the warmest month is July with an average temperature of about 78 degrees Fahrenheit. The average annual rainfall is approximately 45 inches. The growing season, that period without killing frosts, lasts from mid April to the end of October. The moderate weather and abundant rainfall support the lush growth of natural vegetation and crops of many kinds. Undeveloped areas are often heavily forested with stands of evergreen and deciduous trees. Fields and pastures support crops and grasses much of the year.

GEOHYDROLOGY

The principal components of the ground-water system in the study area are illustrated schematically in figure 3. The regolith consists of an unconsolidated or semiconsolidated mixture of clay and fragmental material ranging in size from silt and sand to boulders. The porosity of the regolith is on the order of 35 to 55 percent near land surface but decreases with depth as the degree of weathering decreases. Because of its high porosity, the regolith acts as a reservoir which slowly feeds water downward into the bedrock. The consolidated bedrock contains very little intergranular pore space. Rather, the water within the bedrock is contained primarily in planar secondary openings developed as a result of fracturing. Secondary porosity ranges from 1 to 10 percent in fractured crystalline rock (Freeze and Cherry, 1979, table 2.4). Porosities of 10 percent are atypical, whereas values of 1 to 3 percent are much more representative of the North Carolina Piedmont.

As a general rule, very few open fractures occur in bedrock of the Piedmont at depths greater than 400 feet (LeGrand, 1967). At greater depths, the pressure of the overlying material, or lithostatic pressure, holds these fractures closed and the porosity can be less than 1 percent. Fractures are most numerous and have the largest openings near the top of the bedrock. These fractures are the openings along which water can move.

The implications for the drilling of wells is obvious. The chances of penetrating open fractures and obtaining water (or additional water) at depths below 400 feet is low. In fact, 85 percent of the total possible yield from the average well is already obtained at a depth of 200 feet; the average yield increases only 5 percent by drilling to 300 feet (LeGrand, 1967). From the standpoint of ground-water production, two 200-foot deep wells are more effective, on

soil and saprolite as a reservoir and the desirability of having as large a reservoir as possible from which to draw water, the smaller drainages underlain by thick regolith seem to be better sites than the larger, broader stream bottoms which may only contain a thin veneer of alluvium on top of bedrock.

Using average casing depth of wells as an indication of regolith thickness (table 1), one might assume that the upland flats have the largest, thickest regolith reservoir and therefore represent the best location for a well site. However, under the influence of gravity ground water flows away from the hilltops and toward lower lying discharge areas along streams and lakes. Consequently wells in the lower part of a drainage area are able to intercept water flowing toward them and, in effect, derive water from a larger area because of the natural gradient toward the well. Wells on hilltops, on the other hand, must induce flow toward the well by pumping.

The Ideal Well Site

An ideal site would be located in the geologic unit having the greatest probability of high yields, have thick regolith, a high water table, be underlain by highly-fractured bedrock, and have a large contributing drainage area. High-yield geologic units of the area are known (fig. 8); regolith thickness can be estimated from existing well data (table 1); and fracture locations can be inferred from types of stream drainage patterns discussed earlier.

Sites having the greatest possible saturated thickness of regolith must also be identified. The porosity and specific yield of the regolith decrease with depth (fig. 5). Consequently, sites with a large saturated thickness of regolith, and a high water table, will have the greater amount of available water in storage. In addition, the higher the water table, the greater the available drawdown to wells (in comparison to a well of similar depth in an area with a low water table). In the upper Cape Fear River basin the regolith is generally thickest in the interstream areas and thinnest in the flood plains of perennial streams. On the other hand, the depth to

SUMMARY

Ground water is used by nearly half the population of the Piedmont and Blue Ridge provinces of North Carolina as their source of water supply, yet it is a vastly underutilized resource and little used for large municipal and industrial sources of water. In a 1978 survey, only 13 percent of the public water supplies serving 500 or more customers in this region were using ground water as a supply source.

In contrast to the small amount of ground water actually used (approximately 200 million gallons per day) the amount of potentially available water stored in the ground is very large. In the Piedmont and Blue Ridge provinces, ground water is stored in the regolith and in the underlying fractured bedrock. Nearly all of the storage capacity is in the regolith. The storage capacity within fractures in the bedrock is low and below a depth of about 400 feet the storage capacity decreases nearly to zero. In the upper Cape Fear River basin, the average thickness of the regolith is about 50 feet and the average depth to the water table 15 feet. Given that the remaining 35 feet is saturated with water and has a 20 percent drainable porosity, each square mile contains an estimated 1.5 billion gallons of water some of which drains to springs, streams, lakes, and wells. Due to seasonal changes in the water table, the amount of water in storage can vary from about 1.3 to 1.7 billion gallons per square mile.

On an annual basis, the change in ground-water storage is usually small and recharge will be about equal to ground-water discharge or base runoff. Within the upper Cape Fear River basin average annual precipitation is 45.9 inches per year or about 1,500 $(gal/min)/mi^2$. Of this amount, about 19 percent infiltrates to the water table and part is available to wells.

The most favorable area for ground-water development within the upper Cape Fear River basin is the area underlain by the mafic volcanics unit. The second best is the area underlain by the sheared granite unit. The likelihood of obtaining a high-yield well is

greatest in these areas. Selection of the best sites within any rock unit is based on considerations of topography and drainage patterns. The best well sites will be in topographically low areas having a high water table and large saturated thickness of regolith, all of which is underlain by highly fractured bedrock. The best sites are within the smaller valleys and draws of fracture-controlled intermittent streams. Drainage patterns provide clues as to the presence of fractured rock; drainage linears that cut across lithologic boundaries are a good indication of fracture control. Reconnaissance geologic mapping is used to confirm interpretations of drainage patterns, help determine the presence and thickness of regolith, and facilitate final site selection.

Two test sites were selected for evaluating the site selection procedure. One site was in the Rock Creek basin southwest of Gibsonville, an area underlain by sheared granite. The other site was in the Horsepen Creek basin, about 1 mile southeast of the Greensboro-High Point Regional Airport. The second site is in an area underlain by the mafic volcanics unit.

Between December 14, 1982 and April 26, 1983, two wells were drilled at the Rock Creek site and 20 wells were drilled at the airport site. Two potential production wells were drilled at each site; however, only one production well was successfully completed at each site. The Rock Creek well yielded about 18 gal/min, above average for the sheared granite. The airport well was pumped at rates as high as 65 gal/min, much more than the average yield of 28 gal/min for the mafic volcanics unit, as reported by Mundorff (1948).

The remaining wells at the airport were used for monitoring water levels during a pumping test of the production well, conducted May 9 to 13, 1983. The average pumping rate for 62 hours of continuous pumping was 38.5 gal/min and a total volume of 143,200 gallons was pumped from the well. Nearly all of this water was derived from storage in the regolith. Water levels in the production well declined to 153.5 feet below the top of the casing by the end of the test.

The final pumping level was 61.5 feet above the pump intake. Water levels in all 18 observation wells declined during the test; declines ranged from less than 1 foot to more than 13 feet. The water table assumed the shape of an elliptical cone by the end of the test. The long axis of the cone was approximately parallel to the strike of foliation in the bedrock, or N. 50° E.

After the pump was turned off the water level recovered to 28.6 feet below the top of the casing at the end of one hour and to 19.7 feet, within 1.9 feet of the starting level, after 14 hours.

The successful completion of wells at test sites chosen using site-selection criteria based on geologic units, fracture identification by geomorphic analysis, and regolith thickness, demonstrated the usefulness of the criteria for identifying well sites.

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REFERENCE 17

GREENHORNE & O'MARA, INC.

ENGINEERS • ARCHITECTS • PLANNERS • SCIENTISTS
SURVEYORS • PHOTOGRAMMETRISTS

BY RMS DATE 11/19/91 SUBJECT Union Camp SHEET NO. 1 OF 1
CHKD. BY ____ DATE ____ Jamestown JOB NO. ____
REV. BY ____ DATE ____ NCD 003216959 FILE NO. ____

Within 4-mile Radius:

High Point: 14982.1 ac = 26.5 sq miles
Jamestown: 946.7 ac = 1.5 sq miles
Greensboro Water Dept. = 4,458.2 ac = 7 sq miles

High Point Population

Radius	Acreage	miles^2	Population*	Cumulative Pop.
¼-mile	0	0	0	0
½-mile	0	0	0	0
1-mile	0	0	0	0
2-mile	3005.5	4.7	8,888	8,888
3-mile	4966.0	10.8	20,423	29,311
4-mile	7010.6	11.0	20,801	50,112
Total	14982.1	26.5	50,112	50,112

* Population = m^2 X density (persons/sq mile)

1990 Census - High Point City Density = 1891 persons/m^2

REFERENCE 18

NUS CORPORATION AND SUBSIDIARIES **TELECON NOTE**

CONTROL NO.	DATE: 4/24/89	TIME: 1630

DISTRIBUTION:

BETWEEN: John Frezell, Town Manager	nn	PHONE: (704) 454-1138

AND: Eric Corbin, NUS Corporation Eric Corbin 5/18/89

DISCUSSION:

Mr. Frezell was contacted in an effort to determine the source of water for the Jamestown Water Department. He stated that they purchase water from the High Point Water Dept., from the Greensboro Water Dept., and they have a surface water intake located at the Oakdale treatment facility on the Deep River. He further stated that they served at 1,000 residences and at 150 businesses.

REFERENCE 19

September 16, 1991

TO: Technical Staff

FROM: Pat DeRosa

RE: US Census Bureau 1990 Population Data
Persons Per Household by County
Persons Per Household by Town
Total Population by County
Total Population by Town

Please find attached the subject population data which I recently received from the US Census Bureau. Please note that the Persons Per Household by County data which I distributed in June has not been revised and is still accurate as included here. I have also included the remainder of Table 6 which lists information on Persons Per Household by Town, and Table 5 which lists Total Population Values for each County or Town. Please let me know if you have any questions about using this data or if you require additional census data.

Attachments

Table 6. Household, Family, and Group Quarters Characteristics: 1990

[For definitions of terms and meanings of symbols, see text]

State County Place and (In Selected States) County Subdivision	Persons in households	All households	Family households			Nonfamily households				Persons per—		Persons in group quarters		
							Householder living alone							
			Total	Married-couple family	Female householder, no husband present	Total	Total	65 years and over		Household	Family	Total	Institutionalized persons	Other persons in group quarters
								Total	Female					
The State	6 404 167	2 517 028	1 812 053	1 424 206	308 876	704 973	596 969	228 384	182 329	2.54	3.03	224 479	83 400	141 079
COUNTY														
Alamance County	105 327	42 652	30 745	24 295	5 130	11 907	10 467	4 566	3 748	2.47	2.94	2 886	1 173	1 713
Alexander County	27 245	10 331	8 049	6 715	952	2 282	2 032	839	651	2.64	3.05	256	256	-
Alleghany County	8 381	3 894	2 629	2 221	353	1 265	990	535	433	2.41	2.88	226	183	16
Anson County	23 117	8 521	6 358	4 556	1 472	2 163	2 042	1 073	869	2.71	3.23	357	344	13
Ashe County	21 965	8 648	6 748	5 643	771	2 100	1 835	1 014	809	2.48	2.88	324	300	24
Avery County	13 918	5 528	4 162	3 500	460	1 356	1 228	546	420	2.62	2.95	646	20	626
Beaufort County	41 704	16 157	11 840	9 140	2 186	4 317	3 915	1 974	1 605	2.58	3.07	578	441	136
Bertie County	20 321	7 412	5 501	3 831	1 416	1 911	1 767	957	755	2.74	3.28	67	67	-
Bladen County	28 150	10 760	8 017	5 854	1 762	2 743	2 578	1 243	1 000	2.61	3.11	513	506	4
Brunswick County	50 467	20 089	15 291	12 636	2 031	4 778	4 227	1 840	1 194	2.52	2.91	448	267	181
Buncombe County	188 713	70 802	49 335	39 637	7 684	21 467	18 866	8 174	6 845	2.40	2.80	5 108	2 966	2 142
Burke County	73 281	28 184	21 711	17 462	3 148	7 473	6 566	2 706	2 228	2.51	2.83	2 463	2 418	45
Cabarrus County	97 255	37 515	28 367	23 279	3 572	9 148	8 038	3 589	2 971	2.56	3.02	1 680	1 223	457
Caldwell County	68 917	25 172	20 656	16 653	2 944	6 516	5 860	2 287	1 846	2.57	2.97	732	735	57
Camden County	5 675	2 180	1 662	1 365	225	668	437	224	169	2.69	3.11	38	-	29
Carteret County	51 554	21 226	15 276	12 661	2 013	5 950	5 081	2 497	1 431	2.43	2.88	1 002	726	276
Caswell County	20 053	7 466	5 781	4 454	1 314	1 685	1 563	731	573	2.68	3.13	840	824	16
Catawba County	116 387	45 700	33 773	27 418	4 841	11 927	10 270	3 844	3 115	2.55	2.96	2 018	1 134	881
Chatham County	36 315	15 233	11 227	9 115	1 655	4 006	3 445	1 412	1 141	2.51	2.96	844	377	467
Cherokee County	19 899	7 966	6 068	5 055	765	1 897	1 764	975	759	2.50	2.91	291	198	93
Chowan County	13 233	5 113	3 775	2 842	787	1 338	1 236	641	498	2.59	3.07	223	223	-
Clay County	7 150	2 928	2 177	1 864	253	751	699	418	314	2.44	2.90	5	4	1
Cleveland County	83 612	35 037	24 282	19 011	4 168	7 756	7 011	3 202	2 624	2.59	3.02	1 574	915	79
Columbus County	48 965	18 456	13 734	10 381	2 757	4 705	4 351	2 152	1 806	2.65	3.15	824	824	10
Craven County	78 014	28 542	22 481	18 189	3 511	7 061	6 121	2 436	1 800	2.64	3.07	3 588	811	2 788
Cumberland County	283 382	91 800	69 866	54 433	12 863	21 534	17 718	4 724	3 752	2.77	3.16	21 224	1 488	19 736
Currituck County	13 466	5 038	3 856	3 272	467	1 184	984	418	312	2.68	3.08	226	213	13
Dare County	22 542	9 349	6 425	5 486	662	2 924	2 264	714	522	2.41	2.88	1 193	149	44
Davidson County	126 356	48 844	37 176	30 410	5 120	11 768	10 282	4 188	3 318	2.58	2.96	1 318	1 312	6
Davie County	27 541	10 785	8 270	6 999	953	2 515	2 244	1 005	817	2.55	2.95	318	226	92
Duplin County	39 368	14 825	11 024	8 378	2 098	3 888	3 553	1 779	1 436	2.64	3.12	857	369	488
Durham County	173 310	72 297	45 265	33 614	10 321	26 312	23 935	5 563	4 471	2.40	2.96	8 732	2 175	6 557
Edgecombe County	55 856	20 319	15 085	10 000	4 293	5 234	4 703	2 124	1 717	2.75	3.23	2 220	857	1 363
Forsyth County	257 466	107 618	72 821	55 715	14 852	34 798	29 870	8 729	7 175	2.40	2.94	8 172	3 853	4 319
Franklin County	35 227	13 523	10 047	7 640	1 865	3 476	3 180	1 394	1 126	2.61	3.07	1 177	568	609
Gaston County	172 781	65 347	46 734	36 905	8 438	15 503	13 560	5 722	4 720	2.64	3.07	2 382	1 456	926
Gates County	9 202	3 352	2 563	2 040	404	739	705	364	288	2.75	3.19	183	183	-
Graham County	7 176	2 772	2 166	1 639	246	606	562	294	225	2.59	2.96	18	18	-
Granville County	35 191	13 134	9 863	7 501	1 857	3 251	2 888	1 206	978	2.68	3.13	3 154	3 078	76
Greene County	14 665	5 395	4 066	3 033	875	1 329	1 188	574	441	2.72	3.16	719	704	15
Guilford County	335 348	137 706	92 891	71 195	17 570	44 815	36 578	12 180	9 951	2.44	2.97	12 973	3 994	8 979
Halifax County	54 122	20 335	14 674	10 092	4 018	5 461	5 078	2 368	1 927	2.64	3.18	1 344	1 256	88
Harnett County	61 340	25 150	18 529	14 490	3 154	6 621	5 773	2 436	1 962	2.60	3.06	2 482	1 240	1 242
Haywood County	46 152	19 211	14 120	11 831	1 774	5 091	4 801	2 337	1 886	2.40	2.83	730	731	34
Henderson County	66 206	28 709	21 169	15 113	2 344	7 540	6 836	3 531	2 856	2.36	2.80	1 979	867	112
Hertford County	21 612	8 150	5 981	4 164	1 473	2 223	2 063	977	766	2.65	3.19	911	278	633
Hoke County	21 612	7 405	5 734	3 847	1 805	1 611	1 419	523	420	2.92	3.34	1 244	1 244	-
Hyde County	5 383	2 094	1 533	1 151	321	561	516	269	191	2.57	3.07	28	10	18
Iredell County	92 082	35 573	28 869	21 728	4 823	6 704	7 446	3 271	2 662	2.58	3.22	846	814	32
Jackson County	23 834	9 883	6 970	5 748	981	2 713	2 242	968	745	2.46	2.91	3 012	280	2 732
Johnston County	80 341	31 566	23 217	18 566	3 834	8 349	7 441	3 380	2 730	2.55	3.01	965	893	72
Jones County	9 412	3 462	2 639	2 004	442	853	774	406	311	2.70	3.17	2	2	-
Lee County	40 651	15 689	11 739	9 087	2 135	3 950	3 462	1 389	1 107	2.59	3.03	973	973	-
Lenoir County	55 852	21 838	15 611	11 131	3 706	6 327	5 708	2 580	2 073	2.54	3.06	1 832	1 559	83
Lincoln County	49 802	18 784	14 661	12 257	1 827	4 103	3 560	1 467	1 173	2.65	3.03	517	517	-
McDowell County	35 084	13 680	10 366	8 578	1 363	3 314	2 998	1 398	1 135	2.56	2.98	617	416	201
Macon County	22 882	9 834	7 235	6 298	773	2 599	2 388	1 395	1 021	2.34	2.78	967	833	134
Madison County	16 104	6 468	4 809	4 026	516	1 659	1 510	769	581	2.48	2.92	849	104	745
Martin County	24 813	9 317	6 900	5 067	1 518	2 417	2 213	1 100	906	2.66	3.17	265	257	8
Mecklenburg County	498 886	200 219	134 361	103 211	25 013	65 858	52 837	12 980	10 610	2.50	3.05	11 547	3 578	7 969
Mitchell County	14 288	5 776	4 009	3 377	479	1 358	1 283	669	529	2.47	2.88	145	130	15
Montgomery County	22 279	8 290	6 274	4 853	1 119	2 016	1 838	878	690	2.68	3.14	1 067	967	70
Moore County	58 010	23 827	17 483	14 312	2 473	6 344	5 662	2 744	2 231	2.43	2.87	1 088	978	110
Nash County	75 650	28 041	21 224	16 352	3 958	7 817	6 958	2 885	2 315	2.69	3.08	1 911	1 857	54
New Hanover County	116 900	46 136	32 800	24 703	6 387	15 736	12 434	4 372	3 512	2.43	2.96	3 295	1 311	1 984
Northampton County	20 055	7 501	5 644	3 958	1 436	1 947	1 816	724	574	2.64	3.13	748	748	-
Onslow County	115 274	40 858	32 977	22 037	8 843	7 687	6 271	1 752	1 364	2.84	3.16	34 564	934	33 630
Orange County	84 627	36 104	21 123	16 854	3 380	14 981	10 110	2 257	1 838	2.34	2.93	9 224	778	8 446
Pamlico County	11 247	4 503	3 362	2 717	547	1 141	1 055	528	410	2.49	2.93	125	112	13
Pasquotank County	29 884	11 364	8 326	6 356	1 681	3 058	2 725	1 342	1 065	2.63	3.13	1 414	383	1 031
Pender County	28 467	11 112	8 420	6 777	1 371	2 692	2 388	1 065	796	2.56	2.99	359	343	16
Perquimans County	10 203	3 998	3 008	2 444	468	990	892	443	342	2.58	3.07	144	144	-
Person County	29 830	11 423	8 570	6 677	1 547	2 853	2 575	1 208	994	2.61	3.11	350	304	46
Pitt County	108 400	40 931	26 424	19 369	5 857	14 057	10 412	3 104	2 511	2.53	3.10	5 524	946	4 578
Polk County	14 187	6 110	4 344	3 673	511	1 764	1 554	952	768	2.32	2.74	319	319	-
Randolph County	105 440	41 006	31 363	25 135	3 957	9 733	8 59	3 435	2 789	2.57	2.97	1 106	1 050	56
Richmond County	43 534	16 783	12 270	9 128	2 551	4 523	4 174	2 011	1 600	2.58	3.11	984	873	108
Robeson County	103 186	36 154	27 429	16 451	7 353	8 726	7 [illegible]	3 355	2 651	2.85	3.34	1 [illegible]	1 280	713
Rockingham County	85 242	33 446	24 671	19 351	4 193	8 775	7 956	3 668	2 882	2.55	3.02	[illegible]	781	41
Rowan County	107 078	42 512	31 055	25 100	4 618	11 457	10 236	4 748	3 815	2.52	2.96	3 [illegible]	2 408	1 118
Rutherford County	56 197	22 198	16 480	13 191	2 531	5 718	5 255	2 556	2 050	2.53	2.99	721	721	-
Sampson County	46 754	17 528	13 191	10 056	2 525	4 [illegible]	3 975	1 [illegible]	1 610	2.67	3.1	[illegible]	480	[illegible]
Scotland County	35 679	11 837	8 971	6 225	2 338	2 866	2 618	1 [illegible]	935	2.78	3.2	1 [illegible]	451	[illegible]
Stanly County	59 734	19 747	14 967	12 451	1 975	4 780	4 396	2 164	1 785	2.57	3.1	1 [illegible]	470	[illegible]
Stokes County	36 862	14 123	11 [illegible]	9 341	1 [illegible]	3 101	2 825	1 246	1 016	2.61	3.04	[illegible]	361	[illegible]
Surry County	60 950	24 252	18 [illegible]	15 [illegible]	2 341	6 [illegible]	5 474	2 732	2 256	2.51	2.99	[illegible]	650	[illegible]
Swain County	10 653	4 173	3 [illegible]	2 [illegible]	553	1 [illegible]	985	467	369	2.55	3.1	[illegible]	215	[illegible]
Transylvania County	24 283	9 974	7 [illegible]	6 [illegible]	787	2 [illegible]	2 [illegible]	1 [illegible]	912	2.45	2.9	1 [illegible]	178	1 [illegible]
Tyrrell County	3 652	1 471	1 [illegible]	[illegible]	213	[illegible]	359	206	144	2.82	3.13	[illegible]	-	[illegible]
Union County	82 833	29 307	23 530	19 [illegible]	3 083	5 777	5 018	2 148	1 735	2.82	3.16	1 [illegible]	455	1 [illegible]

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Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and (In Selected States) County Subdivision	Persons in households	All households	Family households			Nonfamily households				Persons per—		Persons in group quarters		
							Householder living alone							
			Total	Married-couple family	Female householder, no husband present	Total	Total	65 years and over		Household	Family	Total	Institutionalized persons	Other persons in group quarters
								Total	Female					
COUNTY—Con.														
Wayne County	98 080	38 166	70 502	7 408	2 564	3 664	3 238	1 440	1 137	2.98	3.18	812	517	295
Wilkes County	109 263	40 267	69 543	46 567	16 581	56 200	42 662	8 649	7 828	2.46	3.01	15 113	6 571	8 542
Wilson County	66 918	24 825	4 782	3 357	1 127	1 543	1 422	742	559	2.68	3.15	347	332	15
Yadkin County	13 762	5 052	3 639	2 826	833	1 213	1 151	564	454	2.72	3.21	225	224	1
Yancey County	32 476	12 863	8 415	7 121	913	3 278	3 437	1 041	835	2.77	2.88	4 476	279	4 197
PLACE AND COUNTY SUBDIVISION														
Alamance town, Alamance County	97 572	36 889	27 577	21 197	5 320	9 312	8 263	3 258	2 642	2.65	3.11	7 084	2 668	4 606
Alamance village, Alamance County	58 787	23 021	17 588	14 634	2 274	5 435	4 855	2 182	1 723	2.55	2.96	806	506	28
Albemarle city, Stanly County	84 414	25 093	19 031	12 966	4 180	7 062	6 277	2 979	2 184	2.57	3.08	1 647	876	771
Alexander Mills town, Rutherford County	30 053	12 058	9 173	7 720	1 124	2 885	2 688	1 333	1 058	2.48	2.90	435	424	11
Alexander-Owenbee CDP, Alamance County	15 235	6 124	4 683	4 010	510	1 441	1 354	729	586	2.49	2.80	184	184	-
Alexis town, Moore County	2 979	1 154	773	567	150	381	336	168	162	2.32	2.87	21	-	21
Andrews town, Hertford County	4 258	1 766	1 164	770	356	605	576	272	229	2.41	3.07	133	130	3
Alamance village, Alamance County	258	112	80	67	11	32	30	17	15	2.30	2.78	-	-	-
Albemarle city, Stanly County	14 403	6 054	4 169	3 205	812	1 885	1 746	913	762	2.38	2.92	534	458	77
Alexander Mills town, Rutherford County	852	279	178	111	55	103	83	58	50	2.37	2.97	-	-	-
Alliance town, Pamlico County	543	232	182	150	28	50	48	29	23	2.51	2.91	-	-	-
Alexander-Owenbee CDP, Alamance County	1 076	424	307	233	57	117	113	56	44	2.54	3.06	-	-	-
Andrews town, Cherokee County	2 320	1 065	738	566	139	327	302	181	153	2.37	2.88	31	31	-
Angier town, Harnett County	2 230	901	637	449	154	264	236	97	86	2.48	2.98	5	-	5
Ansonville town, Anson County	816	300	165	106	47	36	36	20	16	3.02	3.45	-	-	-
Apex town, Wake County	4 868	1 752	1 378	1 132	196	374	318	115	108	2.80	3.19	70	67	3
Arapahoe town, Pamlico County	430	175	129	108	15	46	44	26	21	2.46	2.83	-	-	-
Archdale city	8 913	2 803	2 085	1 758	248	718	643	183	155	2.47	2.90	-	-	-
Guilford County	234	82	72	66	5	10	8	3	3	2.85	3.07	-	-	-
Randolph County	8 679	2 721	2 013	1 692	243	708	635	180	152	2.45	2.88	-	-	-
Arlington town, Yadkin County	795	333	239	170	57	94	81	52	41	2.39	2.86	-	-	-
Asheboro city, Randolph County	15 582	6 977	4 455	3 357	830	2 522	2 256	979	820	2.25	2.84	580	536	44
Asheville city, Buncombe County	50 322	21 027	10 218	11 717	3 750	10 809	9 511	4 233	3 508	2.19	2.84	2 285	1 269	1 016
Ashpole town, Bertie County	201	81	60	56	4	21	21	15	14	2.48	3.00	-	-	-
Atkinson town, Pender County	275	119	85	67	13	34	31	21	20	2.31	2.79	-	-	-
Atlantic Beach town, Carteret County	1 867	935	516	434	63	419	335	56	37	2.02	2.82	51	-	51
Aulander town, Bertie County	1 209	454	320	213	96	134	123	78	58	2.64	3.29	-	-	-
Aurora town, Beaufort County	654	260	181	118	53	79	73	51	40	2.52	3.11	-	-	-
Autryville town, Sampson County	166	73	55	40	9	18	18	8	7	2.27	2.58	-	-	-
Avery Creek CDP, Buncombe County	1 144	408	341	304	27	67	60	15	11	2.80	3.13	5	5	-
Ayden town, Pitt County	4 735	1 795	1 305	854	364	463	445	236	199	2.64	3.13	5	5	-
Badin CDP, Stanly County	1 481	616	420	315	87	196	183	110	103	2.40	2.87	-	-	-
Bailey town, Nash County	553	245	151	118	26	94	89	55	42	2.26	2.87	-	-	-
Bakersville town, Mitchell County	256	148	98	71	17	48	44	21	15	2.20	2.71	8	8	-
Bald Head Island village, Brunswick County	78	39	32	31	1	7	7	-	-	2.00	2.22	-	-	-
Balfour CDP, Henderson County	1 118	464	344	280	51	150	132	58	47	2.26	2.72	-	-	-
Banner Elk town, Avery County	335	163	80	67	18	74	64	24	19	2.08	2.80	564	-	564
Banner Heights CDP, Henderson County	1 137	468	345	248	84	123	107	47	33	2.43	2.83	-	-	-
Banner Elk title CDP, Pasquotank County	1 087	372	328	292	28	43	34	12	10	2.92	3.12	-	-	-
Bath town, Beaufort County	154	81	41	29	12	40	36	25	20	1.90	2.66	-	-	-
Battleboro town	447	176	127	87	30	49	46	23	19	2.54	3.06	-	-	-
Edgecombe County	280	100	73	39	28	27	25	9	8	2.80	3.34	-	-	-
Nash County	167	76	54	48	4	22	21	14	13	2.20	2.67	-	-	-
Bayboro town, Pamlico County	720	283	201	130	63	82	75	31	29	2.54	3.10	13	13	-
Bayshore CDP, New Hanover County	1 661	605	517	471	30	88	80	28	22	2.75	3.00	-	-	-
Beargrass town, Martin County	77	35	24	18	4	11	6	6	6	2.20	2.75	-	-	-
Beaufort town, Carteret County	3 796	1 721	1 075	741	292	646	581	255	197	2.21	2.63	13	13	-
Beech Mountain town	230	109	78	75	1	31	25	8	4	2.19	2.55	-	-	-
Avery County	7	3	2	2	-	1	1	-	-	2.33	3.00	-	-	-
Watauga County	232	106	76	73	1	30	24	8	4	2.19	2.54	-	-	-
Belhaven town, Beaufort County	2 241	840	586	358	192	252	233	138	110	2.67	3.29	28	28	-
Belmont city, Gaston County	7 774	3 049	2 140	1 803	407	900	811	354	296	2.55	3.00	660	-	660
Belville town, Brunswick County	66	28	12	7	5	16	11	4	2	2.36	3.75	-	-	-
Belwood town, Cleveland County	631	256	193	164	19	66	59	28	21	2.64	2.87	-	-	-
Benson town, Johnston County	2 728	1 137	718	456	207	419	368	202	176	2.40	3.08	82	67	15
Bent Creek CDP, Buncombe County	1 467	532	452	367	45	80	71	27	18	2.80	3.06	-	-	-
Bessemer City city, Gaston County	4 808	1 762	1 337	975	288	425	368	178	148	2.67	3.10	-	-	-
Bethel town, Pitt County	1 842	706	505	339	159	204	168	101	88	2.66	3.15	-	-	-
Bethlehem CDP, Alexander County	3 186	1 186	966	848	85	220	191	47	35	2.69	2.95	-	-	-
Beulaville town, Duplin County	921	411	274	184	67	137	122	63	52	2.24	2.77	12	12	-
Biltmore Forest town, Buncombe County	1 327	540	420	387	28	120	116	72	58	2.46	2.84	-	-	-
Biscoe town, Montgomery County	1 478	513	389	281	88	124	103	52	38	2.88	3.34	6	6	-
Black Creek town, Wilson County	615	243	182	167	24	61	46	27	24	2.53	2.89	-	-	-
Black Mountain town, Buncombe County	5 032	2 256	1 462	1 168	241	794	722	441	364	2.23	2.81	366	331	35
Bladenboro town, Bladen County	1 768	758	521	364	143	237	228	120	101	2.33	2.91	53	53	-
Bowing Rock town	1 178	570	333	286	34	237	213	85	66	2.07	2.73	78	76	2
Caldwell County	44	21	14	12	2	7	5	3	2	2.10	2.57	-	-	-
Watauga County	1 135	549	319	274	32	230	207	82	64	2.07	2.74	78	76	2
Boiling Spring Lakes city, Brunswick County	1 650	666	525	447	53	143	122	54	36	2.68	2.71	-	-	-
Boiling Springs town, Cleveland County	1 873	668	493	380	89	175	148	58	55	2.81	2.94	770	44	726
Bolton town, Brunswick County	228	87	64	50	12	23	21	15	13	2.62	3.13	-	-	-
Boiling town, Columbus County	331	111	44	34	4	58	54	34	22	2.58	3.16	-	-	-
Bonnie Doone CDP, Cumberland County	3 885	1 580	1 008	637	315	581	431	41	24	2.45	2.99	5	-	5
Boone town, Watauga County	8 607	4 053	1 470	1 141	248	2 583	1 305	275	238	2.12	2.71	4 308	127	4 181
Boonville town, Yadkin County	998	400	298	247	49	104	97	82	54	2.48	2.93	11	-	11
Boonville town, Rutherford County	371	172	111	85	15	28	22	11	8	2.71	3.04	-	-	-
Brevard city, Transylvania County	6 809	2 872	1 331	1 026	272	741	661	421	365	2.27	2.82	778	166	611
Bridgeton town, Craven County	453	193	130	103	16	63	57	20	17	2.34	2.80	-	-	-
Broadway town	973	362	286	247	32	76	71	37	28	2.69	3.08	-	-	-
Harnett County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lee County	973	362	286	247	32	76	71	37	28	2.69	3.08	-	-	-
Brogden CDP, Wayne County	3 246	1 055	851	624	182	208	162	31	25	3.07	3.44	-	-	-
Brookford town, Catawba County	451	189	133	93	27	56	52	31	21	2.39	2.85	-	-	-
Brunswick town, Columbus County	302	106	81	62	15	25	24	8	7	2.85	3.37	-	-	-
Bryson City town, Swain County	1 063	491	305	233	57	188	171	100	84	2.16	2.73	82	82	-

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							Householder living alone							
								65 years and over						
			Total	Married-couple family	Female householder, no husband present	Total	Total	Total	Female	Household	Family	Total	Institutionalized persons	Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Buies Creek CDP, Harnett County	833	447	234	154	28	193	154	43	39	2.19	2.87	1 152	-	1 152
Bunn town, Franklin County	344	157	103	77	22	57	54	25	20	2.32	3.04	-	-	-
Bunyan town, Pender County	1 577	655	437	313	101	196	196	123	102	2.41	3.00	330	330	-
Burlington city, Alamance County	36 021	16 827	11 217	8 466	2 255	5 410	4 803	2 162	1 795	2.35	2.89	477	420	57
Burnsville town, Yancey County	1 408	673	430	317	68	273	268	177	142	2.09	2.81	74	74	-
Butner CDP, Granville County	3 152	1 216	867	642	199	328	294	73	62	2.59	3.07	1 527	1 527	-
Cajah's Mountain town, Caldwell County	2 160	847	682	578	75	165	143	73	56	2.55	2.84	259	259	-
Calabash town, Brunswick County	1 210	568	464	476	14	105	92	46	34	2.02	2.21	-	-	-
Calypso town, Duplin County	481	186	136	104	27	50	47	28	23	2.55	3.09	-	-	-
Cameron town, Moore County	215	79	57	37	18	22	22	11	9	2.72	3.23	-	-	-
Camp Lejeune Central CDP, Onslow County	14 671	4 088	4 043	3 863	116	45	30	-	-	3.59	3.60	22 045	310	21 735
Candor town, Montgomery County	745	299	227	158	40	92	88	33	32	2.49	3.05	3	-	3
Canton town, Haywood County	3 663	1 715	1 152	866	174	613	577	369	307	2.15	2.71	107	107	-
Cape Carteret town, Carteret County	1 008	441	346	323	33	95	91	37	43	2.29	2.56	-	-	-
Carolina Beach town, New Hanover County	3 574	1 635	1 004	835	133	631	478	125	85	2.23	2.77	54	54	-
Carrboro town, Orange County	11 543	5 637	2 914	1 448	445	3 823	2 022	156	122	2.05	2.73	10	-	10
Carthage town, Moore County	912	377	252	194	46	125	113	62	44	2.42	3.03	84	84	-
Cary town, Wake County	43 782	16 908	12 239	10 770	1 142	4 668	3 572	445	361	2.59	3.06	76	76	-
Casar town, Cleveland County	356	127	101	83	11	26	25	10	9	2.58	2.83	-	-	-
Castalia town, Nash County	261	98	74	53	17	24	23	15	11	2.66	3.12	-	-	-
Castle Hayne CDP, New Hanover County	1 178	444	342	256	66	102	97	24	20	2.65	3.22	4	4	-
Caswell Beach town, Brunswick County	175	84	56	55	1	28	28	7	4	2.08	2.56	-	-	-
Catawba town, Catawba County	467	186	145	112	26	41	40	23	19	2.51	2.90	-	-	-
Cedar Point town, Carteret County	628	333	196	181	12	107	97	41	31	2.07	2.56	-	-	-
Centerville town, Franklin County	115	48	35	28	5	13	13	6	7	2.40	2.86	-	-	-
Cerro Gordo town, Columbus County	227	88	68	56	11	20	20	7	6	2.58	3.04	-	-	-
Chadbourn town, Columbus County	2 005	736	541	351	164	255	241	123	98	2.52	3.16	-	-	-
Chapel Hill town	30 054	13 780	6 786	5 301	1 122	7 014	4 552	1 046	862	2.18	2.83	8 665	245	8 420
Durham County	1 115	498	277	246	36	211	152	11	8	2.24	2.85	-	-	-
Orange County	29 939	13 282	6 479	5 145	1 086	6 803	4 370	1 035	874	2.18	2.82	8 665	245	8 420
Charlotte city, Mecklenburg County	380 037	158 991	102 864	75 403	22 334	56 067	44 565	11 059	9 043	2.45	3.05	5 867	2 606	3 271
Cherryville city, Gaston County	4 650	1 950	1 372	1 043	257	578	531	316	269	2.38	2.89	106	106	-
China Grove town, Rowan County	2 719	1 096	777	564	146	319	292	144	117	2.48	3.03	13	-	13
Chocowinity town, Beaufort County	610	253	185	140	34	68	63	29	20	2.41	2.86	14	-	14
Claremont city, Catawba County	980	422	288	238	39	113	97	56	47	2.44	2.91	-	-	-
Clarkton town, Bladen County	661	258	198	131	60	59	57	32	27	2.64	3.09	58	58	-
Clayton town, Johnston County	4 668	1 830	1 330	986	282	537	481	213	184	2.51	3.02	67	67	-
Clemmons village, Forsyth County	5 850	2 182	1 786	1 564	148	413	357	116	92	2.68	3.02	178	178	-
Cleveland town, Rowan County	806	252	197	136	51	55	52	26	23	2.78	3.19	-	-	-
Clinton city, Sampson County	8 005	3 319	2 222	1 527	603	1 097	1 018	525	443	2.41	3.02	198	198	-
Clyde town, Haywood County	993	431	296	247	41	135	121	50	42	2.30	2.82	48	48	-
Coats town, Harnett County	1 483	636	411	323	79	225	182	103	86	2.35	2.92	-	-	-
Cofield village, Hertford County	407	150	105	56	35	45	36	11	11	2.71	3.25	-	-	-
Coleraine town, Bertie County	139	62	45	38	5	17	17	12	12	2.24	2.84	-	-	-
Columbia town, Tyrrell County	832	337	218	127	80	119	109	68	53	2.47	3.14	4	4	-
Columbus town, Polk County	786	378	236	180	41	140	132	85	74	2.09	2.65	28	28	-
Como town, Hertford County	71	31	21	17	4	10	9	5	5	2.29	2.86	-	-	-
Concord city, Cabarrus County	26 341	10 807	7 451	5 621	1 466	3 356	2 959	1 378	1 154	2.44	2.87	1 006	630	376
Conetoe town, Edgecombe County	292	105	73	48	23	30	24	14	14	2.78	3.36	-	-	-
Connelly Springs town, Burke County	1 349	533	404	323	50	129	114	49	45	2.53	2.91	-	-	-
Conover city, Catawba County	5 415	2 135	1 589	1 328	223	546	487	191	157	2.54	2.98	50	47	3
Conway town, Northampton County	758	316	231	186	62	85	82	51	42	2.40	2.85	-	-	-
Cooleemee town, Davie County	971	408	300	240	46	108	104	64	54	2.37	2.81	-	-	-
Cornelius town, Mecklenburg County	2 561	982	720	548	138	262	228	77	61	2.60	3.14	-	-	-
Cory City town, Craven County	457	184	136	110	24	45	40	23	21	2.70	3.19	-	-	-
Courtenay town, Gaston County	2 371	950	690	579	84	260	238	140	114	2.50	2.98	-	-	-
Creedmoor city, Granville County	1 504	634	437	336	102	207	184	77	61	2.37	2.95	-	-	-
Creswell town, Washington County	361	137	105	80	43	32	31	21	16	2.64	3.10	-	-	-
Critical CDP, Wilkes County	2 015	838	591	462	85	247	218	92	78	2.40	2.89	-	-	-
Crossnore town, Avery County	217	89	66	50	11	23	20	12	11	2.44	2.83	-	-	-
Cullowhee CDP, Jackson County	1 274	568	375	272	40	324	306	26	25	2.13	2.82	2 735	72	2 663
Dallas town, Gaston County	3 007	1 184	830	598	191	345	306	126	103	2.54	3.07	5	-	5
Danbury town, Stokes County	119	48	38	32	4	10	9	6	4	2.48	2.84	-	-	-
Davidson town	2 561	1 115	891	538	125	424	357	112	80	2.29	2.91	1 486	265	1 220
Iredell County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mecklenburg County	2 551	1 115	891	538	125	424	357	112	80	2.29	2.91	1 486	265	1 220
Dellview town, Gaston County	10	3	3	2	1	-	-	-	-	3.33	3.33	-	-	-
Denton town, Davidson County	1 282	526	373	304	52	157	140	80	67	2.44	2.97	-	-	-
Dillsboro town, Jackson County	95	50	28	21	5	24	22	6	6	1.90	2.65	-	-	-
Dobbins Heights town, Richmond County	1 144	466	354	151	116	112	106	106	73	2.35	3.17	-	-	-
Dobson town, Surry County	1 032	468	295	216	68	174	160	82	68	2.20	2.81	163	163	-
Dortches town, Nash County	840	308	246	205	34	63	55	33	31	2.72	3.04	-	-	-
Dover town, Craven County	451	173	130	85	28	43	43	24	20	2.61	3.07	-	-	-
Drexel town, Burke County	1 831	666	488	372	91	226	199	95	77	2.34	2.78	115	115	-
Dublin town, Bladen County	246	104	71	52	15	33	29	12	10	2.37	2.86	-	-	-
Dunn city, Harnett County	8 156	3 343	2 252	1 531	634	1 091	1 018	533	447	2.44	3.02	180	159	21
Durham city	128 821	56 001	36 778	22 081	9 038	23 225	18 286	4 757	3 833	2.30	2.96	7 990	1 640	6 350
Durham County	128 804	55 996	36 771	22 078	9 038	23 225	18 286	4 757	3 833	2.30	2.96	7 990	1 640	6 350
Orange County	17	5	5	3	2	-	-	-	-	3.40	3.40	-	-	-
East Bend town, Yadkin County	618	247	184	153	24	63	56	16	14	2.51	2.98	-	-	-
East Flat Rock CDP, Henderson County	3 218	1 384	982	740	163	402	367	157	127	2.33	2.83	-	-	-
East Laurinburg town, Scotland County	332	115	82	44	17	34	32	18	18	2.48	2.99	-	-	-
Eastover CDP, Cumberland County	1 185	461	357	265	71	130	125	50	45	2.43	2.86	56	56	-
East Rockingham CDP, Richmond County	4 158	1 644	1 178	863	229	466	436	214	185	2.53	3.06	-	-	-
East Spencer town, Rowan County	2 050	798	506	247	233	293	276	124	83	2.57	3.38	5	5	-
Eden city, Rockingham County	15 015	6 308	4 308	3 178	945	2 000	1 830	940	784	2.35	2.91	223	223	-
Edenton town, Chowan County	4 995	2 031	1 372	863	453	659	610	341	254	2.46	3.07	213	213	-
Elizabeth City city	12 955	5 340	3 488	2 226	1 127	1 841	1 670	865	722	2.43	3.07	1 337	313	1 024
Camden County	29	16	11	10	1	5	5	2	2	1.81	2.18	-	-	-
Pasquotank County	12 926	5 324	3 488	2 226	1 126	1 836	1 665	863	720	2.43	3.07	1 337	313	1 024

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Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households			Nonfamily households				Persons per—		Persons in group quarters		
							Householder living alone							
								65 years and over						
			Total	Married-couple family	Female householder, no husband present	Total	Total	Total	Female	Household	Family	Total	Institutionalized persons	Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Elizabethtown town, Bladen County	3 509	1 494	998	589	361	496	475	285	222	2.35	2.96	195	195	-
Elkin town	3 587	1 674	1 050	835	175	624	586	300	237	2.15	2.78	163	123	-
Surry County	3 527	1 647	1 028	822	167	619	582	297	236	2.14	2.74	163	163	-
Wilkes County	70	27	22	13	8	5	4	3	1	2.59	2.61	-	-	-
Elk Park town, Avery County	466	198	141	108	23	57	52	23	17	2.45	2.84	-	-	-
Ellenboro town, Rutherford County	514	225	154	104	41	71	68	36	27	2.28	2.84	-	-	-
Ellerbe town, Richmond County	1 132	457	305	206	154	132	121	73	55	2.48	2.91	-	-	-
Elm City town, Wilson County	1 577	596	429	282	115	167	148	67	56	2.65	3.15	47	37	10
Elon College town, Alamance County	2 757	1 066	683	581	77	383	213	72	58	2.56	3.24	1 657	12	1 645
Elrov CDP, Wayne County	4 028	1 545	1 133	821	158	412	331	83	48	2.61	3.24	-	-	-
Emerald Isle town, Carteret County	2 411	1 128	772	714	31	354	283	55	42	2.14	2.77	33	-	33
Enfield town, Halifax County	2 802	1 054	740	366	334	314	298	178	152	2.74	3.26	190	190	-
Enochville CDP, Rowan County	2 873	1 103	804	734	121	299	187	103	80	2.80	2.96	28	28	-
Erwin town, Harnett County	4 054	1 747	1 188	950	181	559	526	232	225	2.32	2.96	7	3	4
Etowah CDP, Henderson County	1 967	853	637	574	52	216	195	82	67	2.34	2.74	-	-	-
Eureka town, Wayne County	282	117	81	67	13	36	35	24	18	2.41	3.11	-	-	-
Everetts town, Martin County	143	63	45	33	9	18	18	14	14	2.27	2.66	-	-	-
Fair Bluff town, Columbus County	1 052	429	277	180	87	152	143	86	62	2.48	3.21	6	6	-
Fairmont town, Robeson County	2 475	997	686	572	284	311	296	172	155	2.48	3.26	14	14	-
Fairview CDP, Wilkes County	2 338	966	692	544	114	274	249	114	94	2.42	2.82	-	-	-
Fairview CDP, Buncombe County	1 630	682	550	485	53	123	104	36	31	2.66	2.96	-	-	-
Faison town, Duplin County	731	288	178	127	33	112	98	60	47	2.63	3.13	-	-	-
Falls town, Rowan County	553	221	163	146	12	58	54	38	35	2.50	3.20	-	-	-
Falcon town	216	86	62	52	4	24	22	9	9	2.51	3.08	-	-	-
Cumberland County	216	86	62	52	4	24	22	9	9	2.51	3.08	-	-	-
Sampson County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fallston town, Pitt County	108	41	29	21	5	12	11	8	7	2.63	3.28	-	-	-
Fallston town, Cleveland County	498	203	142	128	16	54	50	27	22	2.45	2.95	-	-	-
Farmville town, Pitt County	4 392	1 804	1 205	778	380	599	563	334	269	2.43	3.21	-	-	-
Fayetteville city, Cumberland County	73 231	29 639	20 431	14 654	4 992	9 208	7 736	2 515	2 047	2.47	2.96	2 464	955	1 509
Fearrington CDP, Chatham County	1 101	544	420	404	13	124	103	45	37	2.02	2.71	-	-	-
Flat Rock CDP, Surry County	1 812	736	547	453	93	195	180	85	68	2.46	2.81	-	-	-
Fletcher town, Henderson County	2 787	1 135	848	710	110	289	252	98	77	2.46	2.87	-	-	-
Forest City town, Rutherford County	7 450	3 002	2 112	1 387	609	890	812	440	366	2.41	2.97	25	25	-
Forest Oaks CDP, Guilford County	3 054	1 088	678	600	45	112	99	30	27	2.81	2.96	-	-	-
Fort Bragg CDP, Cumberland County	17 760	4 732	4 568	4 315	231	134	130	1	1	3.75	3.81	16 984	-	16 984
Fountain town, Pitt County	445	205	132	81	47	73	73	52	47	2.17	2.80	-	-	-
Four Oaks town, Johnston County	1 303	566	379	279	83	177	161	84	68	2.34	2.86	5	5	-
Fairfax village, Moore County	334	164	135	134	1	29	29	22	16	2.04	2.25	-	-	-
Franklin town, Macon County	2 808	1 357	830	658	145	527	483	268	237	2.07	2.66	65	65	-
Franklinton town, Franklin County	1 615	674	436	279	130	235	215	125	102	2.40	3.05	-	-	-
Franklinville town, Randolph County	666	249	190	145	24	69	61	30	28	2.67	3.15	-	-	-
Fremont town, Wayne County	1 634	667	443	281	139	224	210	126	101	2.45	3.11	78	76	2
Fuquay-Varina town, Wake County	4 456	1 856	1 246	898	256	610	540	273	237	2.40	2.96	164	162	2
Garmon town, Caldwell County	3 357	1 287	1 035	813	163	252	218	58	41	2.61	2.81	-	-	-
Garland town, Sampson County	687	267	221	177	51	66	56	25	21	2.51	3.21	56	-	56
Garner town, Wake County	14 840	5 764	4 338	3 561	829	1 426	1 233	236	204	2.57	3.00	127	127	-
Garysburg town, Northampton County	1 057	378	277	137	123	101	84	41	30	2.80	3.35	-	-	-
Gaston town, Northampton County	1 003	413	308	214	83	105	83	36	28	2.43	2.78	-	-	-
Gastonia city, Gaston County	53 645	20 883	15 085	12 750	3 556	5 808	5 146	2 233	1 879	2.56	3.26	1 067	619	168
Gatesville town, Gates County	308	132	83	75	13	36	36	25	23	2.33	2.96	-	-	-
Gibson town, Scotland County	532	197	145	80	58	52	48	24	22	2.70	3.11	-	-	-
Gibsonville town	3 441	1 343	966	728	177	396	314	141	119	2.56	3.24	-	-	-
Alamance County	1 480	583	404	324	65	179	126	43	33	2.54	3.24	-	-	-
Guilford County	1 961	760	562	404	112	217	188	98	87	2.58	3.11	-	-	-
Glen Alpine town, Burke County	557	224	155	132	18	69	62	36	31	2.46	3.21	-	-	-
Glen Raven CDP, Alamance County	2 604	1 022	780	622	121	233	204	109	91	2.55	2.83	12	12	-
Godwin town, Cumberland County	77	33	30	13	6	13	12	7	6	2.33	3.15	-	-	-
Goldsboro city, Wayne County	34 267	13 423	9 423	6 364	2 668	4 000	3 630	1 466	1 212	2.54	3.12	6 347	2 027	4 315
Goldston town, Chatham County	299	125	92	78	14	33	31	20	18	2.39	2.87	-	-	-
Gorman CDP, Durham County	1 090	403	319	269	38	104	82	43	38	2.68	3.05	-	-	-
Graham city, Alamance County	9 864	4 280	2 953	2 237	596	1 327	1 232	550	463	2.33	2.84	432	425	7
Grandfather village, Avery County	34	14	10	6	1	4	2	-	-	2.43	2.85	-	-	-
Granite Falls town, Caldwell County	3 088	1 287	885	651	185	402	351	185	160	2.40	2.95	167	167	-
Granite Quarry town, Rowan County	1 648	642	475	384	68	167	154	56	41	2.56	3.03	-	-	-
Grantsboro town, Pamlico County	512	186	138	75	52	50	47	24	23	2.75	3.33	-	-	-
Greensboro city, Guilford County	174 800	74 805	46 107	33 801	10 304	28 798	22 836	6 822	5 557	2.33	2.95	6 821	1 573	7 048
Greenville city, Pitt County	36 973	17 017	9 065	6 174	2 455	7 952	5 198	1 148	931	2.35	3.24	5 001	578	4 423
Grifton town	2 309	921	666	480	152	255	242	134	107	2.51	3.23	84	84	-
Lenoir County	253	97	67	35	29	30	28	17	14	2.61	3.28	-	-	-
Pitt County	2 056	824	599	455	123	225	214	117	93	2.50	3.20	84	84	-
Grimesland town, Pitt County	469	182	126	97	28	56	53	38	32	2.58	3.17	-	-	-
Grover town, Cleveland County	516	215	157	120	28	58	53	33	28	2.40	2.84	-	-	-
Half Moon CDP, Onslow County	6 306	1 989	1 723	1 500	177	266	194	31	30	3.20	3.43	-	-	-
Halifax town, Halifax County	275	119	84	70	12	35	33	21	17	2.31	2.83	-	-	-
Hamilton town, Martin County	524	195	149	111	28	46	41	20	15	2.86	3.13	33	33	-
Harbers ch., Richmond County	6 085	2 419	1 723	1 184	443	696	633	351	298	2.51	3.04	101	99	2
Harbers Island CDP, Carteret County	1 756	679	544	472	56	135	122	60	45	2.59	2.93	-	-	-
Harmony town, Iredell County	431	178	134	113	19	44	40	23	21	2.42	2.82	-	-	-
Harrells town	187	74	55	42	10	19	18	11	6	2.53	2.96	-	-	-
Duplin County	2	1	1	1	-	-	-	-	-	2.00	2.00	-	-	-
Sampson County	185	73	54	41	10	19	18	11	6	2.53	2.96	-	-	-
Harrellsville town, Hertford County	126	47	35	28	4	12	12	7	6	2.61	2.91	-	-	-
Harrisburg town, Cabarrus County	1 625	614	511	447	44	103	93	37	34	2.65	2.83	-	-	-
Hassell town, Martin County	98	36	25	17	7	14	12	4	3	2.64	3.08	-	-	-
Havelock city, Craven County	17 550	5 861	4 824	4 364	431	737	563	96	79	3.12	3.33	2 718	-	2 718
Haw River town, Alamance County	1 855	786	562	403	116	224	215	91	73	2.36	2.84	-	-	-
Hayesville town, Clay County	275	158	74	58	11	84	80	51	44	1.74	2.46	-	-	-
Hays CDP, Wilkes County	1 522	566	451	379	52	115	98	38	31	2.69	3.02	-	-	-
Hazelwood town, Haywood County	1 508	701	465	347	88	236	214	125	105	2.29	2.73	-	-	-
Hemby Bridge CDP, Union County	2 878	924	799	695	80	125	95	17	14	3.11	3.26	-	-	-

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							Householder living alone							
								65 years and over						
			Total	Married-couple family	Female householder, no husband present	Total	Total	Total	Female	Household	Family	Total	Institutionalized persons	Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Hendersonville city, Vance County	15 309	6 017	4 165	2 543	1 419	1 852	1 661	817	657	2.54	3.10	346	346	-
Hendersonville city, Henderson County	6 867	3 192	1 904	1 344	467	1 288	1 186	677	554	2.15	2.62	417	318	99
Hertford town, Perquimans County	2 028	809	550	367	163	259	243	147	124	2.51	3.15	77	77	-
Hickory city	26 878	11 800	7 364	5 421	1 562	4 436	3 714	1 266	1 047	2.28	2.86	1 423	568	855
Burke County	40	15	14	12	-	1	1	1	1	2.67	2.75	36	36	-
Catawba County	26 838	11 785	7 350	5 409	1 562	4 435	3 713	1 265	1 046	2.28	2.86	1 364	509	855
Highlands town	934	432	290	243	27	152	148	85	72	2.16	2.74	14	14	-
Jackson County	4	2	2	2	-	-	-	-	-	2.00	2.00	-	-	-
Macon County	930	430	278	241	27	152	148	85	72	2.16	2.74	14	14	-
High Point city	67 640	27 529	18 896	13 407	4 580	8 631	7 435	3 171	2 846	2.46	2.99	1 856	921	935
Davidson County	471	186	126	85	29	60	37	4	4	2.53	2.92	-	-	-
Forsyth County	6	3	3	3	-	-	-	-	-	2.00	2.00	-	-	-
Guilford County	67 126	27 325	18 758	13 319	4 548	8 567	7 396	3 166	2 841	2.46	2.96	1 856	921	935
Randolph County	37	15	11	6	2	4	2	1	1	2.47	2.82	-	-	-
High Shoals city, Gaston County	605	228	167	116	54	61	40	21	16	2.64	2.96	-	-	-
Hildebran town, Burke County	730	325	243	178	52	82	80	51	41	2.41	2.84	-	-	-
Hillsborough town, Orange County	4 131	1 646	1 163	791	350	485	430	186	158	2.51	3.22	132	126	6
Hobgood town, Halifax County	435	173	133	98	35	50	46	33	23	2.51	3.08	-	-	-
Hoffman town, Richmond County	348	138	88	64	24	50	43	24	22	2.50	3.23	-	-	-
Holden Beach town, Brunswick County	626	304	233	163	70	84	77	21	17	2.06	2.42	-	-	-
Holly Ridge town, Onslow County	724	272	208	145	63	64	55	16	15	2.66	3.07	4	-	4
Holly Springs town, Wake County	908	311	236	163	69	72	65	28	23	2.92	3.37	-	-	-
Hookerton town, Greene County	422	173	121	84	33	52	50	28	23	2.44	3.03	-	-	-
Hope Mills town, Cumberland County	8 124	2 955	2 313	1 775	475	642	537	155	134	2.75	3.13	85	85	-
Hot Springs town, Madison County	478	199	137	114	21	62	57	33	28	2.40	2.66	-	-	-
Hudson town, Caldwell County	2 819	1 152	882	722	118	270	241	77	65	2.45	2.83	-	-	-
Huntersville town, Mecklenburg County	3 014	1 257	860	666	158	397	360	127	108	2.40	2.95	6	6	-
Hurdle CDP, Burke County	2 547	967	740	613	91	257	226	80	66	2.55	2.98	-	-	-
Indian Beach town, Carteret County	149	86	51	43	5	18	15	2	1	2.16	2.47	4	-	4
Indian Trail town, Union County	1 642	668	570	526	44	125	102	39	30	2.78	3.06	-	-	-
Jackson town, Northampton County	576	236	156	128	28	77	73	36	32	2.44	3.00	16	-	16
Jacksonville city, Onslow County	28 306	10 916	8 483	6 805	1 435	2 423	2 008	563	478	2.69	3.08	617	505	112
Jamesville town, Martin County	4 165	1 674	1 233	941	214	471	403	157	126	2.48	2.95	114	112	2
Jamestown town, Guilford County	2 803	995	747	637	83	248	195	66	46	2.81	3.02	-	-	-
Jamesville town, Martin County	808	282	163	113	57	98	83	48	44	2.32	3.01	4	-	4
Jefferson town, Ashe County	1 080	474	339	256	65	145	135	72	63	2.28	2.78	23	23	-
Jonesville town, Yadkin County	1 549	666	455	316	111	214	198	103	79	2.32	2.85	-	-	-
Kannapolis city	29 329	12 018	8 476	6 405	1 800	3 542	3 150	1 651	1 387	2.44	2.94	376	315	61
Cabarrus County	21 084	8 632	6 109	4 641	1 221	2 523	2 238	1 138	961	2.44	2.94	136	75	61
Rowan County	8 238	3 386	2 367	1 764	469	1 019	912	513	426	2.43	2.94	240	240	-
Kelford town, Bertie County	204	80	52	31	18	28	28	17	15	2.55	3.31	-	-	-
Kenansville town, Duplin County	656	290	196	155	34	94	80	41	33	2.26	2.82	200	200	-
Kenly town	1 548	657	437	287	134	220	206	109	83	2.36	2.98	-	-	-
Johnston County	1 306	564	366	256	113	198	188	102	87	2.35	2.96	-	-	-
Wilson County	153	63	42	21	21	21	20	7	6	2.13	3.10	-	-	-
Kernersville town	10 868	4 755	3 013	2 264	606	1 742	1 462	367	313	2.24	2.82	164	163	5
Forsyth County	10 868	4 755	3 013	2 264	606	1 742	1 462	367	313	2.24	2.82	164	163	5
Guilford County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kill Devil Hills town, Dare County	4 238	1 817	1 142	943	143	675	455	88	64	2.33	2.81	2	-	2
King city	4 009	1 909	1 207	1 006	134	302	267	100	88	2.66	3.01	50	50	-
Forsyth County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stokes County	4 009	1 909	1 207	1 006	138	302	267	100	88	2.66	3.01	50	50	-
Kings Mountain city	8 638	3 464	2 511	1 757	505	953	877	482	366	2.49	2.99	124	124	-
Cleveland County	7 883	3 234	2 310	1 678	518	924	852	475	361	2.44	2.94	124	124	-
Gaston County	756	230	201	118	77	29	25	7	5	3.29	3.55	-	-	-
Kingstown town, Cleveland County	966	370	235	155	64	35	29	14	8	3.54	3.86	-	-	-
Kinston city, Lenoir County	24 155	9 867	6 576	3 988	2 253	3 411	3 153	1 530	1 258	2.42	3.05	1 140	1 001	45
Kittrell town, Vance County	228	81	66	46	16	15	14	5	5	2.81	3.12	-	-	-
Kitty Hawk town, Dare County	1 902	798	541	474	58	258	232	55	40	2.38	2.86	36	-	36
Knightdale town, Wake County	1 884	733	556	458	78	177	153	36	34	2.57	2.96	-	-	-
Kure Beach town, New Hanover County	618	282	198	178	19	83	73	31	18	2.20	2.56	-	-	-
La Grange town, Lenoir County	2 805	1 153	726	495	231	427	398	158	129	2.53	3.24	-	-	-
Lake Junaluska CDP, Haywood County	2 482	1 006	725	580	99	311	272	134	111	2.28	2.68	-	-	-
Lake Lure town, Rutherford County	861	334	247	223	17	87	78	43	28	2.07	2.42	-	-	-
Lake Waccamaw town, Columbus County	751	333	227	181	40	106	95	43	34	2.26	2.73	23	23	-
Lands town, Rowan County	2 333	987	713	580	102	274	248	152	131	2.36	2.82	-	-	-
Lansing town, Ashe County	171	83	53	41	7	30	29	18	13	2.06	2.57	-	-	-
Lasker town, Northampton County	139	52	43	36	6	9	9	3	3	2.24	2.79	-	-	-
Latimore town, Cleveland County	183	72	53	36	6	19	17	12	11	2.54	2.96	-	-	-
Laurel Park town, Henderson County	1	1	450	422	23	178	167	100	89	2.11	2.51	-	-	-
Laurinburg city, Scotland County	10	4	2 905	1 864	1 102	1 378	1 291	668	551	2.52	3.16	848	174	674
Lawndale town, Cleveland County	573	236	172	140	26	67	63	45	41	2.40	2.87	-	-	-
Leggett town, Edgecombe County	108	36	27	24	1	9	8	1	-	3.00	3.56	-	-	-
Leland town, Brunswick County	1 801	679	520	413	80	159	141	41	28	2.65	3.07	-	-	-
Lenoir city, Caldwell County	13 969	5 928	4 046	2 893	847	1 883	1 708	808	673	2.36	2.86	203	158	45
Lewiston Woodville town, Bertie County	788	299	226	129	71	73	66	41	36	2.64	3.29	-	-	-
Lewisville CDP, Forsyth County	3 228	1 280	982	831	124	298	281	53	41	2.50	2.86	-	-	-
Lexington city, Davidson County	16 481	6 985	4 644	3 177	1 231	2 341	2 058	962	773	2.34	2.91	100	70	30
Liberty town, Randolph County	2 047	865	598	440	131	284	244	140	123	2.37	2.86	-	-	-
Lilly Oak CDP, Cleveland County	1 213	364	315	198	102	69	65	31	25	3.18	3.56	126	126	-
Llewellyn town, Anson County	468	185	125	96	21	60	60	38	36	2.53	3.13	-	-	-
Lillington town, Harnett County	1 408	536	367	256	111	249	229	129	115	2.63	3.25	858	858	-
Lincolnton city, Lincoln County	6 582	2 713	1 861	1 344	434	852	778	415	353	2.43	2.96	265	265	-
Linden town, Cumberland County	180	65	50	43	6	15	13	9	9	2.77	3.24	-	-	-
Littleton town, Halifax County	881	333	208	140	65	112	104	66	63	2.18	2.71	-	-	-
Locust city, Stanly County	1 940	688	562	517	90	107	96	45	41	2.82	3.15	-	-	-
Long Beach town, Brunswick County	3 818	1 663	1 225	1 078	107	458	395	131	85	2.27	2.64	-	-	-

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NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households			Nonfamily households				Persons per—		Persons in group quarters		
							Householder living alone							
								65 years and over						
			Total	Married-couple family	Female householder, no husband present	Total	Total	Total	Female	Household	Family	Total	Institutionalized persons	Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Long View town	3 229	1 309	952	744	158	447	363	184	155	2.51	2.80	-	-	-
Burke County	358	150	113	90	14	37	34	15	14	2.39	2.71	-	-	-
Catawba County	2 871	1 249	839	654	144	410	359	169	141	2.30	2.81	-	-	-
Louisburg town, Franklin County	2 193	963	602	366	208	361	342	200	167	2.28	2.97	844	238	606
Love Valley town, Iredell County	67	29	23	20	1	6	6	1	-	2.31	2.52	-	-	-
Lowell city, Gaston County	2 654	1 073	769	568	137	304	264	133	108	2.47	2.95	55	55	-
Lowesville CDP, Lincoln County	1 092	385	312	271	33	73	61	26	21	2.84	3.22	-	-	-
Lucama town, Wilson County	827	308	271	188	63	37	28	4	4	2.52	2.97	6	6	-
Lumber Bridge town, Robeson County	102	41	33	23	8	11	10	4	4	2.49	3.00	-	-	-
Lumberton city, Robeson County	17 894	7 093	4 953	3 165	1 589	2 130	1 968	891	737	2.52	3.08	797	682	115
McAdenville town, Gaston County	830	336	245	196	30	93	55	24	22	2.79	3.13	-	-	-
Macclesfield town, Edgecombe County	433	218	144	116	21	74	70	47	40	2.26	2.81	-	-	-
McDonald town, Robeson County	88	35	27	17	8	8	6	6	3	2.51	2.89	-	-	-
McFarlan town, Anson County	98	38	26	19	7	12	11	7	6	2.58	3.27	-	-	-
McLeansville CDP, Guilford County	1 154	452	349	301	34	101	82	31	22	2.56	2.97	-	-	-
Macon town, Warren County	154	67	41	34	2	26	24	8	7	2.70	3.12	-	-	-
Madison town, Rockingham County	2 371	943	656	467	148	285	254	128	100	2.51	3.04	-	-	-
Maggie Valley town, Haywood County	185	88	62	52	6	23	22	10	7	2.08	2.47	-	-	-
Magnolia town, Duplin County	747	299	213	136	62	86	89	31	16	2.56	3.03	-	-	-
Maiden town	2 574	973	748	567	142	225	212	109	86	2.64	3.06	-	-	-
Catawba County	2 574	973	748	567	142	225	212	109	86	2.64	3.06	-	-	-
Lincoln County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manteo town, Dare County	964	444	252	195	46	192	164	72	57	2.17	2.86	27	26	1
Marietta town, Robeson County	208	84	52	30	20	32	10	5	4	3.22	3.65	-	-	-
Marion city, McDowell County	4 718	2 091	1 334	969	311	777	712	408	365	2.26	2.90	47	12	35
Mar-Mac CDP, Wayne County	3 282	1 259	968	822	113	311	235	63	53	2.61	2.97	-	-	-
Marshall town, Madison County	802	343	232	166	53	111	104	71	55	2.34	2.67	-	-	-
Mars Hill town, Madison County	911	416	253	233	43	163	138	74	67	2.19	2.83	700	-	868
Marshville town, Union County	1 822	706	517	356	132	152	180	99	83	2.71	3.25	98	98	-
Masonboro CDP, New Hanover County	7 010	2 524	2 150	1 940	166	374	311	78	62	2.78	3.03	-	-	-
Matthews town, Mecklenburg County	13 567	4 812	3 905	3 544	242	907	759	281	244	2.83	3.18	54	50	4
Maxton town	2 371	826	616	356	226	210	196	116	94	2.87	3.41	2	-	2
Robeson County	2 162	781	556	333	214	222	191	115	83	2.84	3.40	-	-	-
Scotland County	209	65	57	43	12	8	8	1	1	3.22	3.47	2	-	2
Mayodan town, Rockingham County	2 471	1 137	742	554	161	395	373	199	178	2.17	2.75	-	-	-
Maysville town, Jones County	892	347	241	163	60	106	100	57	41	2.57	3.18	-	-	-
Mebane city	4 744	1 891	1 375	1 050	282	516	474	212	177	2.51	3.00	10	10	-
Alamance County	4 258	1 697	1 229	939	251	468	432	196	165	2.51	3.01	10	10	-
Orange County	485	194	146	111	31	48	42	16	12	2.50	2.93	-	-	-
Mesic town, Pamlico County	310	119	80	72	16	29	27	20	13	2.61	3.07	-	-	-
Micro town, Johnston County	417	160	122	96	20	38	56	35	29	2.32	2.89	-	-	-
Middleburg town, Vance County	131	47	34	21	11	13	11	5	5	2.79	3.29	-	-	-
Middlesex town, Nash County	730	294	206	143	53	88	78	50	47	2.48	2.95	-	-	-
Miami Creek CDP, Wilkes County	1 787	686	557	460	82	132	116	44	30	2.59	2.92	-	-	-
Milton town, Caswell County	185	84	55	41	10	29	28	16	14	2.20	2.80	-	-	-
Minnesott Beach town, Pamlico County	266	129	99	91	6	30	26	19	15	2.06	2.36	-	-	-
Mint Hill town, Mecklenburg County	11 567	3 987	3 444	3 128	242	543	448	168	144	2.90	3.15	-	-	-
Mocksville town, Davie County	3 235	1 360	922	803	100	461	417	191	163	2.33	2.90	174	163	11
Monroe city, Union County	15 868	5 935	4 184	2 797	1 166	1 751	1 507	664	563	2.67	3.21	259	219	40
Montreat town, Buncombe County	304	181	131	117	12	50	43	14	13	2.18	2.54	299	-	299
Mooresboro city, Cleveland County	294	126	91	58	21	45	40	28	19	2.33	3.01	-	-	-
Mooresville town, Iredell County	9 088	3 563	2 524	1 915	511	1 088	961	470	402	2.52	3.07	248	248	-
Morehead City town, Carteret County	1 728	730	496	364	86	232	189	50	43	2.37	2.85	6	-	6
Morganton city, Burke County	5 746	2 673	1 573	1 058	419	1 102	972	446	343	2.15	2.82	300	295	5
	13 610	6 048	3 956	2 818	866	2 092	1 865	793	666	2.25	2.80	1 475	1 422	53
Morrisville town	1 022	415	291	236	37	124	96	22	15	2.46	2.94	-	-	-
Durham County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wake County	1 022	415	291	236	37	124	96	22	15	2.46	2.94	-	-	-
Morven town, Anson County	580	221	154	84	64	67	62	35	30	2.67	3.27	-	-	-
Mountain Home CDP, Henderson County	1 808	774	595	503	72	179	158	74	58	2.45	2.82	-	-	-
Mountain View CDP, Catawba County	3 897	1 293	1 082	830	127	191	171	52	41	2.88	3.17	-	-	-
Mount Airy city, Surry County	6 983	3 214	1 988	1 382	506	1 226	1 140	629	517	2.17	2.80	173	127	46
Mount Gilead town, Montgomery County	1 279	480	348	236	98	132	124	74	64	2.66	3.25	57	57	-
Mount Holly city, Gaston County	7 710	3 115	2 225	1 603	425	895	782	339	283	2.48	2.97	-	-	-
Mount Olive town	4 177	1 710	1 130	675	364	580	545	298	254	2.44	3.10	405	147	258
Duplin County	1	1	-	-	-	1	1	-	-	1.00	-	-	-	-
Wayne County	4 176	1 709	1 130	675	364	579	544	298	254	2.44	3.10	405	147	258
Mount Pleasant town, Cabarrus County	1 027	426	301	242	45	119	109	56	53	2.45	2.94	-	-	-
Mulberry CDP, Wilkes County	2 338	897	718	619	83	179	151	65	56	2.61	2.92	-	-	-
Murfreesboro town, Hertford County	1 993	854	588	452	117	266	247	145	126	2.33	2.87	567	4	563
Murphy town, Cherokee County	1 547	711	441	304	118	270	259	145	127	2.18	2.84	28	24	4
Myrtle Grove CDP, New Hanover County	4 275	1 681	1 222	1 127	132	369	313	93	70	2.54	2.93	-	-	-
Nags Head town, Dare County	1 720	756	478	425	45	280	220	50	31	2.24	2.78	118	114	4
Nashville town, Nash County	3 351	1 291	857	722	197	344	318	158	126	2.62	3.14	256	256	-
Navassa town, Brunswick County	445	132	114	67	33	21	20	8	7	3.30	3.68	-	-	-
Neuse Forest CDP, Craven County	1 110	382	343	315	24	39	29	7	4	2.51	3.06	-	-	-
New Bern city, Craven County	16 828	7 264	4 567	3 010	1 378	2 697	2 382	1 063	869	2.33	2.96	437	415	22
New Hope CDP, Wake County	5 569	2 248	1 695	1 460	172	553	436	98	71	2.48	2.84	125	125	-
New Hope CDP, Wayne County	4 467	1 823	1 295	1 108	151	528	184	48	37	2.95	3.22	4	4	-
Newland town, Avery County	837	334	194	126	62	95	86	42	36	2.24	2.74	8	8	-
New London town, Stanly County	414	158	128	105	22	30	27	10	9	2.62	2.97	-	-	-
Newport town, Carteret County	2 228	856	646	553	74	210	180	49	40	2.60	3.03	287	282	5
New River Station CDP, Onslow County	1 651	442	432	415	9	10	9	1	-	3.74	3.79	8 081	-	8 081
Newton city, Catawba County	9 065	3 783	2 580	1 673	575	1 203	1 078	518	433	2.42	2.94	239	223	16
Newton Grove town, Sampson County	511	205	147	108	31	58	55	25	23	2.49	3.02	-	-	-
Norlina town, Warren County	936	419	293	203	75	126	119	76	61	2.36	2.86	-	-	-
Norman town, Richmond County	105	45	27	23	4	18	18	7	6	2.33	3.04	-	-	-
North Hickory CDP, Catawba County	4 298	1 805	1 305	1 181	90	500	264	108	89	2.58	3.01	-	-	-

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							Householder living alone							
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			Total	Married-couple family	Female householder, no husband present	Total	Total	Total	Female	Household	Family	Total	Institutionalized persons	Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Northlakes CDP, Caldwell County	1 219	449	377	355	17	72	63	9	8	2.71	2.90	-	-	-
North Wilkesboro town, Wilkes County	3 258	1 471	867	565	264	604	550	274	222	2.21	2.64	126	121	5
Norwood town, Stanly County	1 617	659	474	342	109	155	147	78	65	2.57	3.02	-	-	-
Oakboro town, Stanly County	620	232	168	130	31	64	60	38	31	2.56	3.14	-	-	-
Oak City town, Martin County	356	147	105	86	15	42	38	19	14	2.65	3.22	-	-	-
Ocean Isle Beach town, Brunswick County	513	242	183	171	6	59	56	16	14	2.16	2.51	-	-	-
Ogden CDP, New Hanover County	3 228	1 216	964	827	106	252	197	46	32	2.65	2.98	-	-	-
Old Fort town, McDowell County	720	305	204	136	51	101	82	46	34	2.36	2.67	-	-	-
Oriental town, Pamlico County	786	365	275	231	39	90	67	50	36	2.15	2.50	-	-	-
Orrum town, Robeson County	133	38	28	16	9	12	11	7	5	2.71	3.36	-	-	-
Oxford city, Granville County	7 364	2 824	2 040	1 305	630	894	835	467	383	2.52	3.08	519	513	6
Pantego town, Beaufort County	173	74	48	32	13	26	25	20	17	2.31	2.80	-	-	-
Parkton town, Robeson County	367	155	105	81	20	50	50	34	31	2.32	2.85	-	-	-
Parkwood CDP, Durham County	4 123	1 439	1 145	988	127	283	210	43	36	2.83	3.26	-	-	-
Parmele town, Martin County	321	117	81	43	30	36	35	19	14	2.74	3.44	-	-	-
Patterson Springs town, Cleveland County	600	266	204	165	28	62	51	24	21	2.56	2.96	-	-	-
Peachland town, Anson County	364	135	107	81	23	28	28	17	15	2.84	3.33	-	-	-
Pembroke town, Robeson County	2 212	863	576	283	255	287	253	103	75	2.56	3.20	34	33	1
Pikeville town, Wayne County	568	256	184	154	25	75	71	41	36	2.31	2.79	-	-	-
Pilot Mountain town, Surry County	1 181	522	350	263	71	172	159	90	79	2.26	2.81	-	-	-
Pinebluff town, Moore County	676	342	256	214	34	86	81	36	36	2.56	3.22	-	-	-
Pinehurst town, Moore County	4 950	2 465	1 841	1 754	64	624	562	332	265	2.01	2.31	153	153	-
Pine Knoll Shores town, Carteret County	1 360	682	720	663	23	152	137	64	45	2.12	2.42	-	-	-
Pine Level town, Johnston County	1 217	526	373	305	54	144	144	79	69	2.31	2.74	-	-	-
Pinetops town, Edgecombe County	1 514	566	408	285	123	157	152	85	65	2.67	3.27	-	-	-
Pineville town, Mecklenburg County	2 917	1 302	715	582	93	577	505	98	88	2.10	2.82	53	46	7
Piney Green CDP, Onslow County	8 999	3 143	2 574	2 151	319	569	432	65	51	2.86	3.13	-	-	-
Pink Hill town, Lenoir County	547	214	147	109	33	67	58	24	19	2.56	3.13	-	-	-
Pittsboro town, Chatham County	1 352	564	364	284	63	200	180	95	82	2.28	2.82	84	84	-
Pleasant Garden CDP, Guilford County	2 185	836	652	521	95	187	158	49	36	2.80	2.97	43	43	-
Pleasant Hill CDP, Wilkes County	1 114	472	354	306	33	118	110	60	53	2.36	2.77	-	-	-
Plymouth town, Washington County	4 313	1 648	1 187	736	392	461	456	250	222	2.62	3.19	15	15	-
Polkton town, Anson County	662	236	166	110	46	68	64	40	28	2.81	3.42	-	-	-
Polkville city, Cleveland County	1 514	566	446	392	41	147	140	78	66	2.54	3.00	-	-	-
Pollocksville town, Jones County	296	134	89	73	13	45	45	19	12	2.22	2.78	-	-	-
Pope AFB CDP, Cumberland County	1 751	468	455	419	22	13	12	-	-	3.74	3.81	1 106	-	1 106
Poplar Tent CDP, Cabarrus County	3 872	1 414	1 138	980	116	276	244	90	72	2.74	3.08	-	-	-
Powellsville town, Bertie County	103	46	28	21	6	18	15	11	10	2.24	2.63	-	-	-
Princeton town, Johnston County	1 181	505	336	245	80	167	152	87	74	2.34	2.92	-	-	-
Princeville town, Edgecombe County	1 648	621	432	175	234	189	180	106	87	2.65	3.30	4	-	4
Proctorville town, Robeson County	168	63	46	36	8	17	15	8	7	2.67	3.07	-	-	-
Pumpkin Center CDP, Craven County	2 857	987	790	697	73	117	96	36	31	3.15	3.39	-	-	-
Raeford city, Hoke County	3 312	1 250	842	641	171	308	297	149	131	2.65	3.13	157	157	-
Raleigh city, Wake County	194 230	85 882	48 253	36 325	9 703	37 568	27 657	5 650	4 862	2.28	2.92	13 721	5 493	8 228
Ramseur town, Randolph County	1 186	503	354	286	52	149	137	67	75	2.36	2.85	-	-	-
Randleman city, Randolph County	2 612	1 080	758	532	163	332	293	137	129	2.40	2.90	-	-	-
Rankin town, Gaston County	1 650	670	470	365	85	157	143	78	63	2.63	3.09	-	-	-
Raynham town, Robeson County	108	40	31	23	6	9	9	1	1	2.85	3.23	-	-	-
Red Oak town, Nash County	280	107	75	56	12	32	30	14	12	2.82	3.23	-	-	-
Red Springs town, Robeson County	3 781	1 433	1 005	631	327	428	399	228	196	2.62	3.24	36	36	-
Reidsville city, Rockingham County	11 671	5 054	3 303	2 244	906	1 725	1 565	806	673	2.27	2.96	212	206	6
Rennert town, Robeson County	217	79	53	34	13	26	26	14	12	2.73	3.48	-	-	-
Rhodhiss town	636	230	174	126	32	56	51	25	25	2.77	3.21	-	-	-
Burke County	226	88	64	50	10	24	21	10	7	2.57	3.06	-	-	-
Caldwell County	412	142	110	76	22	32	30	15	18	2.90	3.29	-	-	-
Richfield town, Stanly County	535	198	144	122	15	44	41	15	12	2.85	3.33	-	-	-
Richlands town, Onslow County	868	366	273	198	62	111	104	64	55	2.54	3.13	-	-	-
Rich Square town, Northampton County	964	395	294	227	67	111	107	64	52	2.44	2.94	94	94	-
River Bend town, Craven County	2 225	1 033	804	747	50	219	191	89	86	2.17	2.45	183	183	-
River Road CDP, Beaufort County	3 882	1 521	1 154	960	158	367	331	108	80	2.56	2.96	-	-	-
Roanoke Rapids city, Halifax County	15 549	6 321	4 406	3 268	944	1 915	1 767	835	705	2.46	3.01	173	135	38
Robbins city, Moore County	957	395	277	192	62	118	105	61	55	2.42	2.88	13	13	-
Robbinsville town, Graham County	733	311	204	145	47	107	98	47	41	2.35	2.87	6	6	-
Robersonville town, Martin County	1 840	788	527	366	153	232	220	136	111	2.52	3.13	-	-	-
Rockingham city, Richmond County	9 041	3 727	2 558	1 828	637	1 168	1 098	511	419	2.43	3.00	358	341	17
Rockwell town, Rowan County	1 522	616	458	377	66	157	144	70	56	2.47	2.83	76	76	-
Rocky Mount city	48 648	18 971	13 223	8 878	3 758	5 648	4 980	2 103	1 736	2.56	3.13	349	314	35
Edgecombe County	17 040	6 124	4 416	2 327	1 856	1 708	1 523	713	583	2.78	3.33	17	4	13
Nash County	31 608	12 747	8 807	6 552	1 902	3 940	3 460	1 390	1 153	2.48	3.02	332	310	22
Roberdel town, Wake County	572	220	177	147	24	43	41	22	22	2.60	2.95	-	-	-
Ronda town, Wilkes County	367	149	107	86	15	42	38	21	15	2.46	2.96	-	-	-
Roper town, Washington County	668	334	175	104	63	59	56	30	24	2.86	3.42	-	-	-
Rosebore town, Sampson County	1 441	534	368	257	117	136	132	75	61	2.70	3.21	-	-	-
Rose Hill town, Duplin County	1 278	538	356	256	88	182	172	114	82	2.37	2.98	11	11	-
Rosman town, Transylvania County	385	147	101	79	16	46	44	25	18	2.53	3.09	-	-	-
Rowland town, Robeson County	1 139	451	296	168	114	155	149	81	74	2.53	3.22	-	-	-
Roxboro city, Person County	7 057	3 020	1 978	1 270	579	1 042	951	474	402	2.34	2.90	275	262	13
Roxobel town, Bertie County	244	102	71	56	9	31	30	22	22	2.39	2.97	-	-	-
Royal Pines CDP, Buncombe County	4 414	1 668	1 323	1 184	108	345	314	88	57	2.61	2.98	4	4	-
Rural Hall town, Forsyth County	1 852	736	454	368	78	282	245	82	69	2.24	2.80	-	-	-
Ruth town, Rutherford County	366	135	111	83	19	24	24	15	11	2.71	3.06	-	-	-
Rutherford College town, Burke County	1 128	468	338	278	46	129	123	59	50	2.41	2.86	-	-	-
Rutherfordton town, Rutherford County	3 433	1 473	973	781	180	468	460	236	202	2.33	2.82	184	184	-
St. Helena village, Pender County	321	127	87	79	8	40	36	15	12	2.53	3.15	4	4	-
St. Pauls town, Robeson County	1 888	800	556	401	130	245	223	117	101	2.48	3.04	4	4	-
St. Stephens CDP, Catawba County	8 673	3 247	2 617	2 192	315	630	543	144	123	2.67	3.03	61	55	6
Salem CDP, Burke County	2 271	853	689	560	96	204	180	61	55	2.51	2.86	-	-	-
Salemburg town, Sampson County	409	164	132	108	20	62	61	36	33	2.11	2.62	-	-	-
Salisbury city, Rowan County	21 092	8 162	5 822	4 130	1 412	3 340	3 012	1 452	1 232	2.30	2.92	1 995	923	1 072
Saluda city	466	206	153	124	24	55	51	25	21	2.35	2.77	-	-	-
Henderson County	3	2	1	1	-	1	1	-	-	1.50	2.00	-	-	-
Polk County	465	204	152	123	24	54	50	25	21	2.35	2.79	-	-	-
Sandy Creek town, Brunswick County	243	79	60	54	3	10	9	2	1	3.08	3.30	-	-	-

TPSS [POSTSCRIPT] CPH127 CENSUS80 7258080D 04/23/91 5:06 PM MACHINE: C DATA:CENSUS80'PHITPSDATS7. 04/23/91 165104 OUTPUT:ONSITE-PS198 PAGE: 111
TBF:CENSUS80'HE. 04/23/91 165123 LITF:CENSUS80'63. 04/23/91 165123 META:CENSUS80'PHITABLES37. 04/23/91 17:02:16

NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households			Nonfamily households				Persons per—		Persons in group quarters		
							Householder living alone							
								65 years and over						
			Total	Married-couple family	Female householder, no husband present	Total	Total	Total	Female	Household	Family	Total	Institutionalized persons	Other persons in group quarters
PLACE AND COUNTY SUBDIVISION—Con.														
Sanford city, Lee County	14 089	5 735	3 810	2 674	1 054	1 805	1 635	682	562	2.46	3.02	366	370	16
Sanseemah town, Graham County	47	27	15	14	1	12	9	6	5	1.74	2.13	-	-	-
Saratoga town, Wilson County	342	135	96	83	8	39	37	19	18	2.53	3.11	-	-	-
Sawmills town, Caldwell County	4 088	1 513	1 157	977	124	356	289	75	60	2.70	3.07	-	-	-
Saxapahaw CDP, Alamance County	1 178	425	344	265	66	81	72	23	17	2.77	3.12	-	-	-
Scotland Neck town, Halifax County	2 503	993	678	416	233	304	256	159	145	2.55	3.18	72	72	-
Seaboard town, Northampton County	791	296	211	115	86	65	76	45	37	2.67	3.24	-	-	-
Seagate CDP, New Hanover County	5 304	2 101	1 579	1 348	174	522	405	134	126	2.57	2.95	50	50	-
Seagrove town, Randolph County	244	103	75	63	9	28	27	14	12	2.37	2.63	-	-	-
Secrest Garden CDP, Forsyth County	2 784	1 253	877	800	69	176	154	75	60	2.64	2.94	-	-	-
Selma town, Johnston County	4 598	1 857	1 255	816	368	602	561	315	259	2.48	3.08	1	-	1
Seven Devils town	117	55	38	33	4	17	17	3	-	2.13	2.63	-	-	-
Avery County	23	10	6	5	-	4	4	2	-	2.30	2.67	-	-	-
Watauga County	97	45	32	28	4	13	13	1	-	2.16	2.63	-	-	-
Seven Lakes CDP, Moore County	1 991	956	771	741	23	98	88	56	43	2.29	2.43	56	56	-
Seven Springs town, Wayne County	163	79	47	36	11	32	32	17	17	2.06	2.77	-	-	-
Severn town, Northampton County	260	107	75	57	14	32	31	23	16	2.43	2.97	-	-	-
Shallotte town, Brunswick County	857	367	282	253	22	85	80	30	25	2.34	2.70	108	108	-
Shannon town	1 536	576	424	278	131	152	124	33	25	2.67	3.12	-	-	-
Edgecombe County	73	28	21	17	2	4	3	-	-	2.60	3.13	-	-	-
Hoke County	1 054	421	295	222	63	126	123	25	20	2.50	3.00	-	-	-
Wilson County	412	130	108	37	67	22	18	6	5	3.17	3.44	-	-	-
Shelby city, Cleveland County	14 266	6 081	3 995	2 486	1 315	2 094	1 837	949	811	2.35	2.96	403	372	31
Sherrills Ford CDP, Catawba County	3 174	1 268	968	884	67	306	238	81	60	2.50	2.85	11	-	11
Siler City town, Chatham County	4 627	1 906	1 329	943	319	567	506	230	191	2.44	2.92	181	181	-
Silver City CDP, Hoke County	1 343	434	327	151	154	107	97	46	34	3.09	3.68	-	-	-
Silver Lake CDP, New Hanover County	4 031	1 435	1 149	943	145	286	212	47	33	2.84	3.16	-	-	-
Simpsons village, Pitt County	410	161	117	88	23	44	42	21	20	2.56	3.08	-	-	-
Sims town, Wilson County	124	56	35	28	7	21	20	16	16	2.21	2.91	-	-	-
Smith Creek CDP, New Hanover County	7 461	2 660	2 173	1 845	266	487	366	81	68	2.80	3.10	-	-	-
Smithfield town, Johnston County	7 174	3 056	1 997	1 352	554	1 059	981	460	369	2.35	2.96	366	338	28
Sneads Ferry CDP, Onslow County	2 031	824	600	512	58	224	193	65	43	2.46	2.93	-	-	-
Snow Hill town, Greene County	1 360	556	387	257	113	172	156	66	65	2.43	2.66	18	3	15
Southern Pines town, Moore County	9 727	3 953	2 423	1 704	634	1 530	1 365	626	530	2.23	2.67	332	332	-
Southern Shores town, Dare County	1 447	617	499	466	24	118	103	47	36	2.35	2.62	-	-	-
South Gastonia CDP, Gaston County	5 487	2 011	1 572	1 216	257	439	371	137	107	2.73	3.11	-	-	-
South Henderson CDP, Vance County	1 374	509	378	255	91	131	121	64	48	2.70	3.16	-	-	-
Southport city, Brunswick County	2 174	981	650	483	133	331	325	166	136	2.32	2.91	96	96	-
South Rosemary CDP, Halifax County	955	781	551	366	151	230	200	83	56	2.50	2.97	-	-	-
South Weldon CDP, Halifax County	1 640	542	417	216	172	125	111	56	47	3.03	3.53	-	-	-
Sparta town, Alleghany County	1 759	808	484	365	100	325	307	180	155	2.17	2.88	198	193	5
Speed town, Edgecombe County	88	32	25	16	6	7	7	3	2	2.75	3.16	-	-	-
Spencer town, Rowan County	3 033	1 279	837	609	183	442	364	206	178	2.37	2.97	186	186	-
Spencer Mountain town, Gaston County	135	42	38	34	3	4	2	-	-	3.21	3.38	-	-	-
Spindale town, Rutherford County	3 868	1 628	1 093	804	232	535	499	305	251	2.38	2.96	172	172	-
Spring Hope town, Nash County	1 221	522	360	255	85	162	148	89	75	2.34	2.86	-	-	-
Spring Lake town, Cumberland County	7 324	2 739	2 019	1 325	566	720	546	72	46	2.75	3.16	-	-	-
Spruce Pine town, Mitchell County	2 010	858	610	474	118	248	234	134	126	2.34	2.84	-	-	-
Stanley town, Randolph County	294	81	57	45	9	24	23	8	8	2.52	3.17	-	-	-
Stallings town, Union County	2 132	744	617	523	72	127	106	36	31	2.87	3.17	-	-	-
Stanfield town, Stanly County	517	232	146	105	17	56	54	28	23	2.56	3.12	-	-	-
Stanley town, Gaston County	2 734	1 073	801	608	152	272	247	112	97	2.55	3.01	86	86	-
Stanleyville CDP, Forsyth County	4 779	2 043	1 417	1 151	195	626	531	184	136	2.34	2.81	-	-	-
Stantonsburg town, Wilson County	782	316	224	167	48	92	86	55	45	2.47	3.00	-	-	-
Star town, Montgomery County	708	291	202	146	36	89	85	41	36	2.43	3.00	51	51	-
Statesville city, Iredell County	17 270	7 315	4 791	3 137	1 418	2 524	2 270	1 105	821	2.36	2.96	257	242	15
Stedman town, Cumberland County	577	210	165	143	17	45	41	23	22	2.73	3.13	-	-	-
Stem town, Granville County	248	103	69	56	8	34	31	18	15	2.42	3.01	-	-	-
Stokesdale town, Guilford County	2 052	768	608	524	59	160	147	85	75	2.68	3.06	82	82	-
Stonerville town, Rockingham County	1 109	460	314	227	65	146	135	84	74	2.41	2.97	-	-	-
Stonewall town, Pamlico County	279	120	80	63	14	40	34	24	21	2.33	2.86	-	-	-
Stony Point CDP	1 286	492	366	303	51	126	108	63	52	2.61	3.06	-	-	-
Alexander County	1 131	436	331	274	46	105	93	56	46	2.59	3.03	-	-	-
Iredell County	155	56	35	29	5	21	15	5	3	2.77	3.34	-	-	-
Stovall town, Granville County	409	156	122	91	26	33	32	22	19	2.64	3.24	-	-	-
Sugar Mountain village, Avery County	132	65	41	35	5	24	21	5	3	2.03	2.51	-	-	-
Summerfield CDP, Guilford County	2 051	747	608	511	74	139	123	52	45	2.75	3.06	-	-	-
Sunset Beach town, Brunswick County	311	139	113	110	1	26	24	10	6	2.24	2.49	-	-	-
Surf City town	970	494	310	279	21	184	151	35	23	1.96	2.34	-	-	-
Onslow County	317	156	109	98	5	47	39	14	8	2.03	2.36	-	-	-
Pender County	653	338	201	180	16	137	112	21	14	1.93	2.36	-	-	-
Swannanoa CDP, Buncombe County	3 347	1 377	977	756	156	400	356	190	158	2.43	2.94	191	130	61
Swansboro town, Onslow County	1 160	522	358	278	70	164	152	67	56	2.22	2.72	5	-	5
Swepsonville CDP, Alamance County	1 195	466	358	313	34	108	82	34	28	2.56	2.98	-	-	-
Sylva town, Jackson County	1 863	797	484	362	99	313	283	132	102	2.12	2.73	116	100	16
Tabor City town, Columbus County	2 267	938	635	448	156	303	286	169	132	2.42	3.02	63	54	9
Tarboro town, Edgecombe County	10 533	4 241	3 005	2 155	730	1 236	1 163	600	520	2.48	3.05	50	48	16
Tar Heel town, Bladen County	115	42	34	25	6	8	7	2	2	2.74	3.06	-	-	-
Taylorsville town, Alexander County	1 417	637	367	227	99	240	228	116	98	2.22	2.86	149	149	-
Taylortown town, Moore County	343	208	141	81	50	65	57	23	16	2.64	3.25	-	-	-
Teachey town, Duplin County	244	95	69	50	15	26	25	12	8	2.57	3.07	-	-	-
Thomasville city, Davidson County	15 582	6 529	4 361	2 985	1 137	2 148	1 865	838	684	2.39	2.94	323	322	1
Toast CDP, Surry County	2 072	848	614	478	113	234	216	110	88	2.44	2.83	53	53	-
Topsail Beach town, Pender County	346	179	112	108	1	67	61	28	20	1.93	2.42	-	-	-
Trenton town, Jones County	248	111	68	53	14	43	42	27	22	2.23	2.98	-	-	-
Trent Woods town, Craven County	2 366	898	779	725	45	119	109	55	44	2.63	2.97	-	-	-
Trinity CDP, Randolph County	5 469	2 102	1 648	1 352	208	454	395	152	125	2.60	2.96	-	-	-
Trousdale town, Iredell County	1 463	554	412	333	59	142	130	68	56	2.68	3.19	-	-	-
Troy town, Montgomery County	2 868	1 096	734	557	179	361	328	177	149	2.44	3.02	234	227	8
Tryon town, Polk County	1 578	846	434	335	87	412	382	204	164	1.87	2.61	102	102	-
Tuscarora town, Sampson County	234	92	85	56	8	27	27	15	13	2.54	3.17	-	-	-
Valdese town, Burke County	3 914	1 662	1 166	900	209	526	462	257	235	2.31	2.80	-	-	-

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NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

Table 6. Household, Family, and Group Quarters Characteristics: 1990 —Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households			Nonfamily households				Persons per—		Persons in group quarters		
							Householder living alone							
			Total	Married-couple family	Female householder, no husband present	Total	Total	65 years and over		Household	Family	Total	Institutionalized persons	Other persons in group quarters
								Total	Female					
PLACE AND COUNTY SUBDIVISION—Con.														
Valley Hill CDP, Henderson County	1 784	760	540	445	73	220	211	95	81	2.35	2.82	18	18	-
Vanceboro town, Craven County	941	361	218	136	63	103	98	50	51	2.47	2.99	-	-	-
Vandemere town, Pamlico County	298	133	84	62	19	36	31	15	13	2.43	3.06	-	-	-
Vander CDP, Cumberland County	1 179	450	341	256	61	109	95	36	24	2.62	3.01	-	-	-
Varnamtown town, Brunswick County	404	160	107	77	9	53	32	18	13	2.53	2.87	-	-	-
Vass town, Moore County	670	282	197	145	40	85	47	25	22	2.66	3.01	-	-	-
Waco town, Cleveland County	333	116	96	83	8	22	21	9	6	2.71	3.04	-	-	-
Wade town, Cumberland County	236	101	66	50	13	35	35	18	14	2.36	3.03	-	-	-
Wadesboro town, Anson County	3 513	1 437	943	567	300	464	435	235	197	2.50	3.15	111	111	13
Wagram town, Scotland County	480	190	133	88	38	57	52	35	22	2.53	3.12	-	-	-
Wake Forest town, Wake County	5 563	2 143	1 615	1 237	308	528	452	162	163	2.61	3.06	176	63	113
Walkertown town, Forsyth County	1 220	511	374	315	50	137	129	73	62	2.35	2.80	-	-	-
Wallace town	2 879	1 178	821	564	196	348	332	177	148	2.46	2.99	80	80	-
Duplin County	2 851	1 157	811	586	195	346	318	177	148	2.46	2.96	80	80	-
Pender County	28	13	10	8	1	3	3	-	-	2.15	2.50	-	-	-
Walnut Cove town, Stokes County	969	426	298	198	66	144	140	55	46	2.31	2.85	126	126	-
Walnut Creek village, Wayne County	823	315	251	195	5	74	63	5	4	2.90	3.16	-	-	-
Walstonburg town, Greene County	158	84	54	43	8	30	28	18	15	2.24	2.85	-	-	-
Wanchese CDP, Dare County	1 380	513	371	310	48	142	116	48	31	2.69	3.12	-	-	-
Warrenton town, Warren County	935	410	281	190	56	144	134	80	64	2.28	2.96	-	-	-
Warsaw town, Duplin County	2 753	1 095	781	473	258	328	314	160	129	2.51	3.10	126	126	-
Washington city, Beaufort County	9 729	3 978	2 754	1 853	780	1 224	1 118	584	500	2.44	3.08	346	313	33
Washington Park town, Beaufort County	453	183	129	112	14	54	54	30	29	2.50	2.88	-	-	-
Watha town, Pender County	98	36	24	20	4	12	12	5	4	2.54	3.00	-	-	-
Waxhaw town, Union County	1 248	459	346	274	55	83	79	30	25	3.00	3.40	-	-	-
Waynesville town, Haywood County	6 579	2 858	1 834	1 473	266	964	874	481	412	2.27	2.78	178	176	2
Weaverville town, Buncombe County	2 107	882	608	462	95	274	252	86	65	2.38	2.95	-	-	-
Webster town, Jackson County	410	180	128	99	20	61	38	23	18	2.43	2.84	-	-	-
Weddington town	3 803	1 223	1 111	1 034	46	112	88	32	25	3.11	3.28	-	-	-
Mecklenburg County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Union County	3 803	1 223	1 111	1 034	46	112	88	32	25	3.11	3.28	-	-	-
Welcome CDP, Davidson County	3 377	1 290	1 028	882	93	264	224	80	64	2.62	2.96	-	-	-
Weldon town, Halifax County	1 392	574	368	247	104	205	161	100	78	2.43	3.14	-	-	-
Wendell town, Wake County	2 719	1 064	774	604	143	290	269	136	118	2.56	3.09	133	91	42
West Canton CDP, Haywood County	1 119	450	345	287	48	105	103	53	48	2.49	2.90	-	-	-
West Jefferson town, Ashe County	1 032	476	359	283	77	185	173	89	74	2.11	2.74	-	-	-
West Marion CDP, McDowell County	1 291	540	397	305	70	143	126	54	42	2.39	2.78	-	-	-
Westport CDP, Lincoln County	1 280	500	430	405	16	70	58	18	15	2.56	2.77	-	-	-
West Smithfield CDP, Johnston County	2 246	912	660	536	112	252	234	124	99	2.46	2.67	165	165	-
Whispering Pines village, Moore County	1 243	649	510	408	11	139	136	104	80	1.92	2.15	-	-	-
Whitakers town	860	321	225	147	63	96	91	49	46	2.68	3.33	-	-	-
Edgecombe County	464	158	119	78	31	39	36	22	17	2.94	3.46	-	-	-
Nash County	396	163	106	69	32	57	55	27	29	2.43	3.15	-	-	-
White Lake town, Bladen County	388	173	119	108	11	54	53	14	10	2.21	2.72	4	-	4
White Plains CDP, Surry County	1 027	429	304	256	29	125	105	46	38	2.39	2.87	-	-	-
Whiteville city, Columbus County	4 830	2 078	1 358	912	362	720	663	313	264	2.27	3.00	154	148	6
Wilkesboro town, Wilkes County	2 238	964	673	503	142	311	271	98	79	2.28	2.78	334	330	4
Williamston town, Martin County	5 353	2 178	1 474	942	462	704	652	344	290	2.46	3.06	156	146	10
Wilmington city, New Hanover County	53 309	23 557	13 923	8 031	4 226	9 654	7 736	3 673	2 552	2.26	2.91	2 221	847	1 374
Wilson city, Wilson County	35 351	14 461	9 688	6 267	2 958	4 773	4 258	1 748	1 427	2.44	3.04	1 578	1	1 577
Winds-ore CDP, New Hanover County	4 231	1 673	1 224	1 089	114	449	339	105	88	2.53	2.96	313	-	313
Windsor town, Bertie County	2 042	856	586	460	116	280	247	146	117	2.39	2.94	14	14	-
Winfall town, Perquimans County	498	218	147	111	30	71	64	36	36	2.28	2.90	5	5	-
Wingate town, Union County	1 775	632	481	361	69	151	131	51	45	2.81	3.25	1 046	-	1 046
Winston-Salem city, Forsyth County	136 239	56 919	36 268	24 545	10 825	23 650	20 277	6 784	5 529	2.27	2.83	7 246	2 385	4 861
Winterville town, Pitt County	2 783	1 057	773	518	234	287	269	113	101	2.63	3.16	33	33	-
Winton town, Hertford County	771	302	218	141	68	84	78	34	28	2.56	3.10	15	15	-
Woodfin town, Buncombe County	2 736	1 167	774	587	157	413	365	182	149	2.35	2.85	-	-	-
Woodland town, Northampton County	760	272	226	137	64	64	61	30	30	2.79	3.24	-	-	-
Wrightsboro CDP, New Hanover County	4 544	1 867	1 309	1 081	191	368	317	107	88	2.68	3.06	228	228	-
Wrightsville Beach town, New Hanover County	2 934	1 401	673	559	71	728	432	73	57	2.09	2.57	3	-	3
Yadkinville town, Yadkin County	2 198	958	658	491	137	301	278	130	83	2.29	2.81	350	350	-
Yanceyville town, Caswell County	1 823	720	459	256	176	261	234	120	102	2.52	2.96	-	-	-
Yaupon Beach town, Brunswick County	734	342	233	205	28	109	102	46	28	2.15	2.62	-	-	-
Youngsville town, Franklin County	424	168	117	82	30	51	47	30	30	2.52	3.13	-	-	-
Zebulon town, Wake County	3 092	1 178	848	555	246	328	303	165	145	2.63	3.16	81	69	12

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NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

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SUPERVISED SECTION

Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race						Not of Hispanic origin				Housing
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race§	Hispanic† origin (of any race)‡	White	Black		
North Carolina		6,628,637	5,008,491	1,456,323	80,155	52,166	31,502	76,726	4,971,127	1,449,142	131,642	2,816,193
	18 years and over	5,022,488	3,902,539	1,007,856	53,649	36,824	21,620	52,769	3,876,739	1,003,427	89,553	
Alamance County		108,213	86,373	20,822	303	487	228	736	85,913	20,763	801	45,312
	18 years and over	84,538	68,636	15,190	239	325	148	473	68,341	15,163	561	
Alexander County		27,544	25,667	1,673	52	49	103	184	25,597	1,662	101	11,197
	18 years and over	20,771	19,462	1,178	34	25	71	128	19,415	1,170	58	
Alleghany County		9,590	9,338	177	8	5	62	85	9,316	176	13	5,344
	18 years and over	7,535	7,337	140	8	2	48	64	7,322	139	10	
Anson County		23,474	12,264	11,106	69	27	8	67	12,232	11,078	97	9,255
	18 years and over	17,130	9,622	7,434	47	20	7	50	9,595	7,417	68	
Ashe County		22,209	21,960	144	21	31	53	102	21,910	144	53	11,119
	18 years and over	17,406	17,205	113	15	23	50	94	17,160	113	39	
Avery County		14,867	14,596	158	23	23	67	118	14,554	156	39	8,923
	18 years and over	11,529	11,300	137	16	17	59	94	11,269	136	30	
Beaufort County		42,283	28,949	13,194	28	48	64	197	28,845	13,155	86	19,598
	18 years and over	31,328	22,442	8,786	25	36	39	123	22,368	8,769	68	
Bertie County		20,388	7,790	12,531	46	14	7	32	7,782	12,512	62	8,331
	18 years and over	14,547	6,154	8,351	30	11	1	25	6,147	8,336	39	
Bladen County		28,663	16,926	11,199	464	30	44	150	16,860	11,167	486	12,685
	18 years and over	21,057	13,067	7,624	314	21	31	97	13,022	7,607	331	
Brunswick County		50,985	41,336	9,211	242	81	115	376	41,120	9,172	317	37,114
	18 years and over	38,960	32,438	6,210	174	62	76	243	32,303	6,186	228	
Buncombe County		174,821	158,978	14,336	486	765	255	1,173	158,117	14,279	1,252	77,951
	18 years and over	135,886	124,838	10,026	346	530	146	788	124,242	9,993	803	
Burke County		75,744	69,521	5,178	133	794	118	344	69,306	5,159	935	31,575
	18 years and over	57,937	53,688	3,693	95	382	79	232	53,546	3,684	475	
Cabarrus County		98,935	85,286	12,853	313	375	108	483	84,964	12,805	683	39,713
	18 years and over	75,038	65,610	8,863	213	267	85	330	65,400	8,834	474	
Caldwell County		70,709	66,506	3,881	105	111	106	315	66,322	3,864	208	29,454
	18 years and over	54,022	51,087	2,695	80	82	78	208	50,973	2,685	156	
Camden County		5,904	4,388	1,481	21	9	5	24	4,375	1,481	24	2,466
	18 years and over	4,469	3,354	1,088	14	9	4	18	3,344	1,088	19	
Carteret County		52,556	47,445	4,385	269	293	164	450	47,188	4,369	549	34,576
	18 years and over	40,749	37,305	2,916	204	225	99	291	37,132	2,907	419	
Caswell County		20,693	12,155	8,436	26	20	56	136	12,099	8,409	49	8,254
	18 years and over	15,774	9,376	6,326	19	19	34	86	9,341	6,307	40	
Catawba County		118,412	106,370	10,689	232	830	291	921	105,795	10,649	1,047	49,192
	18 years and over	90,127	82,057	7,177	173	521	199	629	81,665	7,150	683	
Chatham County		38,759	29,423	8,845	125	69	297	564	29,194	8,794	207	16,642
	18 years and over	30,073	23,306	6,419	87	49	212	413	23,137	6,385	138	
Cherokee County		20,170	19,313	361	405	42	49	131	19,233	358	448	10,319
	18 years and over	15,599	14,950	270	320	33	26	79	14,899	269	352	
Chowan County		13,506	8,349	5,087	24	29	17	95	8,314	5,041	56	5,910
	18 years and over	9,970	6,481	3,438	18	23	10	60	6,458	3,411	41	
Clay County		7,155	7,061	41	39	7	7	40	7,028	41	46	4,156
	18 years and over	5,540	5,465	32	34	4	5	31	5,439	32	38	
Cleveland County		84,714	66,362	17,741	114	394	103	376	66,152	17,701	485	34,232
	18 years and over	63,940	51,480	12,041	91	256	72	265	51,335	12,019	321	
Columbus County		49,587	32,897	15,181	1,370	53	86	242	32,816	15,122	1,407	20,513
	18 years and over	35,886	25,030	9,924	936	42	54	159	24,972	9,886	969	
Craven County		81,613	58,660	21,116	319	765	753	1,821	57,796	20,940	1,056	32,293
	18 years and over	59,570	44,115	14,142	224	578	511	1,172	43,588	14,045	765	
Cumberland County		274,566	170,069	87,496	4,425	5,769	6,807	13,298	165,057	86,216	9,995	98,300
	18 years and over	197,792	127,233	58,773	3,082	4,231	4,473	8,620	124,006	58,050	7,116	
Currituck County		13,736	12,051	1,545	66	51	23	110	11,965	1,542	119	7,367
	18 years and over	10,242	9,026	1,117	47	39	13	63	8,979	1,115	85	
Dare County		22,746	21,766	811	37	79	53	199	21,626	807	114	21,567
	18 years and over	17,657	16,956	574	32	53	42	142	16,862	570	83	
Davidson County		126,677	113,396	12,314	395	477	195	602	112,937	12,275	863	53,266
	18 years and over	96,357	87,041	8,611	287	292	126	409	86,805	8,583	560	
Davie County		27,859	25,194	2,482	86	53	44	129	25,115	2,473	142	11,496
	18 years and over	21,333	19,407	1,821	49	31	25	82	19,355	1,817	79	
Duplin County		39,995	25,927	13,259	104	47	658	1,015	25,635	13,200	145	16,335
	18 years and over	29,441	19,826	9,031	66	35	483	713	19,628	9,003	97	
Durham County		181,835	109,886	67,654	425	3,233	637	2,054	108,722	67,385	3,674	77,710
	18 years and over	140,425	88,355	48,788	316	2,498	468	1,558	87,446	48,621	2,800	
Edgecombe County		56,558	24,665	31,661	73	68	91	255	24,581	31,565	157	21,627
	18 years and over	40,539	19,245	21,123	56	44	71	181	19,181	21,066	111	
Forsyth County		265,878	196,918	66,102	551	1,662	645	2,102	195,660	65,858	2,258	115,715
	18 years and over	205,470	156,596	46,855	409	1,214	396	1,456	155,709	46,691	1,614	
Franklin County		36,414	23,288	12,843	74	63	146	290	23,197	12,791	136	14,957
	18 years and over	27,577	18,279	9,097	50	47	104	205	18,212	9,067	93	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race						Not of Hispanic origin			
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Gaston County		175,093	150,868	22,676	397	915	237	864	150,285	22,602	1,332	69,133
	18 years and over	130,910	114,780	15,082	290	604	154	597	114,384	15,037	892	
Gates County		9,305	5,101	4,180	8	13	3	21	5,087	4,176	21	3,696
	18 years and over	6,932	3,934	2,981	8	7	2	12	3,926	2,979	15	
Graham County		7,196	6,731	1	454	6	4	29	6,707	1	459	4,132
	18 years and over	5,499	5,212	1	278	5	3	21	5,194	1	283	
Granville County		38,345	23,069	14,909	99	100	168	356	22,913	14,872	204	14,164
	18 years and over	29,108	17,891	10,846	82	64	125	280	17,765	10,916	147	
Greene County		15,384	8,747	6,521	16	6	94	169	8,690	6,505	20	5,814
	18 years and over	11,391	6,849	4,468	10	5	59	108	6,813	4,456	14	
Guilford County		347,420	249,584	91,655	1,637	3,726	818	2,887	247,891	91,282	5,360	146,812
	18 years and over	269,703	199,203	66,194	1,205	2,551	550	2,081	197,960	65,950	3,712	
Halifax County		55,516	26,009	27,586	1,711	145	65	237	25,915	27,488	1,876	22,480
	18 years and over	40,391	20,511	18,392	1,151	96	41	159	20,445	18,329	1,258	
Harnett County		67,822	51,117	15,315	601	299	490	1,159	50,553	15,221	889	27,636
	18 years and over	50,536	39,212	10,370	403	215	336	784	38,830	10,314	608	
Haywood County		46,942	46,011	648	180	67	36	240	45,815	647	240	23,975
	18 years and over	37,196	36,508	481	138	50	19	153	36,377	481	185	
Henderson County		69,285	66,158	2,361	197	286	283	846	65,606	2,348	485	34,131
	18 years and over	54,708	52,629	1,587	127	183	182	545	52,275	1,579	309	
Hertford County		22,523	9,214	12,970	228	94	17	81	9,172	12,952	318	8,870
	18 years and over	16,416	7,389	8,779	158	77	13	55	7,362	8,767	232	
Hoke County		22,856	9,635	9,878	3,176	85	82	218	9,556	9,840	3,242	7,999
	18 years and over	15,878	7,358	6,494	1,909	60	57	137	7,305	6,474	1,902	
Hyde County		5,411	3,596	1,781	4	3	27	43	3,582	1,778	8	2,905
	18 years and over	4,052	2,768	1,268	-	3	13	24	2,759	1,266	3	
Iredell County		92,931	77,207	14,869	193	356	306	672	76,897	14,821	541	39,191
	18 years and over	70,496	59,915	10,006	146	234	195	466	59,684	9,974	372	
Jackson County		26,846	23,609	425	2,667	109	36	155	23,507	425	2,759	14,052
	18 years and over	21,434	19,216	374	1,726	86	32	108	19,145	374	1,807	
Johnston County		81,306	65,773	14,389	178	159	807	1,262	65,370	14,331	343	34,172
	18 years and over	61,203	50,624	9,805	131	122	521	822	50,358	9,774	249	
Jones County		9,414	5,687	3,677	8	19	23	53	5,665	3,670	26	3,829
	18 years and over	6,911	4,300	2,574	7	15	15	32	4,288	2,570	21	
Lee County		41,374	31,216	9,401	169	191	397	800	30,928	9,310	336	16,554
	18 years and over	30,618	23,908	6,199	109	139	263	551	23,691	6,141	235	
Lenoir County		57,274	34,322	22,539	70	151	192	463	34,136	22,456	219	23,739
	18 years and over	42,389	26,900	15,194	58	105	132	310	26,781	15,140	158	
Lincoln County		50,319	45,710	4,108	120	172	209	570	45,359	4,096	294	20,189
	18 years and over	37,809	34,794	2,697	77	108	133	362	34,573	2,690	184	
McDowell County		35,681	33,901	1,479	72	200	29	114	33,820	1,474	273	15,091
	18 years and over	27,153	25,877	1,088	52	118	18	89	25,812	1,084	168	
Macon County		23,499	22,919	385	76	60	59	165	22,818	384	132	17,174
	18 years and over	18,834	18,414	282	61	38	39	109	18,346	282	97	
Madison County		16,953	16,744	136	19	32	22	86	16,684	135	48	7,667
	18 years and over	13,256	13,079	121	17	22	17	59	13,039	120	38	
Martin County		25,078	13,788	11,166	20	40	44	99	13,772	11,149	58	10,104
	18 years and over	18,384	10,714	7,583	16	33	38	67	10,705	7,565	47	
Mecklenburg County		511,433	364,651	134,468	1,936	8,461	1,917	6,693	360,554	133,866	10,320	216,416
	18 years and over	387,980	286,958	92,487	1,408	5,784	1,343	4,909	283,897	92,096	7,078	
Mitchell County		14,433	14,354	23	19	19	18	50	14,324	23	36	6,983
	18 years and over	11,324	11,262	20	17	13	12	31	11,245	20	28	
Montgomery County		23,346	16,773	6,001	92	150	330	556	16,564	5,986	240	10,421
	18 years and over	17,325	12,917	4,035	77	79	217	365	12,785	4,025	150	
Moore County		59,013	47,464	10,882	309	150	208	470	47,260	10,832	451	27,358
	18 years and over	45,677	37,891	7,343	204	93	146	311	37,753	7,320	293	
Nash County		76,677	51,874	24,142	218	223	220	606	51,563	24,067	441	31,024
	18 years and over	57,107	40,159	16,446	164	162	176	446	39,931	16,404	326	
New Hanover County		120,284	94,895	24,097	435	616	241	924	94,288	23,983	1,089	57,076
	18 years and over	92,923	75,455	16,532	334	452	150	670	74,997	16,459	797	
Northampton County		20,798	8,397	12,328	42	11	20	116	8,371	12,257	54	8,974
	18 years and over	15,595	6,842	8,695	28	7	13	89	6,822	8,641	43	
Onslow County		149,838	111,939	29,808	939	2,994	4,158	8,035	108,890	29,137	3,776	47,526
	18 years and over	113,534	85,882	21,625	744	2,082	3,201	5,757	83,844	21,226	2,705	
Orange County		93,851	75,871	14,893	286	2,361	440	1,279	75,055	14,847	2,670	38,683
	18 years and over	76,104	62,383	11,330	241	1,837	313	944	61,774	11,301	2,085	
Pamlico County		11,372	8,362	2,951	33	20	6	61	8,317	2,940	54	6,050
	18 years and over	8,662	6,53	2,083	24	15	5	33	6,513	2,077	39	
Pasquotank County		31,298	19,403	11,583	59	184	69	246	19,259	11,557	230	12,298
	18 years and over	22,829	14,542	8,082	46	119	40	146	14,458	8,064	161	
Pender County		28,855	19,823	8,770	76	44	137	273	19,723	8,729	120	15,437
	18 years and over	21,742	15,557	6,005	56	35	89	184	15,485	5,984	89	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race					Not of Hispanic origin				
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)1	White	Black	Other race	Housing units
Pasquotank County	10,447	6,979	3,426	18	20	4	28	6,959	3,421	39	4,972
18 years and over	7,875	5,483	2,358	16	15	3	23	5,467	2,354	31	
Person County	30,180	20,740	9,106	181	15	138	249	20,655	9,080	196	12,546
18 years and over	22,761	16,034	6,477	149	12	89	155	15,984	6,461	161	
Pitt County	107,924	70,643	35,921	214	709	437	977	70,217	35,813	917	43,070
18 years and over	81,820	56,670	24,144	167	520	319	695	56,365	24,085	675	
Polk County	14,416	13,276	1,053	17	25	45	115	13,201	1,053	47	7,273
18 years and over	11,633	10,828	744	16	15	20	75	10,773	744	31	
Randolph County	106,546	99,042	6,367	453	358	326	734	98,659	6,350	803	43,634
18 years and over	80,828	75,449	4,563	325	257	235	508	75,201	4,549	571	
Richmond County	44,518	30,816	12,569	502	195	136	293	30,729	12,798	698	18,218
18 years and over	32,745	23,615	8,582	337	108	103	205	23,556	8,539	445	
Robeson County	105,179	37,986	26,185	40,511	239	258	704	37,850	26,125	40,500	39,045
18 years and over	72,903	29,518	16,870	26,162	169	184	445	29,421	16,834	26,203	
Rockingham County	86,064	67,893	17,548	149	190	284	620	67,603	17,492	349	35,657
18 years and over	65,632	52,694	12,520	114	121	183	389	52,531	12,479	233	
Rowan County	110,605	91,851	17,773	262	444	275	651	91,521	17,719	714	46,264
18 years and over	84,409	71,303	12,431	188	314	173	445	71,073	12,389	502	
Rutherford County	56,918	50,133	6,514	95	98	78	342	49,896	6,488	192	25,220
18 years and over	43,037	38,457	4,392	67	69	52	237	38,295	4,372	133	
Sampson County	47,297	30,273	15,686	876	75	387	727	30,016	15,630	924	19,183
18 years and over	34,852	23,274	10,695	583	53	247	460	23,105	10,662	625	
Scotland County	33,754	19,025	12,176	2,430	83	40	318	18,867	12,071	2,498	12,759
18 years and over	23,823	14,353	7,792	1,591	61	26	209	14,248	7,725	1,641	
Stanly County	51,765	45,269	5,972	155	249	120	309	45,102	5,954	460	21,808
18 years and over	39,064	34,784	3,976	93	147	64	214	34,651	3,963	236	
Stokes County	37,223	34,917	2,069	52	79	106	254	34,787	2,063	119	15,160
18 years and over	28,146	26,485	1,524	35	47	55	150	26,396	1,520	80	
Surry County	61,704	58,383	2,780	66	84	391	602	58,160	2,765	177	26,022
18 years and over	47,583	45,241	1,976	50	65	251	391	45,097	1,964	131	
Swain County	11,268	7,950	196	3,075	31	16	78	7,930	191	3,069	5,664
18 years and over	8,413	6,336	138	1,907	20	12	44	6,321	135	1,913	
Transylvania County	25,520	24,121	1,189	79	99	32	154	24,004	1,185	177	12,893
18 years and over	19,948	18,993	800	53	76	26	112	18,912	796	128	
Tyrrell County	3,856	2,297	1,543	4	5	7	11	2,294	1,542	9	1,907
18 years and over	2,782	1,747	1,034	4	3	4	8	1,744	1,033	7	
Union County	84,211	70,023	13,427	294	257	210	675	69,624	13,358	554	33,765
18 years and over	61,201	52,041	8,628	212	166	154	473	51,760	8,590	378	
Vance County	38,892	21,146	17,512	69	60	105	271	21,019	17,475	127	15,743
18 years and over	28,497	16,478	11,856	55	44	64	189	16,377	11,833	98	
Wake County	423,380	324,011	88,057	1,148	8,177	1,987	5,396	321,008	87,565	9,411	177,146
18 years and over	325,565	253,422	63,937	918	5,901	1,387	3,878	251,281	63,587	6,819	
Warren County	17,265	6,593	9,847	763	14	48	98	6,571	9,818	778	8,714
18 years and over	12,916	5,372	6,959	542	9	34	62	5,358	6,944	552	
Washington County	13,997	7,556	6,366	13	35	27	65	7,531	6,351	50	5,644
18 years and over	10,116	5,865	4,207	8	23	13	37	5,849	4,199	31	
Watauga County	36,952	35,930	768	59	152	43	249	35,725	766	212	19,538
18 years and over	30,630	29,722	687	51	132	38	189	29,573	685	183	
Wayne County	104,666	69,172	33,793	265	839	597	1,356	68,529	33,683	1,098	39,493
18 years and over	77,296	53,020	23,099	208	584	385	883	52,617	23,028	771	
Wilkes County	59,393	56,237	2,824	69	100	163	362	56,044	2,818	169	24,960
18 years and over	45,423	43,143	2,029	55	68	128	272	43,003	2,026	122	
Wilson County	66,061	40,623	24,896	70	177	295	537	40,461	24,817	246	26,662
18 years and over	48,833	31,777	16,697	43	131	185	341	31,675	16,647	175	
Yadkin County	30,488	28,884	1,295	22	26	261	388	28,755	1,294	51	12,921
18 years and over	23,648	22,461	969	21	22	175	248	22,386	969	45	
Yancey County	15,419	15,221	151	27	11	9	49	15,181	151	38	7,994
18 years and over	11,985	11,837	119	17	8	4	38	11,803	119	25	
Aberdeen town	2,700	2,282	400	17	25	3	19	2,244	395	42	1,239
18 years and over	2,085	1,778	278	13	13	3	14	1,769	276	26	
Ahoskie town	4,391	2,185	2,146	34	24	2	21	2,174	2,139	57	1,897
18 years and over	3,250	1,777	1,432	24	15	2	14	1,768	1,430	38	
Alamance village	258	256	-	-	-	2	2	256	-	-	123
18 years and over	213	213	-	-	-	-	-	213	-	-	
Albemarle city	14,939	12,102	2,633	24	170	10	66	12,058	2,626	189	6,542
18 years and over	11,521	9,667	1,734	21	90	9	52	9,633	1,728	108	
Alexander Mills town	662	573	83	1	-	5	13	565	83	1	299
18 years and over	496	444	49	-	-	3	8	439	49	-	
Allenton town	583	499	78	2	4	-	-	499	78	6	256
18 years and over	438	378	57	1	2	-	-	378	57	3	
Altamahaw-Ossipee CDP	1,076	983	92	-	1	-	2	981	92	1	468
18 years and over	800	736	63	-	1	-	1	735	63	1	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race					Not of Hispanic origin			
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Andrews town		2,551	2,451	58	23	1	18	36	2,431	57	37	1,032
	18 years and over	1,980	1,904	45	19	1	11	23	1,891	45	31	
Angier town		2,235	1,553	653	10	14	5	22	1,540	653	20	840
	18 years and over	1,652	1,219	413	6	9	5	16	1,210	413	13	
Ansonville town		614	125	487	-	2	-	1	124	487	2	225
	18 years and over	452	98	352	-	2	-	1	97	352	2	
Apex town		4,968	3,927	960	15	33	33	63	3,905	954	46	1,626
	18 years and over	3,531	2,793	683	12	25	18	44	2,773	679	35	
Arapahoe town		430	399	30	1	-	-	4	395	30	1	195
	18 years and over	332	311	20	1	-	-	1	310	20	1	
Archdale city		6,913	6,737	85	21	63	7	29	6,715	85	84	2,932
	18 years and over	5,390	5,255	68	18	44	5	26	5,234	68	62	
Arlington town		785	739	51	-	-	5	6	738	51	-	359
	18 years and over	589	557	30	-	-	2	2	557	30		
Asheboro city		16,362	13,838	2,141	47	112	124	180	13,881	2,139	162	7,464
	18 years and over	12,835	11,208	1,427	33	80	87	120	11,175	1,427	113	
Asheville city		61,607	48,726	12,207	165	374	135	533	48,367	12,162	545	29,713
	18 years and over	48,997	40,048	8,479	125	273	72	353	39,796	8,455	393	
Askewville town		201	201	-	-	-	-	-	201	-	-	83
	18 years and over	160	160	-	-	-	-	-	160	-	-	
Atkinson town		2,275	2,244	31	-	-	-	-	244	31	-	141
	18 years and over	217	202	15	-	-	-	-	202	15	-	
Atlantic Beach town		1,938	1,878	25	10	21	4	17	1,864	25	32	4,599
	18 years and over	1,672	1,622	19	10	17	4	12	1,613	19	28	
Aulander town		1,209	661	544	-	4	-	-	661	544	4	493
	18 years and over	820	522	295	-	3	-	-	522	295	3	
Aurora town		654	373	279	1	-	1	7	367	279	1	296
	18 years and over	473	284	187	1	-	1	7	278	187	1	
Autryville town		166	166	-	-	-	-	-	166	-	-	79
	18 years and over	135	135	-	-	-	-	-	135	-	-	
Avery Creek CDP		1,144	1,116	27	-	1	-	10	1,106	27	1	424
	18 years and over	815	797	17	-	1	-	5	792	17	1	
Ayden town		4,740	2,324	2,404	6	5	1	20	2,311	2,398	11	1,893
	18 years and over	3,366	1,799	1,558	4	4	1	8	1,795	1,555	8	
Badin CDP		1,481	867	612	2	-	-	5	864	610	2	678
	18 years and over	1,123	692	430	1	-	-	4	689	429	1	
Baileytown		553	469	76	-	-	8	15	462	76	-	271
	18 years and over	431	370	57	-	-	4	8	366	57	-	
Bakersville town		332	331	-	-	-	1	-	331	-	1	166
	18 years and over	269	268	-	-	-	1	-	268	-	1	
Bald Head Island village		78	78	-	-	-	-	-	78	-	-	394
	18 years and over	73	73	-	-	-	-	-	73	-	-	
Balfour CDP		1,118	1,088	20	4	2	4	18	1,074	20	6	533
	18 years and over	901	881	12	2	2	4	14	871	12	4	
Banner Elk town		933	858	66	-	6	3	4	856	66	7	229
	18 years and over	863	788	66	-	6	3	4	786	66	7	
Barker Heights CDP		1,137	1,104	2	3	6	22	38	1,089	2	8	588
	18 years and over	863	839	1	2	2	19	31	827	1	4	
Barker Ten Mile CDP		1,087	988	30	64	5	-	4	987	27	69	383
	18 years and over	786	73	16	39	5	-	3	735	14	44	
Bath town		154	142	12	-	-	-	-	142	12	-	108
	18 years and over	137	127	10	-	-	-	-	127	10	-	
Battleboro town		447	255	192	-	-	-	-	255	192	-	187
	18 years and over	366	221	145	-	-	-	-	221	145	-	
Bayboro town		733	385	346	-	1	1	4	381	346	2	322
	18 years and over	526	292	233	-	1	-	1	291	233	1	
Bayshore CDP		1,661	1,621	30	7	3	-	3	1,619	30	9	669
	18 years and over	1,240	1,211	25	2	2	-	2	1,209	25	4	
Beargrass town		77	75	2	-	-	-	-	75	2	-	39
	18 years and over	66	64	2	-	-	-	-	64	2	-	
Beaufort town		3,808	2,852	908	18	14	16	25	2,847	905	31	2,085
	18 years and over	2,992	2,335	625	12	11	9	16	2,331	613	22	
Beech Mountain town		239	239	-	-	-	-	1	238	-	-	1,477
	18 years and over	204	204	-	-	-	-	1	203	-	-	
Belhaven town		2,269	843	1,421	3	2	-	5	841	1,418	5	980
	18 years and over	1,596	663	928	3	2	-	2	662	927	5	
Belmont city		8,434	7,354	829	24	218	9	78	7,286	820	233	3,217
	18 years and over	6,369	5,584	615	21	143	6	65	5,532	609	163	
Belville town		66	52	14	-	-	-	-	52	14	-	33
	18 years and over	43	36	7	-	-	-	-	36	7	-	
Belvoid town		631	592	36	1	1	1	1	592	36	2	277
	18 years and over	498	474	22	1	-	1	1	474	22	1	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race						Not of Hispanic origin			
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Benson town	2,810	1,871	892	6	8	33	45	1,858	892	15	1,248
18 years and over	2,076	1,469	587	3	6	11	19	1,461	587	9	
Bent Creek CDP	1,487	1,462	7	3	10	5	11	1,456	7	13	556
18 years and over	1,111	1,092	4	3	7	5	10	1,087	4	13	
Bessemer City city	4,698	4,104	570	9	4	11	19	4,087	569	13	1,864
18 years and over	3,492	3,071	405	7	4	5	9	3,067	405	11	
Bethel town	1,842	807	1,032	-	-	3	1	807	1,031	3	743
18 years and over	1,317	622	695	-	-	-	1	622	694	-	
Bethlehem CDP	3,186	3,163	10	4	8	1	13	3,151	10	12	1,310
18 years and over	2,384	2,370	4	2	7	1	10	2,361	4	9	
Boulaville town	933	755	176	-	-	2	8	752	173	-	453
18 years and over	736	620	115	-	-	1	4	617	115	-	
Biltmore Forest town	1,327	1,324	-	-	3	-	-	1,324	-	3	607
18 years and over	1,033	1,032	-	-	1	-	-	1,032	-	1	
Biscoe town	1,484	808	549	-	-	127	126	806	549	3	544
18 years and over	1,024	625	315	-	-	84	84	625	315	-	
Black Creek town	615	574	37	-	1	3	3	573	37	2	250
18 years and over	468	440	26	-	1	1	-	440	26	2	
Black Mountain town	5,418	4,909	440	7	56	6	28	4,895	439	56	2,519
18 years and over	4,346	3,966	344	5	27	4	21	3,955	343	27	
Bladenboro town	1,821	1,525	292	-	1	3	10	1,517	292	2	821
18 years and over	1,357	1,209	146	-	1	1	4	1,205	146	2	
Blowing Rock town	1,257	1,244	9	1	3	-	8	1,236	9	4	1,427
18 years and over	1,046	1,036	9	1	-	-	3	1,033	9	1	
Bogue City CDP	1,373	1,289	24	8	8	44	54	1,282	24	13	596
18 years and over	1,080	1,031	13	4	5	27	33	1,027	13	7	
Boiling Spring Lakes city	1,650	1,600	31	12	5	2	10	1,597	27	16	824
18 years and over	1,281	1,247	19	9	5	1	6	1,244	17	14	
Boiling Springs town	2,445	2,086	340	6	6	7	12	2,082	339	12	713
18 years and over	2,015	1,741	255	6	6	7	12	1,737	254	12	
Bolivia town	228	211	14	3	-	-	1	210	14	3	100
18 years and over	167	155	9	3	-	-	-	155	9	3	
Bolton town	531	171	339	21	-	-	-	171	339	21	229
18 years and over	396	145	236	15	-	-	-	145	236	15	
Bonnie Doone CDP	3,893	1,566	2,021	67	77	162	311	1,477	1,962	143	2,061
18 years and over	2,729	1,223	1,300	47	55	104	198	1,161	1,268	102	
Boone town	12,915	12,169	602	24	100	20	86	12,102	601	126	4,534
18 years and over	11,986	11,298	555	22	91	20	78	11,239	554	115	
Boonville town	1,009	952	51	1	5	-	-	952	51	6	422
18 years and over	758	712	40	1	5	-	-	712	40	6	
Bostic town	371	344	27	-	-	-	1	344	26	-	151
18 years and over	268	244	24	-	-	-	1	244	23	-	
Brevard city	5,388	4,552	749	10	61	16	48	4,525	745	70	2,362
18 years and over	4,417	3,833	511	8	51	14	44	3,808	507	58	
Bridgeton town	453	433	16	3	1	-	9	424	16	4	242
18 years and over	366	350	13	3	-	-	4	346	13	3	
Broadway town	973	897	76	-	-	-	3	894	76	-	393
18 years and over	713	663	50	-	-	-	3	660	50	-	
Brogden CDP	3,246	1,371	1,823	9	24	19	43	1,353	1,821	29	1,154
18 years and over	2,197	969	1,190	9	18	11	29	956	1,189	23	
Brookford town	451	446	4	1	-	-	-	446	4	1	205
18 years and over	360	355	4	1	-	-	-	355	4	1	
Brunswick town	302	106	196	-	-	-	2	106	194	-	117
18 years and over	208	84	124	-	-	-	2	84	122	-	
Bryson City town	1,145	1,064	4	64	12	1	6	1,062	4	73	619
18 years and over	942	884	2	48	8	-	4	883	2	53	
Buies Creek CDP	2,085	1,903	132	7	33	10	29	1,890	131	35	521
18 years and over	1,895	1,745	107	5	28	10	24	1,734	106	31	
Bunn town	364	241	116	6	1	-	-	241	116	7	177
18 years and over	281	183	95	3	-	-	-	183	95	3	
Burgaw town	1,807	1,140	640	6	6	15	24	1,130	639	14	702
18 years and over	1,415	921	476	6	4	8	14	914	476	11	
Burlington city	39,498	30,152	8,909	78	308	51	234	29,986	8,886	392	17,656
18 years and over	31,018	24,468	6,260	56	203	31	151	24,357	6,251	259	
Burnsville town	1,482	1,446	33	3	-	-	10	1,436	33	3	747
18 years and over	1,209	1,183	23	3	-	-	7	1,176	23	3	
Butner CDP	4,679	2,704	1,949	8	9	9	21	2,691	1,948	19	1,244
18 years and over	3,777	2,268	1,492	6	7	4	12	2,261	1,491	13	
Cajah's Mountain town	2,429	2,350	72	2	1	4	5	2,350	71	3	873
18 years and over	1,972	1,895	70	2	1	4	5	1,895	69	3	
Calabash town	1,210	1,202	8	-	-	-	4	1,198	8	-	786
18 years and over	1,142	1,139	3	-	-	-	4	1,135	3	-	

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Table 5. Age by Race and Hispanic Origin: 1990
Governmental Units

		Race						Not of Hispanic origin			
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Calypso town		481	372	99	7	-	3	4	371	99	7	195
	18 years and over	347	267	74	3	-	3	4	266	74	3	
Cameron town		215	127	86	1	1	-	1	127	85	2	95
	18 years and over	159	99	59	1	-	-	-	99	59	1	
Camp Lejeune Central CDP		36,716	24,815	9,064	267	744	1,826	3,072	23,895	8,806	943	4,175
	18 years and over	30,229	20,680	7,309	237	607	1,496	2,357	20,025	7,144	703	
Camp Lejeune		748	648	43	11	5	41	64	626	43	15	326
	18 years and over	579	515	26	6	5	20	36	500	20	10	
Canton town		3,790	3,718	69	2	1		12	3,706	69	3	1,654
	18 years and over	3,146	3,089	55	1	1	-	9	3,080	55	2	
Cape Carteret town		1,008	1,001	-	2	5	-	5	996	-	7	580
	18 years and over	845	838	-	2	5	-	3	835	-		
Carolina Beach town		3,630	3,568	33	19	4	6	40	3,536	33	1	3,342
	18 years and over	2,965	2,911	32	15	3	4	29	2,888	32	1	
Carrboro town		11,553	9,066	1,930	39	427	91	199	8,976	1,916	462	6,108
	18 years and over	9,353	7,982	1,507	33	361	70	161	7,902	1,498	352	
Carthage town		976	772	197	6	-	1	5	768	197	6	438
	18 years and over	743	599	139	4	-	1	3	597	139	4	
Cary town		43,858	39,374	2,417	119	1,684	264	683	38,962	2,393	1,820	18,008
	18 years and over	32,317	29,153	1,736	93	1,156	179	460	28,880	1,721	1,256	
Casar town		328	327	-	1	-	-	-	327	-	1	137
	18 years and over	246	245	-	1	-	-	-	245	-	1	
Castalia town		261	164	97	-	-	-	-	164	97	-	114
	18 years and over	191	122	69	-	-	-	-	122	69	-	
Castle Hayne CDP		1,182	1,044	127	8	-	3	7	1,042	125	6	462
	18 years and over	888	788	94	5	-	1	2	787	94	5	
Caswell Beach town		175	174	-	-	-	1	1	174	-	-	439
	18 years and over	155	154	-	-	-	1	1	154	-	-	
Catawba town		467	378	89	-	-	-	-	378	89	-	194
	18 years and over	367	309	58	-	-	-	-	309	58	-	
Cedar Point town		628	625	-	1	2	-	2	623	-	3	631
	18 years and over	534	53.	-	1	2	-	2	529	-	3	
Centerville town		115	112	3	-	-	-	-	112	3	-	53
	18 years and over	87	85	2	-	-	-	-	85	2	-	
Cerro Gordo town		227	186	40	1	-	-	-	186	40	1	96
	18 years and over	170	140	29	1	-	-	-	140	[illegible]	1	
Chadbourn town		2,005	1,116	850	34	5	-	14	1,105	[illegible]	36	973
	18 years and over	1,427	862	533	27	5	-	9	854	533	31	
Chapel Hill town		38,719	31,875	4,853	123	1,684	184	607	31,444	[illegible]	1,828	14,850
	18 years and over	33,271	27,882	3,822	106	1,314	147	480	27,547	3,812	1,432	
Charlotte city		395,934	259,760	125,827	1,425	7,211	1,711	5,571	256,517	125,264	8,582	173,430
	18 years and over	300,216	206,930	86,138	1,038	4,910	1,200	4,072	204,516	85,772	5,856	
Cherryville city		4,756	4,311	389	9	40	7	19	4,301	389	47	2,079
	18 years and over	3,737	3,413	292	8	22	2	9	3,407	292	29	
China Grove town		2,732	2,453	255	6	14	4	11	2,446	255	20	1,163
	18 years and over	2,059	1,876	165	5	10	3	7	1,872	165	15	
Chocowinity town		624	503	121	-	-	-	2	501	121	-	271
	18 years and over	475	411	64	-	-	-	1	410	64	-	
Claremont city		980	961	11	2	6	-	4	961	11	4	427
	18 years and over	773	759	8	2	4	-	2	759	8	4	
Clarkton town		739	544	186	6	-	3	10	537	186	6	291
	18 years and over	536	432	97	6	-	1	8	425	97	6	
Clayton town		4,756	3,554	1,149	8	11	34	59	3,537	[illegible]	19	2,018
	18 years and over	3,547	2,734	773	5	10	25	45	2,719	[illegible]	15	
Clemmons village		6,020	5,797	146	4	70	3	47	5,753	146	24	2,256
	18 years and over	4,589	4,437	100	4	48	-	29	4,408	100	52	
Cleveland town		696	497	197	-	-	2	-	497	197	2	296
	18 years and over	499	364	135	-	-	-	-	[illegible]	135	-	
Clinton city		8,204	4,639	3,460	60	18	27	101	[illegible]	3,448	76	3,557
	18 years and over	6,160	3,752	2,336	38	17	17	63	[illegible]	[illegible]	54	
Clyde town		1,041	991	43	4	2	1	8	984	43	6	475
	18 years and over	828	795	26	4	2	1	6	790	26	6	
Coats town		1,493	1,273	195	11	1	13	21	1,266	195	11	688
	18 years and over	1,158	1,016	127	7	-	8	14	1,010	127	7	
Cofield village		407	41	353	13	-	-	2	40	352	13	179
	18 years and over	282	33	238	11	-	-	2	32	237	11	
Colerain town		139	126	11	1	1	-	2	126	9	2	69
	18 years and over	116	104	10	1	1	-	2	104	8	2	
Columbia town		836	352	481	2	1	-	-	352	481	3	392
	18 years and over	598	287	308	2	1	-	-	287	308	3	
Columbus town		812	785	21	-	1	5	8	782	21	1	397
	18 years and over	684	667	14	-	1	2	3	666	14	1	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race					Not of Hispanic origin			
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Coho town	71	69	2	-	-	-	-	69	2		32
18 years and over	56	54	2	-	-	-	-	54	2		
Concord city	27,347	21,495	5,623	63	150	16	150	21,378	5,606	213	11,616
18 years and over	21,269	17,161	3,930	52	113	13	104	17,082	3,920	163	
Conetoe town	292	109	183	-	-	-	-	109	183	-	117
18 years and over	209	89	120	-	-	-	-	89	120	-	
Connelly Springs town	1,349	1,302	19	5	23	-	2	1,300	19	28	577
18 years and over	1,007	976	18	4	9	-	1	975	18	13	
Conover city	5,465	4,806	532	9	101	17	89	4,738	528	110	2,241
18 years and over	4,214	3,783	347	8	63	13	55	3,745	343	71	
Conway town	759	506	253	-	-	-	1	506	252	-	343
18 years and over	562	400	162	-	-	-	1	400	161	-	
Cooleemee town	971	921	32	15	-	3	3	921	32	15	444
18 years and over	777	747	22	7	-	1	1	747	22	7	
Cornelius town	2,581	2,020	525	9	26	1	19	2,007	525	30	1,079
18 years and over	1,932	1,548	362	5	17	-	13	1,537	362	20	
Cove City town	497	264	233	-	-	-	-	264	233	-	193
18 years and over	381	219	162	-	-	-	-	219	162	-	
Cramerton town	2,371	2,283	67	8	12	1	10	2,275	67	19	1,007
18 years and over	1,802	1,735	51	6	9	1	8	1,729	51	14	
Creedmoor city	1,504	1,048	435	2	17	2	1	1,048	425	20	684
18 years and over	1,171	838	323	2	10	-	-	836	323	12	
Creswell town	361	192	168	-	-	-	9	192	160	-	149
18 years and over	253	148	105	-	-	-	5	147	101	-	
Cricket CDP	2,015	1,988	20	3		4	15	1,978	20	2	903
18 years and over	1,574	1,559	10	3	-	2	10	1,552	10	2	
Crossnore town	271	264	7	-	-	-	2	262	7	-	137
18 years and over	184	182	2	-	-	-	1	181	2	-	
Cullowhee CDP	4,029	3,729	206	30	58	6	28	3,709	206	86	784
18 years and over	3,820	3,534	199	24	57	6	28	3,514	199	79	
Dallas town	3,012	2,367	625	13	4	3	15	2,358	624	15	1,272
18 years and over	2,263	1,834	414	9	4	2	9	1,828	414	12	
Danbury town	119	108	8	-	3	-	-	108	8	3	50
18 years and over	96	86	7	-	3	-	-	86	7	3	
Davidson town	4,046	3,334	639	16	50	7	48	3,302	633	63	1,332
18 years and over	3,518	2,969	487	9	46	7	34	2,945	484	55	
Dellview town	10	8	-	-	2	-	-	8	-	2	3
18 years and over	8	7	-	-	1	-	-	7	-	1	
Denton town	1,292	1,292	-	-	-	-	-	1,292	-	-	567
18 years and over	989	989	-	-	-	-	-	989	-	-	
Dillsboro town	95	93	-	2	-	-	-	93	-	2	63
18 years and over	81	79	-	2	-	-	-	79	-	2	
Dobbins Heights town	1,144	156	977	8	1	2	5	156	974	9	592
18 years and over	830	119	706	4	-	1	3	119	704	4	
Dobson town	1,195	1,122	46	1	1	25	24	1,119	46	6	499
18 years and over	962	904	39	1	-	18	17	903	39	3	
Dortches town	840	623	216	1	-	-	-	623	216	1	325
18 years and over	619	463	155	1	-	-	-	463	155	1	
Dover town	451	257	194	-	-	-	1	257	193	-	189
18 years and over	336	197	139	-	-	-	1	197	138	-	
Drexel town	1,746	1,676	47	8	13	2	12	1,671	41	22	727
18 years and over	1,381	1,337	29	8	6	1	5	1,336	26	14	
Dublin town	246	235	9	2	-	-	-	235	9	2	113
18 years and over	196	187	7	2	-	-	-	187	7	2	
Dunn city	8,336	4,768	3,435	61	44	28	77	4,746	3,409	104	3,638
18 years and over	6,165	3,836	2,249	38	25	17	55	3,819	2,229	62	
Durham city	136,611	70,640	62,449	334	2,672	516	1,610	69,773	62,193	3,335	60,607
18 years and over	106,578	58,815	45,007	248	2,109	399	1,262	58,110	44,847	2,359	
Earl town	230	208	22	-	-	-	-	208	22		104
18 years and over	169	155	14	-	-	-	-	155	14	-	
East Arcadia town	468	12	455	1	-	-	-	12	455	1	174
18 years and over	290	6	283	1	-	-	-	6	283	1	
East Bend town	619	604	14	-	1	-	5	600	13	1	271
18 years and over	463	454	8	-	1	-	2	452	8	1	
East Flat Rock CDP	3,218	3,096	59	35	9	19	51	3,065	59	43	1,572
18 years and over	2,484	2,404	44	18	5	13	34	2,382	44	24	
East Laurinburg town	302	282	7	13	-	-	6	277	7	12	126
18 years and over	238	228	2	8	-	-	4	225	2	7	
Eastover CDP	1,243	1,019	170	38	11	5	15	1,010	170	48	529
18 years and over	972	807	129	23	8	5	11	801	129	31	
East Rockingham CDP	4,158	3,732	331	76	14	5	36	3,714	319	89	1,813
18 years and over	3,082	2,840	178	54	7	3	24	2,828	169	61	

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Table 5. Age by Race and Hispanic Origin: 1990
Governmental Units

		Race						Not of Hispanic origin			
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
East Spencer town		2,055	317	1,734	2	-	2	6	317	1,728	4	894
	18 years and over	1,411	259	1,151	1	-	-	-	259	1,151	1	
Eden city		15,238	12,312	2,833	26	47	20	68	12,269	2,825	76	6,797
	18 years and over	11,872	9,867	1,944	20	30	11	46	9,839	1,937	50	
Edenton town		5,268	2,315	2,924	7	18	4	49	2,304	2,890	25	2,199
	18 years and over	3,858	1,903	1,935	4	13	3	28	1,896	1,917	17	
Elizabeth City city		14,292	6,722	7,448	23	69	30	100	6,673	7,431	88	5,850
	18 years and over	10,665	5,345	5,235	21	47	17	62	5,314	5,223	66	
Elizabethtown town		3,704	1,907	1,765	12	13	7	22	1,897	1,762	23	1,586
	18 years and over	2,736	1,516	1,198	9	10	3	14	1,508	1,197	17	
Elkin town		3,790	3,419	355	1	9	6	27	3,398	355	15	1,758
	18 years and over	3,100	2,837	252	1	8	2	19	2,821	252	8	
Elk Park town		486	485	-	-	1	-	-	485	-	1	220
	18 years and over	375	374	-	-	1	-	-	374	-	1	
Ellenboro town		514	461	52	-	-	1	2	460	52	-	250
	18 years and over	393	354	38	-	-	1	2	353	38	-	
Elloree town		1,132	574	537	1	-	20	25	574	532	1	484
	18 years and over	843	484	342	1	-	16	17	484	341	1	
Elm City town		1,624	887	731	1	1	4	6	885	731	2	634
	18 years and over	1,170	677	490	1	1	1	3	675	490	2	
Elon College town		4,394	3,969	388	5	24	8	20	3,958	388	28	1,113
	18 years and over	3,839	3,477	329	4	22	7	17	3,468	329	25	
Emerald Isle CDP		4,028	3,249	687	14	54	24	56	3,218	685	69	1,654
	18 years and over	2,965	2,459	442	11	39	14	34	2,440	441	50	
Emerald Isle town		2,434	2,413	7	7	5	2	20	2,397	7	10	4,574
	18 years and over	2,092	2,076	5	4	5	2	17	2,063	5	7	
Enfield town		3,082	804	2,271	2	4	1	1	804	2,271	6	1,139
	18 years and over	2,140	693	1,442	1	3	1	1	693	1,442	4	
Enochville CDP		2,901	2,870	11	4	15	1	4	2,867	11	19	1,157
	18 years and over	2,278	2,256	6	3	12	1	4	2,253	6	15	
Erwin town		4,061	3,543	409	21	10	18	42	3,526	462	31	1,891
	18 years and over	3,262	2,888	342	13	7	12	25	2,878	339	20	
Etowah CDP		1,997	1,955	29	-	8	5	19	1,941	29	8	834
	18 years and over	1,587	1,559	21	-	5	2	11	1,550	21	5	
Eureka town		282	210	69	-	-	3	4	209	69	-	120
	18 years and over	223	172	49	-	-	2	3	171	49	-	
Everetts town		143	108	35	-	-	-	-	108	35	-	66
	18 years and over	113	86	27	-	-	-	-	86	27	-	
Fair Bluff town		1,068	478	586	3	-	1	1	478	586	3	467
	18 years and over	764	385	377	2	-	-	-	385	377	2	
Fairmont town		2,489	902	1,357	227	1	2	5	901	1,355	228	1,097
	18 years and over	1,763	750	871	133	1	2	4	749	876	134	
Fairplains CDP		2,339	1,982	342	5	-	10	16	1,977	342	4	1,020
	18 years and over	1,828	1,561	256	3	-	8	12	1,557	256	3	
Fairview CDP		1,830	1,802	6	14	1	7	19	1,739	6	16	718
	18 years and over	1,364	1,350	4	8	-	2	9	1,343	4	8	
Faison town		701	530	166	-	5	60	69	520	106	6	319
	18 years and over	518	402	84	-	2	30	33	385	84	3	
Faith town		553	552	-	-	1	-	2	550	-	1	234
	18 years and over	424	423	-	-	1	-	2	421	-	1	
Falcon town		216	215	-	1	-	-	-	215	-	1	90
	18 years and over	153	152	-	1	-	-	-	152	-	1	
Falkland town		108	72	36	-	-	-	-	72	36	-	45
	18 years and over	80	53	27	-	-	-	-	53	27	-	
Fallston town		498	487	11	-	-	-	-	487	11	-	219
	18 years and over	397	387	10	-	-	-	-	387	10	-	
Farmville town		4,392	2,345	2,024	6	14	3	26	2,332	2,015	19	1,887
	18 years and over	3,345	1,889	1,440	5	8	3	14	1,883	1,436	12	
Fayetteville city		75,695	43,578	28,979	973	1,151	1,014	2,381	42,576	28,655	2,083	31,712
	18 years and over	56,874	34,380	20,238	694	867	695	1,585	33,698	20,062	1,529	
Fearrington CDP		1,101	1,085	12	-	1	3	2	1,084	12	3	574
	18 years and over	1,005	994	8	-	1	2	2	993	8	2	
Flat Rock CDP		1,812	1,662	142	1	-	7	32	1,640	139	1	735
	18 years and over	1,432	1,320	108	1	-	3	18	1,307	106	1	
Fletcher town		2,787	2,709	47	5	20	6	26	2,696	47	18	1,193
	18 years and over	2,140	2,078	38	5	15	4	17	2,069	38	16	
Forest City town		7,475	5,443	1,980	11	29	12	69	5,395	1,972	39	3,310
	18 years and over	5,519	4,274	1,208	11	20	6	39	4,248	1,201	31	
Forest Hills CDP		3,054	2,948	85	4	16	1	11	2,938	85	20	1,123
	18 years and over	2,343	2,274	54	3	11	1	11	2,264	54	14	
Fort Bragg CDP		34,744	21,150	10,111	317	906	2,260	3,587	20,066	9,874	1,217	4,896
	18 years and over	20,412	16,078	7,301	247	637	1,599	2,486	15,905	7,165	866	

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		Race					Not of Hispanic origin				
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Fountain town	445	268	172	-	-	5	8	266	171	-	216
18 years and over	337	218	116	-	-	3	6	216	115		
Four Oaks town	1,308	1,114	173	3	6	12	22	1,109	173	4	598
18 years and over	982	859	114	3	4	8	14	851	114	3	
Fowlers Village	334	334	-	-	2	-	4	328	-	2	308
18 years and over	308	306	-	-	2	-	4	302	-	2	
Franklin town	2,873	2,735	98	14	19	7	32	2,711	98	32	1,682
18 years and over	2,361	2,255	74	13	16	3	24	2,235	74	28	
Franklinton town	1,615	935	671	2	6	1	1	935	671	8	755
18 years and over	1,255	763	485	1	5	1	1	763	485	6	
Franklinville town	666	627	12	2	1	24	27	623	12	4	259
18 years and over	504	469	10	2	1	22	24	467	10	3	
Fremont town	1,710	789	916	3	-	2	5	787	915	3	725
18 years and over	1,300	618	678	2	-	1	4	617	677	2	
Fuquay-Varina town	4,562	3,425	1,075	17	11	34	100	3,361	1,073	28	1,959
18 years and over	3,449	2,640	764	11	9	25	70	2,597	762	20	
Garysburg town	3,357	3,194	144	3	5	11	15	3,190	144	8	1,359
18 years and over	2,543	2,423	101	3	5	11	14	2,420	101	8	
Garland town	746	430	304	4	-	8	13	427	302	4	302
18 years and over	563	348	207	2	-	5	8	346	207	2	
Garner town	14,967	12,168	2,633	39	94	33	118	12,102	2,613	134	5,975
18 years and over	11,183	9,241	1,822	34	69	17	71	9,201	1,810	101	
Garysburg town	1,057	30	1,024	2	-	1	8	30	1,017	2	428
18 years and over	716	29	684	2	-	1	6	29	679	2	
Gaston town	1,003	808	192	3	-	-	1	807	192	3	451
18 years and over	750	633	114	3	-	-	1	632	114	3	
Gastonia city	54,732	40,501	13,617	103	384	127	294	40,346	13,568	524	22,196
18 years and over	40,881	31,695	8,784	75	247	80	205	31,592	8,751	333	
Gatesville town	308	238	66	-	2	2	2	238	66	2	148
18 years and over	236	189	45	-	1	1	1	189	45	1	
Gibson town	532	263	216	53	-	-	1	262	216	53	214
18 years and over	370	212	124	34	-	-	1	211	124	34	
Gibsonville town	3,441	2,795	626	10	9	1	16	2,787	619	19	1,443
18 years and over	2,597	2,177	406	8	5	1	10	2,171	403	13	
Glen Alpine town	563	544	1	-	18	-	1	543	1	18	248
18 years and over	446	439	1	-	6	-	-	439	1	6	
Glen Raven CDP	2,616	2,026	561	19	7	3	19	2,010	561	26	1,060
18 years and over	2,063	1,608	433	16	5	1	10	1,599	433	21	
Godwin town	77	61	16	-	-	-	-	61	16	-	39
18 years and over	56	47	9	-	-	-	-	47	9	-	
Goldsboro city	40,709	20,490	19,314	130	539	236	599	20,195	19,247	668	14,345
18 years and over	30,366	16,603	13,145	102	360	156	409	16,405	13,101	451	
Golston town	299	271	26	1	1	-	1	271	26	1	141
18 years and over	230	210	18	1	1	-	1	210	18	1	
Gorman CDP	1,090	993	95	-	-	2	2	993	95	-	442
18 years and over	863	792	70	-	-	1	1	792	70	-	
Graham city	10,426	8,659	1,673	30	40	24	97	8,588	1,667	74	4,517
18 years and over	8,216	6,954	1,194	24	27	17	67	6,909	1,190	50	
Grandfather Village	34	34	-	-	-	-	-	34	-	-	28
18 years and over	27	27	-	-	-	-	-	27	-		
Granite Falls town	3,253	3,146	88	4	3	12	17	3,141	88	7	1,306
18 years and over	2,524	2,431	74	4	3	12	14	2,429	74	7	
Granite Quarry town	1,646	1,509	117	3	17	-	8	1,501	117	20	688
18 years and over	1,213	1,109	89	3	12	-	3	1,106	89	15	
Greenevers town	512	27	481	-	-	4	9	27	476	-	205
18 years and over	335	23	310	-	-	2	3	23	309	-	
Greensboro city	183,521	117,237	62,305	852	2,633	494	1,765	116,225	62,017	3,514	80,411
18 years and over	144,273	95,552	45,955	635	1,804	327	1,272	94,809	45,766	2,426	
Greenville city	44,972	28,867	15,337	105	524	139	379	28,654	15,312	697	18,054
18 years and over	36,115	25,007	10,517	86	394	111	305	24,835	10,501	474	
Grifton town	2,393	1,491	886	3	9	4	11	1,487	883	12	982
18 years and over	1,834	1,214	609	3	5	3	9	1,210	607	8	
Grimesland town	469	320	149	-	-	-	5	315	149		205
18 years and over	359	257	102	-	-	-	2	255	102		
Grover town	516	498	15	1	2	-	3	495	15	3	233
18 years and over	398	387	8	1	2	-	3	384	8	3	
Half Moon CDP	6,306	4,702	1,242	24	167	171	301	4,584	1,211	210	2,106
18 years and over	3,984	3,042	716	19	123	84	158	2,984	702	140	
Halifax town	327	221	105	1			-	221	105	1	138
18 years and over	268	176	91	1	-	-	-	176	91	1	
Hamilton town	544	310	234	-	-	-	2	308	234	-	215
18 years and over	403	245	158	-	-	-	1	244	158	-	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race					Not of Hispanic origin				
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Hamlet city	6,196	4,036	2,099	50	7	4	42	4,022	2,070	[illegible]	[illegible]
18 years and over	4,545	3,147	1,358	35	3	2	26	3,137	1,345	37	
Harmony town	1,759	1,753	-	6	-	-	1	1,752	-	6	1,036
18 years and over	1,391	1,385	-	6	-	-	1	1,384	-	6	
Harrells town	431	421	8	1	-	1	3	419	8	1	155
18 years and over	334	327	5	1	-	1	2	326	5	1	
Harrellsville town	187	110	68	3	-	6	7	109	68	3	79
18 years and over	139	84	46	3	-	6	7	83	46	3	
Harrisville town	106	88	18	-	-	-	-	88	18	-	47
18 years and over	83	72	11	-	-	-	-	72	11	-	
Harrisburg town	1,625	1,565	39	8	11	2	6	1,561	39	15	624
18 years and over	1,270	1,222	31	6	9	2	3	1,221	31	15	
Hassell town	95	35	60	-	-	-	-	35	60	-	45
18 years and over	71	33	38	-	-	-	-	33	38	-	
Havelock city	20,268	15,350	3,639	109	526	584	1,284	14,795	3,531	658	6,096
18 years and over	13,704	10,487	2,319	112	389	397	824	10,156	2,256	468	
Hav River town	1,855	1,580	267	2	5	1	12	1,569	267	7	837
18 years and over	1,427	1,232	188	2	4	1	8	1,225	188	6	
Hayesville town	279	279	-	-	-	-	-	279	-	-	179
18 years and over	250	250	-	-	-	-	-	250	-	-	
Hays CDP	1,522	1,517	-	4	-	1	10	1,508	-	4	612
18 years and over	1,117	1,113	-	3	-	1	5	1,109	-	3	
Hazelwood town	1,678	1,631	22	15	7	3	20	1,619	22	17	786
18 years and over	1,339	1,300	21	12	4	2	11	1,293	21	14	
Honey Brook CDP	2,876	2,727	125	11	12	1	12	2,716	125	23	956
18 years and over	1,943	1,856	72	8	7	-	9	1,847	72	15	
Henderson city	15,655	7,293	8,278	21	30	33	84	7,260	8,263	48	6,446
18 years and over	11,566	5,904	5,602	19	23	18	57	5,875	5,594	40	
Hendersonville city	7,284	5,760	1,430	19	49	26	110	5,691	1,426	67	3,090
18 years and over	5,755	4,771	923	15	30	16	69	4,721	921	44	
Hertford town	2,105	1,068	1,032	-	5	-	8	1,063	1,029	5	913
18 years and over	1,503	872	626	-	5	-	7	867	624	5	
Hickory city	28,301	23,032	4,827	77	286	79	221	22,917	4,808	355	12,701
18 years and over	22,462	18,950	3,217	52	185	58	160	18,861	3,205	236	
Highlands town	948	946	-	-	2	-	8	938	-	2	1,596
18 years and over	755	753	-	-	2	-	4	749	-	2	
High Point city	69,496	47,347	20,980	375	653	141	552	47,039	20,919	956	29,408
18 years and over	52,738	37,929	14,005	273	429	102	403	37,697	13,968	670	
High Shoals city	605	558	44	3	-	-	-	558	44	3	241
18 years and over	416	397	16	3	-	-	-	397	16	3	
Hildebran town	790	789	-	1	-	-	3	786	-	1	345
18 years and over	618	617	-	1	-	-	1	616	-	1	
Hillsborough town	4,263	2,557	1,663	13	23	7	24	2,540	1,660	39	1,783
18 years and over	3,191	1,965	1,198	10	15	3	14	1,955	1,197	25	
Hobgood town	435	236	199	-	-	-	1	235	199	-	186
18 years and over	320	190	130	-	-	-	1	189	130	-	
Hoffman town	348	130	212	5	-	1	1	130	212	5	150
18 years and over	259	108	149	1	-	1	1	108	149	1	
Holden Beach town	626	626	-	-	-	-	6	620	-	-	1,624
18 years and over	560	560	-	-	-	-	6	554	-	-	
Holly Ridge town	728	623	80	7	18	-	1	623	79	25	372
18 years and over	496	447	35	5	9	-	-	447	35	14	
Holly Springs town	908	203	705	-	-	-	-	203	705	-	335
18 years and over	635	160	475	-	-	-	-	160	475	-	
Hookerton town	422	258	164	-	-	-	-	258	164	-	188
18 years and over	308	197	111	-	-	-	-	197	111	-	
Hope Mills town	8,184	7,282	610	140	73	79	248	7,135	597	204	3,133
18 years and over	5,640	5,065	374	102	54	45	153	4,970	368	149	
Hot Springs town	478	474	-	-	1	3	1	474	-	3	240
18 years and over	357	355	-	-	-	2	-	355	-	2	
Hudson town	2,819	2,810	2	6	-	1	3	2,807	2	7	1,188
18 years and over	2,263	2,256	2	4	-	1	3	2,253	2	5	
Huntersville town	3,014	2,553	439	11	10	1	8	2,546	439	21	1,330
18 years and over	2,253	1,944	292	10	6	1	7	1,938	292	16	
Icard CDP	2,553	2,548	1	2	1	1	10	2,539	1	3	1,000
18 years and over	1,918	1,913	1	2	1	1	8	1,906	1	3	
Indian Beach town	153	148	-	-	5	-	-	148	-	5	827
18 years and over	136	133	-	-	3	-	-	133	-	3	
Indian Trail town	1,943	1,866	52	17	4	3	14	1,855	52	21	717
18 years and over	1,390	1,340	34	11	4	1	10	1,331	34	15	
Jackson town	592	346	246	-	-	-	6	340	246	-	260
18 years and over	456	268	188	-	-	-	3	265	188	-	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race						Not of Hispanic origin			
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Jacksonville city		30,013	20,303	8,007	144	902	657	1,571	19,599	7,845	598	11,810
	18 years and over...	21,237	14,954	5,170	98	598	417	977	14,512	5,087	661	
James City CDP		4,279	3,459	783	8	16	13	35	3,441	777	26	1,823
	18 years and over...	3,245	2,666	550	8	12	9	15	2,662	547	21	
Jamestown town		2,600	2,327	204	1	64	4	21	2,310	204	65	1,051
	18 years and over...	1,965	1,765	153	1	45	1	11	1,755	153	46	
Jamesville town		612	333	279	-	-	-	-	333	279	-	283
	18 years and over...	422	263	159	-	-	-	-	263	159	-	
Jefferson town		1,300	1,263	22	5	8	2	4	1,261	22	13	521
	18 years and over...	1,088	1,057	22	3	6	1	3	1,055	22	9	
Jonesville town		1,549	1,316	222	1	-	10	10	1,316	222	1	730
	18 years and over...	1,174	1,010	159	1	-	4	4	1,010	159	1	
Kannapolis city		29,696	24,149	5,342	38	71	96	187	24,073	5,327	109	12,717
	18 years and over...	22,923	19,267	3,515	26	49	66	123	19,223	3,503	74	
Kelford town		204	99	105	-	-	-	-	99	105	-	103
	18 years and over...	144	73	71	-	-	-	-	73	71	-	
Kenansville town		856	532	317	-	2	5	9	532	313	2	328
	18 years and over...	716	454	255	-	2	5	9	454	251	2	
Kenly town		1,549	932	601	11	4	1	2	931	601	15	717
	18 years and over...	1,137	739	385	8	4	1	2	738	385	12	
Kernersville town		10,836	10,071	606	20	63	76	161	9,996	596	83	5,069
	18 years and over...	8,366	7,833	432	14	44	43	95	7,786	428	57	
Kill Devil Hills town		4,238	4,153	21	11	31	22	51	4,124	21	42	4,809
	18 years and over...	3,352	3,289	16	10	18	19	39	3,269	16	28	
King city		4,059	3,998	25	8	24	4	20	3,983	25	31	1,562
	18 years and over...	3,046	3,001	18	6	18	3	16	2,989	18	23	
Kings Mountain city		8,763	6,812	1,791	17	137	6	43	6,798	1,785	137	3,689
	18 years and over...	6,590	5,386	1,107	12	80	5	27	5,375	1,106	82	
Kingstown town		956	15	941	-	-	-	3	15	938	-	275
	18 years and over...	644	13	631	-	-	-	2	13	629	-	
Kinston city		25,295	10,512	14,615	34	104	30	120	10,478	14,559	138	10,826
	18 years and over...	18,751	8,764	9,872	28	69	18	79	8,742	9,834	96	
Kitrell town		228	171	57	-	-	-	-	171	57	-	90
	18 years and over...	179	134	45	-	-	-	-	134	45	-	
Kitty Hawk town		1,937	1,915	2	3	11	6	30	1,891	2	14	2,105
	18 years and over...	1,504	1,491	2	1	6	4	16	1,479	2	7	
Knightdale town		1,884	1,692	170	-	12	10	28	1,678	166	12	785
	18 years and over...	1,351	1,226	107	-	8	10	21	1,217	105	8	
Kure Beach town		619	617	-	1	1	-	2	615	-	2	937
	18 years and over...	522	520	-	1	1	-	1	519	-	2	
La Grange town		2,805	1,198	1,594	1	7	5	14	1,195	1,590	6	1,220
	18 years and over...	2,049	952	1,085	1	6	5	10	950	1,083	6	
Lake Junaluska CDP		2,482	2,445	16	10	10	1	8	2,438	16	20	1,612
	18 years and over...	2,056	2,028	11	8	8	1	5	2,024	11	16	
Lake Lure town		691	671	17	3	-	-	4	667	17	3	1,155
	18 years and over...	626	609	14	3	-	-	4	605	14	3	
Lake Waccamaw town		954	762	164	27	-	1	1	762	164	27	482
	18 years and over...	738	610	118	9	-	1	1	610	118	9	
Landis town		2,333	2,269	54	3	6	1	12	2,258	54	9	1,055
	18 years and over...	1,880	1,827	47	3	2	1	11	1,817	47	5	
Lansing town		171	171	-	-	-	-	-	171	-	-	92
	18 years and over...	142	142	-	-	-	-	-	142	-	-	
Lasker town		139	138	1	-	-	-	-	138	1	-	76
	18 years and over...	112	111	1	-	-	-	-	111	1	-	
Lattimore town		183	166	15	-	-	2	2	166	15	-	78
	18 years and over...	140	131	7	-	-	2	2	131	7		
Laurel Park town		1,322	1,312	1	3	5	1	3	1,309	1	9	827
	18 years and over...	1,145	1,139	1	2	2	1	1	1,138	1	5	
Laurinburg city		11,643	5,827	5,239	504	48	25	78	5,801	5,218	546	4,637
	18 years and over...	8,416	4,745	3,287	330	37	17	54	4,728	3,272	362	
Lawndale town		573	444	119	-	10	-	3	441	119	10	254
	18 years and over...	468	376	86	-	6	-	3	373	86	6	
Leggett town		108	69	39	-	-	-	-	69	39		37
	18 years and over...	87	60	27	-	-	-	-	60	27		
Leland town		1,801	1,611	186	3	1	-	6	1,611	180	4	750
	18 years and over...	1,305	1,181	120	3	1	-	5	1,181	115	4	
Lenoir city		14,192	11,864	2,240	26	40	22	76	11,819	2,232	65	6,338
	18 years and over...	10,984	9,417	1,516	17	28	6	35	9,395	1,512	42	
Lewiston Woodville town		788	257	528	3	-	-	2	255	528	3	324
	18 years and over...	515	198	315	2	-	-	1	197	315	2	
Lewisville CDP		3,206	3,085	96	3	20	2	21	3,073	96	16	1,337
	18 years and over...	2,394	2,303	75	2	13	1	18	2,292	75	9	

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		Race					Not of Hispanic origin				
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Lexington city		16,581	11,305	4,916	71	244	45	112	11,256	4,904	309	7,486
	18 years and over	12,698	9,147	3,334	49	138	30	83	9,109	3,325	181	
Liberty town		2,047	1,498	528	9	4	8	13	1,493	528	13	829
	18 years and over	1,601	1,213	373	6	4	5	7	1,211	373	10	
Light Oak CDP		1,339	374	958	6	1	-	3	374	955	7	425
	18 years and over	943	270	666	6	1	-	1	270	665	7	
Lilesville town		468	257	206	5	-	-	-	257	206	5	241
	18 years and over	348	204	141	3	-	-	-	204	141	3	
Lillington town		2,078	1,193	808	15	2	30	35	1,186	808	19	699
	18 years and over	1,708	988	681	12	2	25	29	982	681	16	
Lincolnton city		6,847	5,443	1,308	9	38	49	121	5,378	1,302	46	2,880
	18 years and over	5,197	4,325	809	7	23	33	72	4,288	808	29	
Linden town		180	163	15	1	-	1	3	161	15	1	71
	18 years and over	134	125	7	1	-	1	1	125	7	1	
Littleton town		691	415	276	-	-	-	5	414	272	-	356
	18 years and over	546	365	181	-	-	-	2	364	180	-	
Locust city		1,940	1,891	1	4	2	42	50	1,883	1	6	735
	18 years and over	1,405	1,376	1	4	1	23	30	1,369	1	5	
Long Beach town		3,816	3,790	2	20	1	3	16	3,777	2	21	4,618
	18 years and over	3,114	3,092	2	16	1	3	10	3,085	2	17	
Long View town		3,229	2,843	228	17	31	10	16	2,938	227	48	1,474
	18 years and over	2,588	2,381	169	16	16	6	12	2,376	168	32	
Louisburg town		3,037	1,920	1,097	4	15	1	21	1,913	1,084	19	1,064
	18 years and over	2,563	1,710	837	4	12	-	17	1,703	828	15	
Love Valley town		67	67	-	-	-	-	-	67	-	-	74
	18 years and over	54	54	-	-	-	-	-	54	-	-	
Lowell city		2,704	2,481	207	11	-	5	6	2,480	207	11	1,124
	18 years and over	2,153	1,990	156	5	-	2	3	1,989	156	5	
Lowesville CDP		1,092	956	124	11	-	1	5	952	124	11	407
	18 years and over	772	692	73	6	-	1	5	686	73	6	
Lucama town		933	858	71	-	3	1	1	858	71	3	397
	18 years and over	686	635	48	-	3	-	-	635	48	3	
Lumber Bridge town		109	96	2	11	-	-	-	96	2	11	50
	18 years and over	79	75	-	4	-	-	-	75	-	4	
Lumberton city		18,601	10,539	5,653	2,261	115	33	83	10,506	5,634	2,378	7,606
	18 years and over	13,487	8,308	3,590	1,496	77	16	55	8,282	3,579	1,571	
Macedonia town		830	814	7	3	4	2	4	813	7	6	313
	18 years and over	610	598	4	3	3	2	3	598	4	5	
Macclesfield town		493	423	70	-	-	-	1	422	70	-	232
	18 years and over	396	345	51	-	-	-	1	344	51	-	
McDonald town		88	40	17	27	-	4	8	40	17	23	39
	18 years and over	68	32	12	21	-	3	7	32	12	17	
McFarlan town		98	73	25	-	-	-	-	73	25	-	43
	18 years and over	78	61	17	-	-	-	-	61	17	-	
McLeansville CDP		1,154	1,106	47	-	-	1	5	1,102	47	-	468
	18 years and over	885	847	37	-	-	1	1	847	37	-	
Macon town		154	123	14	2	-	15	15	123	14	2	69
	18 years and over	114	95	9	2	-	8	8	95	9	2	
Madison town		2,371	1,532	825	3	8	3	12	1,526	820	13	1,042
	18 years and over	1,838	1,226	603	2	6	1	5	1,225	600	8	
Maggie Valley town		185	184	-	1	-	-	-	184	-	1	156
	18 years and over	157	156	-	1	-	-	-	156	-	1	
Magnolia town		747	372	369	6	-	-	10	363	368	6	319
	18 years and over	526	299	225	2	-	-	6	293	225	2	
Maiden town		2,574	2,168	375	5	2	24	83	2,110	374	7	1,023
	18 years and over	1,960	1,682	257	4	1	16	54	1,645	256	5	
Manteo town		991	873	112	-	2	4	15	863	112	1	684
	18 years and over	790	701	84	-	2	3	8	697	84	1	
Marietta town		206	82	117	6	1	-	-	82	117	7	70
	18 years and over	133	58	72	2	1	-	-	58	72	3	
Marion city		4,765	4,167	554	13	25	6	21	4,152	554	38	2,256
	18 years and over	3,758	3,318	408	12	18	2	14	3,306	408	30	
Mar-Mac CDP		3,282	3,029	217	2	21	13	24	3,037	217	24	1,324
	18 years and over	2,461	2,297	140	2	14	8	16	2,249	140	16	
Marshall town		809	802	4	2	1	-	2	800	4	3	387
	18 years and over	627	620	4	2	1	-	-	620	4	3	
Mars Hill town		1,611	1,515	82	3	6	5	11	1,510	81	9	466
	18 years and over	1,421	1,333	76	3	4	5	10	1,329	75	7	
Marshville town		2,020	1,199	801	7	7	6	23	1,180	801	16	755
	18 years and over	1,466	930	518	4	4	4	14	925	518	9	
Mascboro CDP		7,010	6,761	194	11	37	7	56	6,714	193	47	2,687
	18 years and over	5,177	5,002	137	8	27	3	35	4,971	137	34	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race						Not of Hispanic origin			
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Matthews town		13,651	13,003	467	37	132	12	121	12,896	462	172	5,330
	18 years and over	9,655	9,222	317	29	79	8	92	9,140	315	108	
Maxton town		2,373	828	1,367	168	7	3	5	828	1,366	174	588
	18 years and over	1,592	640	847	99	5	1	1	640	847	104	
Maydan town		2,471	2,233	222	3	12	1	11	2,224	221	15	1,031
	18 years and over	2,016	1,858	147	2	9	-	8	1,851	146	11	
Maysville town		892	450	436	1	1	4	8	447	435	2	353
	18 years and over	634	346	283	1	1	3	5	344	283	2	
Mebane city		4,754	3,756	952	7	24	15	48	3,722	951	33	2,017
	18 years and over	3,566	2,877	665	4	14	6	27	2,857	664	18	
Music town		310	98	211	-	-	1	2	97	211	-	123
	18 years and over	238	76	161	-	-	1	2	75	161	-	
Micro town		417	396	21	-	-	-	-	396	21	-	193
	18 years and over	334	318	16	-	-	-	-	318	16	-	
Middleburg town		131	56	75	-	-	-	-	56	75	-	52
	18 years and over	96	48	48	-	-	-	-	48	48	-	
Middlesex town		730	524	184	1	-	21	27	517	184	2	315
	18 years and over	545	404	122	1	-	18	22	399	122	2	
Millers Creek CDP		1,787	1,780	1	3	2	1	2	1,779	1	5	735
	18 years and over	1,348	1,343	1	2	1	1	2	1,342	1	3	
Milton town		185	109	74	-	2	-	-	109	74	2	97
	18 years and over	162	90	70	-	2	-	-	90	70	2	
Minnesott Beach town		266	264	2	-	-	-	2	262	2	-	231
	18 years and over	239	237	2	-	-	-	2	235	2	-	
Mint Hill town		11,567	11,212	246	46	58	5	77	11,141	246	103	4,093
	18 years and over	8,584	8,336	172	36	36	4	50	8,291	172	71	
Mocksville town		3,399	2,676	701	12	9	1	10	2,669	699	21	1,514
	18 years and over	2,641	2,138	490	7	5	1	9	2,131	489	12	
Monroe city		16,127	9,397	6,483	55	95	97	215	9,311	6,448	153	6,347
	18 years and over	11,605	7,443	3,984	42	59	77	161	7,372	3,971	101	
Montreat town		693	649	29	2	12	1	1	649	29	14	516
	18 years and over	635	591	29	2	12	1	1	591	29	14	
Mooresboro city		294	228	66	-	-	-	-	228	66	-	144
	18 years and over	228	183	45	-	-	-	-	183	45	-	
Mooresville town		9,317	7,088	2,139	25	44	21	45	7,067	2,137	68	3,808
	18 years and over	7,018	5,527	1,431	17	32	11	33	5,508	1,429	48	
Moravian Falls CDP		1,736	1,595	95	1	15	30	37	1,588	95	16	802
	18 years and over	1,362	1,254	70	1	11	26	30	1,250	70	12	
Morehead City town		6,046	4,877	1,066	35	52	16	56	4,850	1,061	79	3,206
	18 years and over	4,697	3,931	693	24	39	10	31	3,917	690	59	
Morganton city		15,085	12,520	2,319	21	208	17	58	12,480	2,315	232	6,558
	18 years and over	12,132	10,301	1,685	18	118	10	45	10,270	1,683	134	
Morrisville town		1,022	840	176	-	4	2	12	830	176	4	502
	18 years and over	813	668	141	-	2	2	11	659	141	2	
Marven town		590	180	408	-	-	2	5	179	405	1	255
	18 years and over	411	151	258	-	-	2	5	150	255	1	
Mountain Home CDP		1,898	1,872	11	4	5	6	17	1,861	11	9	868
	18 years and over	1,456	1,443	5	2	3	3	6	1,440	5	5	
Mountain View CDP		3,697	3,511	146	6	33	1	11	3,501	146	33	1,311
	18 years and over	2,556	2,440	91	5	19	1	10	2,431	91	24	
Mount Airy city		7,156	6,469	638	9	11	29	60	6,445	630	21	3,417
	18 years and over	5,694	5,236	423	7	10	18	44	5,218	415	17	
Mount Gilead town		1,336	754	577	5	-	-	5	751	575	5	523
	18 years and over	1,006	624	377	5	-	-	2	622	377	5	
Mount Holly city		7,710	7,006	645	19	37	3	31	6,979	645	55	3,264
	18 years and over	5,869	5,485	441	14	26	3	25	5,463	441	40	
Mount Olive town		4,582	2,156	2,405	5	10	6	18	2,151	2,398	15	1,553
	18 years and over	3,462	1,782	1,662	5	9	4	15	1,777	1,656	14	
Mount Pleasant town		1,027	921	102	4	-	-	-	921	102	4	447
	18 years and over	806	727	77	2	-	-	-	727	77	2	
Mulberry CDP		2,339	2,316	22	-	-	1	11	2,305	22	1	911
	18 years and over	1,810	1,801	9	-	-	-	8	1,793	9	-	
Murfreesboro town		2,580	1,594	914	7	59	6	14	1,586	914	66	931
	18 years and over	2,131	1,376	683	4	54	4	11	1,369	683	58	
Murphy town		1,575	1,455	81	21	14	4	16	1,442	81	36	803
	18 years and over	1,233	1,140	61	17	12	3	11	1,133	61	29	
Myrtle Grove CDP		4,275	4,155	100	3	17	-	13	4,143	99	20	1,828
	18 years and over	3,325	3,230	79	3	13	-	13	3,218	78	16	
Nags Head town		1,838	1,773	48	-	14	3	10	1,766	48	14	3,117
	18 years and over	1,534	1,481	42	-	8	3	10	1,474	42	8	
Nashville town		3,617	2,044	1,561	8	2	2	12	2,040	1,554	11	1,333
	18 years and over	2,745	1,589	1,147	6	2	1	11	1,585	1,141	8	

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		Race						Not of Hispanic origin			
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Navassa town		445	34	409	2	-	-	-	34	409	2	144
	18 years and over	310	22	286	2	-	-	-	22	286	2	
House Forest CDP		1,110	1,042	39	-	24	5	20	1,035	34	21	409
	18 years and over	788	744	20	-	20	4	14	739	19	17	
New Bern city		17,363	9,654	7,563	53	61	32	121	9,587	7,532	123	8,024
	18 years and over	12,842	7,799	4,941	33	49	20	80	7,753	4,925	84	
New Hope CDP		5,694	4,837	735	10	80	32	102	4,769	727	96	2,354
	18 years and over	4,522	3,919	521	9	53	20	67	3,878	516	61	
New Hope CDP		4,491	3,084	1,330	11	56	10	47	3,047	1,330	67	1,604
	18 years and over	3,158	2,193	905	9	42	9	31	2,171	905	51	
Newland town		645	635	-	1	-	9	9	635	-	1	334
	18 years and over	495	486	-	1	-	8	8	486	-	1	
New London town		414	385	21	4	-	4	4	385	21	4	167
	18 years and over	310	292	14	3	-	1	1	292	14	3	
Newport town		2,516	2,089	334	18	41	34	61	2,067	329	55	920
	18 years and over	1,917	1,581	277	14	27	18	38	1,566	274	39	
New River Station CDP		8,732	7,091	2,031	96	107	407	709	6,852	1,977	194	447
	18 years and over	8,859	6,496	1,894	87	87	395	655	6,287	1,848	169	
Newton city		9,304	7,770	1,437	13	42	42	100	7,716	1,435	53	3,986
	18 years and over	7,153	6,122	959	11	31	30	63	6,093	957	40	
Newton Grove town		3,511	3,375	125	-	-	11	13	375	123	-	214
	18 years and over	391	300	85	-	-	6	8	300	83		
Norlina town		1,996	634	354	2	-	6	18	623	353	2	456
	18 years and over	2750	504	240	2	-	4	11	497	240	2	
Norman town		105	75	29	1	-	-	-	75	29	1	49
	18 years and over	83	60	22	1	-	-	-	60	22	1	
North Hickory CDP		4,299	4,194	72	6	22	5	13	4,188	70	28	1,664
	18 years and over	3,262	3,194	46	4	13	5	10	3,190	45	17	
Northlakes CDP		1,219	1,210	3	-	6	-	1	1,209	3	6	502
	18 years and over	919	912	3	-	4	-	1	911	3	4	
North Wilkesboro town		3,384	2,799	574	3	4	4	9	2,794	574	7	1,607
	18 years and over	2,588	2,220	357	3	4	4	9	2,215	357	7	
Norwood town		1,617	1,155	437	3	2	20	39	1,136	435	7	679
	18 years and over	1,201	900	287	3	2	9	22	888	280	5	
Oakboro town		600	443	154	2	1	-	7	438	152	3	247
	18 years and over	442	343	96	2	1	-	7	338	94	3	
Oak City town		389	202	181	3	2	1	4	202	180	3	172
	18 years and over	299	165	128	3	2	1	4	165	127	3	
Ocean Isle Beach town		523	521	1	-	1	-	2	519	1	1	1,915
	18 years and over	443	441	1	-	1	-	2	439	1	1	
Ogden CDP		13,228	3,145	56	16	7	4	23	3,127	56	22	1,319
	18 years and over	2,400	2,337	40	13	6	4	16	2,326	40	18	
Old Fort town		720	603	116	-	1	-	-	603	116	1	352
	18 years and over	564	478	85	-	1	-	-	478	85	1	
Oriental town		786	687	98	-	1	-	2	685	98	1	487
	18 years and over	666	606	59	-	1	-	2	604	59	1	
Orrum town		103	60	43	-	-	-	-	60	43	-	45
	18 years and over	73	49	24	-	-	-	-	49	24	-	
Oxford city		7,913	3,579	4,295	9	16	14	32	3,564	4,291	26	3,111
	18 years and over	5,902	2,812	3,064	7	11	8	20	2,801	3,062	15	
Pantego town		171	143	27	1	-	-	2	143	25	1	86
	18 years and over	137	112	24	1	-	-	1	112	23	1	
Parkton town		367	292	62	13	-	-	-	292	62	13	182
	18 years and over	301	248	46	7	-	-	-	248	46	7	
Parkwood CDP		4,123	3,345	608	21	123	26	83	3,292	607	141	1,403
	18 years and over	2,877	2,359	397	17	91	13	48	2,327	396	106	
Parmele town		321	38	282	1	-	-	-	38	282	1	129
	18 years and over	235	34	200	1	-	-	-	34	200	1	
Patterson Springs town		690	682	2	5	-	1	12	671	2	5	305
	18 years and over	509	503	2	3	-	1	6	498	2	3	
Peachland town		384	256	127	-	1	-	-	256	127	1	146
	18 years and over	285	199	85	-	1	-	-	199	85	1	
Pembroke town		2,241	265	74	1,894	3	5	29	260	73	1,879	919
	18 years and over	1,516	210	52	1,241	3	4	14	215	51	1,236	
Pikeville town		598	579	17	-	1	1	4	575	17	2	274
	18 years and over	484	468	14	-	1	1	1	467	14	2	
Pilot Mountain town		1,181	1,046	130	1	-	4	6	1,043	130	2	574
	18 years and over	954	86	91	1	-	1	3	858	91	2	
Pinebluff town		876	823	31	11	9	2	3	822	31	20	367
	18 years and over	646	608	21	10	5	2	3	607	21	15	
Pinehurst town		5,103	4,995	89	1	14	4	24	4,978	88	13	3,326
	18 years and over	4,691	4,602	77	1	9	2	20	4,586	76	9	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race					Not of Hispanic origin				
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Pine Knoll Shores town		1,360	1,351	-	1	7	1	3	1,349		8	1,542
	18 years and over	1,208	1,200	-	1	6	1	3	1,198		7	
Pine Level town		1,217	1,132	84	1	-	-	3	1,129	84	1	558
	18 years and over	958	891	66	1	-	-	3	888	66	1	
Pinetops town		1,514	728	785	-	1	-	6	727	780	1	557
	18 years and over	1,109	567	542	-	-	-	3	566	540	-	
Pineville town		2,970	2,812	115	12	15	16	67	2,763	112	28	1,495
	18 years and over	2,413	2,299	82	8	14	10	46	2,267	79	21	
Piney Green CDP		8,999	6,362	2,031	57	283	266	534	6,163	1,973	329	3,561
	18 years and over	6,192	4,480	1,284	44	206	178	332	4,360	1,257	243	
Pink Hill town		547	408	135	1	1	2	2	408	135	2	244
	18 years and over	392	311	79	1	1	-	-	311	79	2	
Pittsboro town		1,436	1,001	412	7	6	10	17	995	411	13	638
	18 years and over	1,148	816	319	3	3	7	11	813	318	6	
Pleasant Garden CDP		2,228	1,922	290	12	1	3	11	1,914	290	13	871
	18 years and over	1,694	1,478	203	9	1	3	9	1,472	203	10	
Pleasant Hill CDP		1,114	1,105	-	-	-	9	23	1,091	-	-	502
	18 years and over	913	908	-	-	-	5	18	895	-	-	
Plymouth town		4,328	1,861	2,437	-	22	8	22	1,848	2,435	23	1,793
	18 years and over	3,040	1,493	1,530	-	13	4	12	1,486	1,528	14	
Polkton town		662	363	297	2	-	-	-	363	297	2	260
	18 years and over	463	265	197	1	-	-	-	265	197	1	
Polkville city		1,514	1,419	93	-	1	1	6	1,414	93	1	650
	18 years and over	1,147	1,086	59	-	1	1	1	1,086	59	1	
Pollocksville town		299	239	58	-	-	2	2	239	58	-	147
	18 years and over	240	195	44	-	-	1	1	195	44	-	
Pope AFB CDP		2,857	2,044	659	18	76	60	144	1,984	642	87	472
	18 years and over	2,042	1,459	464	15	54	50	99	1,425	456	62	
Porter Tent CDP		3,872	3,381	420	27	25	19	36	3,365	416	55	1,470
	18 years and over	2,832	2,495	292	16	16	13	28	2,483	269	32	
Powellsville town		103	53	50	-	-	-	-	53	50	-	49
	18 years and over	80	42	38	-	-	-	-	42	38	-	
Princeton town		1,181	826	348	4	-	3	8	819	348	6	537
	18 years and over	900	652	245	2	-	1	7	646	245	2	
Princeville town		1,652	51	1,601	-	-	-	2	51	1,599	-	650
	18 years and over	1,104	37	1,067	-	-	-	1	37	1,066	-	
Proctorville town		168	95	57	8	-	8	8	95	57	8	70
	18 years and over	138	86	38	6	-	8	8	86	38	6	
Pumpkin Center CDP		2,857	2,311	348	24	100	74	130	2,268	344	115	955
	18 years and over	1,957	1,608	215	17	72	45	77	1,584	212	84	
Raeford city		3,469	1,974	1,355	109	24	7	38	1,955	1,346	130	1,330
	18 years and over	2,505	1,570	856	63	13	3	16	1,563	851	75	
Raleigh city		207,951	143,862	57,354	584	5,127	1,024	2,940	142,237	57,010	5,764	92,643
	18 years and over	167,138	119,590	42,512	493	3,810	733	2,226	118,949	42,255	4,308	
Ramseur town		1,186	1,120	47	2	8	8	11	1,117	47	11	550
	18 years and over	919	875	31	1	6	6	6	875	31	7	
Randleman city		2,612	2,504	82	20	5	1	16	2,491	80	25	1,170
	18 years and over	1,961	1,897	46	14	3	1	13	1,887	44	17	
Ranlo town		1,650	1,537	90	12	8	3	11	1,529	90	20	663
	18 years and over	1,253	1,169	69	6	6	3	9	1,163	69	12	
Raynham town		106	53	11	42	-	-	-	53	11	42	47
	18 years and over	79	46	6	27	-	-	-	46	6	27	
Red Oak town		280	242	36	2	-	-	1	241	36	2	114
	18 years and over	225	195	29	1	-	-	1	194	29	1	
Red Springs town		3,799	1,553	1,965	267	13	1	14	1,543	1,964	278	1,549
	18 years and over	2,726	1,285	1,266	166	8	1	11	1,277	1,265	173	
Reidsville city		12,183	7,353	4,745	15	40	30	74	7,326	4,724	59	5,369
	18 years and over	9,454	5,992	3,412	14	24	12	44	5,977	3,396	37	
Rennert town		217	1	111	92	-	-	-	14	111	92	87
	18 years and over	141	14	69	58	-	-	-	14	69	58	
Rhodhiss town		638	637	1	-	-	-	1	636	1	-	250
	18 years and over	483	482	1	-	-	-	1	481	1		
Richfield town		535	456	57	3	19	-	-	456	57	22	233
	18 years and over	375	329	36	1	9	-	-	329	36	10	
Richlands town		996	768	223	1	1	3	11	760	223	2	431
	18 years and over	729	568	159	1	1	1	5	564	159	1	
Rich Square town		1,058	577	465	7	5	4	12	577	457	12	443
	18 years and over	852	490	352	6	2	2	9	490	345	8	
River Bend town		2,408	2,287	103	2	13	8	23	2,267	103	15	1,173
	18 years and over	2,062	1,981	65	2	9	5	17	1,969	65	11	
River Road CDP		3,892	2,986	898	4	3	1	13	2,975	897	7	1,799
	18 years and over	2,874	2,317	549	4	3	1	8	2,311	548	7	

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		Race						Not of Hispanic origin			
		Total	White	Black	Am Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Roanoke Rapids city,		15,722	12,849	2,719	41	100	13	78	12,795	2,708	141	6,738
	18 years and over	11,592	9,790	1,705	26	60	11	56	9,751	1,700	85	
Rocbins city		970	861	45	-	-	64	66	859	45		449
	18 years and over	742	667	25	-	-	50	50	667	25		
Robbinsville town		1,709	684	1,023	23	2	-	5	679	-	25	360
	18 years and over	1,524	507	1,015	15	2	-	4	503	-	1	
Robersonville town		1,940	860	1,063	5	12	-	-	860	1,063	17	821
	18 years and over	1,469	713	735	3	11	-	-	713	735	11	
Rockingham city		9,399	6,891	2,334	61	109	4	41	6,870	2,318	170	3,971
	18 years and over	7,001	5,418	1,475	42	63	3	29	5,404	1,463	105	
Rockwell town		1,598	1,578	14	-	6	-	2	1,576	14	6	650
	18 years and over	1,207	1,189	13	-	5	-	2	1,187	13	5	
Rocky Mount city		48,997	24,314	24,297	122	193	71	264	24,196	24,214	323	20,173
	18 years and over	35,427	19,814	15,923	94	137	59	189	19,128	15,875	235	
Rolesville town		572	531	39	-	1	1	1	531	39	1	227
	18 years and over	424	401	21	-	1	1	1	401	21	1	
Ronda town		367	367	-	-	-	-	-	367	-	-	166
	18 years and over	288	288	-	-	-	-	-	288	-	-	
Roper town		669	170	499	-	-	-	-	170	499	-	200
	18 years and over	462	132	330	-	-	-	-	132	330	-	
Roseboro town		1,441	733	696	9	1	2	14	727	690	10	583
	18 years and over	979	562	411	4	1	1	8	557	409	5	
Rose Hill town		1,287	903	381	3	-	-	23	880	381	3	586
	18 years and over	981	710	269	2	-	-	18	692	269	2	
Rosman town		385	382	-	3	-	-	-	382	-	3	166
	18 years and over	284	281	-	3	-	-	-	281	-	3	
Rowland town		1,139	373	714	52	-	-	2	373	712	52	485
	18 years and over	830	319	474	37	-	-	1	319	473	37	
Roxboro city		7,332	4,167	3,097	41	12	15	55	4,140	3,081	53	3,195
	18 years and over	5,675	3,479	2,143	36	9	8	27	3,466	2,137	45	
Roxobel town		244	172	72	-	-	-	1	171	72	-	124
	18 years and over	191	142	49	-	-	-	1	141	49	-	
Royal Pines CDP		4,418	4,311	78	3	23	3	24	4,290	78	26	1,865
	18 years and over	3,282	3,213	51	3	14	1	17	3,197	51	17	
Rural Hall town		1,652	1,429	214	5	4	-	6	1,423	214	9	786
	18 years and over	1,273	1,123	144	5	1	-	4	1,119	144	6	
Ruth town		366	349	12	4	1	-	4	345	12	5	147
	18 years and over	254	241	10	2	1	-	2	239	10	3	
Rutherford College town		1,126	1,122	-	3	1	-	1	1,121	-	4	486
	18 years and over	859	857	-	1	1	-	-	857	-	2	
Rutherfordton town		3,617	3,142	461	2	7	5	18	3,130	460	9	1,572
	18 years and over	2,832	2,480	343	2	4	3	13	2,471	342	6	
St. Helena village		321	275	46	-	-	-	-	275	46	-	145
	18 years and over	236	211	25	-	-	-	-	211	25	-	
St. Pauls town		1,992	1,435	440	112	1	4	14	1,425	440	113	861
	18 years and over	1,477	1,123	277	74	-	3	10	1,116	277	74	
St. Stephens CDP		8,734	8,377	221	16	103	17	71	8,327	217	119	3,360
	18 years and over	6,553	6,334	139	10	61	9	48	6,300	136	69	
Salem CDP		2,271	2,237	6	6	21	1	8	2,230	6	27	949
	18 years and over	1,781	1,764	3	5	8	-	5	1,760	3	13	
Salemburg town		409	400	4	1	1	3	3	400	4	2	208
	18 years and over	340	332	4	1	1	2	2	332	4	2	
Salisbury city		23,087	14,728	8,124	42	153	40	136	14,657	8,097	197	9,906
	18 years and over	18,284	12,436	5,689	30	107	22	101	12,379	5,666	138	
Saluda city		488	480	8	-	-	-	1	479	8	-	391
	18 years and over	391	383	8	-	-	-	1	382	8	-	
Sandy Creek town		243	241	-	2	-	-	3	238	-	2	82
	18 years and over	168	166	-	2	-	-	1	165	-	2	
Sanford city		14,475	9,154	5,045	85	82	109	227	9,068	5,014	166	6,223
	18 years and over	10,722	7,279	3,253	59	65	66	141	7,222	3,235	124	
Santeetlah town		47	47	-	-	-	-	1	46	-	-	150
	18 years and over	45	45	-	-	-	-	1	44			
Saratoga town		342	320	19	-	3	-	1	319	19	3	141
	18 years and over	266	248	17	-	1	-	1	247	17	1	
Sawmills town		4,088	4,055	1	13	9	10	17	4,049	1	21	1,598
	18 years and over	3,033	3,003	1	12	7	10	15	2,999	1	18	
Scaly Mountain CDP		1,178	947	223	1	2	5	6	946	222	4	445
	18 years and over	833	678	149	1	2	3	2	678	149	4	
Scotland Neck town		2,575	1,095	1,475	1	-	4	14	1,089	1,471	1	1,066
	18 years and over	1,907	911	994	1	-	1	6	908	992	1	
Seaboard town		791	193	597	1	-	-	7	193	590	1	327
	18 years and over	536	172	363	1	-	-	3	172	360	1	

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Table 5 Age by Race and Hispanic Origin: 1990
Governmental Units

		Race					Hispanic origin (of any race)	Not of Hispanic origin			Housing units
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other races		White	Black	Other races	
Seagate CDP	5,444	5,314	79	24	18	9	37	5,284	79	44	2,259
18 years and over...	4,165	4,054	67	22	16	6	27	4,032	67	33	
Seagrove town	244	242	-	2	-	-	5	237	-	2	116
18 years and over...	196	195	-	1	-	-	3	192	-	1	
Seago Garden CDP	2,784	2,697	75	1	5	6	9	2,695	75	5	1,097
18 years and over...	2,147	2,090	50	1	3	3	5	2,089	50	3	
Selma town	4,600	2,664	1,908	7	3	18	37	2,647	1,905	11	1,357
18 years and over...	3,339	2,101	1,221	7	3	7	19	2,092	1,218	10	
Seven Devils town	117	113	4		-	-	-	113	4	-	336
18 years and over...	98	94	4	-	-	-	-	94	4	-	
Seven Lakes CDP	2,049	1,979	68	-	1	1	10	1,975	62	2	935
18 years and over...	1,799	1,748	50	-	1	-	6	1,745	47	1	
Seven Springs town	163	147	16	-	-	-	-	147	16	-	84
18 years and over...	131	119	12	-	-	-	-	119	12	-	
Severn town	260	157	103	-	-	-	-	157	103	-	122
18 years and over...	208	122	86	-	-	-	-	122	86	-	
Shallotte town	965	914	42	5	3	1	5	910	42	8	413
18 years and over...	797	752	38	3	3	1	5	748	38	6	
Sharpsburg town	1,536	947	584	-	2	3	14	938	580	4	622
18 years and over...	1,071	703	364	-	2	2	8	698	362	3	
Shelby city	14,669	8,366	6,234	20	34	15	69	8,329	6,215	56	6,474
18 years and over...	11,050	6,977	4,020	15	28	10	48	6,950	4,011	41	
Sherrills Ford CDP	3,185	3,056	117	6	6	-	6	3,050	117	12	2,061
18 years and over...	2,514	2,410	94	4	6	-	5	2,405	94	10	
Silver City town	4,808	3,393	1,293	13	8	101	184	3,322	1,276	20	2,027
18 years and over...	3,730	2,740	895	13	5	77	142	2,685	883	20	
Silver City CDP	1,343	34	1,297	11	1	-	1	34	1,296	12	480
18 years and over...	933	29	896	7	1	-	1	29	895	8	
Silver Lake CDP	4,071	3,802	215	27	17	10	33	3,776	215	47	1,503
18 years and over...	2,913	2,749	128	20	11	5	26	2,728	128	31	
Simpson village	410	167	240	-	-	3	3	167	240	-	175
18 years and over...	293	129	162	-	-	2	2	129	162	-	
Sims town	124	103	21	-	-	-	-	103	21	-	57
18 years and over...	104	87	17	-	-	-	-	87	17	-	
Smith Creek CDP	7,461	6,764	579	36	77	5	52	6,721	575	113	2,815
18 years and over...	5,446	4,981	378	28	54	5	42	4,945	377	82	
Smithfield town	7,540	4,730	2,654	11	50	95	153	4,677	2,647	63	3,278
18 years and over...	5,828	3,808	1,917	6	36	61	106	3,768	1,912	42	
Sneads Ferry CDP	2,031	1,826	159	9	14	23	38	1,812	159	22	1,081
18 years and over...	1,560	1,404	127	7	8	14	24	1,395	127	14	
Snow Hill town	1,378	63	733	8	1	4	10	631	729	8	607
18 years and over...	1,042	508	527	3	-	4	9	507	523	3	
Southern Pines town	9,129	5,906	3,155	43	18	7	60	5,871	3,137	61	4,438
18 years and over...	7,087	4,973	2,070	31	10	3	35	4,946	2,065	41	
Southern Shores town	1,447	1,435	6	2	2	2	5	1,432	6	4	1,452
18 years and over...	1,165	1,154	5	2	2	2	5	1,151	5	4	
South Gastonia CDP	5,487	4,981	471	13	15	7	20	4,970	471	26	2,131
18 years and over...	4,123	3,777	320	9	10	7	13	3,772	320	18	
South Henderson CDP	1,374	698	674	-	-	2	13	691	670	-	563
18 years and over...	998	521	476	-	-	1	7	516	475	-	
Southport city	2,369	1,742	619	4	1	3	12	1,733	619	5	1,166
18 years and over...	1,884	1,404	475	1	1	3	8	1,399	475	2	
South Rosemary CDP	1,955	1,083	868	2	1	1	3	1,081	868	3	850
18 years and over...	1,472	878	591	1	1	1	2	877	591	2	
South Weldon CDP	1,640	311	1,324	2	3	-	1	311	1,323	5	591
18 years and over...	1,051	249	798	2	2	-	1	249	797	4	
Sparta town	1,957	1,897	43	4	1	12	16	1,894	42	5	915
18 years and over...	1,574	1,519	39	4	-	12	14	1,518	38	4	
Speed town	88	45	43	-	-	-	-	45	43	-	34
18 years and over...	65	34	31	-	-	-	-	34	31	-	
Spencer town	3,219	2,467	725	13	8	6	26	2,453	719	21	1,384
18 years and over...	2,478	2,039	425	9	4	1	12	2,032	421	13	
Spencer Mountain town	135	135	-	-	-	-	-	135	-	-	43
18 years and over...	92	92	-	-	-	-	-	92	-	-	
Spindale town	4,040	3,083	934	6	13	4	14	3,075	928	23	1,735
18 years and over...	3,161	2,458	687	5	11	-	12	2,450	683	16	
Spring Hope town	1,221	675	537	4	-	5	6	674	537	4	618
18 years and over...	980	577	394	4	-	5	5	577	394	4	
Spring Lake town	7,524	3,044	3,787	68	324	301	567	2,862	3,712	383	3,090
18 years and over...	4,862	2,165	2,373	47	247	180	337	2,051	2,289	285	
Spruce Pine town	2,010	2,001	3	-	1	5	11	1,996	3	-	1,010
18 years and over...	1,549	1,544	2	-	1	2	7	1,540	2	-	

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		Race					Hispanic origin (of any race)	Not of Hispanic origin			Housing units
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race		White	Black	Other race	
Staley town	204	200	3	-	-	1	1	200	3		97
18 years and over	164	161	2	-	-	1	1	161	2		
Stallings town	2,132	1,857	236	35	1	3	14	1,846	236	36	778
18 years and over	1,594	1,421	147	22	1	3	7	1,417	147	23	
Stanfield town	517	510	-	-	-	7	12	505	-	-	205
18 years and over	387	385	-	-	-	2	7	380	-	-	
Stanley town	2,823	2,738	73	2	8	2	20	2,724	73	6	1,122
18 years and over	2,084	2,041	34	2	5	2	11	2,033	34	6	
Stanleyville CDP	4,779	4,196	549	8	24	2	18	4,185	545	31	2,212
18 years and over	3,752	3,347	379	7	17	2	17	3,336	376	23	
Stantonsburg town	782	491	291	-	-	-	-	491	291	-	334
18 years and over	611	409	202	-	-	-	-	409	202	-	
Star town	775	749	18	4	4	-	18	735	18	4	318
18 years and over	599	578	15	4	2	-	12	568	15	4	
Statesville city	17,567	11,057	6,280	36	118	76	164	10,998	6,252	153	7,916
18 years and over	13,472	9,223	4,106	27	71	45	107	9,179	4,088	98	
Stedman town	577	472	100	1	1	3	4	472	99	2	225
18 years and over	432	354	75	1	1	1	1	354	75	2	
Stem town	249	240	6	-	2	1	3	238	6	2	111
18 years and over	201	194	5	-	1	1	3	192	5	1	
Stokesdale town	2,134	1,932	169	4	1	28	31	1,929	169	5	823
18 years and over	1,640	1,487	131	3	1	18	20	1,485	131	4	
Stonyville town	1,109	866	228	1	-	14	15	863	228	3	477
18 years and over	861	686	165	1	-	9	8	685	165	3	
Stonewall town	279	200	78	1	-	-	5	195	78	1	133
18 years and over	223	162	60	1	-	-	4	158	60	1	
Stony Point CDP	1,286	1,263	20	-	-	3	10	1,256	20	-	530
18 years and over	1,004	982	19	-	-	3	9	976	19	-	
Stovall town	409	234	175	-	-	-	-	234	175	-	173
18 years and over	314	178	136	-	-	-	-	178	136	-	
Sugar Mountain village	132	132	-	-	-	-	-	132	-	-	1,090
18 years and over	113	113	-	-	-	-	-	113	-	-	
Summerfield CDP	2,051	1,922	104	17	5	3	17	1,909	104	21	793
18 years and over	1,513	1,422	78	9	3	1	13	1,411	78	11	
Sunset Beach town	311	311	-	-	-	-	4	307	-	-	1,006
18 years and over	268	268	-	-	-	-	2	266	-	-	
Surf City town	970	948	4	8	6	4	7	946	4	13	2,242
18 years and over	871	851	4	6	6	4	6	850	4	11	
Swannanoa CDP	3,538	3,386	127	12	11	2	22	3,369	124	23	1,458
18 years and over	2,628	2,566	50	5	6	1	16	2,553	48	11	
Swansboro town	1,165	1,103	38	7	15	2	14	1,096	38	17	586
18 years and over	913	877	18	5	12	1	9	873	18	13	
Swepsonville CDP	1,195	1,186	2	-	4	3	10	1,179	2	4	530
18 years and over	939	933	2	-	2	2	9	926	2	2	
Sylva town	1,809	1,699	85	20	3	2	6	1,695	55	23	959
18 years and over	1,499	1,411	70	14	2	2	5	1,408	70	16	
Tabor City town	2,330	1,606	713	11	-	-	5	1,605	709	11	1,026
18 years and over	1,755	1,252	498	5	-	-	4	1,251	495	5	
Tarboro town	11,037	7,479	3,483	14	45	16	49	7,442	3,480	66	4,520
18 years and over	8,280	5,876	2,350	11	29	14	41	5,847	2,347	45	
Tar Heel town	115	115	-	-	-	-	-	115	-	-	46
18 years and over	82	82	-	-	-	-	-	82	-	-	
Taylorsville town	1,566	1,317	245	3	-	1	13	1,306	244	3	710
18 years and over	1,250	1,069	177	3	-	1	5	1,066	176	3	
Taylortown town	543	49	491	1	2	-	-	49	491	3	252
18 years and over	393	31	359	1	2	-	-	31	359	3	
Teachey town	244	105	139	-	-	-	1	104	139	-	113
18 years and over	178	84	94	-	-	-	1	83	94	-	
Thomasville city	15,915	11,357	4,420	72	26	40	96	11,302	4,410	107	6,928
18 years and over	12,113	8,958	3,070	47	17	21	68	8,920	3,063	62	
Toast CDP	2,125	1,811	307	2	1	4	9	1,806	307	3	857
18 years and over	1,701	1,456	240	2	-	3	6	1,453	240	2	
Topsail Beach town	346	344	1	1	-	-	2	343	1	1	998
18 years and over	314	312	1	1	-	-	2	310	1	1	
Trenton town	248	181	66	-	1	-	-	181	66	1	128
18 years and over	203	155	47	-	1	-	-	155	47	1	
Trent Woods town	2,366	2,360	-	1	5	-	9	2,352	-	5	819
18 years and over	1,813	1,808	-	-	5	-	7	1,801	-	5	
Trinity CDP	5,469	5,019	399	10	8	3	31	5,001	394	43	1,149
18 years and over	4,241	3,882	321	29	6	3	23	3,869	317	32	
Troutman town	1,493	1,091	395	4	3	-	1	1,090	395	7	578
18 years and over	1,084	846	232	3	3	-	1	845	232	6	

Note: The population counts set forth herein are subject to possible correction for undercount or overcount. The U.S. Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

		Race					Not of Hispanic origin				
	Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race	Hispanic origin (of any race)	White	Black	Other race	Housing units
Troy town	3,404	2,177	1,172	43	3	9	83	2,107	1,168	46	1,181
18 years and over	2,700	1,752	894	43	3	8	55	1,710	890	45	
Tryon town	1,680	1,269	406	2	-	3	9	1,261	400	4	904
18 years and over	1,460	1,171	287	1	-	1	8	1,164	287	1	
Turkey town	234	196	36	2	-	-	5	191	36	2	100
18 years and over	177	153	23	1	-	-	1	152	23	1	
Valdese town	3,914	3,820	30	6	28	30	56	3,794	30	34	1,795
18 years and over	3,080	3,012	21	5	14	28	44	2,996	21	19	
Valley Hill CDP	1,802	1,765	6	9	18	4	38	1,730	6	28	866
18 years and over	1,423	1,397	6	6	12	2	25	1,373	6	19	
Vanceboro town	946	736	204	4	-	2	5	733	204	4	417
18 years and over	652	543	104	3	-	2	4	541	104	3	
Vandemere town	299	157	142	-	-	-	-	157	142	-	148
18 years and over	240	122	118	-	-	-	-	122	118	-	
Vander CDP	1,178	886	271	18	1	3	10	881	269	15	470
18 years and over	896	679	203	11	1	2	8	674	202	12	
Varnamtown town	404	403	-	1	-	-	1	402	-	1	208
18 years and over	324	323	-	1	-	-	1	322	-	1	
Vass town	670	569	88	13	-	-	3	566	88	13	288
18 years and over	497	431	58	8	-	-	3	428	58	8	
Vaco town	320	253	67	-	-	-	2	251	67	-	137
18 years and over	232	183	49	-	-	-	2	181	49	-	
Vade town	238	186	46	3	2	-	1	186	46	5	110
18 years and over	182	143	34	3	2	-	1	142	34	5	
Vadesboro town	3,645	1,926	1,698	12	8	1	10	1,918	1,697	20	1,552
18 years and over	2,696	1,580	1,100	10	5	1	8	1,574	1,099	15	
Vagram town	480	284	180	16	-	-	13	273	178	16	208
18 years and over	365	218	136	11	-	-	9	209	136	11	
Wake Forest town	5,769	4,338	1,360	9	50	12	38	4,315	1,353	63	2,299
18 years and over	4,266	3,260	957	8	34	7	29	3,242	952	43	
Walkertown town	1,200	1,112	71	-	4	13	18	1,107	70	5	539
18 years and over	974	909	56	-	1	8	10	907	56	1	
Wallace town	2,939	2,134	786	10	4	5	19	2,123	783	14	1,251
18 years and over	2,187	1,668	507	6	4	2	11	1,660	506	10	
Walnut Cove town	1,088	821	259	2	3	3	10	815	259	4	461
18 years and over	887	676	205	2	3	1	4	674	205	4	
Walnut Creek village	623	616	3	-	4	-	4	612	3	4	221
18 years and over	467	460	3	-	4	-	4	456	3	4	
Walstonburg town	188	171	16	-	1	-	-	171	16	1	92
18 years and over	153	140	12	-	1	-	-	140	12	1	
Wanchese CDP	1,380	1,366	1	4	5	4	15	1,355	1	9	583
18 years and over	966	955	1	4	4	2	9	948	1	8	
Warrenton town	949	597	346	-	1	5	9	593	346	1	470
18 years and over	775	503	266	-	1	5	7	501	266	1	
Warsaw town	2,859	1,296	1,510	14	12	27	46	1,292	1,500	21	1,195
18 years and over	2,070	1,065	970	9	10	16	23	1,063	968	16	
Washington city	9,075	4,865	4,158	5	21	26	74	4,836	4,131	34	3,873
18 years and over	6,634	3,895	2,707	5	13	14	41	3,874	2,695	24	
Washington Park town	403	399	4	-	-	-	1	398	4	-	193
18 years and over	337	335	2	-	-	-	1	334	2	-	
Watha town	99	97	2	-	-	-	-	97	2	-	41
18 years and over	79	77	2	-	-	-	-	77	2	-	
Washaw town	1,294	971	322	1	-	-	2	970	321	1	453
18 years and over	882	661	220	1	-	-	1	660	220	1	
Waynesville town	6,758	6,414	278	37	19	10	43	6,380	278	57	3,355
18 years and over	5,398	5,144	208	29	13	4	28	5,120	208	42	
Weaverville town	2,107	2,057	40	9	-	1	6	2,051	40	10	928
18 years and over	1,637	1,609	25	3	-	-	6	1,603	25	3	
Webster town	410	396	2	2	7	3	7	393	2	8	185
18 years and over	308	301	-	1	4	2	5	298	-	5	
Weddington town	3,803	3,651	108	14	26	4	27	3,631	108	37	1,252
18 years and over	2,617	2,512	73	13	17	2	16	2,499	73	29	
Welcome CDP	3,377	3,207	146	10	9	5	8	3,205	145	19	1,357
18 years and over	2,561	2,455	89	8	6	3	5	2,454	88	14	
Weldon town	1,392	608	779	-	4	1	18	600	770	4	666
18 years and over	1,051	526	521	-	3	1	12	521	515	3	
Wendell town	2,822	2,493	315	2	9	3	10	2,486	315	11	1,141
18 years and over	2,050	1,839	198	2	8	3	7	1,835	198	10	
West Canton CDP	1,119	1,104	10	5	-	-	3	1,102	9	5	484
18 years and over	892	881	7	4	-	-	2	879	7	4	
West Jefferson town	1,002	984	7	4	7	-	-	984	7	11	548
18 years and over	791	780	3	3	5	-	-	780	3	8	

Note: The population counts set forth herein are subject to possible correction for undercount or overcount. The U.S. Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

		Race					Not of Hispanic origin				
		Total	White	Black	Am. Indian, Eskimo, and Aleut	Asian and Pacific Islander	Other race[1]	Hispanic origin (of any race)[1]	White	Black	Other race[1]	Housing units
West Marion CDP		1,291	1,162	123	2	3	1	2	1,161	123	5	600
	18 years and over	1,016	930	80	2	3	1	1	930	80	5	
Westport CDP		1,280	1,270	4	-	2	4	10	1,264	4	2	559
	18 years and over	1,034	1,027	2	-	2	3	6	1,024	2	2	
West Smithfield CDP		2,411	2,124	272	1	9	5	34	2,104	268	8	905
	18 years and over	1,895	1,689	196	1	5	4	19	1,676	195	5	
Whispering Pines village		1,243	1,238	-	1	4	-	1	1,237	-	5	719
	18 years and over	1,190	1,186	-	1	3	-	1	1,185	-	4	
Whiteville city		860	415	444	-	1	-	3	415	441	1	356
	18 years and over	636	334	302	-	-	-	2	334	300	-	
White Lake town		1,390	377	5	4	4	-	6	373	5	6	816
	18 years and over	310	299	5	4	2	-	3	298	5	4	
Whitehall Mills CDP		1,027	1,009	6	1	6	5	-	1,009	6	12	455
	18 years and over	808	800	3	1	2	2	-	800	3	5	
Whitevill city		5,078	3,326	1,681	41	19	11	26	3,320	1,673	59	2,287
	18 years and over	3,801	2,638	1,108	32	14	9	20	2,636	1,100	45	
Wilkesboro town		2,673	2,251	283	-	23	16	31	2,238	277	27	1,027
	18 years and over	2,086	1,839	219	-	14	14	22	1,832	216	16	
Williamston town		5,503	2,668	2,820	4	9	2	15	2,664	2,811	13	2,327
	18 years and over	4,079	2,174	1,891	4	8	2	6	2,171	1,890	12	
Wilmington city		55,530	36,059	18,815	167	319	170	477	35,790	18,740	523	26,469
	18 years and over	43,424	30,143	12,821	123	235	102	347	29,937	12,767	373	
Wilson city		36,930	19,338	17,326	40	113	113	259	19,247	17,276	148	15,383
	18 years and over	27,275	15,571	11,517	23	89	75	172	15,513	11,485	105	
Windemere CDP		4,604	4,318	244	15	24	3	39	4,292	237	30	1,807
	18 years and over	3,747	3,517	190	15	22	3	32	3,495	186	34	
Windsor town		2,056	1,328	718	3	7	-	3	1,325	718	10	927
	18 years and over	1,599	1,062	530	2	5	-	3	1,059	530	7	
Winfall town		501	339	155	4	3	-	-	339	155	7	253
	18 years and over	398	276	117	2	3	-	-	276	117	5	
Wingate town		2,821	2,229	551	3	22	16	23	2,222	550	26	679
	18 years and over	2,278	1,868	373	3	18	16	22	1,862	372	22	
Winston-Salem city		143,485	85,330	56,328	325	1,097	405	1,236	84,654	56,132	1,163	65,631
	18 years and over	112,364	71,056	39,996	237	828	247	883	70,563	39,857	1,061	
Winterville town		2,816	1,622	1,175	8	10	1	11	1,616	1,175	14	1,104
	18 years and over	2,037	1,180	845	4	7	1	7	1,176	845	9	
Winton town		796	241	512	40	-	3	9	236	512	35	359
	18 years and over	571	196	342	30	-	3	5	194	342	30	
Woodfin town		2,736	2,718	10	3	3	2	16	2,704	10	6	1,329
	18 years and over	2,147	2,135	8	2	2	-	9	2,126	8	4	
Woodland town		760	422	336	2	-	-	-	422	336	2	297
	18 years and over	530	342	186	2	-	-	-	342	186	2	
Wrightsboro CDP		4,752	3,276	1,427	27	17	5	22	3,261	1,423	46	1,504
	18 years and over	3,580	2,586	959	21	11	3	18	2,575	955	32	
Wrightsville Beach town		2,937	2,921	5	2	8	1	12	2,909	5	11	2,413
	18 years and over	2,621	2,608	4	2	6	1	11	2,597	4	9	
Yadkinville town		2,525	2,295	191	4	5	30	53	2,272	191	9	1,033
	18 years and over	1,997	1,806	148	3	4	16	30	1,812	148	7	
Yanceyville town		1,973	921	1,040	1	4	7	21	912	1,035	5	734
	18 years and over	1,545	765	768	1	4	7	14	761	765	5	
Yaupon Beach town		734	722	4	1	4	3	4	721	4	5	533
	18 years and over	612	603	3	1	3	2	3	602	3	4	
Youngsville town		424	303	115	-	-	6	4	302	115	3	191
	18 years and over	312	238	72	-	-	2	2	237	72	1	
Zebulon town		3,173	1,847	1,307	1	-	18	27	1,844	1,299	3	1,233
	18 years and over	2,264	1,428	825	-	-	11	18	1,426	819	1	
Eastern Cherokee Reservation		6,527	1,094	15	5,388	13	17	66	1,086	15	5,360	2,370
	18 years and over	4,341	914	6	3,400	6	15	29	910	6	3,386	
Cherokee TDSA (state)		116,053	69,164	44,335	1,306	531	717	1,637	68,475	44,140	1,801	48,156
	18 years and over	86,076	54,340	30,040	886	372	438	1,032	53,884	29,527	1,237	
Haliwa-Saponi TDSA (state)		6,436	509	3,647	2,244	12	24	43	505	3,615	2,273	2,273
	18 years and over	4,471	428	2,500	1,519	9	15	27	424	2,481	1,539	
Lumbee TDSA (state)		50,039	8,975	12,022	28,863	88	91	383	8,904	11,977	28,775	17,217
	18 years and over	33,381	7,029	7,643	18,577	67	65	212	6,983	7,619	18,562	
Meherrin TDSA (state)		55,306	24,104	30,742	296	132	32	161	24,027	30,693	485	23,414
	18 years and over	40,295	19,116	20,850	208	102	19	110	19,066	20,814	305	
Waccamaw Siouan TDSA (state)		2,667	799	629	1,226	3	10	40	793	612	1,222	986
	18 years and over	1,839	594	421	817	2	5	23	590	411	815	

[1] Note: The population counts set forth herein are subject to possible correction for undercount or overcount. The U.S. Department of Commerce is considering whether to correct these counts and will announce its decision by July 15, 1991

Introduction

This is a special computer listing of Public Law 94-171 redistricting data. Contact Customer Services (301-763-4100) for information on the availability of Tables 1-4. The population counts set forth herein are subject to possible correction for undercount or overcount. The U.S. Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

P.L. 94-171 Program

The objective of this program is to meet the requirements of Public Law 94-171. This law, enacted in 1975, requires the Census Bureau to provide redistricting data in a geographic format requested by State governments if specified that within a year following Census Day (by April 1, 1991), the Census Bureau must send to the Governor and the legislature of each State the population data it will need to redraw districts for its State legislature.

To meet the legal requirement, the Census Bureau established a voluntary program to allow States to receive data for voting districts (e.g., election precincts, city wards) in addition to standard census geographic areas such as counties, cities, census tracts, and blocks. These files contain data for voting districts for those counties for which a State outlined voting district boundaries around a set of census blocks on census maps, in accordance with the guidelines of this program.

Area Classifications

AMERICAN INDIAN AND ALASKA NATIVE AREA

Alaska Native Village Statistical Area

Alaska Native villages (ANV's) constitute tribes, bands, clans, groups, villages, communities, or associations in Alaska that are recognized pursuant to the Alaska Native Claims Settlement Act of 1972, Public Law 92-203. Because ANV's do not have legally designated boundaries, the Census Bureau has established Alaska Native village statistical areas (ANVSA's) for statistical purposes. For the 1990 census, the Census Bureau cooperated with officials of the nonprofit corporation within each participating Alaska Native Regional Corporation (ANRC), as well as other knowledgeable officials, to delineate boundaries that encompass the settled area associated with each ANV. ANVSA's are located within ANRC's and do not cross ANRC boundaries. ANVSA's for the 1990 census replace the ANV's that the Census Bureau recognized for the 1980 census.

Each ANVSA is assigned a four-digit census code ranging from 6001 through 8989. Each ANVSA also is assigned a five-digit FIPS code. Both the census and FIPS codes are assigned in alphabetical order of ANVSA's.

American Indian Reservation and Trust Land

American Indian Reservation--Federal American Indian reservations are areas with boundaries established by treaty, statute, and/or executive or court order, and recognized by the Federal Government as territory in which American Indian tribes have jurisdiction. State reservations are lands held in trust by State governments for the use and benefit of a given tribe. The reservations and their boundaries were identified for the 1990 census by the Bureau of Indian Affairs (BIA), Department of Interior (for Federal reservations), and State governments (for State reservations). The names of American Indian reservations recognized by State governments, but not by the Federal Government, are followed by "(State)." Areas composed of reservation lands that are administered jointly and/or are claimed by two reservations, as identified by the BIA, are called "joint areas," and are treated as separate American Indian reservations for census purposes.

Federal reservations may cross State boundaries, and Federal and State reservations may cross county, county subdivision, and place boundaries. For reservations that cross State boundaries, only the portion of the reservations in a given State are shown in the data products for that State; the entire reservations are shown in data products for the United States.

Each American Indian reservation is assigned a four-digit census code ranging from 0001 through 4989. These census codes are assigned in alphabetical order of American Indian reservations nationwide, except that joint areas appear at the end of the code range. Each American Indian reservation also is assigned a five-digit FIPS code; because the FIPS codes are assigned in alphabetical sequence of American Indian reservations within each State, the FIPS code is different in each State for reservations in more than one State.

Trust Land--Trust lands are property associated with a particular American Indian reservation or tribe, held in trust by the Federal Government. Trust lands may be held in trust either for a tribe (tribal trust land) or for an individual member of a tribe (individual trust land). Trust lands recognized for the 1990 census comprise all tribal trust lands and inhabited individual trust lands located outside of a reservation boundary. As with other American Indian areas, trust lands may be located in more than one State. Only the trust lands in a given State are shown in the data products for that State; all trust lands associated with a reservation or tribe are shown in data products for the United States. The Census Bureau first reported data for tribal trust lands for the 1980 census.

Trust lands are assigned a four-digit census code and a five-digit FIPS code, the same as that for the reservation with which they are associated. Trust lands not associated with a reservation are presented by tribal name, interspersed alphabetically among the reservations.

Tribal Designated Statistical Area (TDSA)

Tribal designated statistical areas (TDSA's) are areas, delineated outside Oklahoma by federally- and State-recognized tribes without a land base or associated trust lands, to provide statistical areas for which the Census Bureau tabulates data. TDSA's represent areas generally containing the American Indian population over which federally-recognized tribes have jurisdiction and areas in which State tribes provide benefits and services to their members. The names of TDSA's delineated by State-recognized tribes are followed by "(State)." The Census Bureau did not recognize TDSA's before the 1990 census.

Each TDSA is assigned a four-digit census code ranging from 9001 through 9589. The census codes are assigned in alphabetical order of TDSA's nationwide. Each TDSA also is assigned a five-digit FIPS code in alphabetical order within State.

Tribal Jurisdiction Statistical Area (TJSA)

Tribal jurisdiction statistical areas (TJSA's) are areas, delineated by federally-recognized tribes in Oklahoma without a reservation, for which the Census Bureau tabulates data. TJSA's represent areas generally containing the American Indian population over which one or more tribal governments have jurisdiction; if trical officials delineated adjacent TJSA's so that they include some duplicate territory, the overlap area is called a "joint use area," which is treated as a separate TJSA for census purposes.

TJSA's replace the "Historic Areas of Oklahoma (excluding urbanized areas)" shown in 1980 census data products. The Historic Areas of Oklahoma comprised the territory located within reservations that had legally established boundaries from 1900 to 1907; these reservations were dissolved during the 2- to 3-year period preceding the statehood of Oklahoma in 1907. The Historic Areas of Oklahoma (excluding urbanized areas) were identified only for the 1980 census.

Each TJSA is assigned a four-digit census code ranging from 5001 through 5989. The census codes are assigned in alphabetical order of TJSA's, except that joint areas appear at the end of the code range. Each TJSA also is assigned a five-digit FIPS code in alphabetical order within Oklahoma.

COUNTY

The primary political divisions of most States are termed "counties." In Louisiana, these divisions are known as "parishes." In Alaska, which has no counties, the county equivalents are the organized "boroughs" and the "census areas" that are delineated for statistical purposes by the State of Alaska and the Census Bureau. In four States (Maryland, Missouri, Nevada, and Virginia), there are one or more cities that are independent of any county organization and thus constitute primary divisions of their States. These cities are known as "independent cities" and are treated as equivalent to counties for statistical purposes. That part of Yellowstone National Park in Montana is treated as a county equivalent. The District of Columbia has no primary divisions, and the entire area is considered equivalent to a county for statistical purposes.

Each county and county equivalent is assigned a three-digit FIPS code that is unique within State. These codes are assigned in alphabetical order of county or county equivalent within State, except for the

independent cities, which follow the listing of counties.

COUNTY SUBDIVISION

County subdivisions are the primary subdivisions of counties and their equivalents for the reporting of decennial census data. They include census county divisions, census subareas, minor civil divisions, and unorganized territories.

Each county subdivision is assigned a three-digit census code in alphabetical order within county, and a five-digit FIPS code in alphabetical order within State.

Minor Civil Division

Minor civil divisions (MCD's) are the primary political or administrative divisions of a county. MCD's represent many different kinds of legal entities with a wide variety of governmental and/or administrative functions. MCD's are variously designated as American Indian reservations, assessment districts, boroughs, election districts, gores, grants, magisterial districts, parish governing authority districts, plantations, precincts, purchases, supervisors' districts, towns, and townships. In some States, all or some incorporated places are not located in any MCD and thus serve as MCD's in their own right. In other States, incorporated places are subordinate to (part of) the MCD's in which they are located, or the pattern is mixed--some incorporated places are independent of MCD's and others are subordinate to one or more MCD's.

The Census Bureau recognizes MCD's in the following 28 States: Arkansas, Connecticut, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Vermont, Virginia, West Virginia, and Wisconsin. The District of Columbia has no primary divisions, and the entire area is considered equivalent to an MCD for statistical purposes.

Unorganized Territory (unorg.)

In nine States (Arkansas, Iowa, Kansas, Louisiana, Maine, Minnesota, North Carolina, North Dakota, and South Dakota), some counties contain territory that is not included in an MCD recognized by the Census Bureau. Each separate area of unorganized territory in these States is recognized as one or more separate county subdivisions for census purposes. Each unorganized territory is given a descriptive name, followed by the designation "unorg."

PLACE

Places, for the reporting of decennial census data, include census designated places and incorporated places. Each place is assigned a four-digit census code that is unique within State. Each place is also assigned a five-digit FIPS code that is unique within State. Both the census and FIPS codes are assigned based on alphabetical order within State. Consolidated cities (see below) are assigned a one-character alphabetical census code that is unique nationwide and a five-digit FIPS code that is unique within State.

Census Designated Place (CDP)

Census designated places (CDP's) are delineated for the decennial census as the statistical counterparts of incorporated places. CDP's comprise densely settled concentrations of population that are identifiable by name, but are not legally incorporated places. Their boundaries, which usually coincide with visible features or the boundary of an adjacent incorporated place, have no legal status, nor do these places have officials elected to serve traditional municipal functions. CDP boundaries may change with changes in the settlement pattern; a CDP with the same name as in previous censuses does not necessarily have the same boundaries.

Beginning with the 1950 census, the Census Bureau, in cooperation with State agencies and local census statistical areas committees, has identified and delineated boundaries for CDP's. For the 1990 census, the name of each such place is followed by "CDP." For the 1980 census, "(CDP)" was used; for 1970, 1960, and 1950 censuses, these places were identified by "(U)," meaning "unincorporated place."

To qualify as a CDP for the 1990 census, an unincorporated community must have met the following criteria:

1. In all States except Alaska and Hawaii, the Census Bureau uses three population size criteria to designate a CDP. These criteria are:

   a. 1,000 or more persons if outside the boundaries of an urbanized area (UA) delineated for the 1980 census or a subsequent special census.

   b. 2,500 or more persons if inside the boundaries of a UA delineated for the 1980 census or a subsequent special census.

   c. 250 or more persons if outside the boundaries of a UA delineated for the 1980 census or a subsequent special census, and within the official boundaries of an American Indian reservation recognized for the 1990 census.

2. In Alaska, 25 or more persons if outside a UA, and 2,500 or more persons if inside a UA delineated for the 1980 census or a subsequent special census.

3. In Hawaii, 300 or more persons, regardless of whether the community is inside or outside a UA.

For the 1990 census, CDP's qualified on the basis of the population counts prepared for the 1990 Postcensus Local Review Program. Because these counts were subject to change, a few CDP's may have final population counts lower than the minimums shown above.

Hawaii is the only State with no incorporated places recognized by the Bureau of the Census. All places shown for Hawaii in the data products are CDP's. By agreement with the State of Hawaii, the Census Bureau does not show data separately for the city of Honolulu, which is coextensive with Honolulu County.

Consolidated City

A consolidated government is a unit of local government for which the functions of an incorporated place and its county or minor civil division (MCD) have merged. The legal aspects of this action may result in both the primary incorporated place and the county or MCD continuing to exist as legal entities, even though the county or MCD performs few or no governmental functions and has few or no elected officials. Where this occurs, and where one or more other incorporated places in the county or MCD continue to function as separate governments, even though they have been included in the consolidated government, the primary incorporated place is referred to as a "consolidated city."

The data presentation for consolidated cities varies depending upon the geographic presentation. In hierarchical presentations, consolidated cities are not shown. These presentations include the semi-independent places and the "consolidated city (remainder)." Where the consolidated city is coextensive with a county or county subdivision, the data shown for those areas in hierarchical presentations are equivalent to those for the consolidated government.

For inventory geographic presentations, the consolidated city appears at the end of the listing of places. The data for the consolidated city include places that are part of the consolidated city. The "consolidated city (remainder)" is the portion of the consolidated government minus the semi-independent places, and is shown in alphabetical sequence with other places.

In summary presentations by size of place, the consolidated city is not included. The places semi-independent of consolidated cities are categorized by their size, as is the "consolidated city (remainder)."

Each consolidated city is assigned a one-character alphabetic census code. Each consolidated city also is assigned a five-digit FIPS code that is unique within State. The semi-independent places and the "consolidated city (remainder)" are assigned a four-digit census code and a five-digit FIPS place code that are unique within State. Both the census and FIPS codes are assigned based on alphabetical order within State.

Incorporated Place

Incorporated places recognized in 1990 census data products are those reported to the Census Bureau as legally in existence on January 1, 1990 under the laws of their respective States as cities, boroughs, towns, and villages, with the following exceptions: the towns in the

New England States, New York, and Wisconsin, and the boroughs in New York are recognized as minor civil divisions for census purposes; the boroughs in Alaska are county equivalents.

STATE

States are the primary governmental divisions of the United States. The District of Columbia is treated as a statistical equivalent of a State for census purposes.

DEFINITIONS OF SUBJECT CHARACTERISTICS

POPULATION CHARACTERISTICS

AGE

The data on age were derived from answers to questionnaire item 5, which was asked of all persons. The age classification is based on the age of the person in completed years as of April 1, 1990. The age response in question 5a was normally used to represent a person's age. However, when the age response was unacceptable or unavailable, a person's age was derived from an acceptable year of birth response in question 5b.

Data on age are used to determine the applicability of other questions for a person and to classify other characteristics in census tabulations. Age data are needed to interpret most social and economic characteristics used to plan and examine many programs and policies.

HISPANIC ORIGIN

The data on Spanish/Hispanic origin were derived from answers to questionnaire item 7, which was asked of all persons. Persons of Hispanic origin are those who classified themselves in one of the specific Hispanic origin categories listed on the questionnaire--"Mexican," "Puerto Rican," or "Cuban"--as well as those who indicated that they were of "other Spanish/Hispanic" origin. Persons of "Other Spanish/Hispanic" origin are those whose origins are from Spain, the Spanish-speaking countries of Central or South America, or the Dominican Republic, or they are persons of Hispanic origin identifying themselves generally as Spanish, Spanish-American, Hispanic, Hispano, Latino, and so on. Write-in responses to the "other Spanish/Hispanic" category were coded only for sample data.

Origin can be viewed as the ancestry, nationality group, lineage, or country of birth of the person or the person's parents or ancestors before their arrival in the United States. Persons of Hispanic origin may be of any race.

Some tabulations are shown by the Hispanic origin of the householder. In all cases where households, families, or occupied housing units are classified by Hispanic origin, the Hispanic origin of the householder is used.

During direct interviews conducted by enumerators, if a person could not provide a single origin response, he or she was asked to select, based on self-identification, the group which best described his or her origin or descent. If a person could not provide a single group, the origin of the person's mother was used. If a single group could not be provided for the person's mother, the first origin reported by the person was used.

If any household member failed to respond to the Spanish/Hispanic origin question, a response was assigned by the computer according to the reported entries of other household members by using specific rules of precedence of household relationship. In the processing of sample questionnaires, responses to other questions on the questionnaire, such as ancestry and place of birth, were used to assign an origin before any reference was made to the origin reported by other household members. If an origin was not entered for any household member, an origin was assigned from another household according to the race of the householder.

The 1990 data on Hispanic origin are generally comparable with those for the 1980 census. However, there are some differences in the format of the Hispanic origin question between the two censuses. For 1990, the word "descent" was deleted from the 1980 wording. In addition, the term "Mexican-Amer." used in 1980 was shortened further to "Mexican-Am." to reduce misreporting (of "American") in this category detected in the 1980 census. Finally, the 1990 question allowed those who reported as "other Spanish/Hispanic" to write in their specific Hispanic origin group.

Misreporting in the "Mexican-Amer." category of the 1980 census item on Spanish/Hispanic origin may affect the comparability of 1980 and 1990 census data for persons of Hispanic origin for certain areas of the country. An evaluation of the 1980 census item on Spanish/Hispanic origin indicated that there was misreporting in the Mexican origin category by White and Black persons in certain areas. The study results showed evidence that the misreporting occurred in the South (excluding Texas), the Northeast (excluding the New York City area), and a few States in the Midwest Region. Also, results based on available data suggest that the impact of possible misreporting of Mexican origin in the 1980 census was severe in those portions of the above-mentioned regions where the Hispanic origin population was generally sparse. However, national 1980 census data on the Mexican origin population or total Hispanic origin population at the national level was not seriously affected by the reporting problem. (For a more detailed discussion of the evaluation of the 1980 census Spanish/Hispanic origin item, see the 1980 census Supplementary Reports.)

The 1990 and 1980 census data on the Hispanic population are not directly comparable with 1970 Spanish origin data because of a number of factors: (1) overall improvements in the 1980 and 1990 censuses, (2) better coverage of the population, (3) improved question designs, and (4) an effective public relations campaign by the Census Bureau with the assistance of national and community ethnic groups.

Specific changes in question design between the 1980 and 1970 censuses included the placement of the category "No, not Spanish/Hispanic" as the first category in that question. (The corresponding category appeared last in the 1970 question.) Also, the 1970 category "Central or South American" was deleted because in 1970 some respondents misinterpreted the category; furthermore, the designations "Mexican-American" and "Chicano" were added to the Spanish/Hispanic origin question in 1980. In the 1970 census, the question on Spanish origin was asked of only a 5-percent sample of the population.

RACE

The data on race were derived from answers to questionnaire item 4, which was asked of all persons. The concept of race as used by the Census Bureau reflects self-identification; it does not denote any clear-cut scientific definition of biological stock. The data for race represent self-classification by people according to the race with which they most closely identify. Furthermore, it is recognized that the categories of the race item include both racial and national origin or socio-cultural groups.

During direct interviews conducted by enumerators, if a person could not provide a single response to the race question, he or she was asked to select, based on self-identification, the group which best described his or her racial identity. If a person could not provide a single race response, the race of the mother was used. If a single race response could not be provided for the person's mother, the first race reported by the person was used. In all cases where occupied housing units, households, or families are classified by race, the race of the householder was used.

The racial classification used by the Census Bureau generally adheres to the guidelines in Federal Statistical Directive No. 15, issued by the Office of Management and Budget, which provides standards on ethnic and racial categories for statistical reporting to be used by all Federal agencies. The racial categories used in the 1990 census data products are provided below.

White--Includes persons who indicated their race as "White" or reported entries such as Canadian, German, Italian, Lebanese, Near Easterner, Arab, or Polish.

Black--Includes persons who indicated their race as "Black or Negro" or reported entries such as African American, Afro-American, Black Puerto Rican, Jamaican, Nigerian, West Indian, or Haitian.

American Indian, Eskimo, or Aleut--Includes persons who classified themselves as such in one of the specific race categories identified below.

American Indian--Includes persons who indicated their race as "American Indian," entered the name of an Indian tribe, or reported such entries as Canadian Indian, French-American Indian, or Spanish-American Indian.

American Indian Tribe--Persons who identified themselves as American Indian were asked to report their enrolled or principal tribe. Therefore, tribal data in tabulations reflect the written tribal entries reported on the questionnaires. Some of the entries (for example, Iroquois, Sioux, Colorado River, and Flathead) represent nations or reservations.

The information on tribe is based on self-identification and therefore does not reflect any designation of Federally- or State-recognized tribe. Information on American Indian tribes is presented in summary tape files and special data products. The information is derived from the American Indian Detailed Tribal Classification List for the 1990 census. The classification list represents all tribes, bands, and clans that had a specified number of American Indians reported on the census questionnaire.

Eskimo--Includes persons who indicated their race as "Eskimo" or reported entries such as Arctic Slope, Inupiat, and Yupik.

Aleut--Includes persons who indicated their race as "Aleut" or reported entries such as Alutiiq, Egegik, and Pribilovian.

Asian or Pacific Islander--Includes persons who reported in one of the Asian or Pacific Islander groups listed on the questionnaire or who provided write-in responses such as Thai, Nepali, or Tongan.

Other Race--Includes all other persons not included in the "White," "Black," "American Indian, Eskimo, or Aleut," and the "Asian or Pacific Islander" race categories described above. Persons reporting in the "Other race" category and providing write-in entries such as multiracial, multiethnic, mixed, interracial, or some sort, or a Spanish/Hispanic origin group (such as Mexican, Cuban, or Puerto Rican) are included here.

Written entries to three categories on the race item--"Indian

criteria of separateness and direct access are applied to the intended occupants whenever possible. If that information cannot be obtained, the criteria are applied to the previous occupants.

Both occupied and vacant housing units are included in the housing unit inventory, except that recreational vehicles, boats, caves, tents, railroad cars, and the like are included only if they are occupied as someone's usual place of residence. Vacant mobile homes are included provided they are intended for occupancy on the site where they stand. Vacant mobile homes on dealers' sales lots, at the factory, or in storage yards are excluded from the housing inventory.

If the living quarters contain 9 or more persons unrelated to the householder or person in charge (a total of 10 unrelated persons), they are classified as group quarters. If the living quarters contain eight or fewer persons unrelated to the householder or person in charge, they are classified as housing units.

Occupied Housing Units--A housing unit is classified as occupied if it is the usual place of residence of the person or group of persons living in it at the time of enumeration, or if the occupants are only temporarily absent; that is, away on vacation. If all the persons staying in the unit at the time of the census have their usual place of residence elsewhere, the unit is classified as vacant. A household includes all the persons who occupy a housing unit as their usual place of residence. By definition, the count of occupied housing units for 100-percent tabulations is the same as the count of households or householders.

Vacant Housing Units--A housing unit is vacant if no one is living in it at the time of enumeration, unless its occupants are only temporarily absent. Units temporarily occupied at the time of enumeration entirely by persons who have a usual residence elsewhere are also classified as vacant.

New units not yet occupied are classified as vacant housing units if construction has reached a point where all exterior windows and doors

Table 15. Land Area and Population Density: 1990

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
The State	6 628 637	126 179.9	48 718.1	52.5	136.1
Alamance County	108 213	1 115.5	430.7	97.0	251.2
Township 1, Patterson	2 800	132.8	51.3	21.1	54.6
Township 2, Coble	3 231	79.4	30.7	40.7	105.2
Alamance village	258	1.2	.5	215.0	516.0
Township 3, Boone Station	14 895	67.1	25.9	222.0	575.1
Burlington city (pt.)	4 449	8.7	3.4	511.4	1 308.5
Elon College town	4 394	6.5	2.5	676.0	1 757.6
Gibsonville town (pt.)	1 480	2.1	.8	704.8	1 850.0
Glen Raven CDP (pt.)	1 296	5.3	2.0	244.5	648.0
Township 4, Morton	4 501	96.1	37.1	46.8	121.3
Altamahaw-Ossipee CDP	1 076	6.0	2.3	179.3	467.8
Township 5, Faucette	3 007	89.7	34.6	33.5	86.9
Township 6, Graham	19 327	48.1	18.6	401.8	1 039.1
Burlington city (pt.)	6 089	8.6	3.3	708.0	1 845.2
Graham city (pt.)	10 303	16.1	6.2	639.9	1 661.8
Haw River town (pt.)	209	–	–	–	–
Township 7, Albright	2 567	53.1	20.5	48.3	125.2
Saxapahaw CDP (pt.)	–	–	–	–	–
Township 8, Newlin	3 296	170.8	65.9	19.3	50.0
Saxapahaw CDP (pt.)	458	6.9	2.7	66.4	169.6
Township 9, Thompson	4 809	90.4	34.9	53.2	137.8
Saxapahaw CDP (pt.)	720	6.7	2.6	107.5	276.9
Swepsonville CDP (pt.)	1 066	4.0	1.5	266.5	710.7
Township 10, Melville	9 277	73.7	28.5	125.9	325.5
Mebane city (pt.)	4 269	7.7	3.0	554.4	1 423.0
Swepsonville CDP (pt.)	129	1.0	.4	129.0	322.5
Township 11, Pleasant Grove	2 779	114.2	44.1	24.3	63.0
Township 12, Burlington	32 797	60.4	23.3	543.0	1 407.6
Burlington city (pt.)	28 960	35.3	13.6	820.4	2 129.4
Glen Raven CDP (pt.)	1 320	5.9	2.3	223.7	573.9
Township 13, Haw River	4 927	39.7	15.3	124.1	322.0
Burlington city (pt.)	–	.1	–	–	–
Graham city (pt.)	123	2.2	.9	55.9	136.7
Haw River town (pt.)	1 646	5.2	2.0	316.5	823.0
Swepsonville CDP (pt.)	–	.1	–	–	–
Alexander County	27 544	674.2	260.3	40.9	105.8
Ellendale township	3 047	122.8	47.4	24.8	64.3
Gwaltneys township	1 860	114.6	44.2	16.2	42.1
Little River township	630	46.5	17.9	13.5	35.2
Millers township	1 162	66.3	25.6	17.5	45.4
Sharpes township	4 076	68.5	26.5	59.5	153.8
Stony Point CDP (pt.)	1 131	6.2	2.4	182.4	471.3
Sugar Loaf township	1 023	53.1	20.5	19.3	49.9
Taylorsville township	8 334	109.0	42.1	76.5	198.0
Taylorsville town	1 566	3.2	1.2	489.4	1 305.0
Wittenburg township	7 412	93.5	36.1	79.3	205.3
Bethlehem CDP	3 186	19.7	7.6	161.7	419.2
Alleghany County	9 590	607.8	234.7	15.8	40.9
Cherry Lane township	1 205	107.1	41.4	11.3	29.1
Cranberry township	451	63.3	24.4	7.1	18.5
Gap Civil township	3 676	90.3	34.9	40.7	105.3
Sparta town	1 957	6.1	2.4	320.8	815.4
Glade Creek township	2 134	133.1	51.4	16.0	41.5
Piney Creek township	666	66.1	25.5	10.1	26.1
Prathers Creek township	767	96.6	37.3	7.9	20.6
Whitehead township	691	51.2	19.8	13.5	34.9
Anson County	23 474	1 376.9	531.6	17.0	44.2
Ansonville township	1 581	178.4	68.9	8.9	22.9
Ansonville town	614	3.8	1.5	161.6	409.3
Burnsville township	1 402	126.6	48.9	11.1	28.7
Gulledge township	2 096	174.3	67.3	12.0	31.1
Lanesboro township	3 021	158.2	61.1	19.1	49.4
Peachland town	384	2.5	1.0	153.6	384.0
Polkton town	662	5.0	1.9	132.4	348.4
Lilesville township	3 489	268.7	103.7	13.0	33.6
Lilesville town	468	2.6	1.0	180.0	468.0
Morven township	1 736	124.3	48.0	14.0	36.2
McFarlan town	98	2.4	.9	40.8	108.9
Morven town	590	2.7	1.1	218.5	536.4
Wadesboro township	9 761	189.3	73.1	51.6	133.5
Wadesboro town	3 645	7.7	3.0	473.4	1 215.0
White Store township	388	157.1	60.7	2.5	6.4
Ashe County	22 209	1 103.8	426.2	20.1	52.1
Chestnut Hill township	535	49.5	19.1	10.8	28.0
Clifton township	1 691	77.7	30.0	21.8	56.4
Lansing town (pt.)	46	.3	.1	153.3	460.0
Creston township	670	66.8	25.8	10.0	26.0
Elk township	526	42.0	16.2	12.5	32.5
Grassy Creek township	386	38.1	14.7	10.1	26.3
Helton township	772	52.4	20.2	14.7	38.2
Horse Creek township	639	39.7	15.3	16.1	41.8
Lansing town (pt.)	–	.1	–	–	–
Hurricane township	571	50.4	19.5	11.3	29.3
Jefferson township	3 691	76.8	29.6	48.1	124.7
Jefferson town	1 300	4.9	1.9	265.3	684.2
Laurel township	452	34.6	13.4	13.1	33.7
North Fork township	798	72.0	27.8	11.1	28.7
Obids township	1 132	58.5	22.6	19.4	50.1
Oldfields township	1 562	50.0	19.3	31.2	80.9
Peak Creek township	970	104.4	40.3	9.3	24.1
Pine Swamp township	1 456	86.7	33.5	16.8	43.5
Piney Creek township	889	31.8	12.3	28.0	72.3
Lansing town (pt.)	125	.7	.3	178.6	416.7
Pond Mountain township	275	44.3	17.1	6.2	16.1
Walnut Hill township	1 222	60.5	23.4	20.2	52.2
West Jefferson township	3 972	67.5	26.1	58.8	152.2
West Jefferson town	1 002	3.8	1.5	263.7	668.0
Avery County	14 867	639.8	247.0	23.2	60.2
Altamont township	1 633	50.1	19.3	32.6	84.6
Crossnore town	271	1.1	.4	246.4	677.5
Banner Elk township	2 614	62.0	23.9	42.2	109.4
Banner Elk town	933	2.2	.8	424.1	1 166.3
Beech Mountain town (pt.)	5	1.1	.4	4.5	12.5
Seven Devils town (pt.)	20	1.6	.6	12.5	33.3
Sugar Mountain village (pt.)	96	3.6	1.4	26.7	68.6
Beech Mountain township	662	48.3	18.6	13.7	35.6
Beech Mountain town (pt.)	2	3.0	1.2	.7	1.7
Cranberry township	2 561	81.1	31.3	31.6	81.8
Elk Park town	486	1.8	.7	270.0	694.3
Linville township	4 477	129.4	50.0	34.6	89.5
Grandfather village	34	3.9	1.5	8.7	22.7
Newland town	645	1.7	.7	379.4	921.4
Seven Devils town (pt.)	–	.1	–	–	–
Sugar Mountain village (pt.)	36	2.3	.9	15.7	40.0
Roaring Creek township	842	41.3	15.9	20.4	53.0
Toe River township	1 786	98.0	37.8	18.2	47.2
Wilsons Creek township	292	129.6	50.1	2.3	5.8
Beaufort County	42 283	2 143.5	827.6	19.7	51.1
Bath township	3 797	286.0	110.4	13.3	34.4
Bath town	154	.8	.3	192.5	513.3
Chocowinity township	6 489	414.1	159.9	15.7	40.6
Chocowinity town	624	2.1	.8	297.1	780.8
River Road CDP (pt.)	–	–	–	–	–
Long Acre township	7 845	284.2	109.7	27.6	71.5
River Road CDP (pt.)	3 892	18.3	7.1	212.7	548.2
Washington Park town	403	.7	.3	575.7	1 343.3
Pantego township	6 925	476.2	183.9	14.5	37.7
Belhaven town	2 269	3.9	1.5	581.8	1 512.7
Pantego town	171	2.1	.8	81.4	213.8
Richland township	3 543	434.3	167.7	8.2	21.1
Aurora town	654	2.3	.9	284.3	726.7
Washington township	13 684	248.6	96.0	55.0	142.5
Washington city	9 075	14.8	5.7	613.2	1 592.1
Bertie County	20 388	1 811.0	699.2	11.3	29.2
Colerain township	3 428	211.9	81.8	16.2	41.9
Colerain town	139	.7	.3	198.6	463.3
Powellsville town (pt.)	81	.7	.3	115.7	270.0
Indian Woods township	640	101.1	39.0	6.3	16.4
Merry Hill township	1 144	183.1	70.7	6.2	16.2
Mitchells township	2 766	171.0	66.0	16.2	41.9
Aulander town	1 209	3.8	1.5	318.2	806.8
Powellsville town (pt.)	22	.2	.1	110.0	220.0
Roxobel township	1 569	152.1	58.7	10.3	26.7
Kelford town	204	1.3	.5	156.9	408.0
Lewiston Woodville town (pt.)	1	.1	–	10.0	–
Roxobel town	244	2.7	1.0	90.4	244.0
Sacks Bite township	1 204	170.2	65.7	7.1	18.3
Whites township	1 578	163.4	63.1	9.7	25.0
Windsor township	6 322	392.6	151.6	16.1	41.7
Askewville town	201	1.4	.5	143.6	402.0
Windsor town	2 056	5.9	2.3	348.5	893.9
Woodville township	1 737	265.5	102.5	6.5	16.9
Lewiston Woodville town (pt.)	787	5.1	2.0	154.3	393.5
Bladen County	28 663	2 266.3	875.0	12.6	32.8
Abbotts township	1 173	84.5	32.6	13.9	36.0
Bethel township	2 842	111.2	42.9	25.6	66.2
Dublin town	246	1.1	.4	223.6	615.0
Bladenboro township	5 362	162.3	62.6	33.0	85.7
Bladenboro town	1 821	4.9	1.9	371.6	958.4
Brown Marsh township	1 911	80.1	30.9	23.9	61.8
Clarkton town	739	2.9	1.1	254.8	671.8
Carvers Creek township	2 035	200.3	77.3	10.2	26.3
East Arcadia town	468	5.6	2.2	83.6	212.7
Central township	996	78.2	30.2	12.7	33.0
Colly township	1 462	222.2	85.8	6.6	17.0
White Lake town	390	2.3	.9	169.6	433.3
Cypress Creek township	718	135.2	52.2	5.3	13.8
Elizabethtown township	5 921	162.3	62.7	36.5	94.4
Elizabethtown town	3 704	9.6	3.7	385.8	1 001.1
Franchs Creek township	731	210.6	81.3	3.5	9.0
Hollow township	1 611	117.8	45.5	13.7	35.4
Tar Heel town	115	6	.2	191.7	575.0
Lake Creek township	604	188.4	72.7	3.2	8.3
Turnbull township	475	130.7	50.5	3.6	9.4
White Oak township	1 210	214.1	82.7	5.7	14.6
Whites Creek township	1 612	168.3	65.0	9.6	24.8
Brunswick County	50 985	2 214.2	854.9	23.0	59.6
Lockwoods Folly township	10 705	569.7	220.0	18.8	48.7
Holden Beach town	626	7.7	3.0	81.3	208.7
Shallotte town (pt.)	433	4.4	1.7	98.4	254.7
Varnamtown town	404	2.6	1.0	155.4	404.0
Northwest township	7 454	200.8	77.5	37.1	96.2
Belville town (pt.)	–	–	–	–	–
Leland town (pt.)	1 559	3.6	1.4	433.1	1 113.6
Navassa town	445	6.2	2.4	71.8	185.4
Sandy Creek town	243	1.6	.6	151.9	405.0
Shallotte township	11 818	302.0	116.6	39.1	101.4
Calabash town	1 210	4.7	1.8	257.4	672.2
Ocean Isle Beach town	523	6.6	2.5	79.2	209.2
Shallotte town (pt.)	532	3.9	1.5	136.4	354.7
Sunset Beach town	311	6.2	2.4	50.2	129.6
Smithville township	9 488	204.6	79.0	46.4	120.1
Bald Head Island village	78	11.1	4.3	7.0	18.1
Caswell Beach town	175	7.9	3.0	22.2	58.3
Long Beach town	3 816	15.9	6.1	240.0	625.6
Southport city	2 349	5.0	1.9	473.8	1 246.8
Yaupon Beach town	734	2.0	.8	367.0	917.5

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Brunswick County—Con.					
Town Creek township	9 260	605.3	233.7	15.3	39.6
Belville town (pt.)	66	.6	.2	110.0	330.0
Boiling Spring Lakes city	1 650	59.1	22.8	27.9	72.4
Bolivia town	228	1.7	.7	134.1	325.7
Leland town (pt.)	242	1.7	.7	142.4	345.7
Waccamaw township	2 260	331.8	128.1	6.8	17.6
Buncombe County	174 821	1 699.8	656.3	102.8	266.4
Asheville township	71 247	160.5	62.0	443.9	1 149.1
Asheville city (pt.)	55 589	74.0	28.6	751.2	1 943.7
Biltmore Forest town (pt.)	690	3.6	1.4	191.7	492.9
Woodfin town (pt.)	2 661	6.6	2.6	403.2	1 023.5
Avery Creek township	4 653	74.7	28.8	62.3	161.6
Asheville city (pt.)	6	–	–	–	–
Avery Creek CDP	1 144	4.4	1.7	260.0	672.9
Bent Creek CDP	1 487	6.1	2.3	243.8	646.5
Black Mountain township	10 840	146.8	56.7	73.8	191.2
Black Mountain town	5 418	12.5	4.8	433.4	1 128.8
Montreat town	693	7.2	2.8	96.3	247.5
Swannanoa CDP (pt.)	549	1.8	.7	305.0	784.3
Broad River township	1 070	109.2	42.1	9.8	25.4
Fairview township	6 544	126.0	48.6	51.9	134.7
Fairview CDP	1 830	16.1	6.2	113.7	295.2
Flat Creek township	3 602	53.1	20.5	67.8	175.7
French Broad township	3 940	60.2	23.2	65.4	169.8
Woodfin town (pt.)	75	1.9	.7	39.5	107.1
Ivy township	2 757	160.7	62.0	17.2	44.5
Leicester township	11 445	175.9	67.9	65.1	168.6
Asheville city (pt.)	4	.2	.1	20.0	40.0
Limestone township	16 007	87.6	33.8	182.7	473.6
Asheville city (pt.)	4 466	11.3	4.4	395.2	1 015.0
Biltmore Forest town (pt.)	637	4.2	1.6	151.7	398.1
Royal Pines CDP	4 418	7.9	3.0	559.2	1 472.7
Lower Hominy township	8 760	63.9	24.7	137.1	354.7
Asheville city (pt.)	245	2.2	.8	111.4	306.3
Reems Creek township	9 458	109.6	42.3	86.3	223.6
Weaverville town	2 107	5.6	2.2	376.3	957.7
Sandy Mush township	1 003	85.7	33.1	11.7	30.3
Swannanoa township	12 666	127.3	49.1	99.5	258.0
Asheville city (pt.)	1 297	2.9	1.1	447.2	1 179.1
Swannanoa CDP (pt.)	2 989	13.0	5.0	229.9	597.8
Upper Hominy township	10 829	158.8	61.3	68.2	176.7
Burke County	75 744	1 312.5	506.7	57.7	149.5
Drexel township	6 131	30.1	11.6	203.7	528.5
Drexel town	1 746	3.4	1.3	513.5	1 343.1
Valdese town (pt.)	36	.2	.1	180.0	360.0
Icard township	14 060	146.3	56.5	96.1	248.8
Connelly Springs town (pt.)	261	2.9	1.1	90.0	237.3
Hickory city (pt.)	79	1.9	.7	41.6	112.9
Hildebran town	790	3.5	1.3	225.7	607.7
Icard CDP	2 553	10.1	3.9	252.8	654.6
Long View town (pt.)	358	.6	.2	596.7	1 790.0
Rhodhiss town (pt.)	226	.9	.4	251.1	565.0
Jones Ridge township	659	75.2	29.0	8.8	22.7
Linville township	1 131	106.5	41.1	10.6	27.5
Lovelady township	8 005	57.5	22.2	139.2	360.6
Connelly Springs town (pt.)	1 088	6.1	2.4	178.4	453.3
Rutherford College town	1 126	5.0	1.9	225.2	592.6
Valdese town (pt.)	3 878	10.7	4.1	362.4	945.9
Lower Creek township	2 079	55.5	21.4	37.5	97.1
Lower Fork township	2 364	155.3	59.9	15.2	39.5
Morganton township	24 730	154.6	59.7	160.0	414.2
Morganton city (pt.)	13 623	36.6	14.1	372.2	966.2
Salem CDP	2 271	11.3	4.4	201.0	516.1
Quaker Meadow township	5 827	94.8	36.6	61.5	159.2
Morganton city (pt.)	1 163	5.5	2.1	211.5	553.8
Silver Creek township	8 228	139.5	53.9	59.0	152.7
Glen Alpine town	563	2.4	.9	234.6	625.6
Morganton city (pt.)	299	1.2	.5	249.2	598.0
Smoky Creek township	665	24.9	9.6	26.7	69.3
Upper Creek township	1 014	203.7	78.6	5.0	12.9
Upper Fork township	851	68.8	26.6	12.4	32.0
Cabarrus County	98 935	943.9	364.4	104.8	271.5
Township 1, Harrisburg	8 110	110.9	42.8	73.1	189.5
Harrisburg town	1 625	5.4	2.1	300.9	773.8
Township 2, Poplar Tent	11 108	99.4	38.4	111.8	289.3
Concord city (pt.)	969	8.9	3.4	108.9	285.0
Poplar Tent CDP (pt.)	3 086	11.7	4.5	263.8	685.8
Township 3, Odell	3 001	73.6	28.4	40.8	105.7
Township 4, Kannapolis	30 659	86.2	33.3	355.7	920.7
Concord city (pt.)	2 743	8.5	3.3	322.7	831.2
Kannapolis city (pt.)	21 220	28.9	11.1	734.3	1 911.7
Poplar Tent CDP (pt.)	786	2.5	1.0	314.4	786.0
Township 5, New Gilead	3 365	61.9	23.9	54.4	140.8
Concord city (pt.)	182	.8	.3	227.5	606.7
Township 6, Rimertown	1 743	65.6	25.3	26.6	68.9
Township 7, Gold Hill	991	69.4	26.8	14.3	37.0
Township 8, Mount Pleasant	4 733	80.1	30.9	59.1	153.2
Mount Pleasant town	1 027	3.3	1.3	311.2	790.0
Township 9, Georgeville	2 178	77.9	30.1	28.0	72.4
Township 10, Midland	4 123	118.0	45.6	34.9	90.4
Township 11, Central Cabarrus	11 922	78.9	30.5	151.1	390.9
Concord city (pt.)	6 451	16.5	6.4	391.0	1 008.0
Township 12, Concord	17 002	21.9	8.5	776.3	2 000.2
Concord city (pt.)	17 002	21.8	8.4	779.9	2 024.0
Caldwell County	70 709	1 221.6	471.7	57.9	149.9
Globe township	360	106.9	41.3	3.4	8.7
Blowing Rock town (pt.)	14	7	.3	20.0	46.7
Caldwell County—Con.					
Hudson township	10 411	48.1	18.6	216.4	559.7
Cajah's Mountain town (pt.)	938	2.4	.9	390.8	1 042.2
Hudson town	2 819	8.1	3.1	348.0	909.4
Lenoir city (pt.)	257	.9	.3	285.6	856.7
Sawmills town (pt.)	2 012	5.3	2.0	379.6	1 006.0
Johns River township	1 654	112.0	43.2	14.8	38.3
Kings Creek township	1 711	87.7	33.9	19.5	50.5
Lenoir township	18 296	126.9	49.0	144.2	373.4
Cajah's Mountain town (pt.)	394	1.3	.5	303.1	788.0
Gamewell town	3 357	18.6	7.2	180.5	466.3
Lenoir city (pt.)	7 019	17.2	6.6	408.1	1 063.5
Little River township	3 354	143.2	55.3	23.4	60.7
Lovelady township	12 324	106.7	41.2	115.5	299.1
Granite Falls town	3 253	8.5	3.3	382.7	985.8
Northlakes CDP	1 219	9.6	3.7	127.0	329.5
Rhodhiss town (pt.)	412	1.0	.4	412.0	1 030.0
Sawmills town (pt.)	2 076	7.7	3.0	269.6	692.0
Lower Creek township	11 941	94.2	36.4	126.8	328.0
Lenoir city (pt.)	6 916	17.1	6.6	404.4	1 047.9
Mulberry township	924	89.9	34.7	10.3	26.6
North Catawba township	5 912	40.2	15.5	147.1	381.4
Cajah's Mountain town (pt.)	1 097	4.2	1.6	261.2	685.6
Patterson township	2 534	93.6	36.1	27.1	70.2
Blowing Rock town (pt.)	30	.3	.1	100.0	300.0
Wilson Creek township	57	46.9	18.1	1.2	3.1
Yadkin Valley township	1 231	125.3	48.4	9.8	25.4
Camden County	5 904	623.4	240.7	9.5	24.5
Court House township	2 086	140.2	54.1	14.9	38.6
Elizabeth City city (pt.)	29	.1	–	290.0	–
Shiloh township	1 731	179.3	69.2	9.7	25.0
South Mills township	2 087	303.9	117.3	6.9	17.8
Carteret County	52 556	1 376.3	531.4	38.2	98.9
Atlantic township	808	31.0	12.0	26.1	67.3
Beaufort township	7 563	101.8	39.3	74.3	192.4
Beaufort town	3 808	4.5	1.7	846.2	2 240.0
Cedar Island township	316	58.5	22.6	5.4	14.0
Davis township	459	165.1	63.7	2.8	7.2
Harkers Island township	1 761	29.5	11.4	59.7	154.5
Harkers Island CDP	1 759	6.6	2.5	266.5	703.6
Harlowe township	1 072	67.5	26.1	15.9	41.1
Marshallberg township	565	3.7	1.4	152.7	403.6
Merrimon township	469	173.7	67.1	2.7	7.0
Morehead township	21 836	94.4	36.5	231.3	598.2
Atlantic Beach town	1 938	6.0	2.3	323.0	842.6
Emerald Isle town (pt.)	129	.7	.3	184.3	430.0
Indian Beach town	153	1.3	.5	117.7	306.0
Morehead City town	6 046	6.8	2.6	889.1	2 325.4
Pine Knoll Shores town	1 360	5.9	2.3	230.5	591.3
Newport township	7 112	172.7	66.7	41.2	106.6
Newport town	2 516	5.0	1.9	503.2	1 324.2
Portsmouth township	–	15.6	6.0	–	–
Sea Level township	521	29.5	11.4	17.7	45.7
Smyrna township	651	56.9	22.0	11.4	29.6
Stacy township	264	39.6	15.3	6.7	17.3
Straits township	2 115	95.4	36.8	22.2	57.5
White Oak township	7 044	241.4	93.2	29.2	75.6
Cape Carteret town	1 008	5.5	2.1	183.3	480.0
Cedar Point town	628	4.9	1.9	128.2	330.5
Emerald Isle town (pt.)	2 305	12.9	5.0	178.7	461.0
Caswell County	20 693	1 102.6	425.7	18.8	48.6
Anderson township	2 189	130.6	50.4	16.8	43.4
Dan River township	2 361	123.8	47.8	19.1	49.4
Highrowers township	1 363	121.5	46.9	11.2	29.1
Leasburg township	1 318	118.8	45.9	11.1	28.7
Locust Hill township	1 903	116.2	44.9	16.4	42.4
Milton township	2 451	126.4	48.8	19.4	50.2
Milton town	185	.9	.3	205.6	616.7
Pelham township	3 498	133.7	51.6	26.2	67.8
Stony Creek township	2 562	116.8	45.1	21.9	56.8
Yanceyville township	3 048	114.9	44.4	26.5	68.6
Yanceyville town	1 973	10.6	4.1	186.1	481.2
Catawba County	118 412	1 036.0	400.0	114.3	296.0
Bandy's township	3 343	112.9	43.6	29.6	76.7
Caldwell township	5 452	92.4	35.7	59.0	152.7
Maiden town (pt.)	557	1.9	.7	293.2	795.7
Catawba township	6 465	131.5	50.8	49.2	127.3
Catawba town	467	3.1	1.2	150.6	389.2
Clines township	16 074	156.2	60.3	102.9	266.6
Claremont city (pt.)	980	4.6	1.8	213.0	544.4
Conover city (pt.)	1 033	3.1	1.2	333.2	860.8
Hickory city (pt.)	183	2.4	.9	76.3	203.3
St. Stephens CDP (pt.)	2 526	7.7	3.0	328.1	842.0
Hickory township	52 777	176.5	68.2	299.0	773.9
Brookford town	451	1.4	.5	322.1	902.0
Conover city (pt.)	101	1.9	.7	53.2	144.3
Hickory city (pt.)	27 990	48.0	18.5	583.1	1 513.0
Long View town (pt.)	2 871	5.1	2.0	562.9	1 435.5
Mountain View CDP	3 697	12.1	4.7	305.5	786.6
North Hickory CDP	4 299	13.5	5.2	318.4	826.7
St. Stephens CDP (pt.)	6 208	18.0	6.9	344.9	899.7
Jacobs Fork township	3 498	105.1	40.6	33.3	86.2
Mountain Creek township	4 984	110.0	42.5	45.3	117.3
Sherrills Ford CDP	3 185	30.6	11.8	104.1	269.9
Newton township	25 819	151.3	58.4	170.6	442.1
Claremont city (pt.)	–	–	–	–	–
Conover city (pt.)	4 331	13.0	5.0	333.2	866.2
Hickory city (pt.)	49	.3	.1	163.3	490.0
Maiden town (pt.)	2 017	5.3	2.1	380.6	960.5
Newton city	9 304	21.1	8.1	440.9	1 148.6

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Chatham County	38 759	1 769.2	683.1	21.9	56.7
Albright township	2 149	136.2	52.6	15.8	40.9
Baldwin township	4 518	117.2	45.2	38.5	100.0
Bear Creek township	3 221	212.8	82.2	15.1	39.2
Cape Fear township	1 048	129.1	49.8	8.1	21.0
Center township	4 854	168.5	65.1	28.8	74.6
Pittsboro town	1 436	6.3	2.4	227.9	590.3
Gulf township	3 083	188.9	72.9	16.3	42.3
Goldston town	299	2.0	.8	149.5	373.8
Hadley township	1 099	120.8	46.6	8.8	22.7
Haw River township	1 018	54.6	21.1	18.6	48.2
Hickory Mountain township	1 474	160.4	61.9	9.2	23.8
Matthews township	9 406	175.3	67.7	53.7	138.9
Siler City town	4 808	12.0	4.6	400.7	1 045.2
New Hope township	1 732	103.6	40.0	16.7	43.3
Oakland township	948	72.3	27.9	13.1	34.0
Williams township	4 249	129.6	50.0	32.8	85.0
Fearrington CDP	1 101	5.7	2.2	193.2	500.5
Cherokee County	20 170	1 179.0	455.2	17.1	44.3
Beaverdam township	635	226.2	87.3	2.8	7.3
Hot House township	908	67.2	25.9	13.5	35.1
Murphy township	8 215	349.6	135.0	23.5	60.9
Murphy town	1 575	5.9	2.3	266.9	684.8
Notla township	2 649	105.1	40.6	25.2	65.2
Shoal Creek township	1 571	181.3	70.0	8.7	22.4
Valley Town township	6 192	249.6	96.4	24.8	64.2
Andrews town	2 551	8.2	3.2	311.1	797.2
Chowan County	13 506	447.1	172.6	30.2	78.3
Township 1, Edenton	7 447	116.4	45.0	64.0	165.5
Edenton town (pt.)	5 201	9.3	3.6	559.2	1 444.7
Township 2, Middle	3 017	144.4	55.8	20.9	54.1
Township 3, Upper	1 336	87.9	33.9	15.2	39.4
Township 4, Yeopim	1 706	98.4	38.0	17.3	44.9
Edenton town (pt.)	67	3.5	1.4	19.1	47.9
Clay County	7 155	556.1	214.7	12.9	33.3
Brasstown township	1 296	62.2	24.0	20.8	54.0
Hayesville township	2 732	80.3	31.0	34.0	88.1
Hayesville town	279	1.0	.4	279.0	697.5
Hiwassee township	954	31.3	12.1	30.5	78.8
Shooting Creek township	1 078	177.6	68.6	6.1	15.7
Sweetwater township	646	44.2	17.1	14.6	37.8
Tusquitee township	449	160.6	62.0	2.8	7.2
Cleveland County	84 714	1 202.7	464.3	70.4	182.5
Township 1, River	691	44.5	17.2	15.5	40.2
Township 2, Boiling Springs	6 060	106.8	41.2	56.7	147.1
Boiling Springs town	2 445	9.2	3.5	265.8	698.6
Shelby city (pt.)	7	.9	.3	7.8	23.3
Township 3, Kippys	7 710	97.8	37.8	78.8	204.0
Earl town	230	2.1	.8	109.5	287.5
Patterson Springs town	690	2.7	1.0	255.6	690.0
Shelby city (pt.)	-	.1	.1	-	-
Township 4, Kings Mountain	17 611	164.4	63.5	107.1	277.3
Grover town	516	2.2	.9	234.5	573.3
Kings Mountain city (pt.)	8 007	14.3	5.5	559.9	1 455.8
Township 5, Warlick	6 568	112.7	43.5	58.3	151.0
Waco town	320	2.1	.8	152.4	400.0
Township 6, Shelby	29 702	160.0	61.8	185.6	480.6
Light Oak CDP	1 339	3.9	1.5	343.3	892.7
Shelby city (pt.)	14 662	21.7	8.4	675.7	1 745.5
Township 7, Sandy Run	5 013	106.9	41.3	46.9	121.4
Kingstown town (pt.)	868	3.5	1.4	248.0	620.0
Latimore town	183	2.0	.8	91.5	228.8
Mooresboro city	294	4.6	1.8	63.9	163.3
Township 8, Polkville	2 845	127.7	49.3	22.3	57.7
Kingstown town (pt.)	88	1.0	.4	88.0	220.0
Polkville city	1 514	52.0	20.1	29.1	75.3
Township 9, Double Shoals	4 956	115.2	44.5	43.0	111.4
Belwood town (pt.)	307	13.5	5.2	22.7	59.0
Fallston town	498	5.6	2.2	88.9	226.4
Lawndale town	573	1.8	.7	318.3	818.6
Township 10, Knob Creek	1 913	73.7	28.5	26.0	67.1
Belwood town (pt.)	324	18.4	7.1	17.6	45.6
Township 11, Casar	1 645	93.0	35.9	17.7	45.8
Casar town	328	4.3	1.7	76.3	192.9
Columbus County	49 587	2 426.4	936.8	20.4	52.9
Bogue township	2 975	262.7	101.4	11.3	29.3
Lake Waccamaw town (pt.)	-	.2	.1	-	-
Bolton township	1 599	283.8	109.6	5.6	14.6
Bolton town	531	8.0	3.1	66.4	171.3
Bug Hill township	2 357	199.7	77.1	11.8	30.6
Cerro Gordo township	1 918	128.2	49.5	15.0	38.7
Cerro Gordo town	227	2.0	.8	113.5	283.8
Chadbourn township	5 693	133.5	51.5	42.6	110.5
Chadbourn town	2 005	5.5	2.1	364.5	954.8
Fair Bluff township	1 931	97.3	37.6	19.8	51.4
Fair Bluff town	1 068	5.2	2.0	205.4	534.0
Lees township	2 784	232.7	89.8	12.0	31.0
Ransom township	3 739	208.8	80.6	17.9	46.4
South Williams township	4 972	124.3	48.0	40.0	103.6
Tabor City town	2 330	6.6	2.6	353.0	896.2
Tatums township	3 127	190.9	73.7	16.4	42.4
Waccamaw township	1 946	101.9	39.3	19.1	49.5
Lake Waccamaw town (pt.)	954	6.3	2.4	151.4	397.5
Welch Creek township	1 443	102.4	39.6	14.1	36.4
Western Prong township	897	67.5	26.1	13.3	34.4
Whiteville township	10 266	123.5	47.7	83.1	215.2
Brunswick town	302	1.1	.4	274.5	755.0
Whiteville city	5 078	9.9	3.8	512.9	1 336.3
Williams township	3 940	169.1	65.3	23.3	60.3
Craven County	81 613	1 801.5	695.6	45.3	117.3
Township 1	5 938	430.7	166.3	13.8	35.7
Vanceboro town	946	4.4	1.7	215.0	556.5
Township 2	6 371	211.7	81.7	30.1	78.0
Bridgerton town	453	.9	.3	503.3	1 510.0
Township 3	3 427	253.2	97.8	13.5	35.0
Cove City town	497	1.5	.6	331.3	828.3
Dover town	451	2.5	.9	180.4	501.1
Township 5	2 635	155.9	60.2	16.9	43.8
Township 6	25 112	348.9	134.7	72.0	186.4
Havelock city	20 268	38.5	14.9	526.4	1 360.3
Neuse Forest CDP	1 110	7.7	3.0	144.2	370.0
Township 7	6 878	83.5	32.2	82.4	213.6
James City CDP	4 279	12.4	4.8	345.1	891.5
Township 8	28 793	135.6	52.4	212.3	549.5
New Bern city	17 363	26.5	10.2	655.2	1 702.3
River Bend town	2 408	6.6	2.5	364.8	963.2
Trent Woods town	2 366	4.6	1.8	514.3	1 314.4
Township 9	2 459	182.0	70.3	13.5	35.0
Cumberland County	274 566	1 691.6	653.1	162.3	420.4
Beaver Dam township	1 541	207.8	80.2	7.4	19.2
Black River township	2 511	95.5	36.9	26.3	68.0
Falcon town (pt.)	216	3.0	1.1	72.0	196.4
Godwin town	77	.6	.2	128.3	385.0
Carvers Creek township	19 200	212.1	81.9	90.5	234.4
Fayetteville city (pt.)	3 188	3.8	1.5	838.9	2 125.3
Fort Bragg CDP (pt.)	-	.1	-	-	-
Linden town	180	1.3	.5	138.5	360.0
Cedar Creek township	9 422	252.1	97.3	37.4	96.8
Fayetteville city (pt.)	1 552	4.3	1.7	360.9	912.9
Stedman town	577	3.2	1.2	180.3	480.8
Vander CDP (pt.)	385	4.2	1.6	91.7	240.6
Cross Creek township	66 746	91.9	35.5	726.3	1 880.2
Fayetteville city (pt.)	66 746	91.9	35.5	726.3	1 880.2
Eastover township	9 421	231.1	89.2	40.8	105.6
Eastover CDP	1 243	7.8	3.0	159.4	414.3
Fayetteville city (pt.)	619	.7	.3	884.3	2 063.3
Vander CDP (pt.)	794	5.7	2.2	139.3	360.9
Wade town	238	2.5	1.0	95.2	238.0
Grays Creek township	4 789	117.4	45.3	40.8	105.7
Manchester township	35 329	152.3	58.8	232.0	600.8
Fort Bragg CDP (pt.)	20 841	30.4	11.7	685.6	1 781.3
Pope AFB CDP	2 857	7.6	2.9	375.9	985.2
Spring Lake town	7 524	7.8	3.0	964.6	2 508.0
Pearces Mill township	12 272	36.5	14.1	336.2	870.4
Fayetteville city (pt.)	793	.6	.2	1 321.7	3 965.0
Hope Mills town (pt.)	-	-	-	-	-
Rockfish township	32 717	143.0	55.2	228.8	592.7
Hope Mills town (pt.)	8 184	11.8	4.5	693.6	1 818.7
Seventy-First township	80 618	151.7	58.6	531.4	1 375.7
Bonnie Doone CDP	3 893	7.9	3.0	492.8	1 297.7
Fayetteville city (pt.)	2 797	3.7	1.4	755.9	1 997.9
Fort Bragg CDP (pt.)	13 903	18.8	7.3	739.5	1 904.5
Currituck County	13 736	677.8	261.7	20.3	52.5
Crowford township	4 936	224.3	86.6	22.0	57.0
Fruitville township	1 139	80.9	31.2	14.1	36.5
Moyock township	3 091	174.1	67.2	17.8	46.0
Poplar Branch township	4 570	198.5	76.6	23.0	59.7
Dare County	22 746	988.5	381.7	23.0	59.6
Atlantic township	10 378	64.2	24.8	161.7	418.5
Kill Devil Hills town	4 238	14.2	5.5	298.5	770.5
Kitty Hawk town	1 937	21.2	8.2	91.4	236.2
Southern Shores town	1 447	10.3	4.0	140.5	361.8
Croatan township	880	411.7	158.9	2.1	5.5
East Lake township	139	344.6	133.0	.4	1.0
Hatteras township	2 584	41.7	16.1	62.0	160.5
Kinnakeet township	1 230	39.9	15.4	30.8	79.9
Nags Head township	7 335	86.6	33.4	87.0	225.6
Manteo town	991	4.0	1.5	247.8	640.7
Nags Head town	1 838	16.4	6.3	112.1	291.7
Wanchese CDP	1 380	12.1	4.7	114.0	293.6
Davidson County	126 677	1 430.3	552.2	88.6	229.4
Abbotts Creek township	6 285	78.1	30.2	80.5	208.1
High Point city (pt.)	428	.5	.2	856.0	2 140.0
Allegheny township	506	61.8	23.9	8.2	21.2
Arcadia township	6 400	54.3	21.0	117.9	304.8
Welcome CDP (pt.)	33	1.1	.4	30.0	82.5
Boone township	3 383	87.8	33.9	38.5	99.8
Conrad Hill township	8 076	106.1	41.0	76.1	197.0
Lexington city (pt.)	-	.3	.1	-	-
Cotton Grove township	7 318	94.8	36.6	77.2	199.9
Lexington city (pt.)	292	5.0	1.9	58.4	153.7
Emmons township	6 338	136.0	52.5	46.6	120.7
Denton town	1 292	3.5	1.4	369.1	922.9
Hampton township	614	17.8	6.9	34.5	89.0
Healing Spring township	1 644	91.1	35.2	18.0	46.7
Jackson Hill township	790	62.1	24.0	12.7	32.9
Lexington township	29 408	142.4	55.0	206.5	534.7
Lexington city (pt.)	16 289	25.8	10.0	631.4	1 628.9
Welcome CDP (pt.)	3 009	17.8	6.9	169.0	436.1
Midway township	9 897	88.4	34.1	112.0	290.2
Welcome CDP (pt.)	335	2.6	1.0	128.8	335.0
Ready Creek township	3 563	53.7	20.7	66.4	172.1
Welcome CDP (pt.)	-	3	1	-	-
Silver Hill township	4 458	82.2	31.7	54.2	140.9
Thomasville township	30 802	166.5	64.3	185.0	479.0
High Point city (pt.)	43	5	2	86.0	215.0
Thomasville city	15 915	26.1	10.1	609.8	1 575.7
Tyro township	6 376	94.3	36.4	67.6	175.2
Yadkin College township	619	12.7	4.9	48.7	126.3

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Davie County	27 859	686.9	265.2	40.6	105.0
Calahaln township	1 786	96.3	37.2	18.5	48.0
Clarksville township	2 504	110.5	42.7	22.7	58.6
Farmington township	7 990	141.7	54.7	56.4	146.1
Fulton township	1 631	71.6	27.7	22.8	58.9
Jerusalem township	4 636	83.8	32.4	55.3	143.1
Cooleemee town	971	2.0	.8	485.5	1 213.8
Mocksville town (pt.)	–	.2	.1	–	–
Mocksville township	7 014	122.2	47.2	57.4	148.6
Mocksville town (pt.)	3 399	12.8	4.9	265.5	693.7
Shady Grove township	2 298	60.8	23.5	37.8	97.8
Duplin County	39 995	2 118.2	817.8	18.9	48.9
Albertson township	1 359	99.1	38.2	13.7	35.6
Cypress Creek township	2 695	215.8	83.3	12.5	32.4
Faison township	3 170	195.0	75.3	16.3	42.1
Calypso town	481	2.5	1.0	192.4	481.0
Faison town	701	2.2	.8	318.6	876.3
Mount Olive town (pt.)	1	–	–	–	–
Gleason township	1 008	91.5	35.3	11.0	28.6
Island Creek township	7 588	242.2	93.5	31.3	81.2
Greenevers town	512	4.2	1.6	121.9	320.0
Teachey town	244	2.1	.8	116.2	305.0
Wallace town (pt.)	2 911	4.6	1.8	632.8	1 617.2
Kenansville township	3 616	278.2	107.4	13.0	33.7
Kenansville town	856	4.9	1.9	174.7	450.5
Limestone township	5 427	251.6	97.1	21.6	55.9
Beulaville town	933	3.2	1.2	291.6	777.5
Magnolia township	1 972	143.4	55.4	13.8	35.6
Magnolia town	747	2.7	1.0	276.7	747.0
Rockfish township	1 185	134.1	51.8	8.8	22.9
Harrells town (pt.)	2	.7	.3	2.9	6.7
Wallace town (pt.)	–	–	–	–	–
Rose Hill township	2 763	64.6	24.9	42.8	111.0
Rose Hill town	1 287	3.3	1.3	390.0	990.0
Smith township	1 893	121.9	47.1	15.5	40.2
Warsaw township	5 297	145.1	56.0	36.5	94.6
Warsaw town	2 859	6.6	2.5	433.2	1 143.6
Wolfscrape township	2 022	135.8	52.4	14.9	38.6
Durham County	181 835	752.7	290.6	241.6	625.7
Carr township	2 034	63.1	24.4	32.2	83.4
Durham township	138 578	200.3	77.3	691.9	1 792.7
Durham city (pt.)	136 527	175.6	67.8	777.5	2 013.7
Parkwood CDP (pt.)	2	.1	–	20.0	–
Lebanon township	13 882	80.0	30.9	173.5	449.3
Durham city (pt.)	16	.2	.1	80.0	160.0
Mangum township	3 902	178.7	69.0	21.8	56.6
Oak Grove township	12 426	113.4	43.8	109.6	283.7
Durham city (pt.)	33	2.8	1.1	11.8	30.0
Garman CDP	1 090	8.0	3.1	136.3	351.6
Triangle township	11 013	117.2	45.3	94.0	243.1
Chapel Hill town (pt.)	1 115	1.4	.6	796.4	1 858.3
Durham city (pt.)	18	.8	.3	22.5	60.0
Morrisville town (pt.)	–	.1	–	–	–
Parkwood CDP (pt.)	4 121	5.2	2.0	792.5	2 060.5
Edgecombe County	56 558	1 308.1	505.1	43.2	112.0
Township 1, Tarboro	16 144	96.7	37.4	166.9	431.7
Princeville town	1 652	2.7	1.0	611.9	1 652.0
Tarboro town	11 037	23.5	9.1	469.7	1 212.9
Township 2, Lower Conetoe	1 553	104.8	40.5	14.8	38.3
Conetoe town	292	.9	.4	324.4	730.0
Township 3, Upper Conetoe	724	148.7	57.4	4.9	12.6
Speed town	88	.7	.3	125.7	293.3
Township 4, Deep Creek	804	87.0	33.6	9.2	23.9
Township 5, Lower Fishing Creek	1 481	92.8	35.8	16.0	41.4
Leggett town	108	1.8	.7	60.0	154.3
Township 6, Upper Fishing Creek	1 754	140.9	54.4	12.4	32.2
Whitakers town (pt.)	464	1.0	.4	464.0	1 160.0
Township 7, Swift Creek	3 253	138.5	53.5	23.5	60.8
Battleboro town (pt.)	280	.3	.1	933.3	2 800.0
Rocky Mount city (pt.)	–	1.2	.4	–	–
Township 8, Sparta	1 333	102.7	39.7	13.0	33.6
Township 9, Otter Creek	1 748	63.8	24.6	27.4	71.1
Macclesfield town	493	1.3	.5	379.2	986.0
Township 10, Lower Town Creek	3 293	63.5	24.5	51.9	134.4
Pinetops town	1 514	2.6	1.0	582.3	1 514.0
Township 11, Walnut Creek	1 597	63.4	24.5	25.2	65.2
Township 12, Rocky Mount	20 232	99.4	38.4	203.5	526.9
Rocky Mount city (pt.)	17 057	15.2	5.9	1 122.2	2 891.0
Township 13, Coker	1 471	73.9	28.5	19.9	51.6
Township 14, Upper Town Creek	1 171	32.1	12.4	36.5	94.4
Sharpsburg town (pt.)	70	.3	.1	233.3	700.0
Forsyth County	265 878	1 061.0	409.7	250.6	649.0
Abbotts Creek township	12 434	89.5	34.6	138.9	359.4
High Point city (pt.)	6	.1	–	60.0	–
Kernersville town (pt.)	152	1.3	.5	116.9	304.0
Sedge Garden CDP (pt.)	2 295	7.4	2.9	310.1	791.4
Belews Creek township	4 357	78.3	30.2	55.6	144.3
Bethania township	12 671	78.7	30.4	161.0	416.8
Rural Hall town	1 652	2.6	1.0	635.4	1 652.0
Stanleyville CDP (pt.)	4 617	16.6	6.4	278.1	721.4
Broadbay township	7 770	46.8	18.1	166.0	429.3
Sedge Garden CDP (pt.)	477	2.0	.8	238.5	596.3
Clemmonsville township	8 833	47.9	18.5	184.4	477.5
Clemmons village (pt.)	5 809	11.9	4.6	488.2	1 262.8
Kernersville township	21 995	80.1	30.9	274.6	711.8
Kernersville town (pt.)	10 684	17.4	6.7	614.0	1 594.6
Sedge Garden CDP (pt.)	12	–	–	–	–
Lewisville township	11 505	87.8	33.9	131.0	339.4
Clemmons village (pt.)	211	.2	.1	1 055.0	2 110.0
Lewisville CDP	3 206	9.5	3.7	337.5	866.5
Forsyth County—Con.					
Middle Fork township	9 160	42.6	16.5	215.0	555.2
Stanleyville CDP (pt.)	152	.7	.3	217.1	506.7
Walkertown town (pt.)	113	.8	.3	141.3	376.7
Winston-Salem city (pt.)	14	–	–	–	–
Old Richmond township	4 694	77.8	30.1	60.3	155.9
King city (pt.)	–	.2	.1	–	–
Old Town township	5 107	22.5	8.7	227.0	587.0
Stanleyville CDP (pt.)	10	.2	.1	50.0	100.0
Winston-Salem city (pt.)	53	.1	–	530.0	–
Salem Chapel township	6 098	87.9	33.9	69.4	179.9
Walkertown town (pt.)	1 087	2.9	1.1	374.8	988.2
South Fork township	8 333	61.2	23.6	136.2	353.1
Winston-Salem city (pt.)	–	.4	.1	–	–
Vienna township	9 450	76.1	29.4	124.2	321.4
Winston township	143 471	183.8	71.0	780.6	2 020.7
Winston-Salem city (pt.)	143 418	183.7	70.9	780.7	2 022.8
Franklin County	36 414	1 273.2	491.6	28.6	74.1
Township 1, Dunn	4 936	129.7	50.1	38.1	98.5
Dunn town	364	1.4	.5	260.0	728.0
Township 2, Harris	3 609	149.6	57.8	24.1	62.4
Township 3, Youngsville	4 684	122.6	47.3	38.2	99.0
Youngsville town	424	1.5	.6	282.7	706.7
Township 4, Franklinton	6 970	184.1	71.1	37.9	98.0
Franklinton town	1 615	2.0	.8	807.5	2 018.8
Township 5, Hayesville	1 516	87.3	33.7	17.4	45.0
Township 6, Sandy Creek	2 154	131.5	50.8	16.4	42.4
Township 7, Gold Mine	1 390	102.1	39.4	13.6	35.3
Centerville town	115	.7	.3	164.3	383.3
Township 8, Cedar Rock	1 966	119.9	46.3	16.4	42.5
Township 9, Cypress Creek	1 272	92.8	35.8	13.7	35.5
Township 10, Louisburg	7 917	153.7	59.3	51.5	133.5
Louisburg town	3 037	4.9	1.9	619.8	1 598.4
Gaston County	175 093	923.4	356.5	189.6	491.1
Cherryville township	14 068	169.4	65.4	83.0	215.1
Cherryville city	4 756	9.4	3.6	506.0	1 321.1
Delliview town	10	.1	.1	100.0	100.0
Crowders Mountain township	14 411	126.3	48.8	114.1	295.3
Bessemer City city	4 698	9.2	3.5	510.7	1 342.3
Gastonia city (pt.)	366	.4	.2	915.0	1 830.0
Kings Mountain city (pt.)	756	.8	.3	945.0	2 520.0
Dallas township	18 373	151.3	58.4	121.4	314.6
Dallas town	3 012	3.7	1.4	814.1	2 151.4
Gastonia city (pt.)	–	–	–	–	–
High Shoals city	605	4.6	1.8	131.5	336.1
Ranlo town (pt.)	–	.1	–	–	–
Stanley town (pt.)	466	.9	.4	517.8	1 165.0
Gastonia township	75 545	182.8	70.6	413.3	1 070.0
Gastonia city (pt.)	54 119	77.6	29.9	697.4	1 810.0
Lowell city (pt.)	–	.1	.1	–	–
Ranlo town (pt.)	1 650	2.8	1.1	589.3	1 500.0
South Gastonia CDP	5 487	17.4	6.7	315.3	819.0
Spencer Mountain town (pt.)	115	.9	.3	127.8	383.3
Riverbend township	19 405	144.4	55.8	134.4	347.8
Mount Holly city (pt.)	4 519	12.0	4.6	376.6	982.4
Spencer Mountain town (pt.)	20	.4	.2	50.0	100.0
Stanley town (pt.)	2 357	4.2	1.6	561.2	1 473.1
South Point township	33 291	149.1	57.6	223.3	578.0
Belmont city	8 434	14.9	5.7	566.0	1 479.6
Cramerton town	2 371	9.3	3.6	254.9	658.6
Gastonia city (pt.)	247	.7	.3	352.9	823.3
Lowell city (pt.)	2 704	6.7	2.6	403.6	1 040.0
McAdenville town	830	3.6	1.4	230.6	592.9
Mount Holly city (pt.)	3 191	5.6	2.1	569.8	1 519.5
Gates County	9 305	882.2	340.6	10.5	27.3
Gatesville township	1 780	118.3	45.7	15.0	38.9
Gatesville town	308	1.1	.4	280.0	770.0
Hall township	1 253	139.2	53.8	9.0	23.3
Haslett township	1 020	80.0	30.9	12.8	33.0
Holly Grove township	1 636	143.7	55.5	11.4	29.5
Hunters Mill township	1 269	180.4	69.6	7.0	18.2
Mintonsville township	1 007	90.6	35.0	11.1	28.8
Reynoldson township	1 340	130.0	50.2	10.3	26.7
Graham County	7 196	756.5	292.1	9.5	24.6
Cheoah township	5 652	425.3	164.2	13.3	34.4
Robbinsville town	709	1.2	.4	590.8	1 772.5
Santeetlah town (pt.)	42	.5	.2	84.0	210.0
Stecoah township	957	145.9	56.3	6.6	17.0
Yellow Creek township	587	185.3	71.5	3.2	8.2
Santeetlah town (pt.)	5	–	–	–	–
Granville County	38 345	1 375.7	531.2	27.9	72.2
Brassfield township	4 353	206.0	79.6	21.1	54.7
Dutchville township	10 029	136.8	52.8	73.3	189.9
Butner CDP	4 679	17.8	6.9	262.9	678.1
Creedmoor city	1 504	5.4	2.1	278.5	716.2
Fishing Creek township	7 502	164.2	63.4	45.7	118.3
Oxford city (pt.)	3 571	4.3	1.7	830.5	2 100.6
Oak Hill township	1 560	153.3	59.2	10.2	26.4
Oxford township	6 573	104.0	40.2	63.2	163.5
Oxford city (pt.)	4 342	6.5	2.5	668.0	1 736.8
Salem township	1 181	74.3	28.7	15.9	41.1
Sassafras Fork township	2 186	172.8	66.7	12.7	32.8
Stovall town	409	2.7	1.0	151.5	409.0
Tally Ho township	3 246	193.0	74.5	16.8	43.6
Stem town	249	2.4	.9	103.8	276.7
Walnut Grove township	1 715	171.2	66.1	10.0	25.9

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Greene County	15 384	687.5	265.4	22.4	58.0
Bull Head township	913	70.7	27.3	12.9	33.4
Carrs township	665	51.1	19.7	13.0	33.8
Hookerton township	3 354	101.7	39.3	33.0	85.3
Hookerton town	422	.7	.3	602.9	1 406.7
Snow Hill town (pt.)	39	.1	–	390.0	–
Jason township	1 203	55.2	21.3	21.8	56.5
Olds township	2 206	98.0	37.8	22.5	58.4
Ormonds township	1 835	98.7	38.1	18.6	48.2
Shine township	1 018	47.1	18.2	21.6	55.9
Snow Hill township	2 400	51.4	19.8	46.7	121.2
Snow Hill town (pt.)	1 339	2.5	.9	535.6	1 487.8
Speights Bridge township	1 790	113.7	43.9	15.7	40.8
Walstonburg town	188	.9	.3	208.9	626.7
Guilford County	347 420	1 683.8	650.1	206.3	534.4
Bruce township	6 885	103.0	39.8	66.8	173.0
Stokesdale town (pt.)	394	9.7	3.7	40.6	106.5
Summerfield CDP (pt.)	2 051	23.7	9.2	86.5	222.9
Center Grove township	4 035	78.6	30.3	51.3	133.2
Greensboro city (pt.)	–	.1	–	–	–
Summerfield CDP (pt.)	–	–	–	–	–
Clay township	6 017	98.6	38.1	61.0	157.9
Forest Oaks CDP (pt.)	1 810	7.5	2.9	241.3	624.1
Deep River township	6 190	96.4	37.2	64.2	166.4
Greensboro city (pt.)	–	–	–	–	–
High Point city (pt.)	1 517	9.3	3.6	163.1	421.4
Kernersville town (pt.)	–	–	–	–	–
Fentress township	9 748	95.3	36.8	102.3	264.9
Forest Oaks CDP (pt.)	1 244	5.6	2.2	222.1	565.5
Greensboro city (pt.)	6	.1	–	60.0	–
Pleasant Garden CDP (pt.)	2 211	10.6	4.1	208.6	539.3
Friendship township	9 027	55.3	21.4	163.2	421.8
Greensboro city (pt.)	–	–	–	–	–
High Point city (pt.)	67	4.1	1.6	16.3	41.9
Gilmer township	53 560	58.2	22.5	920.3	2 380.4
Greensboro city (pt.)	53 560	58.2	22.5	920.3	2 380.4
Greene township	2 420	94.2	36.4	25.7	66.5
High Point township	67 736	97.2	37.5	696.9	1 806.3
High Point city (pt.)	67 131	91.9	35.5	730.5	1 891.0
Jamestown town (pt.)	35	–	–	–	–
Jamestown township	10 561	82.4	31.8	128.2	332.1
Archdale city (pt.)	234	1.4	.6	167.1	390.0
Greensboro city (pt.)	–	–	–	–	–
High Point city (pt.)	267	4.1	1.6	65.1	166.9
Jamestown town (pt.)	2 565	5.6	2.2	458.0	1 165.9
Jefferson township	8 716	130.0	50.2	67.0	173.6
McLeansville CDP	1 154	16.8	6.5	68.7	177.5
Madison township	3 758	89.4	34.5	42.0	108.9
Monroe township	8 055	94.7	36.6	85.1	220.1
Morehead township	129 955	148.3	57.2	876.3	2 271.9
Greensboro city (pt.)	129 955	148.3	57.2	876.3	2 271.9
Oak Ridge township	4 716	92.8	35.8	50.8	131.7
Stokesdale town (pt.)	1 740	39.8	15.4	43.7	113.0
Rock Creek township	5 492	90.9	35.1	60.4	156.5
Gibsonville town (pt.)	1 961	3.3	1.3	594.2	1 508.5
Sumner township	8 502	86.0	33.2	98.9	256.1
Greensboro city (pt.)	–	–	–	–	–
Pleasant Garden CDP (pt.)	17	.2	.1	85.0	170.0
Washington township	2 047	92.6	35.7	22.1	57.3
Halifax County	55 516	1 878.9	725.4	29.5	76.5
Brinkleyville township	4 992	299.0	115.4	16.7	43.3
Butterwood township	615	82.6	31.9	7.4	19.3
Conoconnara township	788	130.2	50.3	6.1	15.7
Enfield township	6 745	325.8	125.8	20.7	53.6
Enfield town	3 082	3.2	1.2	963.1	2 568.3
Faucett township	1 814	171.7	66.3	10.6	27.4
Halifax township	2 427	180.1	69.5	13.5	34.9
Halifax town	327	1.1	.4	297.3	817.5
Littleton township	3 755	158.7	61.3	23.7	61.3
Littleton town	691	2.5	1.0	276.4	691.0
Palmyra township	1 382	155.0	59.8	8.9	23.1
Hobgood town	435	2.7	1.0	161.1	435.0
Roanoke Rapids township	22 182	76.5	29.5	290.0	751.9
Roanoke Rapids city (pt.)	15 515	20.0	7.7	775.8	2 014.9
South Rosemary CDP	1 955	10.5	4.1	186.2	476.8
Roseneath township	787	88.6	34.2	8.9	23.0
Scotland Neck township	4 514	125.1	48.3	36.1	93.5
Scotland Neck town	2 575	3.2	1.2	804.7	2 145.8
Weldon township	5 515	85.6	33.1	64.4	166.6
Roanoke Rapids city (pt.)	207	.1	–	2 070.0	–
South Weldon CDP	1 640	7.4	2.8	221.6	585.7
Weldon town	1 392	4.6	1.8	302.6	773.3
Harnett County	67 822	1 541.2	595.0	44.0	114.0
Anderson Creek township	9 435	172.1	66.4	54.8	142.1
Averasboro township	13 101	91.5	35.3	143.2	371.1
Dunn city (pt.)	8 288	13.1	5.1	632.7	1 625.1
Erwin town (pt.)	–	–	–	–	–
Barbecue township	3 712	152.5	58.9	24.3	63.0
Black River township	5 275	75.1	29.0	70.2	181.9
Angier town	2 235	4.5	1.7	496.7	1 314.7
Buckhorn township	1 229	73.8	28.5	16.7	43.1
Duke township	5 532	46.8	18.1	118.2	305.6
Dunn city (pt.)	48	.4	.2	120.0	240.0
Erwin town (pt.)	4 061	8.7	3.3	466.8	1 230.6
Grove township	7 378	137.9	53.3	53.5	138.4
Coats town	1 493	3.1	1.2	481.6	1 244.2
Hectors Creek township	1 972	93.3	36.0	21.1	54.8
Johnsonville township	2 986	168.0	64.9	17.8	46.0
Lillington township	3 975	71.0	27.4	56.0	145.1
Lillington town (pt.)	2 048	5.1	2.0	401.6	1 024.0
Harnett County—Con.					
Neills Creek township	4 695	84.1	32.5	55.8	144.5
Buies Creek CDP	2 085	3.5	1.3	595.7	1 603.8
Lillington town (pt.)	–	–	–	–	–
Stewarts Creek township	3 027	128.9	49.8	23.5	60.8
Upper Little River township	5 505	246.2	95.0	22.4	57.9
Broadway town (pt.)	–	–	–	–	–
Lillington town (pt.)	–	–	–	–	–
Haywood County	46 942	1 434.6	553.9	32.7	84.7
Beaverdam township	10 397	120.2	46.4	86.5	224.1
Canton town	3 790	9.2	3.5	412.0	1 082.9
West Canton CDP (pt.)	1 105	3.1	1.2	356.5	920.8
Catalooche township	41	289.0	111.6	.1	.4
Cecil township	400	143.7	55.5	2.8	7.2
Clyde township	5 218	39.5	15.3	132.1	341.0
Clyde town	1 041	2.2	.8	473.2	1 301.3
Lake Junaluska CDP (pt.)	–	–	–	–	–
West Canton CDP (pt.)	14	.6	.2	23.3	70.0
Crabtree township	1 088	89.4	34.5	12.2	31.5
East Fork township	1 411	123.4	47.7	11.4	29.6
Fines Creek township	839	170.5	65.8	4.9	12.8
Iron Duff township	825	31.5	12.2	26.2	67.6
Ivy Hill township	3 137	112.3	43.3	27.9	72.4
Lake Junaluska CDP (pt.)	148	.9	.4	164.4	370.0
Maggie Valley town (pt.)	185	1.9	.7	97.4	264.3
Jonathan Creek township	1 537	62.0	23.9	24.8	64.3
Maggie Valley town (pt.)	–	–	–	–	–
Pigeon township	4 260	61.2	23.6	69.6	180.5
Waynesville township	17 484	161.9	62.5	108.0	279.7
Hazelwood town	1 678	1.9	.7	883.2	2 397.1
Lake Junaluska CDP (pt.)	2 334	12.8	4.9	182.3	476.3
Waynesville town	6 758	15.0	5.8	450.5	1 165.2
White Oak township	305	30.1	11.6	10.1	26.3
Henderson County	69 285	968.3	373.8	71.6	185.4
Blue Ridge township	5 805	91.5	35.3	63.4	164.4
East Flat Rock CDP (pt.)	48	.7	.3	68.6	160.0
Clear Creek township	3 093	43.3	16.7	71.4	185.2
Crab Creek township	2 830	104.7	40.4	27.0	70.0
Valley Hill CDP (pt.)	–	–	–	–	–
Edneyville township	2 422	137.5	53.1	17.6	45.6
Green River township	3 137	144.1	55.6	21.8	56.4
Saluda city (pt.)	3	2	.1	15.0	30.0
Hendersonville township	36 312	164.2	63.4	221.1	572.7
Balfour CDP	1 118	4.4	1.7	254.1	657.6
Barker Heights CDP	1 137	3.4	1.3	334.4	874.6
East Flat Rock CDP (pt.)	3 170	8.1	3.1	391.4	1 022.6
Hendersonville city	7 284	10.9	4.2	668.3	1 734.3
Laurel Park town	1 322	5.7	2.2	231.9	600.9
Mountain Home CDP	1 898	6.9	2.7	275.1	703.0
Valley Hill CDP (pt.)	1 802	6.2	2.4	290.6	750.8
Hoopers Creek township	7 509	83.4	32.2	90.0	233.2
Fletcher town	2 787	12.2	4.7	228.4	593.0
Mills River township	8 177	199.5	77.0	41.0	106.2
Etowah CDP	1 997	10.8	4.2	184.9	475.5
Hertford County	22 523	916.0	353.7	24.6	63.7
Ahoskie township	8 361	137.4	53.1	60.9	157.5
Ahoskie town	4 391	6.6	2.6	665.3	1 688.8
Harrellsville township	1 335	182.0	70.3	7.3	19.0
Harrellsville town	106	.9	.3	117.8	353.3
Maneys Neck township	1 484	158.6	61.2	9.4	24.2
Cama town	71	8.2	3.2	8.7	22.2
Murfreesboro township	5 880	133.4	51.5	44.1	114.2
Murfreesboro town	2 580	4.8	1.9	537.5	1 357.9
St. Johns township	2 563	184.4	71.2	13.9	36.0
Winton township	2 900	120.2	46.4	24.1	62.5
Cofield village	407	8.1	3.1	50.2	131.3
Winton town	796	2.1	.8	379.0	995.0
Hoke County	22 856	1 013.3	391.2	22.6	58.4
Allendale township	358	61.4	23.7	5.8	15.1
Antioch township	2 912	93.2	36.0	31.2	80.9
Blue Springs township	1 172	82.9	32.0	14.1	36.6
Fort Bragg Military Reservation Township	–	361.6	139.6	–	–
McLauchlin township	4 096	91.0	35.1	45.0	116.7
Quewhiffle township	3 547	142.0	54.8	25.0	64.7
Raeford township	9 256	96.1	37.1	96.3	249.5
Raeford city	3 469	7.3	2.8	475.2	1 238.9
Silver City CDP	1 343	4.1	1.6	327.6	839.4
Stonewall township	1 515	85.2	32.9	17.8	46.0
Hyde County	5 411	1 587.2	612.8	3.4	8.8
Currituck township	1 184	584.0	225.5	2.0	5.3
Fairfield township	487	215.7	83.3	2.3	5.8
Lake Landing township	2 027	552.5	213.3	3.7	9.5
Lake Mattamuskeet unorg.	15	37.3	14.4	.4	1.0
Ocracoke township	713	25.1	9.7	28.4	73.5
Swan Quarter township	985	172.6	66.6	5.7	14.8
Iredell County	92 931	1 487.7	574.4	62.5	161.8
Barringer township	4 070	80.1	30.9	50.8	131.7
Troutman town (pt.)	74	2	1	370.0	740.0
Bethany township	5 151	72.0	27.8	71.5	185.3
Statesville city (pt.)	4	2	2	–	–
Chambersburg township	8 121	126.9	49.0	64.0	165.7
Statesville city (pt.)	8	3	–	–	–
Coddle Creek township	15 871	113.0	43.6	140.5	364.0
Mooresville town (pt.)	9 317	15.3	5.9	609.0	1 579.2
Concord township	4 288	90.3	34.9	47.5	122.9
Stony Point CDP (pt.)	155	1.5	6	103.3	258.3
Cool Springs township	1 823	68.4	26.4	26.7	69.1

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Iredell County—Con.					
Davidson township	8 071	98.1	37.9	82.3	213.0
Davidson town (pt.)	–	.7	.3	–	–
Mooresville town (pt.)	–	–	–	–	–
Eagle Mills township	1 621	103.4	39.9	15.7	40.6
Harmony town (pt.)	82	.7	.3	117.1	273.3
Fallstown township	5 386	81.7	31.5	65.9	171.0
Troutman town (pt.)	1 419	3.5	1.4	405.4	1 013.6
New Hope township	1 447	97.0	37.5	14.9	38.6
Love Valley town	67	.5	.2	134.0	335.0
Olin township	1 372	77.7	30.0	17.7	45.7
Sharpesburg township	1 801	83.2	32.1	21.6	56.1
Shiloh township	6 042	133.9	51.7	45.1	116.9
Statesville city (pt.)	1	.4	.1	2.5	10.0
Statesville township	23 803	87.0	33.6	273.6	708.4
Statesville city (pt.)	17 566	81.9	12.3	550.7	1 428.1
Turnersburg township	2 392	91.3	35.3	26.2	67.8
Harmony town (pt.)	349	2.9	1.1	120.3	317.3
Union Grove township	1 672	83.6	32.3	20.0	51.8
Jackson County	26 846	1 270.6	490.6	21.1	54.7
Barkers Creek township	1 013	58.3	22.5	17.4	45.0
Canada township	403	168.6	65.1	2.4	6.2
Caney Fork township	597	137.2	53.0	4.4	11.3
Cashiers township	1 099	156.7	60.5	7.0	18.2
Highlands town (pt.)	4	1.5	.6	2.7	6.7
Cullowhee township	5 771	81.0	31.3	71.2	184.4
Cullowhee CDP (pt.)	4 013	7.4	2.9	542.3	1 383.8
Dillsboro township	940	18.6	7.2	50.5	130.6
Dillsboro town	95	1.0	.4	95.0	237.5
Sylva town (pt.)	30	.1	–	300.0	–
Greens Creek township	876	34.2	13.2	25.6	66.4
Hamburg township	1 269	117.7	45.4	10.8	28.0
Mountain township	235	45.4	17.5	5.2	13.4
Qualla township	4 352	153.7	59.3	28.3	73.4
River township	764	51.9	20.0	14.7	38.2
Cullowhee CDP (pt.)	16	.4	.2	40.0	80.0
Savannah township	816	60.4	23.3	13.5	35.0
Scott Creek township	1 586	98.6	38.1	16.1	41.6
Sylva township	5 291	62.0	23.9	85.3	221.4
Sylva town (pt.)	1 779	5.8	2.2	306.7	808.6
Webster township	1 834	26.4	10.2	69.5	179.8
Cullowhee CDP (pt.)	–	.4	.2	–	–
Webster town	410	4.2	1.6	97.6	256.3
Johnston County	81 306	2 051.2	792.0	39.6	102.7
Banner township	5 760	94.7	36.6	60.8	157.4
Benson town	2 810	4.4	1.7	638.6	1 652.9
Bentonville township	1 275	139.5	53.9	9.1	23.7
Beulah township	3 774	109.4	42.2	34.5	89.4
Kenly town (pt.)	1 396	2.1	.8	664.8	1 745.0
Boon Hill township	5 143	174.9	67.5	29.4	76.2
Princeton town	1 181	1.8	.7	656.1	1 687.1
Clayton township	11 731	140.4	54.2	83.6	216.4
Clayton town	4 756	10.7	4.1	444.5	1 160.0
Cleveland township	3 273	99.4	38.4	32.9	85.2
Elevation township	3 472	131.5	50.8	26.4	68.3
Ingrams township	5 063	152.0	58.7	33.3	86.3
Four Oaks town	1 308	2.5	1.0	523.2	1 308.0
Meadow township	2 391	123.5	47.7	19.4	50.1
Micro township	1 951	60.3	23.3	32.4	83.7
Micro town	417	1.0	.4	417.0	1 042.5
O'Neals township	5 086	195.0	75.3	26.1	67.5
Pine Level township	2 926	48.5	18.7	60.3	156.5
Pine Level town	1 217	2.7	1.1	450.7	1 106.4
Selma town (pt.)	–	.1	–	–	–
Pleasant Grove township	3 445	117.4	45.3	29.3	76.0
Selma township	8 065	80.4	31.0	100.3	260.2
Selma town (pt.)	4 600	7.9	3.1	582.3	1 483.9
Smithfield town (pt.)	545	1.6	.6	340.6	908.3
Smithfield township	12 974	177.3	68.5	73.2	189.4
Smithfield town (pt.)	6 995	10.7	4.1	653.7	1 706.1
West Smithfield CDP	2 411	8.5	3.3	283.6	730.6
Wilders township	3 347	151.1	58.3	22.2	57.4
Wilson Mills township	1 630	55.9	21.6	29.2	75.5
Jones County	9 414	1 225.9	473.3	7.7	19.9
Township 1, White Oak	1 950	233.7	90.2	8.3	21.6
Maysville town	892	1.8	.7	495.6	1 274.5
Township 2, Pollocksville	2 406	278.9	107.7	8.6	22.3
Pollocksville town	299	.8	.3	373.8	996.7
Township 3, Trenton	1 897	231.1	89.2	8.2	21.3
Trenton town	248	.5	.2	496.0	1 240.0
Township 4, Cypress Creek	895	110.2	42.6	8.1	21.0
Township 5, Tuckahoe	861	132.3	51.1	6.5	16.8
Township 6, Chinquapin	666	99.7	38.5	6.7	17.3
Township 7, Beaver Creek	739	139.9	54.0	5.3	13.7
Lee County	41 374	666.4	257.3	62.1	160.8
Township 1, Greenwood	5 115	126.6	48.9	40.4	104.6
Township 2, Jonesboro	9 972	62.3	24.0	160.1	415.5
Sanford city (pt.)	2 647	8.4	3.3	315.1	802.1
Township 3, Cape Fear	2 922	111.5	43.0	26.2	68.0
Broadway town (pt.)	973	3.1	1.2	313.9	810.8
Township 4, Deep River	1 883	83.5	32.3	22.6	58.3
Township 5, East Sanford	6 031	48.5	18.7	124.4	322.5
Sanford city (pt.)	4 325	5.8	2.2	745.7	1 965.9
Township 6, West Sanford	11 953	101.2	39.1	118.1	305.7
Sanford city (pt.)	7 503	21.9	8.5	342.6	882.7
Township 7, Pocket	3 498	132.7	51.2	26.4	68.3
Lenoir County	57 274	1 035.7	399.9	55.3	143.2
Contentnea Neck township	2 857	96.9	37.4	29.5	76.4
Grifton town (pt.)	253	.4	.1	632.5	2 530.0
Falling Creek township	5 265	80.0	30.9	65.8	170.4
Kinston city (pt.)	738	3.5	1.3	210.9	567.7
Institute township	1 350	58.0	22.4	23.3	60.3
Kinston township	25 619	68.9	26.6	371.8	963.1
Kinston city (pt.)	24 066	27.9	10.7	865.7	2 249.2
Moseley Hall township	4 928	120.2	46.4	41.0	106.2
La Grange town	2 805	5.3	2.0	529.2	1 402.5
Neuse township	5 552	84.6	32.7	65.6	169.8
Kinston city (pt.)	54	1.0	.4	54.0	135.0
Pink Hill township	2 201	94.8	36.6	23.2	60.1
Pink Hill town	547	1.2	.5	455.8	1 094.0
Sand Hill township	941	61.8	23.9	15.2	39.4
Southwest township	1 534	49.4	19.1	31.1	80.3
Kinston city (pt.)	18	.8	.3	22.5	60.0
Trent township	2 029	39.6	50.0	15.7	40.6
Vance township	3 527	79.8	30.8	44.2	114.5
Kinston city (pt.)	419	1.0	.4	419.0	1 047.5
Woodington township	1 471	111.6	43.1	13.2	34.1
Lincoln County	50 319	773.9	298.8	65.0	168.4
Catawba Springs township	10 094	170.2	65.7	59.3	153.6
Lowesville CDP	1 092	17.6	6.8	62.0	160.6
Westport CDP	1 280	8.1	3.1	158.0	412.9
Howards Creek township	5 429	169.5	65.4	32.0	83.0
Ironton township	14 007	186.0	71.8	75.3	195.1
Boger City CDP (pt.)	1 278	2.7	1.0	473.3	1 278.0
Maiden town (pt.)	–	–	–	–	–
Lincolnton township	16 600	113.4	43.8	146.4	379.0
Boger City CDP (pt.)	95	.3	.1	316.7	950.0
Lincolnton city	6 847	14.3	5.5	478.8	1 244.9
Maiden town (pt.)	–	–	–	–	–
North Brook township	4 189	134.8	52.1	31.1	80.4
McDowell County	35 681	1 144.0	441.7	31.2	80.8
Brackett township	290	37.4	14.5	7.8	20.0
Crooked Creek township	2 301	102.0	39.4	22.6	58.4
Dysartsville township	2 400	118.9	45.9	20.2	52.3
Glenwood township	1 406	47.3	18.3	29.7	76.8
Higgins township	1 689	34.9	13.5	48.4	125.1
Marion township	13 727	174.8	67.5	78.5	203.4
Marion city	4 765	8.3	3.2	574.1	1 489.1
West Marion CDP (pt.)	1 234	4.7	1.8	262.6	685.6
Montford Cove township	3 069	87.9	33.9	34.9	90.5
West Marion CDP (pt.)	57	.2	.1	285.0	570.0
Nebo township	4 020	91.1	35.2	44.1	114.2
North Cove township	1 843	214.0	82.6	8.6	22.3
Old Fort township	4 936	235.5	90.9	21.0	54.3
Old Fort town	720	2.4	.9	300.0	800.0
Macon County	23 499	1 337.6	516.5	17.6	45.5
Burningtown township	606	93.5	36.1	6.5	16.8
Cartoogechaye township	1 900	245.3	94.7	7.7	20.1
Cowee township	1 241	110.0	42.5	11.3	29.2
Ellijay township	1 713	69.4	26.8	24.7	63.9
Flats township	405	34.5	13.3	11.7	30.5
Franklin township	9 799	118.7	45.8	82.6	214.0
Franklin town	2 873	9.1	3.5	315.7	820.9
Highlands township	2 093	142.5	55.0	14.7	38.1
Highlands town (pt.)	944	13.8	5.3	68.4	178.1
Millshoal township	2 082	66.6	25.7	31.3	81.0
Nantahala township	771	213.6	82.5	3.6	9.3
Smiths Bridge township	2 297	159.6	61.6	14.4	37.3
Sugar Fork township	592	84.1	32.5	7.0	18.2
Madison County	16 953	1 164.1	449.4	14.6	37.7
Township 1, Marshall	3 712	166.7	64.4	22.3	57.6
Marshall town	809	8.7	3.3	93.0	245.2
Township 2, Laurel	1 271	189.5	73.2	6.7	17.4
Township 3, Mars Hill	3 719	64.8	25.0	57.4	148.8
Mars Hill town	1 611	4.8	1.8	335.6	895.0
Township 4, Beech Glenn	2 222	112.1	43.3	19.8	51.3
Township 5, Walnut	1 198	94.4	36.4	12.7	32.9
Township 6, Hot Springs	992	106.1	41.0	9.3	24.2
Hot Springs town	478	8.0	3.1	59.8	154.2
Township 7, Ebbs Chapel	1 091	105.5	40.7	10.3	26.8
Township 8, Spring Creek	805	191.5	73.9	4.2	10.9
Township 9, Sandy Mush	439	54.0	20.8	8.1	21.1
Township 10, Grapevine	1 043	42.8	16.5	24.4	63.2
Township 11, Revere Rice Cove	461	36.7	14.2	12.6	32.5
Martin County	25 078	1 198.1	462.6	20.9	54.2
Beargrass township	1 748	78.8	30.4	22.2	57.5
Beargrass town	77	.7	.3	110.0	256.7
Cross Roads township	1 131	59.1	22.8	19.1	49.6
Everetts town	143	1.2	.5	119.2	286.0
Goose Nest township	1 686	187.4	72.4	9.0	23.3
Oak City town	389	1.2	.5	324.2	778.0
Griffins township	1 021	178.1	68.8	5.7	14.8
Hamilton township	2 038	132.5	51.1	15.4	39.9
Hamilton town	544	1.2	.5	453.3	1 088.0
Hassell town	95	.7	.3	135.7	316.7
Jamesville township	2 476	146.2	56.5	16.9	43.8
Jamesville town	612	3.5	1.3	174.9	470.8
Poplar Point township	503	47.5	18.3	10.6	27.5
Robersonville township	4 432	141.3	54.6	31.4	81.2
Parmele town	321	2.6	1.0	123.5	321.0
Robersonville town	1 940	3.1	1.2	625.8	1 616.7
Williams township	1 055	121.7	47.0	8.7	22.4
Williamston township	8 988	105.5	40.7	85.2	220.8
Williamston town	5 503	7.6	2.9	724.1	1 897.6

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Mecklenburg County	511 433	1 366.0	527.4	374.4	969.7
Township 1, Charlotte	389 571	429.1	165.7	907.9	2 351.1
Charlotte city (pt.)	389 571	429.1	165.7	907.9	2 351.1
Township 2, Berryhill	3 824	40.9	15.8	93.5	242.0
Township 3, Steel Creek	6 586	106.1	41.0	62.1	160.6
Charlotte city (pt.)	292	4.2	1.6	69.5	182.5
Township 4, Sharon	7	.3	.1	23.3	70.0
Charlotte city (pt.)	7	.3	.1	23.3	70.0
Township 5, Providence	14 712	83.5	32.3	176.2	455.5
Charlotte city (pt.)	1 644	2.6	1.0	632.3	1 644.0
Matthews town (pt.)	3 871	5.5	2.1	703.8	1 843.3
Waddington town (pt.)	–	–	–	–	–
Township 6, Clear Creek	16 157	100.5	38.8	160.8	416.4
Mint Hill town (pt.)	9 827	41.2	15.9	238.5	618.1
Township 7, Crab Orchard	15 851	79.7	30.8	198.9	514.6
Township 8, Mallard Creek	8 812	107.3	41.4	82.1	212.9
Charlotte city (pt.)	1 236	3.2	1.2	386.3	1 030.0
Township 9, Deweese	6 804	52.0	20.1	130.8	338.5
Cornelius town (pt.)	2 051	5.1	2.0	402.2	1 025.5
Davidson town (pt.)	3 695	6.7	2.6	551.5	1 421.2
Township 10, Lemley	6 121	53.7	20.7	114.0	295.7
Cornelius town (pt.)	530	3.5	1.4	151.4	378.6
Davidson town (pt.)	351	.3	.1	1 170.0	3 510.0
Township 11, Long Creek	11 022	102.1	39.4	108.0	279.7
Charlotte city (pt.)	3 174	9.9	3.8	320.6	835.3
Township 12, Paw Creek	6 317	67.0	25.9	94.3	243.9
Charlotte city (pt.)	3	–	–	–	–
Township 13, Morning Star	15 995	53.1	20.5	301.2	780.2
Matthews town (pt.)	9 780	26.3	10.1	371.9	968.3
Mint Hill town (pt.)	1 740	5.6	2.1	310.7	828.6
Township 14, Pineville	4 641	27.7	10.7	167.5	433.7
Charlotte city (pt.)	7	2.0	.8	3.5	8.8
Pineville town	2 970	7.2	2.8	412.5	1 060.7
Township 15, Huntersville	5 013	62.9	24.3	79.7	206.3
Huntersville town	3 014	5.0	1.9	602.8	1 586.3
Mitchell County	14 433	573.6	221.5	25.2	65.2
Bakersville township	1 584	44.0	17.0	36.0	93.2
Bakersville town	332	1.9	.7	174.7	474.3
Bandana township	308	14.1	5.5	21.8	56.0
Bradshaw township	528	52.6	20.3	10.0	26.0
Cane Creek township	671	44.8	17.3	15.0	38.8
Fork Mountain-Little Rock Creek township	758	58.4	22.6	13.0	33.5
Glen township	441	21.4	8.3	20.6	53.1
Grassy Creek township	7 130	126.1	48.7	56.5	146.4
Spruce Pine town	2 010	10.9	4.2	184.4	478.6
Harrell township	1 095	94.8	36.6	11.6	29.9
Poplar township	300	51.0	19.7	5.9	15.2
Red Hill township	336	25.1	9.7	13.4	34.6
Snow Creek township	1 282	41.2	15.9	31.1	80.6
Montgomery County	23 346	1 271.8	491.1	18.4	47.5
Biscoe township	4 538	128.1	49.4	35.4	91.9
Biscoe town (pt.)	1 484	5.1	2.0	291.0	742.0
Candor town	748	2.8	1.1	267.1	680.0
Cheek Creek township	758	92.2	35.6	8.2	21.3
Eldorado township	668	108.6	41.9	6.2	15.9
Little River township	879	92.9	35.9	9.5	24.5
Mount Gilead township	3 810	176.1	68.0	21.6	56.0
Mount Gilead town	1 336	8.1	3.1	164.9	431.0
Ophir township	504	90.5	34.9	5.6	14.4
Peedee township	846	80.8	31.2	10.5	27.1
Rocky Springs township	1 552	166.9	64.4	9.3	24.1
Star township	2 629	81.8	31.6	32.1	83.2
Biscoe town (pt.)	–	–	–	–	–
Star town	775	2.7	1.0	287.0	775.0
Troy township	6 085	136.3	52.6	44.6	115.7
Troy town	3 404	6.6	2.6	515.8	1 309.2
Uwharrie township	1 077	117.7	45.4	9.2	23.7
Moore County	59 013	1 809.8	698.8	32.6	84.4
Township 1, Carthage	4 864	252.7	97.6	19.2	49.8
Carthage town	976	5.3	2.0	184.2	488.0
Township 2, Beaucom	3 038	258.5	99.8	11.8	30.4
Township 3, Sheffields	5 140	186.7	72.1	27.5	71.3
Robbins city (pt.)	872	2.6	1.0	335.4	872.0
Township 4, Ritters	2 394	129.6	50.0	18.5	47.9
Robbins city (pt.)	98	.1	–	980.0	–
Township 5, Deep River	408	107.2	41.4	3.8	9.9
Township 6, Greenwood	2 354	109.6	42.3	21.5	55.7
Cameron town	215	2.7	1.1	79.6	195.5
Township 7, McNeill	13 655	207.6	80.1	65.8	170.5
Pinehurst town (pt.)	17	.3	.1	56.7	170.0
Southern Pines town (pt.)	6 660	20.3	7.8	328.1	853.8
Vass town	670	7.8	3.0	85.9	223.3
Whispering Pines village	1 243	6.6	2.5	188.3	497.2
Township 8, Sand Hill	12 884	214.8	82.9	60.0	155.4
Aberdeen town	2 700	8.5	3.3	317.6	818.2
Foxfire village (pt.)	–	–	–	–	–
Pinebluff town	876	5.8	2.2	151.0	398.2
Pinehurst town (pt.)	291	5.2	2.0	56.0	145.5
Southern Pines town (pt.)	2 444	6.0	2.3	407.3	1 062.6
Township 9, Mineral Springs	12 389	259.8	100.3	47.7	123.5
Foxfire village (pt.)	334	7.2	2.8	46.4	119.3
Pinehurst town (pt.)	4 795	23.3	9.0	205.8	532.8
Seven Lakes CDP	2 049	21.1	8.2	97.1	249.9
Southern Pines town (pt.)	25	.5	.2	50.0	125.0
Taylortown town	543	2.7	1.0	201.1	543.0
Township 10, Little River	1 887	83.3	32.2	22.7	58.6
Nash County	76 677	1 399.4	540.3	54.8	141.9
Bailey township	2 822	81.7	31.5	34.5	89.6
Bailey town	553	1.8	.7	307.2	790.0
Castalia township	1 385	82.7	31.9	16.7	43.4
Castalia town	261	1.9	.7	137.4	372.9
Nash County—Con.					
Coopers township	2 363	78.4	30.3	30.1	78.0
Dry Wells township	2 542	82.0	31.6	31.0	80.4
Middlesex town	730	1.4	.6	521.4	1 216.7
Ferrells township	1 909	79.6	30.7	24.0	62.2
Griffins township	2 412	151.4	58.5	15.9	41.2
Jackson township	2 027	104.9	40.5	19.3	50.0
Mannings township	4 944	161.2	62.2	30.7	79.5
Spring Hope town	1 221	3.5	1.4	348.9	872.1
Nashville township	6 981	119.2	46.0	58.6	151.8
Nashville town	3 617	6.8	2.6	531.9	1 391.2
North Whitakers township	2 254	138.9	53.6	16.2	42.1
Whitakers town (pt.)	396	1.1	.4	360.0	990.0
Oak Level township	3 912	53.9	20.8	72.6	188.1
Rocky Mount city (pt.)	916	.5	.2	1 832.0	4 580.0
Red Oak township	2 351	62.4	24.1	37.7	97.6
Dortches town (pt.)	180	2.8	1.1	64.3	163.6
Red Oak town	280	4.6	1.8	60.9	155.6
Rocky Mount township	18 499	61.9	23.9	298.9	774.0
Rocky Mount city (pt.)	14 524	12.7	4.9	1 143.6	2 964.1
Sharpsburg town (pt.)	1 054	1.6	.6	658.8	1 756.7
South Whitakers township	2 243	60.3	23.3	37.2	96.3
Battleboro town (pt.)	167	.6	.2	278.3	835.0
Dortches town (pt.)	4	.3	.1	13.3	40.0
Rocky Mount city (pt.)	353	3.6	1.4	98.1	252.1
Stony Creek township	20 033	80.9	31.2	247.6	642.1
Dortches town (pt.)	656	16.7	6.5	39.3	100.9
Rocky Mount city (pt.)	16 147	31.5	12.1	512.6	1 334.5
New Hanover County	120 284	515.3	198.9	233.4	604.7
Cape Fear township	12 570	194.9	75.3	64.5	166.9
Castle Hayne CDP	1 182	5.8	2.3	203.8	513.9
Smith Creek CDP (pt.)	1 379	2.8	1.1	492.5	1 253.6
Wrightsboro CDP (pt.)	4 745	32.0	12.3	148.3	385.8
Federal Point township	10 413	66.6	25.7	156.4	405.2
Carolina Beach town	3 630	4.4	1.7	825.0	2 135.3
Kure Beach town	619	2.1	.8	294.8	773.8
Myrtle Grove CDP (pt.)	2 101	10.8	4.2	194.5	500.2
Silver Lake CDP (pt.)	438	2.8	1.1	156.4	398.2
Harnett township	29 221	129.7	50.1	225.3	583.3
Bayshore CDP	1 661	9.3	3.6	178.6	461.4
Ogden CDP	3 228	12.2	4.7	264.6	686.8
Seagate CDP	5 444	11.5	4.4	473.4	1 237.3
Smith Creek CDP (pt.)	6 082	11.0	4.2	552.9	1 448.1
Wilmington city (pt.)	267	.9	.4	296.7	667.5
Windemere CDP	4 604	9.9	3.8	465.1	1 211.6
Wrightsboro CDP (pt.)	7	.1	–	70.0	–
Wrightsville Beach town	2 937	3.4	1.3	863.8	2 259.2
Masonboro township	12 797	48.1	18.6	266.0	688.0
Masonboro CDP (pt.)	6 990	15.8	6.1	442.4	1 145.9
Myrtle Grove CDP (pt.)	2 174	7.0	2.7	310.6	805.2
Silver Lake CDP (pt.)	3 633	14.2	5.5	255.8	660.5
Wilmington township	55 283	76.0	29.3	727.4	1 886.8
Masonboro CDP (pt.)	20	–	–	–	–
Wilmington city (pt.)	55 263	76.0	29.3	727.1	1 884.1
Northampton County	20 798	1 388.6	536.1	15.0	38.8
Gaston township	4 595	161.8	62.5	28.4	73.5
Gaston town	1 003	4.4	1.7	228.0	590.0
Jackson township	956	27.1	10.5	35.3	91.0
Jackson town (pt.)	592	2.6	1.0	227.7	592.0
Kirby township	3 470	218.3	84.3	15.9	41.2
Conway town	759	4.7	1.8	161.5	421.7
Severn town	260	2.6	1.0	100.0	260.0
Occoneechee township	2 192	170.7	65.9	12.8	33.3
Garysburg town	1 057	2.5	1.0	422.8	1 057.0
Pleasant Hill township	533	62.4	24.1	8.5	22.1
Rich Square township	3 516	210.7	81.4	16.7	43.2
Rich Square town	1 058	7.3	2.8	144.9	377.9
Woodland town	760	3.1	1.2	245.2	633.3
Roanoke township	1 890	187.6	72.4	10.1	26.1
Lasker town	139	3.3	1.3	42.1	106.9
Seaboard township	1 818	127.6	49.2	14.2	37.0
Jackson town (pt.)	–	.1	–	–	–
Seaboard town	791	2.7	1.0	293.0	791.0
Wiccacanee township	1 828	222.4	85.9	8.2	21.3
Onslow County	149 838	986.2	766.9	75.4	195.4
Camp Lejeune unorg	50 266	343.4	132.6	146.4	379.1
Camp Lejeune Central CDP (pt.)	36 716	50.7	19.6	724.2	1 873.3
Jacksonville city (pt.)	–	.1	–	–	–
New River Station CDP	9 732	19.8	7.6	491.5	1 280.5
Piney Green CDP (pt.)	24	–	–	–	–
Hofmans Forest unorg	88	207.8	80.2	.4	1.1
Jacksonville township	56 205	281.3	108.6	199.8	517.5
Camp Lejeune Central CDP (pt.)	–	–	–	–	–
Half Moon CDP (pt.)	5 754	9.6	3.7	599.4	1 555.1
Jacksonville city (pt.)	30 013	33.6	13.0	893.2	2 308.7
Pumpkin Center CDP	2 857	5.6	2.2	510.2	1 298.6
Richlands township	10 325	371.2	143.3	27.8	72.1
Half Moon CDP (pt.)	552	6.6	2.6	83.6	212.3
Richlands town	996	3.0	1.2	332.0	830.0
Stump Sound township	9 372	423.9	163.7	22.1	57.3
Holly Ridge town	728	3.6	1.4	202.2	520.0
Swansboro township	2 031	9.7	3.8	209.4	534.5
Swansboro town	1 165	1.6	.6	728.1	1 941.7
White Oak township	13 467	241.0	93.0	55.9	144.8
Jacksonville city (pt.)	–	–	–	–	–
Piney Green CDP (pt.)	8 975	35.2	13.6	255.0	659.9

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Orange County	93 851	1 035.5	399.8	90.6	234.7
Bingham township	5 184	189.4	73.1	27.4	70.9
Cedar Grove township	3 691	202.0	78.0	18.3	47.3
Chapel Hill township	61 973	235.9	91.1	262.7	680.3
Carrboro town	11 553	9.1	3.5	1 269.6	3 300.9
Chapel Hill town (pt.)	37 604	41.4	16.0	908.3	2 350.3
Cheeks township	5 422	131.7	50.9	41.2	106.5
Mebane city (pt.)	485	.6	.2	808.3	2 425.0
Eno township	5 262	110.4	42.6	47.7	123.5
Durham city (pt.)	17	–	–	–	–
Hillsborough township	10 136	68.0	26.3	149.1	385.4
Hillsborough town	4 263	9.2	3.5	463.4	1 218.0
Little River township	2 183	98.0	37.8	22.3	57.8
Pamlico County	11 372	872.7	336.9	13.0	33.8
Township 1	3 025	234.6	90.6	12.9	33.4
Alliance town (pt.)	119	1.1	.4	108.2	297.5
Township 2	2 459	207.0	79.9	11.9	30.8
Oriental town	786	2.8	1.1	280.7	714.5
Stonewall town	279	4.4	1.7	63.4	164.1
Township 3	2 237	144.1	55.7	15.5	40.2
Alliance town (pt.)	464	3.9	1.5	119.0	309.3
Bayboro town	733	3.8	1.5	192.9	488.7
Township 4	1 525	161.4	62.3	9.4	24.5
Mesic town	310	2.8	1.1	110.7	281.8
Vandemere town	299	3.9	1.5	76.7	199.3
Township 5	2 126	125.6	48.5	16.9	43.8
Arapahoe town	430	5.7	2.2	75.4	195.5
Minnesott Beach town	266	3.9	1.5	68.2	177.3
Pasquotank County	31 298	587.7	226.9	53.3	137.9
Elizabeth City township	12 759	13.9	5.4	917.9	2 362.8
Elizabeth City city (pt.)	11 788	8.4	3.2	1 403.3	3 683.8
Mount Herman township	4 340	90.0	34.7	48.2	125.1
Elizabeth City city (pt.)	260	.3	.1	866.7	2 600.0
Newland township	2 046	215.2	83.1	9.5	24.6
Nixonton township	5 839	95.3	36.8	61.3	158.7
Elizabeth City city (pt.)	2 072	2.0	.8	1 036.0	2 590.0
Providence township	4 903	64.6	24.9	75.9	196.9
Elizabeth City city (pt.)	143	.9	.4	158.9	357.5
Salem township	1 411	108.8	42.0	13.0	33.6
Pender County	28 855	2 255.2	870.7	12.8	33.1
Burgaw township	5 515	209.7	81.0	26.3	68.1
Burgaw town	1 807	5.3	2.0	340.9	903.5
St. Helena village	321	14.6	5.7	22.0	56.3
Caswell township	369	114.6	44.3	3.2	8.3
Atkinson town (pt.)	1 016	127.3	49.1	8.0	20.7
Columbia township	275	2.4	.9	114.6	305.6
Atkinson town (pt.)	1 790	254.5	98.3	7.0	18.2
Grady township	–	.2	.1	–	–
Holly township	1 725	133.7	51.6	12.9	33.4
Long Creek township	2 095	532.7	205.7	3.9	10.2
Rocky Point township	1 280	105.1	40.6	12.2	31.5
Topsail township	3 377	138.1	53.3	24.5	63.4
Surf City town (pt.)	8 403	408.2	157.6	20.6	53.3
Topsail Beach town	653	8.7	3.3	75.1	197.9
Union township	346	11.3	4.4	30.6	78.6
Wallace town (pt.)	3 285	231.2	89.3	14.2	36.8
Watha town	28	.8	.3	35.0	93.3
	99	2.4	.9	41.3	110.0
Perquimans County	10 447	640.2	247.2	16.3	42.3
Belvidere township	1 219	153.0	59.1	8.0	20.6
Bethel township	2 455	109.3	42.2	22.5	58.2
Hertford town (pt.)	232	.3	.1	773.3	2 320.0
Hertford township	2 599	129.7	50.1	20.0	51.9
Hertford town (pt.)	1 873	4.6	1.8	407.2	1 040.6
New Hope township	2 337	144.2	55.7	16.2	42.0
Parkville township	1 837	104.0	40.2	17.7	45.7
Hertford town (pt.)	–	.1	.1	–	–
Winfall town	501	5.3	2.0	94.5	250.5
Person County	30 180	1 016.2	392.3	29.7	76.9
Allensville township	2 099	118.9	45.9	17.7	45.7
Bushy Fork township	1 897	115.5	44.6	16.4	42.5
Cunningham township	1 368	101.0	39.0	13.5	35.1
Flat River township	3 083	115.7	44.7	26.6	69.0
Holloway township	1 384	106.8	41.3	13.0	33.5
Mount Tirzah township	2 200	126.4	48.8	17.4	45.1
Olive Hill township	1 999	116.3	44.9	17.2	44.5
Roxboro township	14 536	114.2	44.1	127.3	329.6
Roxboro city (pt.)	7 332	10.1	3.9	725.9	1 880.0
Woodsdale township	1 614	101.4	39.1	15.9	41.3
Roxboro city (pt.)	–	.2	.1	–	–
Pitt County	107 924	1 687.7	651.6	63.9	165.6
Arthur township	3 989	88.6	34.2	45.0	116.6
Greenville city (pt.)	7	.4	.1	17.5	70.0
Ayden township	6 677	88.4	34.1	75.5	195.8
Ayden town	4 740	5.4	2.1	877.8	2 257.1
Belvoir township	6 768	141.6	54.7	47.8	123.7
Greenville city (pt.)	1 418	1.3	.5	1 090.8	2 836.0
Bethel township	3 162	107.9	41.6	29.3	76.0
Bethel town	1 842	2.6	1.0	708.5	1 842.0
Carolina township	1 747	152.4	58.8	11.5	29.7
Greenville city (pt.)	–	–	–	–	–
Chicod township	3 680	165.6	64.0	22.2	57.5
Falkland township	1 605	109.9	42.4	14.6	37.9
Falkland town	108	.6	.2	180.0	540.0
Greenville city (pt.)	214	.2	.1	1 070.0	2 140.0
Farmville township	6 521	94.6	36.5	68.9	178.7
Farmville town	4 392	6.1	2.4	720.0	1 830.0
Fountain township	1 300	69.0	26.6	18.8	48.9
Fountain town	445	1.4	.5	317.9	890.0
Pitt County—Con.					
Greenville township	37 483	56.5	21.8	663.4	1 719.4
Greenville city (pt.)	35 653	34.4	13.3	1 036.4	2 680.7
Grifton township	4 057	115.2	44.5	35.2	91.2
Grifton town (pt.)	2 140	3.6	1.4	594.4	1 528.6
Grimesland township	6 404	117.8	45.5	54.4	140.7
Greenville city (pt.)	372	.2	.1	1 860.0	3 720.0
Grimesland town	469	1.3	.5	360.8	938.0
Simpson village	410	.9	.4	455.6	1 025.0
Pactolus township	4 621	178.9	69.1	25.8	66.9
Greenville city (pt.)	3	1.4	.5	2.1	6.0
Swift Creek township	1 252	81.5	31.5	15.4	39.7
Winterville township	18 658	119.8	46.3	155.7	403.0
Greenville city (pt.)	7 305	8.8	3.4	830.1	2 148.5
Winterville town	2 816	3.3	1.3	853.3	2 166.2
Polk County	14 416	616.0	237.8	23.4	60.6
Columbus township	3 992	114.3	44.1	34.9	90.5
Columbus town	812	4.6	1.8	176.5	451.1
Cooper Gap township	1 364	126.9	49.0	10.7	27.8
Green Creek township	2 448	133.3	51.5	18.4	47.5
Saluda township	1 451	86.4	33.4	16.8	43.4
Saluda city (pt.)	485	3.5	1.4	138.6	346.4
Tryon township	3 630	44.0	17.0	82.5	213.5
Tryon town	1 680	4.6	1.8	365.2	933.3
White Oak township	1 531	111.1	42.9	13.8	35.7
Randolph County	106 546	2 039.5	787.5	52.2	135.3
Asheboro township	20 032	56.3	21.7	355.8	923.1
Asheboro city (pt.)	14 883	25.3	9.8	588.3	1 518.7
Back Creek township	3 711	103.9	40.1	35.7	92.5
Asheboro city (pt.)	–	.2	.1	–	–
Brower township	993	83.0	32.0	12.0	31.0
Cedar Grove township	6 483	114.8	44.3	56.5	146.3
Asheboro city (pt.)	4	.7	.3	5.7	13.3
Coleridge township	1 851	127.6	49.3	14.5	37.5
Columbia township	5 546	143.8	55.5	38.6	99.9
Ramseur town	1 186	3.4	1.3	348.8	912.3
Staley town	204	1.6	.6	127.5	340.0
Concord township	1 671	132.0	51.0	12.7	32.8
Asheboro city (pt.)	2	.2	.1	10.0	20.0
Franklinville township	6 750	106.4	41.1	63.4	164.2
Asheboro city (pt.)	896	2.4	.9	373.3	995.6
Franklinville town	666	2.5	1.0	266.4	666.0
Randleman city (pt.)	26	.1	–	260.0	–
Grant township	3 581	113.1	43.7	31.7	81.9
Asheboro city (pt.)	–	–	–	–	–
Level Cross township	3 017	43.1	16.6	70.0	181.7
Liberty township	4 848	107.4	41.5	45.1	116.8
Liberty town	2 047	6.5	2.5	314.9	818.8
New Hope township	921	130.7	50.4	7.0	18.3
New Market township	6 682	88.5	34.2	75.5	195.4
Pleasant Grove township	558	40.2	15.5	13.9	36.0
Providence township	3 719	99.5	38.4	37.4	96.8
Randleman township	5 770	36.9	14.3	156.4	403.5
Asheboro city (pt.)	577	2.1	.8	274.8	721.3
Randleman city (pt.)	2 586	7.0	2.7	369.4	957.8
Richland township	2 745	123.7	47.7	22.2	57.5
Seagrove town	244	1.9	.7	128.4	348.6
Tabernacle township	4 289	131.3	50.7	32.7	84.6
Trinity township	21 340	130.9	50.6	163.0	421.7
Archdale city (pt.)	6 679	16.5	6.4	404.8	1 043.6
High Point city (pt.)	37	.8	.3	46.3	123.3
Trinity CDP	5 469	33.5	12.9	163.3	424.0
Union township	2 039	126.6	48.9	16.1	41.7
Richmond County	44 518	1 227.8	474.0	36.3	93.9
Beaverdam township	2 360	246.3	95.1	9.6	24.8
Hoffman town	348	8.9	3.4	39.1	102.4
Black Jack township	351	70.9	27.4	5.0	12.8
Marks Creek township	13 298	233.2	90.1	57.0	147.6
Dobbins Heights town	1 144	2.3	.9	497.4	1 271.1
Hamlet city (pt.)	6 060	10.5	4.1	577.1	1 478.0
Rockingham city (pt.)	–	–	–	–	–
Mineral Springs township	3 652	202.9	78.4	18.0	46.6
Ellerbe town	1 132	2.6	1.0	435.4	1 132.0
Norman town	105	1.1	.4	95.5	262.5
Rockingham township	15 782	146.7	56.6	107.6	278.8
Hamlet city (pt.)	136	.2	.1	680.0	1 360.0
Rockingham city (pt.)	8 838	14.1	5.4	626.8	1 636.7
Steeles township	605	180.5	69.7	3.4	8.7
Wolf Pit township	8 470	147.2	56.8	57.5	149.1
East Rockingham CDP	4 158	8.9	3.4	467.2	1 222.9
Rockingham city (pt.)	561	2.8	1.1	200.4	510.0
Robeson County	105 179	2 457.7	948.9	42.8	110.8
Affordsville township	1 743	113.0	43.6	15.4	40.0
Back Swamp township	3 668	96.5	37.2	38.0	98.6
Fairmont town (pt.)	–	–	–	–	–
Lumberton city (pt.)	–	4	2	–	–
Britts township	2 099	68.3	26.4	30.7	79.5
Burnt Swamp township	1 946	29.4	11.4	66.2	170.7
East Howellsville township	1 562	97.4	37.6	16.0	41.5
Fairmont township	6 098	89.1	34.4	68.4	177.3
Fairmont town (pt.)	2 489	5.1	2.0	488.0	1 244.5
Gaddy township	1 009	49.4	19.1	20.4	52.8
Lumber Bridge township	1 639	62.8	24.2	26.1	67.7
Lumber Bridge town	109	1.7	.7	64.1	155.7
Lumberton township	23 769	91.0	35.1	261.2	677.2
Barker Ten Mile CDP (pt.)	587	2.9	1.1	202.4	533.6
Lumberton city (pt.)	18 421	29.7	11.5	620.2	1 601.8
Marietta township	1 125	60.0	23.2	18.8	48.5
Marietta town	206	2.9	1.1	71.0	187.3
Maxton township	5 429	112.5	43.4	48.3	125.1
Maxton town (pt.)	2 164	4.6	1.8	470.4	1 202.2

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Robeson County—Con.					
Orrum township	1 744	93.5	36.1	18.7	48.3
Orrum town	103	1.5	.6	68.7	171.7
Proctorville town	168	1.1	.4	152.7	420.0
Parkton township	2 019	67.3	26.0	30.0	77.7
Parkton town	367	1.6	.6	229.4	611.7
Pembroke township	9 720	97.1	37.5	100.1	259.2
Pembroke town	2 241	5.0	1.9	448.2	1 179.5
Philadelphus township	2 057	73.8	28.5	27.9	72.2
Raft Swamp township	2 964	44.2	17.1	67.1	173.3
Lumberton city (pt.)	45	.5	.2	90.0	225.0
Red Springs township	5 577	49.6	19.2	112.4	290.5
Red Springs town	3 799	6.2	2.4	612.7	1 582.9
Rennert township	1 764	55.2	21.3	32.0	82.8
Rennert town	217	2.1	.8	103.3	271.3
Rowland township	2 639	93.8	36.2	28.1	72.9
Rowland town	1 139	2.6	1.0	438.1	1 139.0
Saddletree township	3 053	82.4	31.8	37.1	96.0
Barker Ten Mile CDP (pt.)	101	1.2	.5	84.2	202.0
Lumberton city (pt.)	125	.5	.2	250.0	625.0
St. Pauls township	6 479	149.8	57.8	43.3	112.1
St. Pauls town	1 992	2.8	1.1	711.4	1 810.9
Shannon township	794	27.8	10.7	28.6	74.2
Smiths township	4 548	136.6	52.7	33.3	86.3
Smyrna township	1 505	48.4	18.7	31.1	80.5
Lumberton city (pt.)	10	–	–	–	–
Sterlings township	1 049	115.0	44.4	9.1	23.6
Thompson township	1 000	67.9	26.2	14.7	38.2
McDonald town	88	.7	.3	125.7	293.3
Union township	2 259	112.2	43.3	20.1	52.2
Raynham town	106	.4	.2	265.0	530.0
West Howellsville township	1 720	99.9	38.6	17.2	44.6
Barker Ten Mile CDP (pt.)	399	1.7	.7	234.7	570.0
Wishart township	4 201	173.8	67.1	24.2	62.6
Rockingham County	86 064	1 467.2	566.5	58.7	151.9
Huntsville township	4 110	105.7	40.8	38.9	100.7
Leaksville township	21 967	119.9	46.3	183.2	474.4
Eden city	15 238	30.3	11.7	502.9	1 302.4
Madison township	8 267	118.6	45.8	69.7	180.5
Madison town	2 371	7.3	2.8	324.8	846.8
Mayodan town	2 471	3.9	1.5	633.6	1 647.3
Mayo township	5 988	114.3	44.1	52.4	135.8
Stoneville town	1 109	3.2	1.2	346.6	924.2
New Bethel township	4 154	160.1	61.8	25.9	67.2
Price township	1 481	80.6	31.1	18.4	47.6
Reidsville township	18 067	114.3	44.1	158.1	409.7
Reidsville city (pt.)	12 158	20.1	7.8	604.9	1 558.7
Ruffin township	5 284	211.6	81.7	25.0	64.7
Simpsonville township	4 889	134.4	51.9	36.4	94.2
Reidsville city (pt.)	25	.3	.1	83.3	250.0
Wentworth township	7 891	181.2	70.0	43.5	112.7
Williamsburg township	3 966	126.4	48.8	31.4	81.3
Rowan County	110 605	1 324.5	511.4	83.5	216.3
Atwell township	8 692	151.4	58.4	57.4	148.8
Enochville CDP (pt.)	2 901	11.4	4.4	254.5	659.3
Kannapolis city (pt.)	–	–	–	–	–
China Grove township	21 616	95.4	36.8	226.6	587.4
China Grove town	2 732	3.8	1.5	718.9	1 821.3
Enochville CDP (pt.)	–	–	–	–	–
Kannapolis city (pt.)	8 476	11.8	4.5	718.3	1 883.6
Landis town	2 333	4.0	1.5	583.3	1 555.3
Cleveland township	1 955	75.7	29.2	25.8	67.0
Cleveland town	696	4.1	1.6	169.8	435.0
Franklin township	9 958	96.9	37.4	102.8	266.3
Salisbury city (pt.)	2 975	6.8	2.6	437.5	1 144.2
Gold Hill township	7 210	79.2	30.6	91.0	235.6
Faith town (pt.)	4	–	–	–	–
Granite Quarry town (pt.)	790	1.6	.6	493.8	1 316.7
Rockwell town	1 598	3.6	1.4	443.9	1 141.4
Litaker township	9 581	111.8	43.1	85.7	222.3
Faith town (pt.)	549	1.9	.7	288.9	784.3
Granite Quarry town (pt.)	208	.7	.3	297.1	693.3
Salisbury city (pt.)	7	.4	.2	17.5	35.0
Locke township	9 302	81.6	31.5	114.0	295.3
Salisbury city (pt.)	751	5.5	2.1	136.5	357.6
Morgan township	2 558	145.6	56.2	17.6	45.5
Mount Ulla township	3 116	72.6	28.0	15.4	39.9
Providence township	7 089	125.6	48.5	56.4	146.2
Granite Quarry town (pt.)	625	1.8	.7	347.2	892.9
Salisbury township	27 189	77.8	30.0	349.5	906.3
East Spencer town	2 055	3.3	1.3	622.7	1 580.8
Granite Quarry town (pt.)	23	.3	.1	76.7	230.0
Salisbury city (pt.)	19 354	29.7	11.5	651.6	1 683.0
Spencer town	3 219	5.6	2.2	574.8	1 463.2
Scotch Irish township	1 347	92.2	35.6	14.6	37.8
Steele township	1 236	57.0	22.0	21.7	56.2
Unity township	1 756	61.8	23.9	28.4	73.5
Rutherford County	56 918	1 461.3	564.2	39.0	100.9
Camp Creek township	1 168	94.6	36.5	12.3	32.0
Chimney Rock township	1 700	167.1	64.5	10.2	26.4
Lake Lure town	691	35.1	13.6	19.7	50.8
Colfax township	6 841	137.4	53.0	49.8	129.1
Ellenboro town	514	2.4	.9	214.2	571.1
Cool Spring township	15 637	85.6	33.0	182.7	473.8
Alexander Mills town	662	1.5	.6	441.3	1 103.3
Bostic town	371	2.3	.9	161.3	412.2
Forest City town	7 475	16.8	6.5	444.9	1 150.0
Spindale town (pt.)	417	2.9	1.1	143.8	379.1
Duncans Creek township	494	77.8	30.0	6.3	16.5
Gilkey township	1 402	50.0	19.3	28.0	72.6
Golden Valley township	1 830	144.2	55.7	5.8	14.9
Green Hill township	1 829	117.4	45.3	15.6	40.4
Rutherfordton town (pt.)	–	.3	.1	–	–
High Shoals township	6 811	104.0	40.2	65.5	169.4
Logan Store township	3 099	148.4	57.3	20.9	54.1
Morgan township	1 166	94.9	36.6	12.3	31.9
Rutherfordton township	10 766	66.9	25.8	160.9	417.3
Ruth town	366	1.1	.4	332.7	915.0
Rutherfordton town (pt.)	3 617	10.3	4.0	351.2	904.3
Spindale town (pt.)	3 623	10.7	4.1	338.6	883.7
Sulphur Springs township	3 902	118.0	45.5	33.1	85.8
Union township	1 273	55.2	21.3	23.1	59.8
Sampson County	47 297	2 448.9	945.5	19.3	50.0
Belvoir township	1 450	67.3	26.0	21.5	55.8
Dismal township	2 642	146.1	56.4	18.1	46.8
Franklin township	2 075	256.6	99.1	8.1	20.9
Harrells town (pt.)	183	7.5	2.9	24.4	63.1
Halls township	1 844	123.7	47.8	14.9	38.6
Herrings township	1 387	100.9	38.9	13.7	35.7
Honeycutts township	2 184	110.0	42.5	19.9	51.4
Salemburg town	409	2.5	1.0	163.6	409.0
Lisbon township	1 082	97.3	37.6	11.1	28.8
Little Coharie township	5 282	179.1	69.1	29.5	76.4
Autryville town	166	1.3	.5	127.7	332.0
Roseboro town	1 441	3.0	1.2	480.3	1 200.8
McDaniels township	1 018	142.1	54.9	7.2	18.5
Mingo township	1 580	84.1	32.5	18.8	48.6
Falcon town (pt.)	–	.3	.1	–	–
Newton Grove township	1 636	77.0	29.7	21.2	55.1
Newton Grove town	511	7.8	3.0	65.5	170.3
North Clinton township	9 652	119.1	46.0	81.0	209.8
Clinton city (pt.)	6 315	12.8	4.9	493.4	1 288.8
Piney Grove township	1 700	188.6	72.8	9.0	23.4
Plain View township	2 596	119.4	46.1	21.7	56.3
South Clinton township	5 360	133.7	51.6	40.1	103.9
Clinton city (pt.)	1 889	4.6	1.8	410.7	1 049.4
South River township	1 669	128.6	49.7	13.0	33.6
Garland town	746	2.8	1.1	266.4	678.2
Taylors Bridge township	1 125	158.8	61.3	7.1	18.4
Harrells town (pt.)	2	–	–	–	–
Turkey township	1 842	125.9	48.6	14.6	37.9
Turkey town	234	1.0	.4	234.0	585.0
Westbrooks township	1 173	90.8	35.1	12.9	33.4
Scotland County	33 754	826.6	319.2	40.8	105.7
Laurel Hill township	3 388	213.8	82.5	15.8	41.1
Laurinburg city (pt.)	911	1.1	.4	828.2	2 277.5
Spring Hill township	4 073	232.3	89.7	17.5	45.4
Wagram town	480	3.1	1.2	154.8	400.0
Stewartsville township	18 952	212.9	82.2	89.0	230.6
East Laurinburg town	302	.3	.1	1 006.7	3 020.0
Laurinburg city (pt.)	10 732	18.4	7.1	583.3	1 511.5
Maxton town (pt.)	209	.6	.2	348.3	1 045.0
Williamson township	7 341	167.6	64.7	43.8	113.5
Gibson town	532	2.5	1.0	212.8	532.0
Stanly County	51 765	1 023.3	395.1	50.6	131.0
Almond township	2 433	86.2	33.3	28.2	73.1
Big Lick township	4 287	105.2	40.6	40.8	105.6
Oakboro town	600	1.6	.6	375.0	1 000.0
Center township	5 755	106.6	41.2	54.0	139.7
Norwood town	1 617	4.1	1.6	394.4	1 010.6
Endy township	1 651	50.1	19.3	33.0	85.5
Furr township	7 064	153.1	59.1	46.1	119.5
Locust city	1 940	9.6	3.7	202.1	524.3
Stanfield town	517	2.9	1.1	178.3	470.0
Harris township	5 419	117.8	45.5	46.0	119.1
Albemarle city (pt.)	146	.3	.1	486.7	1 460.0
Badin CDP (pt.)	94	1.2	.5	78.3	188.0
New London town	414	1.6	.6	258.8	690.0
Richfield town (pt.)	385	4.3	1.7	89.5	226.5
North Albemarle township	13 243	129.5	50.0	102.3	264.9
Albemarle city (pt.)	8 922	26.1	10.1	341.8	883.4
Badin CDP (pt.)	1 387	8.2	3.2	169.1	433.4
Ridenhour township	2 155	93.2	36.0	23.1	59.9
Richfield town (pt.)	150	.7	.3	214.3	500.0
South Albemarle township	7 874	78.0	30.1	100.9	261.6
Albemarle city (pt.)	5 871	11.6	4.5	506.1	1 304.7
Tyson township	1 884	103.8	40.1	18.2	47.0
Stokes County	37 223	1 170.3	451.9	31.8	82.4
Beaver Island township	2 768	134.7	52.0	20.5	53.2
Danbury town (pt.)	–	–	–	–	–
Big Creek township	1 818	127.7	49.3	14.2	36.9
Danbury township	1 198	77.4	29.9	15.5	40.1
Danbury town (pt.)	119	1.6	.6	74.4	198.3
Meadows township	4 276	137.4	53.1	31.1	80.5
Peters Creek township	2 177	120.5	46.5	18.1	46.8
Danbury town (pt.)	–	–	–	–	–
Quaker Gap township	1 843	107.8	41.6	17.1	44.3
Sauratown township	5 291	110.6	42.7	47.8	123.9
Walnut Cove town	1 088	5.2	2.0	209.2	544.0
Snow Creek township	2 279	148.8	57.4	15.3	39.7
Yadkin township	15 573	205.4	79.3	75.8	196.4
King city (pt.)	4 059	9.0	3.5	451.0	1 159.7
Surry County	61 704	1 389.7	536.6	44.4	115.0
Bryan township	2 377	185.9	71.8	12.8	33.1
Dobson township	6 683	180.9	69.9	36.9	95.6
Dobson town	1 195	4.6	1.8	259.8	663.9
White Plains CDP (pt.)	127	1.7	.7	74.7	181.4
Eldora township	2 585	77.9	30.1	33.2	85.9
White Plains CDP (pt.)	123	1.0	.4	123.0	307.5

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County County Subdivision Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Surry County—Con.					
Elkin township	5 842	67.9	26.2	86.0	223.0
Elkin town (pt.)	3 720	13.6	5.2	273.5	715.4
Franklin township	1 598	102.9	39.7	15.5	40.3
Long Hill township	1 434	30.5	11.8	47.0	121.5
Marsh township	1 486	60.8	23.5	24.4	63.2
Mount Airy township	23 378	157.0	60.6	148.9	385.8
Flat Rock CDP	1 812	7.2	2.8	251.7	647.1
Mount Airy city	7 156	16.4	6.3	436.3	1 135.9
Toast CDP	2 125	5.1	2.0	416.7	1 062.5
White Plains CDP (pt.)	777	7.3	2.8	106.4	277.5
Pilot township	3 273	60.0	23.2	54.6	141.1
Pilot Mountain town	1 181	4.3	1.7	274.7	694.7
Rockford township	1 392	70.8	27.3	19.7	51.0
Shoals township	1 407	74.4	28.7	18.9	49.0
Siloam township	859	53.3	20.6	16.1	41.7
South Westfield township	1 302	45.8	17.7	28.4	73.6
Stewarts Creek township	5 939	152.5	58.9	38.9	100.8
Westfield township	2 149	69.0	26.6	31.1	80.8
Swain County	11 268	1 367.9	528.1	8.2	21.3
Charleston township	9 883	698.2	269.6	14.2	36.7
Bryson City town	1 145	5.5	2.1	208.2	545.2
Forneys Creek township	15	465.3	179.6	–	.1
Nantahala township	1 370	204.4	78.9	6.7	17.4
Transylvania County	25 520	979.9	378.4	26.0	67.4
Boyd township	2 806	124.2	48.0	22.6	58.5
Brevard township	10 340	163.6	63.2	63.2	163.6
Brevard city (pt.)	5 388	8.6	3.3	626.5	1 632.7
Catheys Creek township	3 302	82.5	31.9	40.0	103.5
Brevard city (pt.)	–	.1	.1	–	–
Rosman town (pt.)	337	.9	.3	374.4	1 123.3
Dunns Rock township	3 006	80.4	31.0	37.4	97.0
Brevard city (pt.)	–	.1	–	–	–
Easlatoe township	2 335	129.6	50.0	18.0	46.7
Rosman town (pt.)	48	.2	.1	240.0	480.0
Gloucester township	715	143.2	55.3	5.0	12.9
Hogback township	1 488	159.9	61.7	9.3	24.1
Little River township	1 528	96.5	37.2	15.8	41.1
Tyrrell County	3 856	1 009.9	389.9	3.8	9.9
Alligator township	437	221.6	85.6	2.0	5.1
Columbia township	2 181	180.3	69.6	12.1	31.3
Columbia town	836	1.2	.4	696.7	2 090.0
Gum Neck township	438	452.0	174.5	1.0	2.5
Scuppernong township	755	54.8	21.2	13.8	35.6
South Fork township	45	101.2	39.1	.4	1.2
Union County	84 211	1 650.9	637.4	51.0	132.1
Buford township	7 688	255.8	98.8	30.1	77.8
Goose Creek township	8 167	215.2	83.1	38.0	98.3
Jackson township	5 851	151.9	58.7	38.5	99.7
Waxhaw town (pt.)	1 294	2.8	1.1	462.1	1 176.4
Lanes Creek township	1 475	120.4	46.5	12.3	31.7
Marshville township	6 587	201.5	77.8	32.7	84.7
Marshville town	2 020	4.4	1.7	459.1	1 188.2
Wingate town (pt.)	97	–	–	–	–
Monroe township	30 291	257.1	99.3	117.8	305.0
Monroe city	16 127	35.9	13.9	449.2	1 160.2
Wingate town (pt.)	2 724	3.5	1.4	778.3	1 945.7
New Salem township	2 324	176.0	68.0	13.2	34.2
Sandy Ridge township	8 564	169.6	65.5	50.5	130.7
Stallings town (pt.)	13	.3	.1	43.3	130.0
Waxhaw town (pt.)	–	.1	–	–	–
Weddington town (pt.)	3 312	35.2	13.6	94.1	243.5
Vance township	13 264	103.3	39.9	128.4	332.4
Hamby Bridge CDP	2 876	8.9	3.4	323.1	845.9
Indian Trail town	1 942	8.3	3.2	234.0	606.9
Stallings town (pt.)	2 119	7.7	3.0	275.2	706.3
Weddington town (pt.)	491	2.5	1.0	196.4	491.0
Vance County	38 892	656.7	253.5	59.2	153.4
Dabney township	1 967	44.1	17.0	44.6	115.7
Henderson city (pt.)	2	–	–	–	–
Henderson township	22 247	88.6	34.2	251.1	650.5
Henderson city (pt.)	15 653	18.3	7.1	855.4	2 204.6
South Henderson CDP	1 374	5.1	2.0	269.4	687.0
Kittrell township	4 147	125.9	48.6	32.9	85.3
Kittrell town	228	.5	.2	456.0	1 140.0
Middleburg-Nutbush township	2 766	100.0	38.6	27.7	71.7
Middleburg town	131	1.5	.6	87.3	218.3
Sandy Creek township	4 162	85.4	33.0	48.7	126.1
Townsville township	1 181	89.9	34.7	13.1	34.0
Watkins township	592	28.0	10.8	21.1	54.8
Williamsboro township	1 830	94.7	36.6	19.3	50.0
Wake County	423 380	2 159.8	833.9	196.0	507.7
Barbers Creek township	11 732	88.7	34.2	132.3	343.0
Raleigh city (pt.)	101	1.1	.4	91.8	252.5
Buckhorn township	1 646	91.2	35.2	18.0	46.8
Cary township	45 074	82.6	31.9	545.7	1 413.0
Apex town (pt.)	–	.1	–	–	–
Cary town (pt.)	40 926	49.3	19.0	830.1	2 154.0
Raleigh city (pt.)	7	5.1	2.0	1.4	3.5
Cedar Fork township	2 709	93.0	35.9	29.1	75.5
Cary town (pt.)	629	15.0	5.8	41.9	108.4
Morrisville town (pt.)	1 022	14.9	5.8	68.6	176.2
Raleigh city (pt.)	26	13.3	5.1	2.0	5.1
Holly Springs township	5 786	121.5	46.9	47.6	123.4
Apex town (pt.)	223	1.8	.7	123.9	318.6
Fuquay-Varina town (pt.)	105	.7	.3	150.0	350.0
Holly Springs town	908	11.3	4.4	80.4	206.4
House Creek township	44 667	57.1	22.1	782.2	2 021.1
Raleigh city (pt.)	42 565	45.0	17.4	945.9	2 446.3
Wake County—Con.					
Leesville township	15 896	55.2	21.3	288.0	746.3
Raleigh city (pt.)	6 258	4.1	1.6	1 526.3	3 911.3
Little River township	8 666	138.4	53.4	62.6	162.3
Zebulon town	3 173	5.6	2.2	566.6	1 442.3
Marks Creek township	11 305	136.2	52.6	83.0	214.9
Wendell town	2 822	4.1	1.6	688.3	1 763.8
Meredith township	8 090	25.1	9.7	322.3	834.0
Raleigh city (pt.)	6 962	13.2	5.1	527.4	1 365.1
Middle Creek township	15 105	157.1	60.6	96.1	249.3
Fuquay-Varina town (pt.)	4 457	13.3	5.1	335.1	873.9
Neuse township	32 708	70.0	27.0	467.3	1 211.4
Raleigh city (pt.)	26 134	21.4	8.3	1 221.2	3 148.7
New Light township	2 554	104.3	40.3	24.5	63.4
Panther Branch township	7 156	98.5	38.0	72.6	188.3
Garner town (pt.)	24	2.9	1.1	8.3	21.8
Raleigh township	103 755	96.9	37.4	1 070.7	2 774.2
Raleigh city (pt.)	102 979	92.9	35.9	1 108.5	2 868.5
St. Marys township	32 324	156.1	60.3	207.1	536.1
Garner town (pt.)	14 940	25.5	9.8	585.9	1 524.5
Raleigh city (pt.)	7 969	9.8	3.8	813.2	2 097.1
St. Matthews township	26 976	147.9	57.1	182.4	472.4
Knightdale town	1 884	3.6	1.4	523.3	1 345.7
New Hope CDP	5 694	21.4	8.3	266.1	686.0
Raleigh city (pt.)	8 649	16.1	6.2	537.2	1 395.0
Swift Creek township	20 891	111.7	43.1	187.0	484.7
Cary town (pt.)	2 015	6.8	2.6	296.3	775.0
Garner town (pt.)	3	1.0	.4	3.0	7.5
Raleigh city (pt.)	6 301	6.3	2.4	1 000.2	2 625.4
Wake Forest township	15 586	190.6	73.6	81.8	211.8
Bolesville town	572	2.2	.9	260.0	635.6
Wake Forest town	5 769	12.5	4.8	461.5	1 201.9
White Oak township	10 754	137.9	53.2	78.0	202.1
Apex town (pt.)	4 745	9.0	3.5	527.2	1 355.7
Cary town (pt.)	288	9.6	3.7	30.0	77.8
Warren County	17 265	1 110.5	428.8	15.5	40.3
Fishing Creek township	1 501	126.4	48.8	11.9	30.8
Fork township	505	106.4	41.1	4.7	12.3
Hawtree township	1 340	92.1	35.6	14.5	37.6
Judkins township	880	141.8	54.7	6.2	16.1
Nutbush township	1 387	83.5	32.2	16.6	43.1
River township	933	71.8	27.7	13.0	33.7
Roanoke township	544	24.0	9.3	22.7	58.5
Sandy Creek township	1 275	85.9	33.2	14.8	38.4
Shocco township	993	92.7	35.8	10.7	27.7
Sixpound township	1 060	92.6	35.7	11.4	29.7
Macon town (pt.)	153	1.2	.4	127.5	382.5
Smith Creek township	2 266	67.6	26.1	33.5	86.8
Norlina town	996	2.9	1.1	343.4	905.5
Warrenton township	4 581	125.7	48.6	36.4	94.3
Macon town (pt.)	1	–	–	–	–
Warrenton town	949	2.3	.9	412.6	1 054.4
Washington County	13 997	900.9	347.8	15.5	40.2
Lees Mills township	2 935	323.8	125.0	9.1	23.5
Roper town	669	2.2	.9	304.1	743.3
Plymouth township	7 707	191.5	73.9	40.2	104.3
Plymouth town	4 328	9.7	3.8	446.2	1 138.9
Scuppernong township	1 481	176.5	68.2	8.4	21.7
Creswell town	361	1.1	.4	328.2	902.5
Skinnersville township	1 874	209.1	80.7	9.0	23.2
Watauga County	36 952	809.5	312.6	45.6	118.2
Bald Mountain township	370	30.6	11.8	12.1	31.4
Beaverdam township	1 176	69.6	26.9	16.9	43.7
Blowing Rock township	2 332	50.1	19.3	46.5	120.8
Blowing Rock town (pt.)	1 213	6.7	2.6	181.0	466.5
Blue Ridge township	2 204	71.4	27.6	30.9	79.9
Boone township	12 915	14.2	5.5	909.5	2 348.2
Boone town	12 915	14.2	5.5	909.5	2 348.2
Brushy Fork township	3 368	42.1	16.2	80.0	207.9
Cove Creek township	2 335	62.6	24.2	37.3	96.5
Elk township	314	60.6	23.4	5.2	13.4
Laurel Creek township	1 383	68.4	26.4	20.2	52.4
Beech Mountain town (pt.)	229	12.9	5.0	17.8	45.8
Meat Camp township	2 214	78.1	30.2	28.3	73.3
New River township	3 322	43.3	16.7	76.7	198.9
North Fork township	232	31.6	12.2	7.3	19.0
Shawneehaw township	668	32.3	12.5	20.7	53.4
Beech Mountain town (pt.)	3	.2	.1	15.0	30.0
Seven Devils town (pt.)	–	–	–	–	–
Stony Fork township	1 773	67.0	25.9	26.5	68.5
Watauga township	2 346	87.5	33.8	26.8	69.4
Seven Devils town (pt.)	97	3.6	1.4	26.9	69.3
Wayne County	104 666	1 431.2	552.6	73.1	189.4
Brogden township	18 691	209.1	80.8	89.4	231.3
Brogden CDP	3 246	5.6	2.2	579.6	1 475.5
Goldsboro city (pt.)	3	.1	–	30.0	–
Mar-Mac CDP	3 282	11.5	4.5	285.4	729.3
Mount Olive town (pt.)	4 581	5.9	2.3	776.4	1 991.7
Buck Swamp township	2 891	82.4	31.8	35.1	90.9
Fork township	7 690	120.1	46.4	64.0	165.7
Goldsboro city (pt.)	1 377	2.5	1.0	550.8	1 377.0
Goldsboro township	26 736	46.5	18.0	575.0	1 485.3
Goldsboro city (pt.)	25 849	32.4	12.5	797.8	2 067.9
Grantham township	3 285	200.4	77.4	16.4	42.4
Great Swamp township	1 496	76.0	29.3	19.7	51.1
Fremont town (pt.)	72	–	–	–	–
Indian Springs township	4 199	188.2	72.7	22.3	57.8
Goldsboro city (pt.)	–	–	–	–	–
Seven Springs town	163	9	.3	181.1	543.3

Table 15. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State — County — County Subdivision — Place	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
Wayne County—Con.					
Nahunta township	3 553	126.0	48.7	28.2	73.0
Eureka town	282	.9	.4	313.3	705.0
Fremont town (pt.)	1 638	3.5	1.4	468.0	1 170.0
New Hope township	21 282	163.6	63.2	130.1	336.7
Elroy CDP	4 028	17.5	6.8	230.2	592.4
Goldsboro city (pt.)	10 869	13.7	5.3	793.4	2 050.8
New Hope CDP (pt.)	2 290	7.4	2.8	309.5	817.9
Walnut Creek village	623	2.8	1.1	222.5	566.4
Pikeville township	1 968	50.1	19.3	39.3	102.0
Pikeville town	598	1.1	.4	543.6	1 495.0
Seaboard township	3 902	89.1	34.4	43.8	113.4
New Hope CDP (pt.)	381	.6	.2	635.0	1 905.0
Stoney Creek township	8 973	79.8	30.8	112.4	291.3
Goldsboro city (pt.)	2 611	5.8	2.2	450.2	1 186.8
New Hope CDP (pt.)	1 820	4.8	1.9	379.2	957.9
Wilkes County	59 393	1 961.2	757.2	30.3	78.4
Antioch township	924	56.5	21.8	16.4	42.4
Beaver Creek township	476	53.3	20.6	8.9	23.1
Boomer township	1 760	85.5	33.0	20.6	53.3
Brushy Mountain township	502	64.3	24.8	7.8	20.2
Edwards township	6 300	165.9	64.1	38.0	98.3
Elkin town (pt.)	70	.2	.1	350.0	700.0
Pleasant Hill CDP	1 114	9.4	3.6	118.5	309.4
Ronda town	367	2.8	1.1	131.1	333.6
Elk township	943	138.7	53.6	6.8	17.6
Jobs Cabin township	449	95.5	36.9	4.7	12.2
Lewis Fork township	1 194	61.1	23.6	19.5	50.6
Lovelace township	544	57.7	22.3	9.4	24.4
Moravian Falls township	2 357	75.1	29.0	31.4	81.3
Moravian Falls CDP (pt.)	966	7.8	3.0	123.8	322.0
Mulberry township	5 878	146.0	56.4	40.3	104.2
Fairplains CDP (pt.)	485	3.5	1.3	138.6	373.1
Hays CDP (pt.)	45	1.8	.7	25.0	64.3
Mulberry CDP	2 339	13.2	5.1	177.2	458.6
New Castle township	1 529	85.2	32.9	17.9	46.5
North Wilkesboro township	6 954	41.6	16.1	167.2	431.9
Cricket CDP (pt.)	770	4.6	1.8	167.4	427.8
Fairplains CDP (pt.)	1 854	8.4	3.3	220.7	561.8
North Wilkesboro town (pt.)	2 855	10.3	4.0	277.2	713.8
Wilkesboro town (pt.)	18	.3	.1	60.0	180.0
Reddies River township	9 126	96.4	37.2	94.7	245.3
Cricket CDP (pt.)	1 245	5.9	2.3	211.0	541.3
Millers Creek CDP	1 787	11.2	4.3	159.6	415.6
Wilkesboro town (pt.)	18	.7	.3	25.7	60.0
Rock Creek township	5 194	81.6	31.5	63.7	164.9
Hays CDP (pt.)	1 477	14.0	5.4	105.5	273.5
Somers township	958	78.5	30.3	12.2	31.6
Stanton township	488	41.6	16.1	11.7	30.3
Trophill township	2 600	149.1	57.6	17.4	45.1
Union township	1 021	160.9	62.1	6.3	16.4
Walnut Grove township	985	145.0	56.0	6.8	17.6
Wilkesboro township	9 211	81.6	31.5	112.9	292.4
Moravian Falls CDP (pt.)	770	5.6	2.2	137.5	350.0
North Wilkesboro town (pt.)	529	1.9	.7	278.4	755.7
Wilkes County—Con.					
Wilkesboro township—Con.					
Wilkesboro town (pt.)	2 537	10.3	4.0	246.3	634.3
Wilson County	66 061	961.1	371.1	68.7	178.0
Black Creek township	3 259	98.9	38.2	33.0	85.3
Black Creek town	615	1.7	.7	361.8	878.6
Wilson city (pt.)	–	–	–	–	–
Cross Roads township	3 187	73.2	28.2	43.5	113.0
Lucama town	933	1.4	.5	666.4	1 866.0
Gardners township	2 832	109.1	42.1	26.0	67.3
Old Fields township	3 466	131.5	50.8	26.4	68.2
Sims town	124	.3	.1	413.3	1 240.0
Wilson city (pt.)	8	.3	.1	26.7	80.0
Saratoga township	1 868	108.2	41.8	17.3	44.7
Saratoga town	342	.7	.6	201.2	570.0
Springhill township	2 302	92.9	35.9	24.8	64.1
Kenly town (pt.)	153	.1	.1	1 530.0	1 530.0
Stantonsburg township	1 441	62.4	24.1	23.1	59.8
Stantonsburg town	782	1.4	.5	558.6	1 564.0
Taylors township	2 975	54.2	20.9	54.9	142.3
Wilson city (pt.)	447	4.6	1.8	97.2	248.3
Toisnot township	5 162	121.4	46.9	42.5	110.1
Elm City town	1 624	1.9	.7	854.7	2 320.0
Sharpsburg town (pt.)	412	.4	.2	1 030.0	2 060.0
Wilson township	39 569	109.3	42.2	362.0	937.7
Wilson city (pt.)	36 475	43.0	16.6	848.3	2 197.3
Yadkin County	30 488	869.2	335.6	35.1	90.8
Boonville township	3 372	104.5	40.4	32.3	83.5
Boonville town	1 009	2.8	1.1	360.4	917.3
Deep Creek township	1 885	81.1	31.3	23.2	60.2
East Bend township	2 663	81.4	31.4	32.7	84.8
East Bend town	619	3.3	1.3	187.6	476.2
Forbush township	2 944	110.0	42.5	26.8	69.3
North Buck Shoals township	1 951	58.2	22.5	33.5	86.7
North Fall Creek township	1 137	56.5	21.8	20.1	52.2
North Knobs township	4 285	58.9	22.7	72.8	188.8
Arlington town	795	2.2	.8	361.4	993.8
Jonesville town	1 549	4.4	1.7	352.0	911.2
North Liberty township	5 231	63.5	24.5	82.4	213.5
Yadkinville town	2 525	6.7	2.6	376.9	971.2
South Buck Shoals township	1 042	56.7	21.9	18.4	47.6
South Fall Creek township	1 985	61.7	23.8	32.2	83.4
South Knobs township	1 467	51.8	20.0	28.3	73.4
South Liberty township	2 526	84.9	32.8	29.8	77.0
Yancey County	15 419	809.2	312.4	19.1	49.4
Brush Creek township	490	33.1	12.8	14.8	38.3
Burnsville township	4 062	63.3	24.4	64.2	166.5
Burnsville town	1 482	4.1	1.6	361.5	926.3
Cane River township	1 168	62.7	24.2	18.6	48.3
Crabtree township	2 804	76.6	29.6	36.6	94.7
Egypt township	648	61.3	23.7	10.6	27.3
Green Mountain township	565	29.0	11.2	19.5	50.4
Jacks Creek township	1 412	58.3	22.5	24.2	62.8
Pensacola township	505	108.0	41.7	4.7	12.1
Price Creek township	1 295	72.8	28.1	17.8	46.1
Ramseytown township	456	90.3	34.9	5.0	13.1
South Toe township	2 014	153.9	59.4	13.1	33.9

Table 16. Land Area and Population Density: 1990

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
The State	6 628 637	126 179.9	48 718.1	52.5	136.1
COUNTY					
Alamance County	108 213	1 115.5	430.7	97.0	251.2
Alexander County	27 544	674.2	260.3	40.9	105.8
Alleghany County	9 590	607.8	234.7	15.8	40.9
Anson County	23 474	1 376.9	531.6	17.0	44.2
Ashe County	22 209	1 103.8	426.2	20.1	52.1
Avery County	14 867	639.8	247.0	23.2	60.2
Beaufort County	42 283	2 143.5	827.6	19.7	51.1
Bertie County	20 388	1 811.0	699.2	11.3	29.2
Bladen County	28 663	2 266.3	875.0	12.6	32.8
Brunswick County	50 985	2 214.2	854.9	23.0	59.6
Buncombe County	174 821	1 699.8	656.3	102.8	266.4
Burke County	75 744	1 312.5	506.7	57.7	149.5
Cabarrus County	98 935	943.9	364.4	104.8	271.5
Caldwell County	70 709	1 221.6	471.7	57.9	149.9
Camden County	5 904	623.4	240.7	9.5	24.5
Carteret County	52 556	1 376.3	531.4	38.2	98.9
Caswell County	20 693	1 102.6	425.7	18.8	48.6
Catawba County	118 412	1 036.0	400.0	114.3	296.0
Chatham County	38 759	1 769.2	683.1	21.9	56.7
Cherokee County	20 170	1 179.0	455.2	17.1	44.3
Chowan County	13 506	447.1	172.6	30.2	78.3
Clay County	7 155	556.1	214.7	12.9	33.3
Cleveland County	84 714	1 202.7	464.3	70.4	182.5
Columbus County	49 587	2 426.4	936.8	20.4	52.9
Craven County	81 613	1 801.5	695.6	45.3	117.3
Cumberland County	274 566	1 691.6	653.1	162.3	420.4
Currituck County	13 736	677.8	261.7	20.3	52.5
Dare County	22 746	988.5	381.7	23.0	59.6
Davidson County	126 677	1 430.3	552.2	88.6	229.4
Davie County	27 859	686.9	265.2	40.6	105.0
Duplin County	39 995	2 118.2	817.8	18.9	48.9
Durham County	181 835	752.7	290.6	241.6	625.7
Edgecombe County	56 558	1 308.1	505.1	43.2	112.0
Forsyth County	265 878	1 061.0	409.7	250.6	649.0
Franklin County	36 414	1 273.2	491.6	28.6	74.1
Gaston County	175 093	923.4	356.5	189.6	491.1
Gates County	9 305	882.2	340.6	10.5	27.3
Graham County	7 196	756.5	292.1	9.5	24.6
Granville County	38 345	1 375.7	531.2	27.9	72.2
Greene County	15 384	687.5	265.4	22.4	58.0
Guilford County	347 420	1 683.8	650.1	206.3	534.4
Halifax County	55 516	1 878.9	725.4	29.5	76.5
Harnett County	67 822	1 541.2	595.0	44.0	114.0
Haywood County	46 942	1 434.6	553.9	32.7	84.7
Henderson County	69 285	968.3	373.8	71.6	185.4
Hertford County	22 523	916.0	353.7	24.6	63.7
Hoke County	22 856	1 013.3	391.2	22.6	58.4
Hyde County	5 411	1 587.2	612.8	3.4	8.8
Iredell County	92 931	1 487.7	574.4	62.5	161.8
Jackson County	26 846	1 270.6	490.6	21.1	54.7
Johnston County	81 306	2 051.2	792.0	39.6	102.7
Jones County	9 414	1 225.9	473.3	7.7	19.9
Lee County	41 374	666.4	257.3	62.1	160.8
Lenoir County	57 274	1 035.7	399.9	55.3	143.2
Lincoln County	50 319	773.9	298.8	65.0	168.4
McDowell County	35 681	1 144.0	441.7	31.2	80.8
Macon County	23 499	1 337.6	516.5	17.6	45.5
Madison County	16 953	1 164.1	449.4	14.6	37.7
Martin County	25 078	1 198.1	462.6	20.9	54.2
Mecklenburg County	511 433	1 366.0	527.4	374.4	969.7
Mitchell County	14 433	573.6	221.5	25.2	65.2
Montgomery County	23 346	1 271.8	491.1	18.4	47.5
Moore County	59 013	1 809.8	698.8	32.6	84.4
Nash County	76 677	1 399.4	540.3	54.8	141.9
New Hanover County	120 284	515.3	198.9	233.4	604.7
Northampton County	20 798	1 388.6	536.1	15.0	38.8
Onslow County	149 838	1 986.2	766.9	75.4	195.4
Orange County	93 851	1 035.5	399.8	90.6	234.7
Pamlico County	11 372	872.7	336.9	13.0	33.8
Pasquotank County	31 298	587.7	226.9	53.3	137.9
Pender County	28 855	2 255.2	870.7	12.8	33.1
Perquimans County	10 447	640.2	247.2	16.3	42.3
Person County	30 180	1 016.2	392.3	29.7	76.9
Pitt County	107 924	1 687.7	651.6	63.9	165.6
Polk County	14 416	616.0	237.8	23.4	60.6
Randolph County	106 546	2 039.5	787.5	52.2	135.3
Richmond County	44 518	1 227.8	474.0	36.3	93.9
Robeson County	105 179	2 457.7	948.9	42.8	110.8
Rockingham County	86 064	1 467.2	566.5	58.7	151.9
Rowan County	110 605	1 324.5	511.4	83.5	216.3
Rutherford County	56 918	1 461.3	564.2	39.0	100.9
Sampson County	47 297	2 448.9	945.5	19.3	50.0
Scotland County	33 754	826.6	319.2	40.8	105.7
Stanly County	51 765	1 023.3	395.1	50.6	131.0
Stokes County	37 223	1 170.3	451.9	31.8	82.4
Surry County	61 704	1 389.7	536.6	44.4	115.0
Swain County	11 268	1 367.9	528.1	8.2	21.3
Transylvania County	25 520	979.9	378.4	26.0	67.4
Tyrrell County	3 856	1 009.9	389.9	3.8	9.9
Union County	84 211	1 650.9	637.4	51.0	132.1
Vance County	38 892	656.7	253.5	59.2	153.4
Wake County	423 380	2 159.8	833.9	196.0	507.7
Warren County	17 265	1 110.5	428.8	15.5	40.3
Washington County	13 997	900.9	347.8	15.5	40.2
Watauga County	36 952	809.5	312.6	45.6	118.2
Wayne County	104 666	1 431.2	552.6	73.1	189.4
Wilkes County	59 393	1 961.2	757.2	30.3	78.4
Wilson County	66 061	961.1	371.1	68.7	178.0
Yadkin County	30 488	869.2	335.6	35.1	90.8
Yancey County	15 419	809.2	312.4	19.1	49.4
PLACE AND COUNTY SUBDIVISION					
Aberdeen town, Moore County	2 700	8.5	3.3	317.6	818.2
Ahoskie town, Hertford County	4 391	6.6	2.6	665.3	1 688.8
Alamance village, Alamance County	258	1.2	.5	215.0	516.0
Albemarle city, Stanly County	14 939	38.0	14.7	393.1	1 016.3
Alexander Mills town, Rutherford County	662	1.5	.6	441.3	1 103.3
Alliance town, Pamlico County	583	5.0	1.9	116.6	306.8
Altamahaw-Ossipee CDP, Alamance County	1 078	6.0	2.3	179.3	467.8
Andrews town, Cherokee County	2 551	8.2	3.2	311.1	797.2
Angier town, Harnett County	2 235	4.5	1.7	496.7	1 314.7
Ansonville town, Anson County	614	3.8	1.5	161.6	409.3
Apex town, Wake County	4 968	10.8	4.2	460.0	1 182.9
Arapahoe town, Pamlico County	430	5.7	2.2	75.4	195.5
Archdale city	6 913	17.9	6.9	386.2	1 001.9
Guilford County	234	1.4	.6	167.1	390.0
Randolph County	6 679	16.5	6.4	404.8	1 043.6
Arlington town, Yadkin County	795	2.2	.8	361.4	993.8
Asheboro city, Randolph County	16 362	30.8	11.9	531.2	1 375.0
Asheville city, Buncombe County	61 607	90.5	34.9	680.7	1 765.2
Askewville town, Bertie County	201	1.4	.5	143.6	402.0
Atkinson town, Pender County	275	2.6	1.0	105.8	275.0
Atlantic Beach town, Carteret County	1 938	6.0	2.3	323.0	842.6
Aulander town, Bertie County	1 209	3.8	1.5	318.2	806.0
Aurora town, Beaufort County	654	2.3	.9	284.3	726.7
Autryville town, Sampson County	166	1.3	.5	127.7	332.0
Avery Creek CDP, Buncombe County	1 144	4.4	1.7	260.0	672.9
Ayden town, Pitt County	4 740	5.4	2.1	877.8	2 257.1
Badin CDP, Stanly County	1 481	9.5	3.7	155.9	400.3
Bailey town, Nash County	553	1.8	.7	307.2	790.0
Bakersville town, Mitchell County	332	1.9	.7	174.7	474.3
Bald Head Island village, Brunswick County	78	11.1	4.3	7.0	18.1
Balfour CDP, Henderson County	1 118	4.4	1.7	254.1	657.6
Banner Elk town, Avery County	933	2.2	.8	424.1	1 166.3
Barker Heights CDP, Henderson County	1 137	3.4	1.3	334.4	874.6
Barker Ten Mile CDP, Robeson County	1 087	5.9	2.3	184.2	472.6
Bath town, Beaufort County	154	.8	.3	192.5	513.3
Battleboro town	447	.9	.4	496.7	1 117.5
Edgecombe County	280	.3	.1	933.3	2 800.0
Nash County	167	.6	.2	278.3	835.0
Bayboro town, Pamlico County	733	3.8	1.5	192.9	488.7
Bayshore CDP, New Hanover County	1 661	9.3	3.6	178.6	461.4
Beargrass town, Martin County	77	.7	.3	110.0	256.7
Beaufort town, Carteret County	3 808	4.5	1.7	846.2	2 240.0
Beech Mountain town	239	17.2	6.6	13.9	36.2
Avery County	7	4.0	1.6	1.8	4.4
Watauga County	232	13.2	5.1	17.6	45.5
Belhaven town, Beaufort County	2 269	3.9	1.5	581.8	1 512.7
Belmont city, Gaston County	8 434	14.9	5.7	566.0	1 479.6
Belville town, Brunswick County	66	.6	.2	110.0	330.0
Belwood town, Cleveland County	631	31.9	12.3	19.8	51.3
Benson town, Johnston County	2 810	4.4	1.7	638.6	1 652.9
Bent Creek CDP, Buncombe County	1 487	6.1	2.3	243.8	646.5
Bessemer City city, Gaston County	4 698	9.2	3.5	510.7	1 342.3
Bethel town, Pitt County	1 842	2.6	1.0	708.5	1 842.0
Bethlehem CDP, Alexander County	3 186	19.7	7.6	161.7	419.2
Beulaville town, Duplin County	933	3.2	1.2	291.6	777.5
Biltmore Forest town, Buncombe County	1 327	7.7	3.0	172.3	442.3
Biscoe town, Montgomery County	1 484	5.2	2.0	285.4	742.0
Black Creek town, Wilson County	615	1.7	.7	361.8	878.6
Black Mountain town, Buncombe County	5 418	12.5	4.8	433.4	1 128.8
Bladenboro town, Bladen County	1 821	4.9	1.9	371.6	958.4
Blowing Rock town	1 257	7.7	3.0	163.2	419.0
Caldwell County	44	1.0	.4	44.0	110.0
Watauga County	1 213	6.7	2.6	181.0	466.5
Boger City CDP, Lincoln County	1 373	3.0	1.1	457.7	1 248.2
Boiling Spring Lakes city, Brunswick County	1 650	59.1	22.8	27.9	72.4
Boiling Springs town, Cleveland County	2 445	9.2	3.5	265.8	698.6
Bolivia town, Brunswick County	228	1.7	.7	134.1	325.7
Bolton town, Columbus County	531	8.0	3.1	66.4	171.3
Bonnie Doone CDP, Cumberland County	3 892	7.9	3.0	492.8	1 297.7
Boone town, Watauga County	12 915	14.2	5.5	909.5	2 348.2
Boonville town, Yadkin County	1 009	2.8	1.1	360.4	917.3
Bostic town, Rutherford County	371	2.3	.9	161.3	412.2
Brevard city, Transylvania County	5 388	8.8	3.4	612.3	1 584.7
Bridgeton town, Craven County	453	.9	.3	503.3	1 510.0
Broadway town	973	3.1	1.2	313.9	810.8
Harnett County	–	–	–	–	–
Lee County	973	3.1	1.2	313.9	810.8
Brogden CDP, Wayne County	3 246	5.6	2.2	579.6	1 475.5
Brookford town, Catawba County	451	1.4	.5	322.1	902.0
Brunswick town, Columbus County	302	1.1	.4	274.5	755.0
Bryson City town, Swain County	1 145	5.5	2.1	208.2	545.2
Buies Creek CDP, Harnett County	2 085	3.5	1.3	595.7	1 603.8

Table 16. Land Area and Population Density: 1990—Con.

(For definitions of terms and meanings of symbols; see text)

State—County—Place and [In Selected States] County—Subdivision	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
PLACE AND COUNTY SUBDIVISION—Con.					
Bunn town, Franklin County	364	1.4	.5	260.0	728.0
Burgaw town, Pender County	1 807	5.3	2.0	340.9	903.5
Burlington city, Alamance County	39 498	52.7	20.3	749.5	1 945.7
Burnsville town, Yancey County	1 482	4.1	1.6	361.5	926.3
Butner CDP, Granville County	4 679	17.8	6.9	262.9	678.1
Cajah's Mountain town, Caldwell County	2 429	7.9	3.0	307.5	809.7
Calabash town, Brunswick County	1 210	4.7	1.8	257.4	672.2
Calypso town, Duplin County	481	2.5	1.0	192.4	481.0
Cameron town, Moore County	215	2.7	1.1	79.6	195.5
Camp Lejeune Central CDP, Onslow County	36 716	50.7	19.6	724.2	1 873.3
Candor town, Montgomery County	748	2.8	1.1	267.1	680.0
Canton town, Haywood County	3 790	9.2	3.5	412.0	1 082.9
Cape Carteret town, Carteret County	1 008	5.5	2.1	183.3	480.0
Carolina Beach town, New Hanover County	3 630	4.4	1.7	825.0	2 135.3
Carrboro town, Orange County	11 553	9.1	3.5	1 269.6	3 300.9
Carthage town, Moore County	976	5.3	2.0	184.2	488.0
Cary town, Wake County	43 858	80.7	31.2	543.5	1 405.7
Casar town, Cleveland County	328	4.3	1.7	76.3	192.9
Castalia town, Nash County	261	1.9	.7	137.4	372.9
Castle Hayne CDP, New Hanover County	1 182	5.8	2.3	203.8	513.9
Caswell Beach town, Brunswick County	175	7.9	3.0	22.2	58.3
Catawba town, Catawba County	467	3.1	1.2	150.6	389.2
Cedar Point town, Carteret County	628	4.9	1.9	128.2	330.5
Centerville town, Franklin County	115	.7	.3	164.3	383.3
Cerro Gordo town, Columbus County	227	2.0	.8	113.5	283.8
Chadbourn town, Columbus County	2 005	5.5	2.1	364.5	954.8
Chapel Hill town	38 719	42.8	16.5	904.6	2 346.6
Durham County	1 115	1.4	.6	796.4	1 858.3
Orange County	37 604	41.4	16.0	908.3	2 350.3
Charlotte city, Mecklenburg County	395 934	451.3	174.3	877.3	2 271.6
Cherryville city, Gaston County	4 756	9.4	3.6	506.0	1 321.1
China Grove town, Rowan County	2 732	3.8	1.5	718.9	1 821.3
Chocowinity town, Beaufort County	624	2.1	.8	297.1	780.0
Claremont city, Catawba County	980	4.6	1.8	213.0	544.4
Clarkton town, Bladen County	739	2.9	1.1	254.8	671.8
Clayton town, Johnston County	4 756	10.7	4.1	444.5	1 160.0
Clemmons village, Forsyth County	6 020	12.1	4.7	497.5	1 280.9
Cleveland town, Rowan County	696	4.1	1.6	169.8	435.0
Clinton city, Sampson County	8 204	17.4	6.7	471.5	1 224.5
Clyde town, Haywood County	1 041	2.2	.8	473.2	1 301.3
Coats town, Harnett County	1 493	3.1	1.2	481.6	1 244.2
Cofield village, Hertford County	407	8.1	3.1	50.2	131.3
Colerain town, Bertie County	139	.7	.3	198.6	463.3
Columbia town, Tyrrell County	836	1.2	.4	696.7	2 090.0
Columbus town, Polk County	812	4.6	1.8	176.5	451.1
Como town, Hertford County	71	8.2	3.2	8.7	22.2
Concord city, Cabarrus County	27 347	56.5	21.8	484.0	1 254.4
Conetoe town, Edgecombe County	292	.9	.4	324.4	730.0
Connelly Springs town, Burke County	1 349	9.0	3.5	149.9	385.4
Conover city, Catawba County	5 465	18.0	6.9	303.6	792.0
Conway town, Northampton County	759	4.7	1.8	161.5	421.7
Cooleemee town, Davie County	971	2.0	.8	485.5	1 213.8
Cornelius town, Mecklenburg County	2 581	8.6	3.3	300.1	782.1
Cove City town, Craven County	497	1.5	.6	331.3	828.3
Cramerton town, Gaston County	2 371	9.3	3.6	254.9	658.6
Creedmoor city, Granville County	1 504	5.4	2.1	278.5	716.2
Creswell town, Washington County	361	1.1	.4	328.2	902.5
Cricket CDP, Wilkes County	2 015	10.5	4.1	191.9	491.5
Crossnore town, Avery County	271	1.1	.4	246.4	677.5
Cullowhee CDP, Jackson County	4 029	8.3	3.2	485.4	1 259.1
Dallas town, Gaston County	3 012	3.7	1.4	814.1	2 151.4
Danbury town, Stokes County	119	1.6	.6	74.4	198.3
Davidson town	4 046	7.7	3.0	525.5	1 348.7
Iredell County	–	.7	.3	–	–
Mecklenburg County	4 046	7.0	2.7	578.0	1 498.5
Dellview town, Gaston County	10	.1	.1	100.0	100.0
Denton town, Davidson County	1 292	3.5	1.4	369.1	922.9
Dillsboro town, Jackson County	95	1.0	.4	95.0	237.5
Dobbins Heights town, Richmond County	1 144	2.3	.9	497.4	1 271.1
Dobson town, Surry County	1 195	4.6	1.8	259.8	663.9
Dortches town, Nash County	840	19.8	7.6	42.4	110.5
Dover town, Craven County	451	2.5	.9	180.4	501.1
Drexel town, Burke County	1 746	3.4	1.3	513.5	1 343.1
Dublin town, Bladen County	246	1.1	.4	223.6	615.0
Dunn city, Harnett County	8 336	13.5	5.2	617.5	1 603.1
Durham city	136 611	179.4	69.3	761.5	1 971.3
Durham County	136 594	179.4	69.3	761.4	1 971.1
Orange County	17	–	–	–	–
Earl town, Cleveland County	230	2.1	.8	109.5	287.5
East Arcadia town, Bladen County	468	5.6	2.2	83.6	212.7
East Bend town, Yadkin County	619	3.3	1.3	187.6	476.2
East Flat Rock CDP, Henderson County	3 218	8.8	3.4	365.7	946.5
East Laurinburg town, Scotland County	302	.3	.1	1 006.7	3 020.0
Eastover CDP, Cumberland County	1 243	7.8	3.0	159.4	414.3
East Rockingham CDP, Richmond County	4 158	8.9	3.4	467.2	1 222.9
East Spencer town, Rowan County	2 055	3.3	1.3	622.7	1 580.8
Eden city, Rockingham County	15 238	30.3	11.7	502.9	1 302.4
Edenton town, Chowan County	5 268	12.8	4.9	411.6	1 075.1
Elizabeth City city	14 292	11.7	4.5	1 221.5	3 176.0
Camden County	29	.1	–	290.0	–
Pasquotank County	14 263	11.6	4.5	1 229.6	3 169.6
Elizabethtown town, Bladen County	3 704	9.6	3.7	385.8	1 001.1
Elkin town	3 790	13.8	5.3	274.6	715.1
Surry County	3 720	13.6	5.2	273.5	715.4
Wilkes County	70	2	.1	350.0	700.0
Elk Park town, Avery County	486	1.8	.7	270.0	694.3
Ellenboro town, Rutherford County	514	2.4	.9	214.2	571.1
Ellerbe town, Richmond County	1 132	2.6	1.0	435.4	1 132.0
Elm City town, Wilson County	1 624	1.9	.7	854.7	2 320.0
Elon College town, Alamance County	4 394	6.5	2.5	676.0	1 757.6
Elroy CDP, Wayne County	4 028	17.5	6.8	230.2	592.4
Emerald Isle town, Carteret County	2 434	13.6	5.2	179.0	468.1
Enfield town, Halifax County	3 082	3.2	1.2	963.1	2 568.3
Enochville CDP, Rowan County	2 901	11.4	4.4	254.5	659.3
Erwin town, Harnett County	4 061	8.7	3.3	466.8	1 230.6
Etowah CDP, Henderson County	1 997	10.8	4.2	184.9	475.5
Eureka town, Wayne County	282	.9	.4	313.3	705.0
Everetts town, Martin County	143	1.2	.5	119.2	286.0
Fair Bluff town, Columbus County	1 068	5.2	2.0	205.4	534.0
Fairmont town, Robeson County	2 489	5.1	2.0	488.0	1 244.5
Fairplains CDP, Wilkes County	2 339	11.9	4.6	196.6	508.5
Fairview CDP, Buncombe County	1 830	16.1	6.2	113.7	295.2
Faison town, Duplin County	701	2.2	.8	318.6	876.3
Faith town, Rowan County	553	1.9	.8	291.1	691.3
Falcon town	216	3.2	1.3	67.5	166.2
Cumberland County	216	3.0	1.1	72.0	196.4
Sampson County	–	.3	.1	–	–
Falkland town, Pitt County	108	.6	.2	180.0	540.0
Fallston town, Cleveland County	498	5.6	2.2	88.9	226.4
Farmville town, Pitt County	4 392	6.1	2.4	720.0	1 830.0
Fayetteville city, Cumberland County	75 695	105.1	40.6	720.2	1 864.4
Fearrington CDP, Chatham County	1 101	5.7	2.2	193.2	500.5
Flat Rock CDP, Surry County	1 812	7.2	2.8	251.7	647.1
Fletcher town, Henderson County	2 787	12.2	4.7	228.4	593.0
Forest City town, Rutherford County	7 475	16.8	6.5	444.9	1 150.0
Forest Oaks CDP, Guilford County	3 054	13.1	5.1	233.1	598.8
Fort Bragg CDP, Cumberland County	34 744	49.2	19.0	706.2	1 828.6
Fountain town, Pitt County	445	1.4	.5	317.9	890.0
Four Oaks town, Johnston County	1 308	2.5	1.0	523.2	1 308.0
Foxfire village, Moore County	334	7.2	2.8	46.4	119.3
Franklin town, Macon County	2 873	9.1	3.5	315.7	820.9
Franklinton town, Franklin County	1 615	2.0	.8	807.5	2 018.8
Franklinville town, Randolph County	666	2.5	1.0	266.4	666.0
Fremont town, Wayne County	1 710	3.5	1.4	488.6	1 221.4
Fuquay-Varina town, Wake County	4 562	14.0	5.4	325.9	844.8
Gamewell town, Caldwell County	3 357	18.6	7.2	180.5	466.3
Garland town, Sampson County	746	2.8	1.1	266.4	678.2
Garner town, Wake County	14 967	29.5	11.4	507.4	1 312.9
Garysburg town, Northampton County	1 057	2.5	1.0	422.8	1 057.0
Gaston town, Northampton County	1 003	4.4	1.7	228.0	590.0
Gastonia city, Gaston County	54 732	78.7	30.4	695.5	1 800.4
Gatesville town, Gates County	308	1.1	.4	280.0	770.0
Gibson town, Scotland County	532	2.5	1.0	212.8	532.0
Gibsonville town	3 441	5.4	2.1	637.2	1 638.6
Alamance County	1 480	2.1	.8	704.8	1 850.0
Guilford County	1 961	3.3	1.3	594.2	1 508.5
Glen Alpine town, Burke County	563	2.4	.9	234.6	625.6
Glen Raven CDP, Alamance County	2 616	11.2	4.3	233.6	608.4
Godwin town, Cumberland County	77	6	.2	128.3	385.0
Goldsboro city, Wayne County	40 709	54.5	21.0	747.0	1 938.5
Goldston town, Chatham County	299	2.0	.8	149.5	373.8
Gorman CDP, Durham County	1 090	8.0	3.1	136.3	351.6
Graham city, Alamance County	10 426	18.3	7.1	569.7	1 468.5
Grandfather village, Avery County	34	3.9	1.5	8.7	22.7
Granite Falls town, Caldwell County	3 253	8.5	3.3	382.7	985.8
Granite Quarry town, Rowan County	1 646	4.4	1.7	374.1	968.2
Greenevers town, Duplin County	512	4.2	1.6	121.9	320.0
Greensboro city, Guilford County	183 521	206.7	79.8	887.9	2 299.8
Greenville city, Pitt County	44 972	46.7	18.0	963.0	2 498.4
Grifton town	2 393	4.0	1.5	598.3	1 595.3
Lenoir County	253	4	.1	632.5	2 530.0
Pitt County	2 140	3.6	1.4	594.4	1 528.6
Grimesland town, Pitt County	469	1.3	.5	360.8	938.0
Grover town, Cleveland County	516	2.2	.9	234.5	573.3
Half Moon CDP, Onslow County	6 306	16.3	6.3	386.9	1 001.0
Halifax town, Halifax County	327	1.1	.4	297.3	817.5
Hamilton town, Martin County	544	1.2	.5	453.3	1 088.0
Hamlet city, Richmond County	6 196	10.7	4.1	579.1	1 511.2
Harkers Island CDP, Carteret County	1 759	6.6	2.5	266.5	703.6
Harmony town, Iredell County	431	3.6	1.4	119.7	307.9
Harrells town	187	8.2	3.2	22.8	58.4
Duplin County	2	.7	.3	2.9	6.7
Sampson County	185	7.5	2.9	24.7	63.8
Harrellsville town, Hertford County	106	9	.3	117.8	353.3
Harrisburg town, Cabarrus County	1 625	5.4	2.1	300.9	773.8
Hassell town, Martin County	95	.7	.3	135.7	316.7
Havelock city, Craven County	20 268	38.5	14.9	526.4	1 360.3
Haw River town, Alamance County	1 855	5.2	2.0	356.7	927.5
Hayesville town, Clay County	279	1.0	.4	279.0	697.5
Hays CDP, Wilkes County	1 522	15.8	6.1	96.2	249.5
Hazelwood town, Haywood County	1 678	1.9	.7	883.2	2 397.1
Hemby Bridge CDP, Union County	2 876	8.9	3.4	323.1	845.9
Henderson city, Vance County	15 655	18.3	7.1	855.5	2 204.9
Hendersonville city, Henderson County	7 284	10.9	4.2	668.3	1 734.3

Table 16. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State—County—Place and [In Selected States] County Subdivision	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
PLACE AND COUNTY SUBDIVISION—Con.					
Hertford town, Perquimans County	2 105	5.0	1.9	421.0	1 107.9
Hickory city	28 301	52.6	20.3	538.0	1 394.1
Burke County	79	1.9	.7	41.6	112.9
Catawba County	28 222	50.7	19.6	556.6	1 439.9
Highlands town	948	15.3	5.9	62.0	160.7
Jackson County	4	1.5	.6	2.7	6.7
Macon County	944	13.8	5.3	68.4	178.1
High Point city	69 496	111.4	43.0	623.8	1 616.2
Davidson County	471	1.0	.4	471.0	1 177.5
Forsyth County	6	.1	–	60.0	–
Guilford County	68 982	109.5	42.3	630.0	1 630.8
Randolph County	37	.8	.3	46.3	123.3
High Shoals city, Gaston County	605	4.6	1.8	131.5	336.1
Hildebran town, Burke County	790	3.5	1.3	225.7	607.7
Hillsborough town, Orange County	4 263	9.2	3.5	463.4	1 218.0
Hobgood town, Halifax County	435	2.7	1.0	161.1	435.0
Hoffman town, Richmond County	348	8.9	3.4	39.1	102.4
Holden Beach town, Brunswick County	626	7.7	3.0	81.3	208.7
Holly Ridge town, Onslow County	728	3.6	1.4	202.2	520.0
Holly Springs town, Wake County	908	11.3	4.4	80.4	206.4
Hookerton town, Greene County	422	.7	.3	602.9	1 406.7
Hope Mills town, Cumberland County	8 184	11.8	4.6	693.6	1 779.1
Hot Springs town, Madison County	478	8.0	3.1	59.8	154.2
Hudson town, Caldwell County	2 819	8.1	3.1	348.0	909.4
Huntersville town, Mecklenburg County	3 014	5.0	1.9	602.8	1 586.3
Icard CDP, Burke County	2 553	10.1	3.9	252.8	654.6
Indian Beach town, Carteret County	153	1.3	.5	117.7	306.0
Indian Trail town, Union County	1 942	8.3	3.2	234.0	606.9
Jackson town, Northampton County	592	2.6	1.0	227.7	592.0
Jacksonville city, Onslow County	30 013	33.7	13.0	890.6	2 308.7
James City CDP, Craven County	4 279	12.4	4.8	345.1	891.5
Jamestown town, Guilford County	2 600	5.6	2.2	464.3	1 181.8
Jamesville town, Martin County	612	3.5	1.3	174.9	470 8
Jefferson town, Ashe County	1 300	4.9	1.9	265.3	684.2
Jonesville town, Yadkin County	1 549	4.4	1.7	352.0	911.2
Kannapolis city	29 696	40.7	15.7	729.6	1 891.5
Cabarrus County	21 220	28.9	11.1	734.3	1 911.7
Rowan County	8 476	11.8	4.6	718.3	1 842.6
Kelford town, Bertie County	204	1.3	.5	156.9	408.0
Kenansville town, Duplin County	856	4.9	1.9	174.7	450.5
Kenly town	1 549	2.3	.9	673.5	1 721.1
Johnston County	1 396	2.1	.8	664.8	1 745.0
Wilson County	153	.1	.1	1 530.0	1 530.0
Kernersville town	10 836	18.7	7.2	579.5	1 505.0
Forsyth County	10 836	18.7	7.2	579.5	1 505.0
Guilford County	–	–	–	–	–
KR Devil Hals town, Dare County	4 238	14.2	5.5	298.5	770.5
King city	4 059	9.1	3.5	446.0	1 159.7
Forsyth County	–	.2	.1	–	–
Stokes County	4 059	9.0	3.5	451 0	1 159.7
Kings Mountain city	8 763	15.1	5.8	580 3	1 510.9
Cleveland County	8 007	14.3	5.5	559 9	1 455.8
Gaston County	756	.8	.3	945.0	2 520.0
Kingstown town, Cleveland County	956	4.6	1.8	207 8	531.1
Kinston city, Lenoir County	25 295	34.0	13.1	744 0	1 930.9
Kittrell town, Vance County	228	.5	.2	456.0	1 140.0
Kitty Hawk town Dare County	1 937	21.2	8.2	91 4	236.2
Knightdale town, Wake County	1 884	3.6	1.4	523.3	1 345.7
Kure Beach town, New Hanover County	619	2.1	.8	294.8	773.8
La Grange town, Lenoir County	2 805	5.3	2.0	529.2	1 402.5
Lake Junaluska CDP, Haywood County	2 482	13.7	5.3	181.2	468.3
Lake Lure town, Rutherford County	691	35.1	13.6	19 7	50.8
Lake Waccamaw town Columbus County	954	6.5	2.5	146 8	381.6
Landis town, Rowan County	2 333	4.0	1.5	583.3	1 555.3
Lansing town, Ashe County	171	1.0	.4	171.0	427.5
Lasker town, Northampton County	139	3.3	1.3	42 1	106.9
Lattimore town Cleveland County	183	2.0	.8	91 5	228.8
Laurel Park town, Henderson County	1 322	5.7	2.2	231.9	600 9
Laurinburg city, Scotland County	11 643	19.5	7 5	597 1	1 552.4
Lawndale town, Cleveland County	573	1.8	.7	318.3	818.6
Leggett town, Edgecombe County	108	1.8	.7	60 0	154.3
Leland town, Brunswick County	1 801	5.4	2.1	333.5	857.6
Lenoir city, Caldwell County	14 192	35.2	13.6	403 2	1 043 5
Lewiston Woodville town, Bertie County	788	5.1	2.0	154 5	394.0
Lewisville CDP, Forsyth County	3 206	9 5	3.7	337 5	866.5
Lexington city, Davidson County	16 581	31.1	12.0	533 2	1 381.8
Liberty town, Randolph County	2 047	6.5	2.5	314 9	818.8
Light Oak CDP, Cleveland County	1 339	3.9	1.5	343 3	892.7
Lilesville town, Anson County	468	2.6	1.0	180 0	468.0
Lillington town, Harnett County	2 048	5 2	2.0	393 8	1 024 0
Lincolnton city, Lincoln County	6 847	14.3	5.5	478.8	1 244.9
Linden town, Cumberland County	180	1.3	.5	138 5	360.0
Littleton town, Halifax County	691	2.5	1.0	276 4	691.0
Locust city, Stanly County	1 940	9.6	3.7	202 1	524.3
Long Beach town, Brunswick County	3 816	15.9	6.1	240 0	625.6
Long View town	3 229	5.7	2.2	566 5	1 467 7
Burke County	358	.6	.2	596 7	1 790.0
Catawba County	2 871	5 1	2.0	562 9	1 435.5
Louisburg town Franklin County	3 037	4.9	1.9	619 8	1 598.4
Love Valley town, Iredell County	67	.5	.2	134.0	335.0
Lowell city, Gaston County	2 704	6.8	2.6	397.6	1 040.0
Lowesville CDP, Lincoln County	1 092	17.6	6.8	62.0	160.6
Lucama town, Wilson County	933	1.4	.5	666.4	1 866.0
Lumber Bridge town, Robeson County	109	1.7	.7	64.1	155.7
Lumberton city, Robeson County	18 601	31.1	12.0	598.1	1 550.1
McAdenville town, Gaston County	830	3.6	1.4	230.6	592.9
Macclesfield town, Edgecombe County	493	1.3	.5	379.2	986.0
McDonald town, Robeson County	88	.7	.3	125.7	293.3
McFarlan town, Anson County	98	2.4	.9	40.8	108.9
McLeansville CDP, Guilford County	1 154	16.8	6.5	68.7	177.5
Macon town, Warren County	154	1.2	.5	128.3	308.0
Madison town, Rockingham County	2 371	7.3	2.8	324.8	846.8
Maggie Valley town, Haywood County	185	2.0	.8	92.5	231.3
Magnolia town, Duplin County	747	2.7	1.0	276.7	747.0
Maiden town	2 574	7.3	2.8	352.6	919.3
Catawba County	2 574	7.2	2.8	357.5	919.3
Lincoln County	–	.1	–	–	–
Manteo town, Dare County	991	4.0	1.5	247.8	660.7
Marietta town, Robeson County	206	2.9	1.1	71.0	187.3
Marion city, McDowell County	4 765	8.3	3.2	574.1	1 489.1
Mar-Mac CDP, Wayne County	3 282	11.5	4.5	285.4	729.3
Marshall town, Madison County	809	8.7	3.3	93.0	245.2
Mars Hill town, Madison County	1 611	4.8	1.8	335.6	895.0
Marshville town, Union County	2 020	4.4	1.7	459.1	1 188.2
Masonboro CDP, New Hanover County	7 010	15.8	6.1	443.7	1 149.2
Matthews town, Mecklenburg County	13 651	31.8	12.3	429.3	1 109.8
Maxton town	2 373	5.1	2.0	465.3	1 186.5
Robeson County	2 164	4.6	1.8	470.4	1 202.2
Scotland County	209	.6	.2	348.3	1 045.0
Mayodan town, Rockingham County	2 471	3.9	1.5	633.6	1 647.3
Maysville town, Jones County	892	1.8	.7	495.6	1 274.3
Mebane city	4 754	8.4	3.2	566.0	1 485.6
Alamance County	4 269	7.7	3.0	554.4	1 423.0
Orange County	485	.6	.2	808.3	2 425.0
Mesic town, Pamlico County	310	2.8	1.1	110.7	281.8
Micro town, Johnston County	417	1.0	.4	417.0	1 042.5
Middleburg town, Vance County	131	1.5	.6	87.3	218.3
Middlesex town, Nash County	730	1.4	.6	521.4	1 216.7
Millers Creek CDP, Wilkes County	1 787	11.2	4.3	159.6	415.6
Milton town, Caswell County	185	.9	.3	205.6	616.7
Minnesott Beach town, Pamlico County	266	3.9	1.5	68.2	177.3
Mint Hill town, Mecklenburg County	11 567	46.8	18.1	247.2	639.1
Mocksville town, Davie County	3 399	12.9	5.0	263.5	679.8
Monroe city, Union County	16 127	35.9	13.9	449.2	1 160.2
Montreat town, Buncombe County	693	7.2	2.8	96.3	247.5
Mooresboro city, Cleveland County	294	4.6	1.8	63.9	163.3
Mooresville town, Iredell County	9 317	15.3	5.9	609.0	1 579.2
Moravian Falls CDP, Wilkes County	1 736	13.4	5.2	129.6	333.8
Morehead City town, Carteret County	6 046	6.8	2.6	889.1	2 325.4
Morganton city, Burke County	15 085	43.3	16.7	348.4	903 3
Morrisville town	1 022	15.1	5.8	67.7	176.2
Durham County	–	.1	–	–	–
Wake County	1 022	14.9	5.8	68.6	176.2
Marven town, Anson County	590	2.7	1.1	218.5	536.4
Mountain Home CDP, Henderson County	1 898	6.9	2.7	275.1	703.0
Mountain View CDP, Catawba County	3 697	12.1	4.7	305.5	786.6
Mount Airy city, Surry County	7 156	16.4	6.3	436.3	1 135.9
Mount Gilead town, Montgomery County	1 336	8.1	3.1	164.9	431.0
Mount Holly city, Gaston County	7 710	17.5	6.8	440.6	1 133.8
Mount Olive town	4 582	5 9	2.3	776.6	1 992.2
Duplin County	1	–	–	–	–
Wayne County	4 581	5 9	2.3	776.4	1 991.7
Mount Pleasant town, Cabarrus County	1 027	3 3	1.3	311.2	790.0
Mulberry CDP, Wilkes County	2 339	13.2	5.1	177.2	458.6
Murfreesboro town, Hertford County	2 580	4 8	1 9	537.5	1 357.9
Murphy town, Cherokee County	1 575	5.9	2.3	266.9	684.8
Myrtle Grove CDP, New Hanover County	4 275	17 8	6.9	240.2	619.6
Nags Head town, Dare County	1 838	16.4	6.3	112.1	291.7
Nashville town, Nash County	3 617	6 8	2.6	531.9	1 391.2
Navassa town, Brunswick County	445	6 2	2.4	71.8	185.4
Neuse Forest CDP, Craven County	1 110	7 7	3.0	144.2	370 0
New Bern city, Craven County	17 363	26 5	10.2	655.2	1 702.3
New Hope CDP, Wake County	5 694	21 4	8.3	266.1	686 0
New Hope CDP, Wayne County	4 491	12 7	4 9	353.6	916.5
Newland town, Avery County	645	1 7	.7	379.4	921 4
New London town, Stanly County	414	1 6	.6	258.8	690 0
Newport town, Carteret County	2 516	5 0	1.9	503.2	1 324 2
New River Station CDP, Onslow County	9 732	19 8	7.6	491.5	1 280.5
Newton city, Catawba County	9 304	21 1	8.1	440.9	1 148 6
Newton Grove town, Sampson County	311	7 8	3.0	65.5	170 3
Norlina town, Warren County	996	2 9	1.1	343.4	905 5
Norman town, Richmond County	105	1 1	.4	95.5	262.5
North Hickory CDP, Catawba County	4 299	13 5	5.2	318.4	826 7

Table 16. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State—County—Place and [In Selected States] County Subdivision	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
PLACE AND COUNTY SUBDIVISION—Con.					
Northlakes CDP, Caldwell County	1 219	9.6	3.7	127.0	329.5
North Wilkesboro town, Wilkes County	3 384	12.2	4.7	277.4	720.0
Norwood town, Stanly County	1 617	4.1	1.6	394.4	1 010.6
Oakboro town, Stanly County	600	1.6	.6	375.0	1 000.0
Oak City town, Martin County	389	1.2	.5	324.2	778.0
Ocean Isle Beach town, Brunswick County	523	6.6	2.5	79.2	209.2
Ogden CDP, New Hanover County	3 228	12.2	4.7	264.6	686.8
Old Fort town, McDowell County	720	2.4	.9	300.0	800.0
Oriental town, Pamlico County	786	2.8	1.1	280.7	714.5
Orrum town, Robeson County	103	1.5	.6	68.7	171.7
Oxford city, Granville County	7 913	10.8	4.2	732.7	1 884.0
Pantego town, Beaufort County	171	2.1	.8	81.4	213.8
Parkton town, Robeson County	367	1.6	.6	229.4	611.7
Parkwood CDP, Durham County	4 123	5.3	2.0	777.9	2 061.5
Parmele town, Martin County	321	2.6	1.0	123.5	321.0
Patterson Springs town, Cleveland County	690	2.7	1.0	255.6	690.0
Peachland town, Anson County	384	2.5	1.0	153.6	384.0
Pembroke town, Robeson County	2 241	5.0	1.9	448.2	1 179.5
Pikeville town, Wayne County	598	1.1	.4	543.6	1 495.0
Pilot Mountain town, Surry County	1 181	4.3	1.7	274.7	694.7
Pinebluff town, Moore County	876	5.8	2.2	151.0	398.2
Pinehurst town, Moore County	5 103	28.8	11.1	177.2	459.7
Pine Knoll Shores town, Carteret County	1 360	5.9	2.3	230.5	591.3
Pine Level town, Johnston County	1 217	2.7	1.1	450.7	1 106.4
Pinetops town, Edgecombe County	1 514	2.6	1.0	582.3	1 514.0
Pineville town, Mecklenburg County	2 970	7.2	2.8	412.5	1 060.7
Piney Green CDP, Onslow County	8 999	35.2	13.6	255.7	661.7
Pink Hill town, Lenoir County	547	1.2	.5	455.8	1 094.0
Pittsboro town, Chatham County	1 436	6.3	2.4	227.9	598.3
Pleasant Garden CDP, Guilford County	2 228	10.8	4.2	206.3	530.5
Pleasant Hill CDP, Wilkes County	1 114	9.4	3.6	118.5	309.4
Plymouth town, Washington County	4 328	9.7	3.8	446.2	1 138.9
Polkton town, Anson County	662	5.0	1.9	132.4	348.4
Polkville city, Cleveland County	1 514	52.0	20.1	29.1	75.3
Pollocksville town, Jones County	299	.8	.3	373.8	996.7
Pope AFB CDP, Cumberland County	2 857	7.6	2.9	375.9	985.2
Poplar Tent CDP, Cabarrus County	3 872	14.2	5.5	272.7	704.0
Powellsville town, Bertie County	103	.9	.3	114.4	343.3
Princeton town, Johnston County	1 181	1.8	.7	656.1	1 687.1
Princeville town, Edgecombe County	1 652	2.7	1.0	611.9	1 652.0
Proctorville town, Robeson County	168	1.1	.4	152.7	420.0
Pumpkin Center CDP, Onslow County	2 857	5.6	2.2	510.2	1 298.6
Raeford city, Hoke County	3 469	7.3	2.8	475.2	1 238.9
Raleigh city, Wake County	207 951	228.3	88.1	910.9	2 360.4
Ramseur town, Randolph County	1 186	3.4	1.3	348.8	912.3
Randleman city, Randolph County	2 612	7.1	2.7	367.9	967.4
Ranlo town, Gaston County	1 650	2.9	1.1	569.0	1 500.0
Raynham town, Robeson County	106	.4	.2	265.0	530.0
Red Oak town, Nash County	280	4.6	1.8	60.9	155.6
Red Springs town, Robeson County	3 799	6.2	2.4	612.7	1 582.9
Reidsville city, Rockingham County	12 183	20.5	7.9	594.3	1 542.2
Rennert town, Robeson County	217	2.1	.8	103.3	271.3
Rhodhiss town	638	1.9	.7	335.8	911.4
Burke County	226	.9	.4	251.1	565.0
Caldwell County	412	1.0	.4	412.0	1 030.0
Richfield town, Stanly County	535	5.1	2.0	104.9	267.5
Richlands town, Onslow County	996	3.0	1.2	332.0	830.0
Rich Square town, Northampton County	1 058	7.3	2.8	144.9	377.9
River Bend town, Craven County	2 408	6.6	2.5	364.8	963.2
River Road CDP, Beaufort County	3 892	18.3	7.1	212.7	548.2
Roanoke Rapids city, Halifax County	15 722	20.1	7.8	782.2	2 015.6
Robbins city, Moore County	970	2.7	1.0	359.3	970.0
Robbinsville town, Graham County	709	1.2	.4	590.8	1 772.5
Robersonville town, Martin County	1 940	3.1	1.2	625.8	1 616.7
Rockingham city, Richmond County	9 399	16.9	6.5	556.2	1 446.0
Rockwell town, Rowan County	1 598	3.6	1.4	443.9	1 141.4
Rocky Mount city	48 997	64.7	25.0	757.3	1 959.9
Edgecombe County	17 057	16.4	6.3	1 040.1	2 707.5
Nash County	31 940	48.3	18.7	661.3	1 708.0
Rolesville town, Wake County	572	2.2	.9	260.0	635.6
Ronda town, Wilkes County	367	2.8	1.1	131.1	333.6
Roper town, Washington County	669	2.2	.9	304.1	743.3
Roseboro town, Sampson County	1 441	3.0	1.2	480.3	1 200.8
Rose Hill town, Duplin County	1 287	3.3	1.3	390.0	990.0
Rosman town, Transylvania County	385	1.1	.4	350.0	962.5
Rowland town, Robeson County	1 139	2.6	1.0	438.1	1 139.0
Roxboro city, Person County	7 332	10.2	3.9	718.8	1 880.0
Roxobel town, Bertie County	244	2.7	1.0	90.4	244.0
Royal Pines CDP, Buncombe County	4 418	7.9	3.0	559.2	1 472.7
Rural Hall town, Forsyth County	1 652	2.6	1.0	635.4	1 652.0
Ruth town, Rutherford County	366	1.1	.4	332.7	915.0
Rutherford College town, Burke County	1 126	5.0	1.9	225.2	592.6
Rutherfordton town, Rutherford County	3 617	10.6	4.1	341.2	882.2
St. Helena village, Pender County	321	14.6	5.7	22.0	56.3
St. Pauls town, Robeson County	1 992	2.8	1.1	711.4	1 810.9
St. Stephens CDP, Catawba County	8 734	25.7	9.9	339.8	882.2
Salem CDP, Burke County	2 271	11.3	4.4	201.0	516.1
Salemburg town, Sampson County	409	2.5	1.0	163.6	409.0
Salisbury city, Rowan County	23 087	42.4	16.4	544.5	1 407.7
Saluda city	488	3.7	1.4	131.9	348.6
Henderson County	3	.2	.1	15.0	30.0
Polk County	485	3.5	1.4	138.6	346.4
Sandy Creek town, Brunswick County	243	1.6	.6	151.9	405.0
Sanford city, Lee County	14 475	36.1	14.0	401.0	1 033.9
Sawmills town, Caldwell County	4 088	13.0	5.0	314.5	817.6
Saxapahaw CDP, Alamance County	1 178	13.6	5.2	86.6	226.5
Scotland Neck town, Halifax County	2 575	3.2	1.2	804.7	2 145.8
Seaboard town, Northampton County	791	2.7	1.0	293.0	791.0
Seagate CDP, New Hanover County	5 444	11.5	4.4	473.4	1 237.3
Seagrove town, Randolph County	244	1.9	.7	128.4	348.6
Sedge Garden CDP, Forsyth County	2 784	9.4	3.6	296.2	773.3
Selma town, Johnston County	4 600	8.0	3.1	575.0	1 483.9
Seven Devils town	117	5.3	2.1	22.1	55.7
Avery County	20	1.7	.7	11.8	28.6
Watauga County	97	3.6	1.4	26.9	69.3
Seven Lakes CDP, Moore County	2 049	21.1	8.2	97.1	249.9
Seven Springs town, Wayne County	163	.9	.3	181.1	543.3
Severn town, Northampton County	260	2.6	1.0	100.0	260.0
Shallotte town, Brunswick County	965	8.3	3.2	116.3	301.6
Sharpsburg town	1 536	2.4	.9	640.0	1 706.7
Edgecombe County	70	.3	.1	233.3	700.0
Nash County	1 054	1.6	.6	658.8	1 756.7
Wilson County	412	.4	.2	1 030.0	2 060.0
Shelby city, Cleveland County	14 669	22.7	8.8	646.2	1 666.9
Sherrills Ford CDP, Catawba County	3 185	30.6	11.8	104.1	269.9
Siler City town, Chatham County	4 808	12.0	4.6	400.7	1 045.2
Silver City CDP, Hoke County	1 343	4.1	1.6	327.6	839.4
Silver Lake CDP, New Hanover County	4 071	17.0	6.6	239.5	616.8
Simpson village, Pitt County	410	.9	.4	455.6	1 025.0
Sims town, Wilson County	124	.3	.1	413.3	1 240.0
Smith Creek CDP, New Hanover County	7 461	13.8	5.3	540.7	1 407.7
Smithfield town, Johnston County	7 540	12.2	4.7	618.0	1 604.3
Sneads Ferry CDP, Onslow County	2 031	9.7	3.8	209.4	534.5
Snow Hill town, Greene County	1 378	2.5	1.0	551.2	1 378.0
Southern Pines town, Moore County	9 129	26.8	10.4	340.6	877.8
Southern Shores town, Dare County	1 447	10.3	4.0	140.5	361.8
South Gastonia CDP, Gaston County	5 487	17.4	6.7	315.3	819.0
South Henderson CDP, Vance County	1 374	5.1	2.0	269.4	687.0
Southport city, Brunswick County	2 369	5.0	1.9	473.8	1 246.8
South Rosemary CDP, Halifax County	1 955	10.5	4.1	186.2	476.8
South Weldon CDP, Halifax County	1 640	7.4	2.8	221.6	585.7
Sparta town, Alleghany County	1 957	6.1	2.4	320.8	815.4
Speed town, Edgecombe County	88	.7	.3	125.7	293.3
Spencer town, Rowan County	3 219	5.6	2.2	574.8	1 463.2
Spencer Mountain town, Gaston County	135	1.3	.5	103.8	270.0
Spindale town, Rutherford County	4 040	13.5	5.2	299.3	776.9
Spring Hope town, Nash County	1 221	3.5	1.4	348.9	872.1
Spring Lake town, Cumberland County	7 524	7.8	3.0	964.6	2 508.0
Spruce Pine town, Mitchell County	2 010	10.9	4.2	184.4	478.6
Staley town, Randolph County	204	1.6	.6	127.5	340.0
Stallings town, Union County	2 132	8.0	3.1	266.5	687.7
Stanfield town, Stanly County	517	2.9	1.1	178.3	470.0
Stanley town, Gaston County	2 823	5.1	2.0	553.5	1 411.5
Stanleyville CDP, Forsyth County	4 779	17.5	6.7	273.1	713.3
Stantonsburg town, Wilson County	782	1.4	.5	558.6	1 564.0
Star town, Montgomery County	775	2.7	1.0	287.0	775.0
Statesville city, Iredell County	17 567	33.5	12.9	524.4	1 361.8
Stedman town, Cumberland County	577	3.2	1.2	180.3	480.8
Stem town, Granville County	249	2.4	.9	103.8	276.7
Stokesdale town, Guilford County	2 134	49.4	19.1	43.2	111.7
Stoneville town, Rockingham County	1 109	3.2	1.2	346.6	924.2
Stonewall town, Pamlico County	279	4.4	1.7	63.4	164.1
Stony Point CDP	1 286	7.7	3.0	167.0	428.7
Alexander County	1 131	6.2	2.4	182.4	471.3
Iredell County	155	1.5	.6	103.3	258.3
Stovall town, Granville County	409	2.7	1.0	151.5	409.0
Sugar Mountain village, Avery County	132	5.9	2.3	22.4	57.4
Summerfield CDP, Guilford County	2 051	23.7	9.2	86.5	222.9
Sunset Beach town, Brunswick County	311	6.2	2.4	50.2	129.6
Surf City town	970	10.1	3.9	96.0	248.7
Onslow County	317	1.6	.5	226.4	634.0
Pender County	653	8.7	3.3	75.1	197.9
Swannanoa CDP, Buncombe County	3 538	14.8	5.7	239.1	620.7
Swansboro town, Onslow County	1 165	1.6	.6	728.1	1 941.7
Swepsonville CDP, Alamance County	1 195	5.0	1.9	239.0	628.9
Sylva town, Jackson County	1 809	5.9	2.3	306.6	786.5
Tabor City town, Columbus County	2 330	6.6	2.6	353.0	896.2
Tarboro town, Edgecombe County	11 037	23.5	9.1	469.7	1 212.9
Tar Heel town, Bladen County	115	6	2	191.7	575.0
Taylorsville town, Alexander County	1 566	3.2	1.2	489.4	1 305.0
Taylortown town, Moore County	543	2.7	1.0	201.1	543.0
Teachey town, Duplin County	244	2.1	.8	116.2	305.0
Thomasville city, Davidson County	15 915	26.1	10.1	609.8	1 575.7
Toast CDP, Surry County	2 125	5.1	2.0	416.7	1 062.5
Topsail Beach town, Pender County	346	11.3	4.4	30.6	78.6
Trenton town, Jones County	248	5	.2	496.0	1 240.0
Trent Woods town, Craven County	2 366	4.6	1.8	514.3	1 314.4
Trinity CDP, Randolph County	5 469	33.5	12.9	163.3	424.0
Troutman town, Iredell County	1 493	3.8	1.5	392.9	995.3
Troy town, Montgomery County	3 404	6.6	2.6	515.8	1 309.2
Tryon town, Polk County	1 680	4.6	1.8	365.2	933.3
Turkey town, Sampson County	234	1.0	.4	234.0	585.0
Valdese town, Burke County	3 914	10.9	4.2	359.1	931.9

Table 16. Land Area and Population Density: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	All persons	Land area		Persons per—	
		Square kilometers	Square miles	Square kilometer	Square mile
PLACE AND COUNTY SUBDIVISION—Con.					
Valley Hill CDP, Henderson County	1 802	6.2	2.4	290.6	750.8
Vanceboro town, Craven County	946	4.4	1.7	215.0	556.5
Vandemere town, Pamlico County	299	3.9	1.5	76.7	199.3
Vander CDP, Cumberland County	1 179	9.9	3.8	119.1	310.3
Varnamtown town, Brunswick County	404	2.6	1.0	155.4	404.0
Vass town, Moore County	670	7.8	3.0	85.9	223.3
Waco town, Cleveland County	320	2.1	.8	152.4	400.0
Wade town, Cumberland County	238	2.5	1.0	95.2	238.0
Wadesboro town, Anson County	3 645	7.7	3.0	473.4	1 215.0
Wagram town, Scotland County	480	3.1	1.2	154.8	400.0
Wake Forest town, Wake County	5 769	12.5	4.8	461.5	1 201.9
Walkertown town, Forsyth County	1 200	3.7	1.4	324.3	857.1
Wallace town	2 939	5.4	2.1	544.3	1 399.5
Duplin County	2 911	4.7	1.8	619.4	1 617.2
Pender County	28	.8	.3	35.0	93.3
Walnut Cove town, Stokes County	1 068	5.2	2.0	209.2	544.0
Walnut Creek village, Wayne County	623	2.8	1.1	222.5	566.4
Walstonburg town, Greene County	188	.9	.3	208.9	626.7
Wanchese CDP, Dare County	1 380	12.1	4.7	114.0	293.6
Warrenton town, Warren County	949	2.3	.9	412.6	1 054.4
Warsaw town, Duplin County	2 859	6.6	2.5	433.2	1 143.6
Washington city, Beaufort County	9 075	14.8	5.7	613.2	1 592.1
Washington Park town, Beaufort County	403	.7	.3	575.7	1 343.3
Watha town, Pender County	99	2.4	.9	41.3	110.0
Waxhaw town, Union County	1 294	2.9	1.1	446.2	1 176.4
Waynesville town, Haywood County	6 758	15.0	5.8	450.5	1 165.2
Weaverville town, Buncombe County	2 107	5.6	2.2	376.3	957.7
Webster town, Jackson County	410	4.2	1.6	97.6	256.3
Weddington town	3 803	37.7	14.6	100.9	260.5
Mecklenburg County	–	–	–	–	–
Union County	3 803	37.7	14.6	100.9	260.5
Welcome CDP, Davidson County	3 377	21.7	8.4	155.6	402.0
Weldon town, Halifax County	1 392	4.6	1.8	302.6	773.3
Wendell town, Wake County	2 822	4.1	1.6	688.3	1 763.8
West Canton CDP, Haywood County	1 119	3.7	1.4	302.4	799.3
West Jefferson town, Ashe County	1 002	3.8	1.5	263.7	668.0
West Marion CDP, McDowell County	1 291	4.8	1.9	269.0	679.5
Westport CDP, Lincoln County	1 280	8.1	3.1	158.0	412.9
West Smithfield CDP, Johnston County	2 411	8.5	3.3	283.6	730.6
Whispering Pines village, Moore County	1 243	6.6	2.5	188.3	497.2
Whiteburs town	860	2.1	.8	409.5	1 075.0
Edgecombe County	464	1.0	.4	464.0	1 160.0
Nash County	396	1.1	.4	360.0	990.0
White Lake town, Bladen County	390	2.3	.9	169.6	433.3
White Plains CDP, Surry County	1 027	10.0	3.9	102.7	263.3
Whiteville city, Columbus County	5 078	9.9	3.8	512.9	1 336.3
Wilkesboro town, Wilkes County	2 573	11.3	4.4	227.7	584.8
Williamston town, Martin County	5 503	7.6	2.9	724.1	1 897.6
Wilmington city, New Hanover County	55 530	76.9	29.7	722.1	1 869.7
Wilson city, Wilson County	36 930	47.9	18.5	771.0	1 996.2
Windemere CDP, New Hanover County	4 604	9.9	3.8	465.1	1 211.6
Windsor town, Bertie County	2 056	5.9	2.3	348.5	893.9
Winfall town, Perquimans County	501	5.3	2.0	94.5	250.5
Wingate town, Union County	2 821	3.6	1.4	783.6	2 015.0
Winston-Salem city, Forsyth County	143 485	184.2	71.1	779.0	2 018.1
Winterville town, Pitt County	2 816	3.3	1.3	853.3	2 166.2
Winton town, Hertford County	796	2.1	.8	379.0	995.0
Woodfin town, Buncombe County	2 736	8.5	3.3	321.9	829.1
Woodland town, Northampton County	760	3.1	1.2	245.2	633.3
Wrightsboro CDP, New Hanover County	4 752	32.0	12.4	148.5	383.2
Wrightsville Beach town, New Hanover County	2 937	3.4	1.3	863.8	2 259.2
Yadkinville town, Yadkin County	2 525	6.7	2.6	376.9	971.2
Yanceyville town, Caswell County	1 973	10.6	4.1	186.1	481.2
Yaupon Beach town, Brunswick County	734	2.0	.8	367.0	917.5
Youngsville town, Franklin County	424	1.5	.6	282.7	706.7
Zebulon town, Wake County	3 173	5.6	2.2	566.6	1 442.3

REFERENCE 20

NUS CORPORATION
1927 LAKESIDE PARKWAY
SUITE 614
TUCKER, GEORGIA 30084
404-938-7710

C-586-8-0-19

August 3, 1990

Mr. A.R. Hanke
Waste Chemicals Branch
Waste Management Division
Environmental Protection Agency
345 Courtland Street, N. E.
Atlanta, Georgia 30365

Date: _____
Site Disposition: _____
EPA Project Manager: _____

Subject: Screening Site Inspection, Phase I
Union Camp Corporation
Jamestown, Guilford County, North Carolina
EPA ID No. NCD003216959
TDD No. F4-8911-70

Dear Mr. Hanke:

FIT 4 conducted a Phase I Screening Site Inspection at Union Camp Corporation in Jamestown, Guilford County, North Carolina. This assessment included a review of EPA and state file material, completion of a target survey, and an offsite reconnaissance of the facility and surrounding area.

The Union Camp Corporation is located in a small commercial/industrial area of Jamestown. More specifically, the facility is located on Ragsdale Road, less than 100 yards south of Routes 29 and 70. Union Camp Corporation is a single building on approximately 7.9 acres of land and is bordered on the north by Southern Railroad, and on the east by a chemical facility, Chem Central. The south side of the property is heavily wooded down to the Deep River, which is approximately 0.3 miles away. On the west side is Dillon Road, and a convenience store (Ref. 1). The facility has an industrial well on site (Ref. 2).

The Union Camp Corporation has manufactured cardboard boxes at the Jamestown facility since 1946, when the plant was opened by the Highland Container Company. Highland Container merged with Union Camp in 1959 (Ref. 2). In making cardboard containers, the facility has over the years used such raw materials as, inks containing lead and chromium, caustic soda, a water-proofing agent called amerez resin, and formaldehyde, presumably as a preservative. Union Camp stopped using formaldehyde in 1978 (Ref. 2). The utilization of inks with a low lead content began in 1982 (Ref. 3).

Wastes generated from this process resulted from washing the glue and ink off the machinery. The washwater was discharged to the Jamestown city sewer system without pretreatment (Ref. 2). Earlier waste included a potentially hazardous sludge containing ink residues, such as lead (Ref. 3). It is not known where the sludge was disposed.

A small amount of 1,1,1-trichloroethane is used to clean machinery and in removing pads from the printers. All of this is lost by evaporation during use. The rags are reused after offsite laundering (Ref. 2).

Approximately 2 gallons of oil suspected to contain PCBs from an old switch box was disposed of in 1982, as a hazardous waste. The location of disposal is unknown. Number 6 fuel oil also reportedly has been spilled on site and contaminated a nearby stream on at least two occasions in the past. The first fuel oil spill resulted from a broken pipe, and the second spill resulted from a leaking underground storage tank. These fuel oil spills occurred approximately 8 years ago, were reported to state environmental officials at the time, and reportedly have been cleaned up. The plant presently uses natural gas; however, number 6 fuel oil is sometimes used as an alternative (Ref. 2).

The Union Camp Corporation filed a RCRA Part A application for status as a generator and storer of hazardous waste in November 1980 (Ref. 4). In April 1982, the facility requested withdrawal of its Part A application on the grounds of a change in plant processes (Ref. 3). In May 1982, the facility was granted deletion as a generator and storer of waste (Ref. 5). Union Camp was subsequently classified as a small-quantity generator (Ref. 6). Union Camp was deleted as a small-quantity generator in January 1985 and ceased being a RCRA facility at that time (Ref. 6).

Jamestown is located within the Carolina Slate Belt of the Piedmont Physiographic Province (Refs. 7; 8, p. 76). The area is characterized by gently rolling topography with moderately steep slopes along the drainageways (Ref. 9). Jamestown has a temperate climate (Ref. 10, pp. 7, 11). Total annual precipitation averages about 45 inches with a net annual precipitation of 4 inches (Refs. 11, pp. 3, 17; 12).

The geology of Jamestown consists of folded and fractured metamorphic bedrock overlain nearly everywhere by residual material termed saprolite (Refs. 8, p. 77, plate 1; 11, p. 3; 13). The saprolite ranges in thickness from a few feet near rock outcrops to more than 100 feet in interstream areas with an average thickness of 30 feet on most hills and ridges (Refs. 10, p. 38; 11, p. 3). Metamorphic rock types in the area include highly altered granite, gabbro, and diorite (Refs. 7; 8, p. 77, plate 1).

The saprolite and bedrock act as a single hydrologic system, as there is no confining layer present between them. In the saprolite, groundwater occurs within intergranular pore spaces (Ref. 11, p. 4). In the bedrock, groundwater occurs primarily within joints, fractures; and other secondary porosity openings (Ref. 11, p. 4). The frequency, size, and interconnection of both joints and fractures diminishes with depth (Ref. 11, p. 4). There are few open fractures at depths greater than 400 feet (Ref. 10, p. 12).

The saprolite has a hydraulic conductivity of less than 10^{-7} cm/sec and acts as a reservoir which slowly feeds water into the underlying bedrock (Refs. 11, pp. 3, 6; 14). It is also the unit from which most domestic water supplies in the region are obtained (Ref. 8, pp. 23, 77-78). The water is supplied to both dug and bored wells that are completed within the saprolite at, and just below, the water table (Ref. 8, pp. 77-78). The depth to the water table in the facility area is about 15 feet below land surface (Ref. 10, pp. 7, 59).

The surface water pathway from the Union Camp Corporation flows overland in a southerly direction for 0.2 mile until it joins a small stream that enters the Deep River, 0.4 miles south of the facility. One mile farther downstream is the Oakdale treatment facility, which is also the location of the only surface water intake on the 15-mile surface water pathway. This intake serves the city of Jamestown, which maintains connections for 1,000 residences and 150 businesses. The city also purchases water

from the Greensboro and High Point water departments, which have surface water intakes upstream or on different water routes, namely, the Deep River and High Point Lake (Refs. 15, 16, 17). The Deep River is large enough to support recreational fishing (Refs. 1, 15).

Groundwater use in the area is sporadic, with the majority of wells found to the south and southeast of the facility where there is no municipal service. There are approximately 395 residences within a 3-mile radius that rely on private wells for potable supplies; the nearest of these is located on Dillon Road 0.6 mile south of Union Camp. A further 107 potable wells are located between 3 and 4 miles of the study area. The house count was performed using 7.5 minute series topographical maps (Refs. 1, 15).

There are no critical habitats identified in the area of the facility (Ref. 18). Two state-designated threatened species, the Greensboro burrowing crayfish (Cambarus catagius) and the plant Nestronia (Nestronia umbellula), are found in Guilford County (Ref. 19).

Approximately 0.15 mile northeast of Union Camp Corporation is the Jamestown Elementary School, and 0.6 mile to the east is High Point City Park. The nearest residence to the Union Camp facility is located approximately 1,000 feet to the west. The facility's parking lot is easily accessible to the public, although the rest of the actual plant area is either inside the building or in a small, fenced portion behind the facility (Refs. 1, 15). There are approximately 1,011 people living within a 1-mile radius of Union Camp, and 40,421 living within 4 miles (Refs. 15, 20).

Based on the above referenced factors and enclosures, it is recommended that Phase II of this Screening Site Inspection be conducted at Union Camp Corporation on a high-priority basis. If you have any questions or comments please feel free to contact me at NUS Corporation.

Very truly yours,

Bryan J. Williams
Project Manager

Approved:

BJW/tb

Enclosures

cc: Kelly Cain

REFERENCES

1. NUS Corporation Field Logbook No. F4-1926 for Union Camp Corporation, TDD No. F4-8911-70. Documentation of facility reconnaissance, January 5, 1990.

2. Potential Hazardous Waste Site Preliminary Assessment (EPA Form 2070-12) for the Union Camp Corporation (NCD003216959). Filed by Jack Butler, North Carolina Department of Human Resources, December 20, 1985.

3. Richard R. Evans, Plant General Manager, Union Camp, Letter to North Carolina Department of Human Resources, Division of Health Services, April 23, 1982. Subject: Request for RCRA Part A withdrawal.

4. RCRA Part A Application (EPA Forms 3510-1 and 3510-3) for the Union Camp Corporation, Jamestown, Guilford County, North Carolina. Submitted by J. H. Neal, Vice President and General Manager, Union Camp Corporation, November 7, 1980.

5. O. W. Strickland, Solid and Hazardous Waste Branch, letter to Richard Evans, Union Camp Corporation, May 10, 1982. Subject: RCRA status change.

6. O. W. Strickland, Solid and Hazardous Waste Branch, letter to Richard Evans, Union Camp Corporation, January 29, 1985. Subject: RCRA status change.

7. The North Carolina Geological Survey and John M. Parker, III in association with The State Geologic Map Advisory Committee, Geologic Map of North Carolina (1985).

8. M. J. Mundorff, Geology and Ground water in the Greensboro Area, North Carolina, Bulletin Number 55 (Raleigh: USGS, 1948), pp. 23, 76-78, plate 1.

9. U. S. Dept. of Agriculture, Soil Conservation Service, Soil Survey of Guilford County, North Carolina (December 1977), p. 1.

10. Charles C. Daniel III and N. Bonar Sharpless, Ground-Water Supply Potential and Procedures for Well-Site Selection, Upper Fear River Basin (USGS, 1983), pp. 7, 11-12, 38, 59.

11. Edwin O. Floyd and Richard R. Peace, An Appraisal of the Groundwater Resources of the Upper Cape Fear River Basin North Carolina, Groundwater Bulletin Number 20 (USGS and the North Carolina Office of Water and Air Resources, 1974), pp. 3-4, 6, 17.

12. U. S. Dept. of Commerce, Climatic Atlas of the United States (Washington, D. C.: GPO, June 1968) Reprint: 1983, National Oceanic and Atmospheric Administration, p. 63.

13. Charles C. Daniel III, Statistical Analysis Relating Well Yield to Construction Practices and Siting of Wells in the Piedmont and Blue Ridge Provinces of North Carolina, Water Resources Investigations Report 86-4132 (Washington, D. C.: GPO, 1987), pp. 9-10.

14. U. S. Environmental Protection Agency, Uncontrolled Hazardous Waste Site Ranking System: A Users Manual (HW-10), originally published in the July 16, 1982, Federal Register (Washington, D.C.: GPO, 1984), p. 15.

15. U. S. Geological Survey, 7.5 minute series Topographic Quadrangle Maps of North Carolina: High Point West 1969 (Photorevised 1987), High Point East 1950 (PR 1982), Kernersville 1969 (PR 1987), Guilford 1951 (PR 1968), Greensboro 1951 (PR 1968), Pleasant Garden 1970 (PR 1982), scale 1:24,000.

16. NUS Corporation Field Logbook No. F4-1914 for Guardsman Chemicals, Inc., TDD No. F4-8912-06. Documentation of facility reconnaissance, January 4, 1990.

17. John Frezell, Town Manager, Jamestown, North Carolina, telecommunication with Eric Corbin, NUS Corporation, April 24, 1989. Subject: Water Sources of Jamestown, North Carolina.

18. U. S. Fish and Wildlife Service, Endangered and Threatened Species of the Southeastern United States (Atlanta, Georgia, 1988).

19. North Carolina Natural Heritage Program Element List for Guilford County, June 30, 1989, p. 1.

20. U.S. Environmental Protection Agency, Graphical Exposure Modeling System (GEMS) Data Base, compiled from U.S. Bureau of the Census data (1980).

REFERENCE 21

ENDANGERED AND THREATENED SPECIES



U.S. FISH AND WILDLIFE SERVICE

RE[illegible] ATLANTA

Federally Listed Species by State

NORTH CAROLINA

(E=Endangered; T=Threatened; CH=Critical Habitat determined)

Mammals	General Distribution
Bat, gray (Myotis grisescens) - E	Extreme Southwest
Bat, Indiana (Myotis sodalis) - E	West
Bat, Virginia big-eared (Plecotus townsendii virginianus) - E	Avery County
Cougar, eastern (Felis concolor cougar) - E	Entire state
Manatee, West Indian (Trichechus manatus) - E	Coastal waters
Shrew, Dismal Swamp southeastern (Sorex longirostris fisheri) - T	Dismal Swamp; Camden, Gates Pasquotank and Perquimans Counties
Squirrel, Carolina northern flying (Glaucomys sabrinus coloratus) - E	Western mountains (Yancy County)
Whale, finback (Balaenoptera physalus) - E	Coastal waters
Whale, humpback (Megaptera novaeangliae) - E	Coastal waters
Whale, right (Balaena glacialis) - E	Coastal waters
Whale, sei (Balaenoptera borealis) - E	Coastal waters
Whale, sperm (Physeter catodon) - E	Coastal waters
Birds	
Eagle, bald (Haliaeetus leucocephalus) - E	Entire state
Falcon, American peregrine (Falco peregrinus anatum) - E	Western mountains
Falcon, Arctic peregrine (Falco peregrinus tundrius) - T	Entire State
Plover, piping (Charadrius melodus) - T	Coast
Stork, wood (Mycteria americana) - E	Coast
Warbler, Bachman's (Vermivora bachmanii) - E	East
Warbler, Kirtland's (Dendroica kirtlandii) - E	Northwest, Central, Southeast
Woodpecker, ivory-billed (Campephilus principalis) - E	Southeast
Woodpecker, red-cockaded (Picoides (=Dendrocopos) borealis) - E	East

NORTH CAROLINA (Cont'd) — State Lists 12/87

Reptiles	
Alligator, American (*Alligator mississippiensis*) - T (S/A)*	Coastal plain
Turtle, Kemp's (Atlantic) ridley (*Lepidochelys kempii*) - E	Coastal waters
Turtle, green (*Chelonia mydas*) - T	Coastal waters
Turtle, hawksbill (*Eretmochelys imbricata*) - E	Coastal waters
Turtle, leatherback (*Dermochelys coriacea*) - E	Coastal waters
Turtle, loggerhead (*Caretta caretta*) - T	Coastal waters
Fishes	
Chub, spotfin (*Hybopsis monacha*) - T,CH	Little Tennessee River, Swain and Macon Counties
Shiner, Cape Fear (*Notropis mekistocholas* - E,CH	Randolph, Moore, Lee, and Chatham Counties
Silverside, Waccamaw (*Menidia extensa*) - T	Lake Waccamaw and Upper Waccamaw R., Columbus County
Sturgeon, shortnose (*Acipenser brevirostrum*) - E	Coastal rivers
Mollusks	
Mussel, Tar River spiny (*Elliptio* (*Canthyria*) *steinstansana*) - E	Tar River, Edgecombe County; Sandy Creek, Franklin County; Swift Creek, Nash County
Snail, noonday (*Mesodon clarki nantahala*) - T	Swain County
Plants	
Hudsonia montana (mountain golden heather) - T,CH	Burke and McDowell Counties
Isotria medeoloides (small whorled pogonia) - E	Macon and Henderson Counties

*Alligators are biologically neither endangered nor threatened. For law enforcement purposes they are classified as "Threatened due to Similarity of Appearance." Alligator hunting is regulated in accordance with State law.

NORTH CAROLINA (Cont'd)

State Lists 12/87

Liatris helleri (Heller's blazing star) - T	Ashe, Avery, Caldwell, Burke Counties
Lindera melissifolia (pondberry) - E	Bladen County
Lysimachia asperulaefolia (rough-leaved loosestrife) - E	Carteret, Scotland, Cumberland/Bladen, Brunswick, Pender, and Hoke Counties
Oxypolis canbyi (Canby's dropwort) - E	Scotland County
Sagittaria fasciculata (bunched arrowhead) - E	Henderson County
Sarracenia oreophila (green pitcher plant) - E	Clay County
Solidago spithamaea (Blue Ridge goldenrod) - T	Avery and Mitchell Counties

EXPLANATION OF SPECIES STATUS CODES

The attached output from the N.C. Natural Heritage Program database is a listing of the elements (rare species, geologic features, natural communities, special animal habitats) known to occur in your geographic area of interest. Following is an explanation of the four columns of status codes on the righthand side of the printout.

STATE STATUS

Plants:

From Sutter, R.D., L. Mansberg, and J.H. Moore. 1983. Endangered, threatened, and rare plant species of North Carolina: a revised list. ASB Bulletin 30:153-163, and updated lists of the Natural Heritage and Plant Conservation Programs.

E = Endangered
T = Threatened
SC = Special Concern
~~PP = Primary Proposed~~ C = Candidate
SR = Significantly Rare

E,T,and SC species are protected by state law (the Plant Protection and Conservation Act, 1979); the other two categories indicate rarity and the need for population monitoring, as determined by the Plant Conservation and Natural Heritage Programs.

Animals:

From Cooper, J.E., S.S. Robinson, and J.B. Funderburg (Eds.). 1977. Endangered and Threatened Plants and Animals of North Carolina. N.C. Museum of Natural History, Raleigh, NC. 444 pages + i-xvi, and updated lists of the Natural Heritage Program.

E = Endangered
T = Threatened
SR = Significantly Rare
SC = Special Concern
UNK= Undetermined
EX = Extirpated

FEDERAL STATUS

From Endangered & Threatened Wildlife and Plants, April 10, 1987. 50 CFR 17.11 & 17.12. Department of Interior. Established by the Endangered Species Act of 1973, as amended.

E = Taxa currently listed as Endangered
T = Taxa currently listed as Threatened
PE = Taxa currently proposed for listing as Endangered
PT = Taxa currently proposed for listing as Threatened
Taxa under review for possible listing ("candidate species"):
C1 = Taxa with sufficient information to support listing
C2 = Taxa without sufficient information to support listing

GLOBAL RANK (STATE RANK)

The Nature Conservancy's system of measuring rarity and threat status. "Global" refers to worldwide, "State" to statewide.

- G1 = Critically imperiled globally because of extreme rarity or otherwise very vulnerable to exinction throughout its range.
- G2 = Imperiled globally because of rarity or otherwise vulnerable to extinction throughout its range.
- G3 = Either very rare and local throughout its range, or found locally in a restricted area.
- G4 = Apparently secure globally, though it may be quite rare in parts of its range (especially at the periphery).
- G5 = Demonstrably secure globally, though it may be quite rare in parts of its range (especially at the periphery).
- GU = Possibly in peril but status uncertain; need more information.
- GX = Believed to be extinct throughout range.
- Q = a suffix attached to the Global Rank indicating questionable taxonomic status.
- T_ = an additional status for the subspecies or variety; the G rank then refers only to the species as a whole.

State rank codes follow the same definitions, except substitute the words, "in the state," for "globally" or "throughout its range."

REFERENCE 22

Guil,

06/30/89 Page 1
NORTH CAROLINA NATURAL H LIST

scientific and common na	state stat	fed stat	state rank	glob rank
ETHEOSTOMA COLLIS	SC		S3	G3
CAROLINA DARTER				
MEANDER SCARS				
CAMBARUS CATAGIUS	T	C2		G1G3
GREENSBORO BURROWING CRAYFISH				
HESPERIA LEONARDUS	UNK		S2?	G4
LEONARD'S SKIPPER				
DENTARIA MULTIFIDA	SR		S1	G5Q
DIVIDED TOOTHWORT				
EPILOBIUM LEPTOPHYLLUM	PP		S2	G5
NARROWLEAF WILLOWHERB				
NESTRONIA UMBELLULA	T	C2	S3	G3G4
NESTRONIA				

REFERENCE 23

May 18, 1989

TO: Superfund Branch Staff

FROM: Pat DeRosa PD

RE: Critical Habitats of Federally Listed Endangered Species in North Carolina

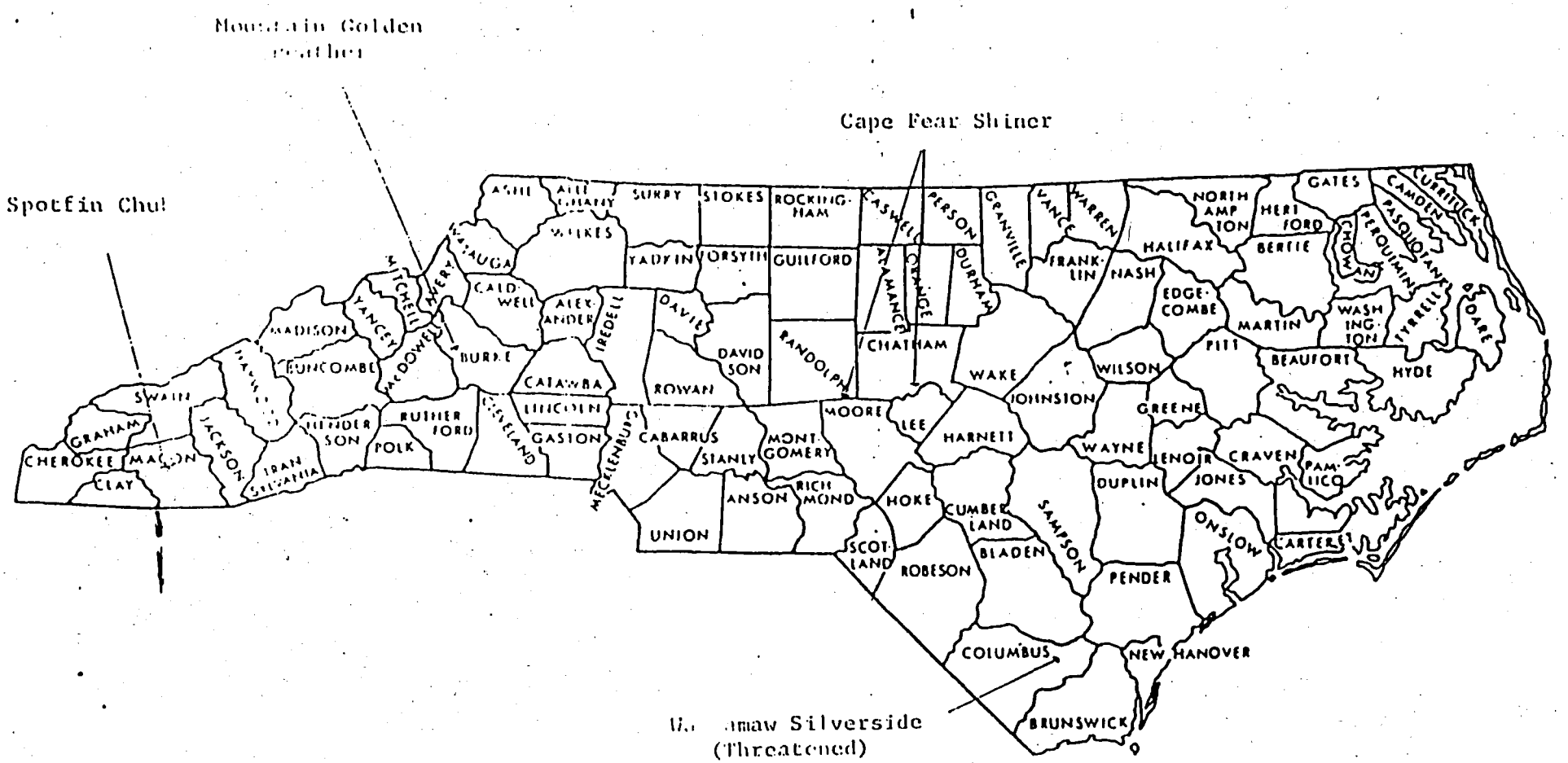
On May 18, 1989, I spoke by telephone with John Fridell, US Fish and Wildlife Service, Asheville, NC (704) 259-0321 to request an update on critical habitats in North Carolina. Mr. Fridell said the Fish and Wildlife Service has been reorganized into a western and eastern office in North Carolina. His office now handles only western North Carolina. He said there have been no changes in the designated critical habitats identified in western North Carolina.

I then spoke by telephone with Debby Mignogno, US Fish and Wildlife Service, Raleigh, NC (919) 856-4520 regarding critical habitats in eastern North Carolina. Ms. Mignogno sent the attached maps of the 2 critical habitats designated in eastern North Carolina. Please note that the Waccamaw Silverside is listed as threatened, not endangered.

PD/pb/critical.hab

CRITICAL HABITATS OF FEDERALLY LISTED

ENDANGERED SPECIES IN NC



1 inch = approx. 53 miles

RECEIVED
MAY 19 1989
6/88
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CAPE FEAR SHINER

Notropis mekistocholas

Order: Cypriniformes

Family: Cyprinidae

Status: Endangered (Federal Register 9/25/87)

Range: The Cape Fear shiner is known from four small populations in the Cape Fear River drainage in Randolph, Moore, Lee, Harnett, and Chatham Counties, North Carolina.

The strongest population is located around the junction of the Rocky River and Deep River in Chatham and Lee Counties where the fish inhabits the Deep River from the upstream limits of the backwaters of Locksville Dam upstream to the Rocky River; then upstream from the Rocky River to Bear Creek, and upstream from Bear Creek to the Chatham County Road 2156 Bridge. A few individuals have been collected just downstream of the Locksville Dam, but because of the limited extent of Cape Fear shiner habitat at this site, it is not believed this is a separate population. Instead, it is thought these fish represent a small number of individuals that periodically drop down from the population above Locksville Dam pool.

The second population is located above the Rocky River Hydroelectric Dam. This population was historically the best, but the area yielded only one specimen after extensive surveys by Pottern and Huish (1985). The third population is found in the Deep River system in Randolph and Moore Counties. This population is believed to be small (Pottern and Huish 1985, 1986). In a 1985 survey, three individuals were found above the Highfalls Hydroelectric Reservoir; one in Fork Creek, Randolph County, and two in the Deep River, Moore County. The species was also found downstream of the Highfalls Dam. However, the extent of suitable habitat in this stream reach is limited, and it is thought that these individuals likely result from downstream movement from above the reservoir where Cape Fear shiner habitat is more extensive. The fourth population is found in Neal Creek, which flows into the Cape Fear River near Lillington in Harnett County.

Three historic populations have apparently been extirpated: one in Robeson Creek, Chatham County, believed lost when Jordan Lake flooded part of the creek; and one each in Parkers Creek and Kenneth Creek in Harnett County, which disappeared for unknown reasons. Other undiscovered populations or population segments have likely been lost due to reservoir construction in the Deep, Haw, and Cape Fear Rivers.

CAPE FEAR SHINER - N. mekistocholas 6/88

Description: The Cape Fear shiner is small, rarely exceeding 2 inches in length. The fish's body is flushed with a pale silvery yellow, and a black band runs along its sides (Snelson 1971). The fins are yellowish and somewhat pointed. The upper lip is black, and the lower lip bears a thin black bar along its margin. The Cape Fear shiner, unlike most other members of the large genus Notropis, feeds extensively on plant material, and its digestive tract is modified for this diet by having an elongated, convoluted intestine.

Reasons for Current Status: The Cape Fear shiner may always have existed in low numbers. However, its recent reduction in range and its small population size (Pottern and Huish 1985, 1986) increases the species' vulnerability to a catastrophic event, such as a toxic chemical spill. Dam construction in the Cape Fear system has probably had the most serious impact on the species by inundating the species' rocky riverine habitat; and changes in flow regulation at existing hydroelectric facilities could further threaten the species.

The deterioration of water quality has likely been another factor in the species' decline. The North Carolina Department of Natural Resources and Community Development (1983) classified water quality in the Deep River, Rocky River, and Bear Creek as good to fair, and referred to the Rocky River below Siler City as an area where their sampling indicates degradation. That report also stated: "Within the Cape Fear Basin, estimated average annual soil losses from cropland ranged from 3 tons per acre in the lower basin to 12 tons in the headwaters." The North Carolina State Division of Soil and Water Conservation considers 5 tons of soil loss per acre as the maximum allowable.

Potential threats to the species and its habitat could come from such activities as road construction, stream channel modification, changes in stream flows for hydroelectric power, impoundments, land use changes, wastewater discharges, and other projects in the watershed if such activities are not planned and implemented with the survival of the species and the protection of its habitat in mind.

Habitat: The species is generally associated with gravel, cobble, and boulder substates and has been observed to inhabit slow pools, riffles, and slow runs (Snelson 1971, Pottern and Huish 1985). In these habitats, the species is typically associated with schools of other related species, but it is never the numerically dominant species. Juveniles are often found in slackwater, among large rock outcrops in midstream, and in flooded side channels and pools (Pottern and Huish 1985).

Critical Habitat: (1) North Carolina, Chatham County. Approximately 4.1 miles of the Rocky River from North Carolina State Highway 902 Bridge downstream to Chatham County Road 1010 Bridge; (2) North Carolina,

Chatham and Lee Counties. Approximately 0.5 river mile of Bear Creek, from Chatham County Road 2156 Bridge downstream to the Rocky River, then downstream in the Rocky River (approximately 4.2 river miles) to the Deep River, then downstream in the Deep River (approximately 2.6 river miles) to a point 0.3 river mile below the Moncure, North Carolina, U.S. Geological Survey Gaging Station; and (3) North Carolina. Randolph and Moore Counties. Approximately 1.5 miles of Fork Creek, from a point 0.1 river mile upstream of Randolph County Road 2873 Bridge downstream to the Deep River then downstream approximately 4.1 river miles of the Deep River in Randolph and Moore Counties, North Carolina, to a point 2.5 river miles below Moore County Road 1456 Bridge.

Constituent elements include clean streams with gravel, cobble, and boulder substrates with pools, riffles, shallow runs and slackwater areas with large rock outcrops and side channels and pools with water of good quality with relatively low silt loads.

Feeding Habits: Plant material forms the primary part of the diet.

Reproduction and Development: No information is presently available on breeding behavior, fecundity, or longevity.

Population Level: Total numbers are unknown, but all populations appear to be small. Surveys conducted in 1984 and 1985 yielded 101 individuals from the population located around the junction of the Rocky River and Deep River in Chatham and Lee Counties, 1 specimen from the Rocky River near State Highway Bridge 902 in Chatham County, and 6 specimens from the Deep River system in Randolph and Moore Counties.

Management and Protection: Assuring survival of the Cape Fear shiner will require, at a minimum, maintaining good water quality and the natural conditions of the remaining habitat. Providing for a higher level of security will necessitate determining limiting factors and reestablishing additional populations into suitable waters within the historic range.

References:

North Carolina Department of Natural Resources and Community Development. 1983. Status of Water Resources in the Cape Fear River Basin. 135 pp.

Pottern, G.B., and M.T. Huish. 1985. Status survey of the Cape Fear shiner (Notropis mekistocholas). U.S. Fish and Wildlife Service Contract No. 14-16-0009-1522. 44 pp.

Pottern, G.B., and M.T. Huish. 1986. Supplement to the status survey of the Cape Fear shiner (Notropis mekistocholas). U.S. Fish and Wildlife Service Contract No. 14-16-0009-1522. 11 pp.

CAPE FEAR SHINER - N. mekistocholas 6/88

Snelson, F.F. 1971. Notropis mekistocholas, a new cyprinid fish endemic to the Cape Fear River basin. North Carolina. Copeia 1971:449-462.

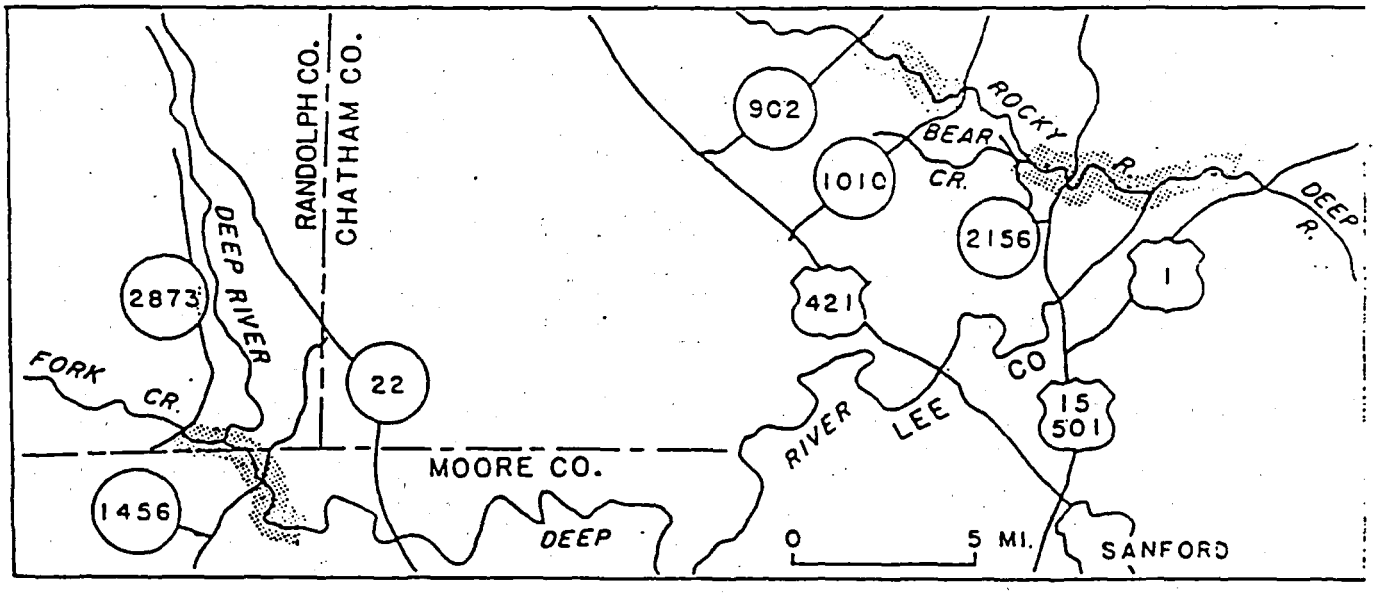
U.S. Fish and Wildlife Service. 1987. Endangered and threatened wildlife and plants; determination of endangered species status and designation of critical habitat for the Cape Fear shiner. Federal Register 52(186):36034-36039.

NORTH CAROLINA - Critical Habitat

Notropis mekistocholas, "Cape Fear shiner"

(1) Chatham County. Approximately 4.1 miles of the Rocky River from North Carolina State Highway 902 Bridge downstream to Chatham County Road 1010 Bridge;
(2) Chatham and Lee Counties. Approximately 0.5 river mile of Bear Creek, from Chatham County Road 2156 Bridge downstream to the Rocky River, then downstream in the Rocky River (approximately 4.2 river miles) to the Deep River, then downstream in the Deep River (approximately 2.6 river miles) to a point 0.3 river mile below the Moncure, North Carolina, U.S. Geological Survey Gaging Station; and
(3) Randolph and Moore Counties. Approximately 1.5 miles of Fork Creek, from a point 0.1 river mile upstream of Randolph County Road 2873 Bridge downstream to the Deep River then downstream approximately 4.1 river miles of the Deep River in Randolph and Moore Counties, North Carolina, to a point 2.5 river miles below Moore County Road 1456 Bridge.

Constituent elements include clean streams with gravel, cobble, and boulder substrates with pools, riffles, shallow runs and slackwater areas with large rock outcrops and side channels and pools with water of good quality with relatively low silt loads.



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WACCAMAW SILVERSIDE

Menidia extensa

Order: Mugiliformes

Family: Atherinidae

Status: Threatened (Federal Register 4/8/87)

Range: Known only from Lake Waccamaw and the upper Waccamaw River in Columbus County, North Carolina. The silverside is found in the upper Waccamaw River only during periods of high water and is not a permanent resident. Lake Waccamaw (not to be confused with the town of Lake Waccamaw) is the property of the State of North Carolina and is administered by the North Carolina Department of Natural Resources and Community Development's Division of Parks and Recreation.

Description: The Waccamaw silverside, also known as "skipjack" or "glass minnow," is a small (growing to about 2.5 inches), slim, almost transparent fish with a silvery stripe along each side. Its body is laterally compressed, the eyes are large, and the jaw is sharply angled upward.

Reasons for Current Status: The primary threat is the deterioration of water quality in Lake Waccamaw resulting from nutrient buildup. Although specific sources are currently unidentified, runoff and leachate from surrounding development may be contributing to the buildup. Nutrients in the lake increased since 1973, and it now appears that any further increase could tip the scales toward water quality conditions that would threaten the species. The existing data, as interpreted by Casterlin et al. (1986), indicate that phosphate concentrations and loading rates in the lake more than tripled in the years between 1973 and 1981. They further state that "continued high rates of phosphorus input (organic pollution) will likely bring the lake to a hyper-eutrophic state . . . by the end of the century." Water quality could also be affected by habitat alteration from development and other changes in land use, both around the lake and in its watershed (especially Big Creek), if these activities are not planned and implemented with the protection of the Lake Waccamaw ecosystem in mind.

A permit to propagate hybrid bass at several sites in the Lake Waccamaw watershed has been granted by the North Carolina Wildlife Resources Commission. Although the permit stipulates certain precautionary measures, escape of non-native predators from such a project into the system could upset the existing predator-prey relationships in the lake to the detriment of the Waccamaw silverside and other fishes now present in the lake.

A final factor that could threaten the Waccamaw silverside relates to its very short life cycle. The fish spawn when one-year-old and most die shortly thereafter. Failure to spawn in any one year could jeopardize the species. Water quality problems related to nutrient loading, even on a short-term basis, could cause the extinction of this fish.

WACCAMAW SILVERSIDE - M. extensa

Habitat: Lake Waccamaw is a natural lake with an approximate surface area of 8,934 acres and an average depth of 7.5 feet. Although it is fed by acidic swamp streams, the lake has a virtually neutral pH. This neutral condition, unusual among North Carolina's coastal plain lakes, is believed to be caused by the buffering effect of the calcareous Waccamaw Limestone formation, which underlies the lake and is exposed on the north shore. The Waccamaw silverside inhabits open water throughout the lake, where schools are commonly found near the surface over shallow, dark-bottomed areas.

Critical habitat: North Carolina, Columbus County. Lake Waccamaw in its entirety to mean high water level, and Big Creek from its mouth at Lake Waccamaw upstream approximately 0.6 kilometers (0.4 miles) to where the creek is crossed by County Road 1947.

Constituent elements include high quality clear open water, with a neutral pH and clean sand substrate.

Reproduction and Development: Spawning occurs from April through June, but reaches to peak when water temperatures are between 68 and 72F. Fully developed larvae form small isolated schools by early May. No parental care of the young has been noted. The silversides reach sexual maturity by the following spring, spawn, and then shortly thereafter most of the adults die off. A few may survive a second winter.

Population level: Estimated to be in the millions.

Management (Activities, Recommendations, Implications): The taking of silversides for fish bait or for scientific purposes is not considered a threat to the species. These activities may continue in accordance with State regulations. Activities which could affect water and substrate quality by increasing siltation and/or nutrient loading, or by altering temperature or pH, will require monitoring and control as necessary and feasible. Some of the activities that could prove detrimental include indiscriminate logging, land use changes, stream alteration such as channelization or impoundment, bridge and road construction, improper pesticide/herbicide application, and point and nonpoint pollution discharge.

References:

Casterlin, M.E., W.W. Reynolds, D.G. Lindquist, and C.G. Yarbrough. 1986. Algal and Physicochemical Indicators of Eutrophication in a Lake Harboring Endemic Species: Lake Waccamaw, North Carolina. Journal of the Elisha Mitchell Scientific Society 100(3):83-103.

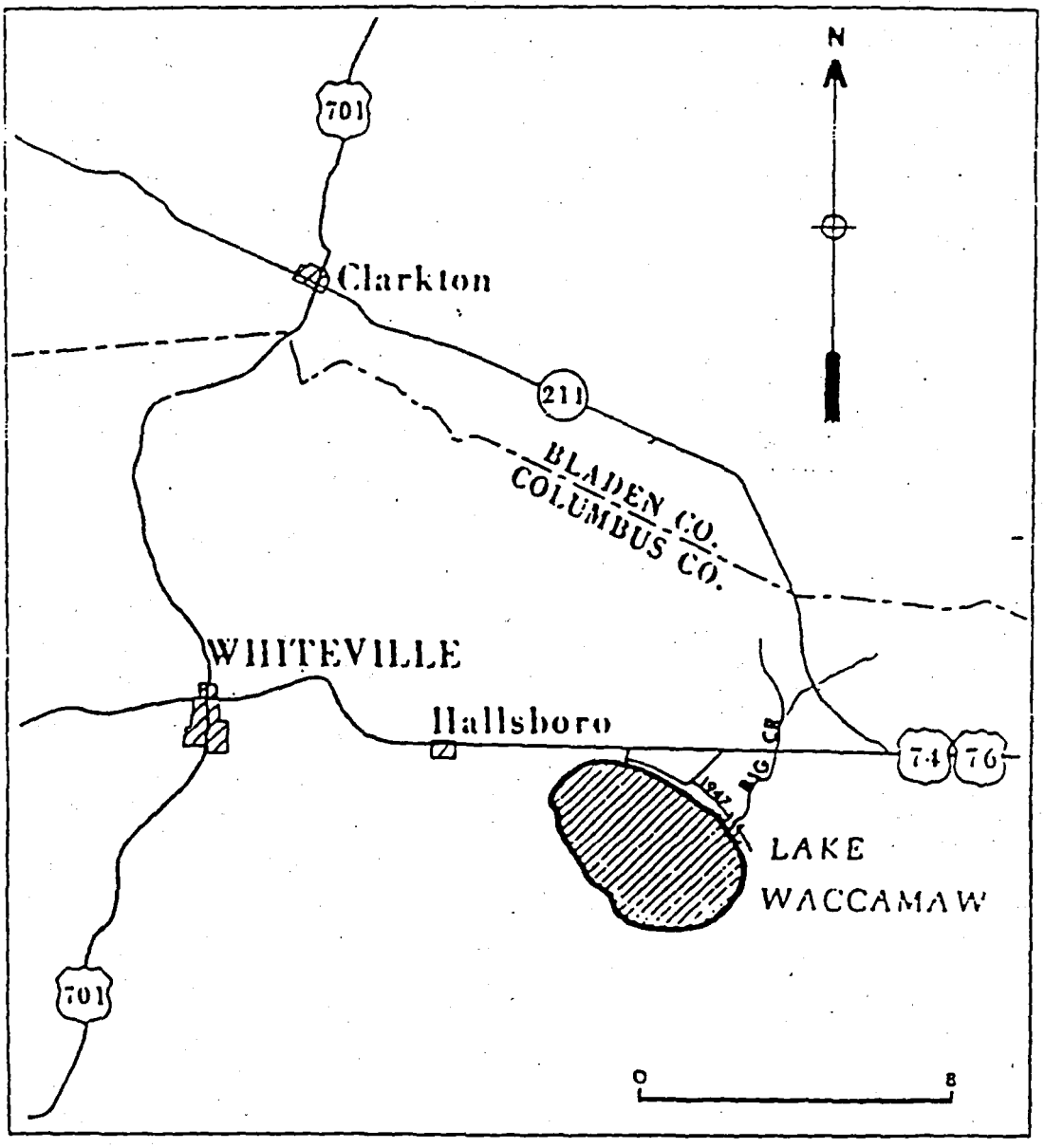
Davis, J.R. and D.E. Louder. 1969. Life History of Menidia extensa. Transactions of the American Fisheries Society 98(3):466-472.

NORTH CAROLINA - Critical Habitat

Menidia extensa, "Waccamaw silverside"

Columbus County. Lake Waccamaw in its entirety to mean high water level, and Big Creek from its mouth at Lake Waccamaw upstream approximately 0.6 kilometer (0.4 mile) to where the creek is crossed by County Road 1247.

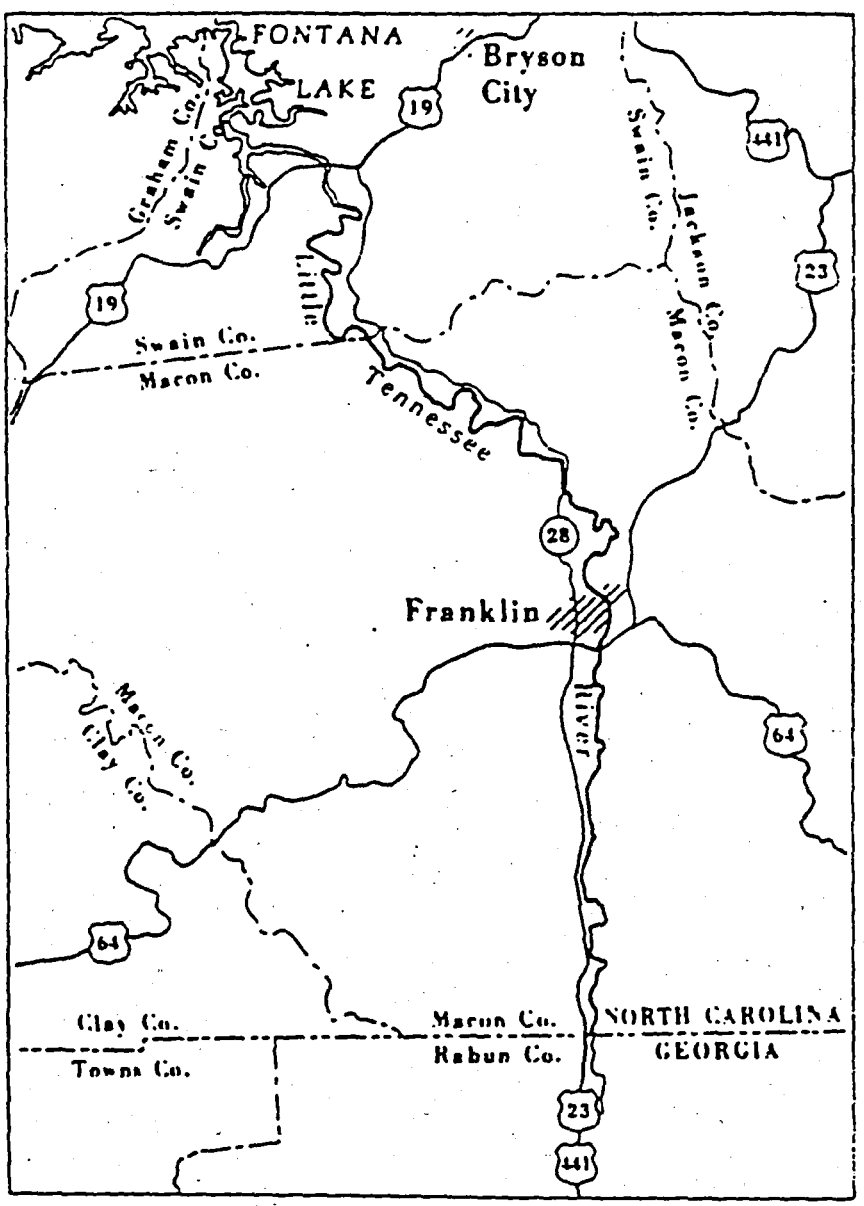
Constituent elements include high quality clear open water, with a neutral pH and clean sand substrate.



NORTH CAROLINA - Critical Habitat

Hybopsis monacha, "spotfin chub"

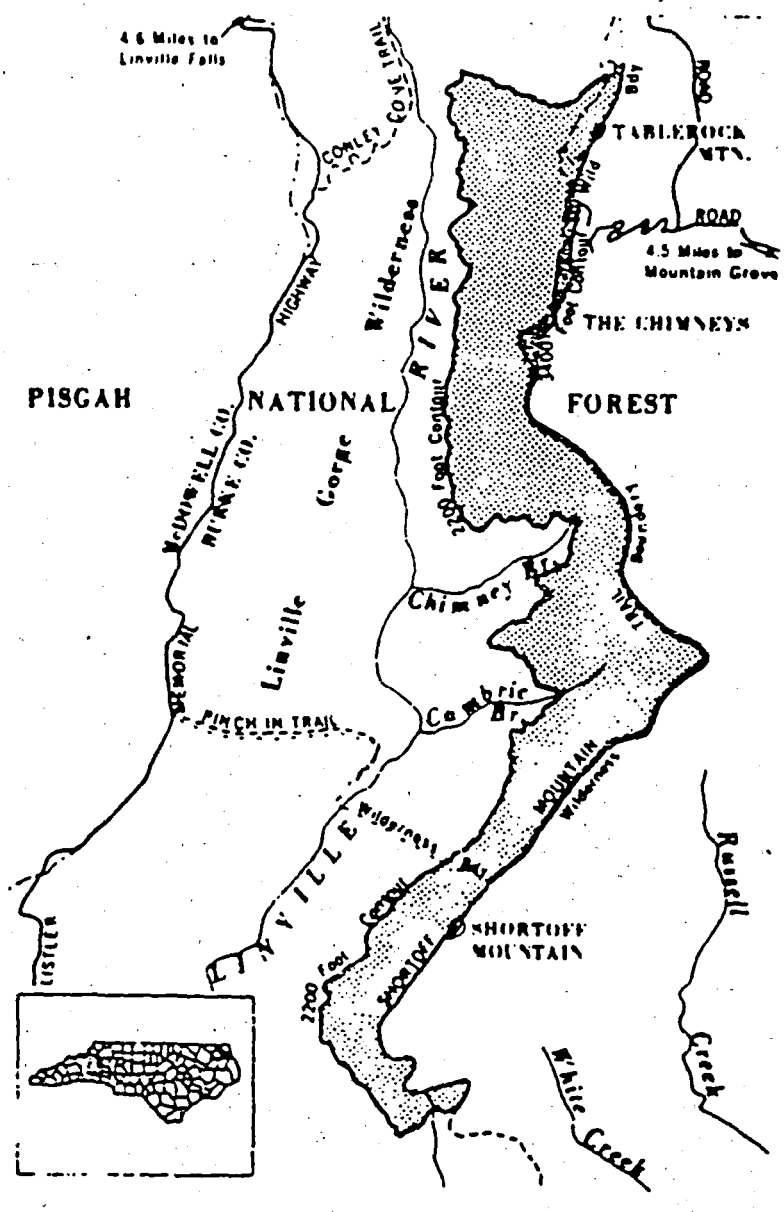
Macon and Swain Counties. Little Tennessee River, main channel from the backwaters of Fontana Lake upstream to the North Carolina-Georgia state line.



NORTH CAROLINA - Critical Habitat

Hudsonia montana, "mountain golden heather"

Burke County. The area bounded by the following: on the west by the 2200' contour; on the east by the Linville Gorge Wilderness Boundary north from the intersection of the 2200' contour and the Shortoff Mountain Trail to where it intersects the 3400' contour at "The Chimneys"--then follow the 3400' contour north until it reintersects the Wilderness Boundary--then follow the Wilderness Boundary again northward until it intersects the 3200' contour extending west from its intersection with the Wilderness Boundary until it begins to turn south--at this point the Boundary extends due east until it intersects the 2200' contour.



REFERENCE 24

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

ENVIRONMENTAL SERVICES DIVISION
ATHENS, GEORGIA 30613

Reference 24

TO WHOM IT MAY CONCERN

Enclosed is one copy of the latest revision (February 1, 1991) of the US EPA, Region IV, Environmental Services Division, Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual (SOPQAM). This SOPQAM was prepared exclusively for use by the Environmental Compliance Branch. Any part of this SOPQAM may be reproduced for use by your organization. However any direct reproductions, in whole or in part, should be referenced as follows:

> Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual, US-EPA, Region IV, ESD, Athens, GA, February 1, 1991 (and subsequent revisions).

If you have received a copy on disk, please be advised that it is in WordPerfect® 5.1 format. You will notice that the following figures are not on the disk:

Figure 1.8.1	Environmental Compliance Branch Time Accounting
Figure 1.8.2	Payroll Distribution Timesheet
Figure 3.2.1	Sample Tag
Figure 3.3.1	Chain-Of-Custody Record
Figure 3.3.2	Custody Seal
Figure 7.2.5	Example of Site Map Showing Traverse Points Used To Locate Monitoring Wells

Should you have any comments or suggestions concerning the SOPQAM, please contact either Michael R. Carter (404-546-3117) or Bill Bokey (404-546-3300).

Sincerely yours,

John T. Marlar

John T. Marlar, Chief
Environmental Compliance Branch

This diskette contains the complete text of the US-EPA, Region IV, Environmental Services Division, Environmental Compliance Branch standard operating procedures manual, dated February 1, 1991. The document is correctly referenced as follows: Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual, February 1, 1991 (ECBSOPQAM).

The procedures described within the ECBSOPQAM may be modified as necessary (procedures for modification are described within the document), with the following proviso: If the procedures are changed they may no longer be referred to as the procedures described in this document. The Environmental Compliance Branch (which is an integral part of the document review and field overview process in Region IV) will strongly resist any attempt to modify these procedures and have them submitted for review as the original procedures.

The files are in WordPerfect(c) 5.1 format. The files are organized such that each major section of the sop is in its own directory, with each major sub-section saved as a separate file. As stated above, the text is complete, however, two figures (3.2.1 and 3.3.1) are not included because these figures were reproduced by photocopy in the original document. The files are saved in a prestige elite (12p) font and are formatted for printing on a Hewlett-Packard Laser Jet(c) printer. We are unable to support other files at this time, although this file is saved in ASCII format to enable any user to read it.

ENVIRONMENTAL COMPLIANCE BRANCH

STANDARD OPERATING PROCEDURES

AND

QUALITY ASSURANCE MANUAL

FEBRUARY 1, 1991

U. S. Environmental Protection Agency
Region IV
Environmental Services Division
College Station Road
Athens, Georgia 30613

FOREWORD

This manual contains the standard operating and field quality assurance procedures used by Environmental Compliance Branch employees during field operations. The specific procedures outlined are based on the experience of Branch personnel over the years or are specifically referenced at the end of each chapter. The specific quality control procedures outlined in the manual are provided as required by the Agency's Mandatory Quality Assurance Policy.

This manual shall be provided to each Branch employee engaged in field operations. Each employee is expected to read and be familiar with each section of the manual. This manual will serve as a source-book for training new employees as well as a reference for current employees. The manual is meant to be a dynamic document. It will be periodically reviewed and updated. When changes are made in the manual, a memo will be sent to each Branch employee. Each employee will be responsible for keeping his or her manual current. To assist in this updating, a log is included inside the front cover for tracking revisions of individual sections.

The SOP and specific quality assurance procedures outlined in this manual (SOPQAM) are to be incorporated by reference into all study plans issued by Branch personnel. Any deviation from this SOP or specific quality assurance procedures as outlined in this manual must be thoroughly documented and cleared (if possible) with the appropriate Unit Chief and/or Section Chief. Any deviation from this SOPQAM shall also be documented in all study plans and reports resulting from that project.

DISCLAIMER

This SOPQAM has been prepared for use by the Environmental Compliance Branch, Environmental Services Division, Region IV, United States Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

..TABLE OF CONTENTS

SECTION 1 STANDARD OPERATING POLICIES AND PROCEDURES

1.1 INTRODUCTION

1.2 BRANCH ORGANIZATION

1.2.1 General

1.2.2 Line of Authority

1.3 PROJECT ACTIVITY FLOW

1.4 PROJECT LEADER RESPONSIBILITIES

1.5 STUDY PLANS

1.6 STUDY REPORTS

1.7 EMPLOYEE CONDUCT

1.7.1 General

1.7.2 Entering A Facility

1.7.3 Requesting Information

1.7.4 Disclosure of Official Information

1.8 BASIC ADMINISTRATIVE FUNCTIONS

1.8.1 Timekeeping

1.8.2 Purchase Requisitions

1.8.3 Travel Authorization Requests

1.8.4 Word Processing Procedures

1.8.5 Report and Correspondence Distribution

1.8.6 Vehicle Use and Check-out

1.8.7 Field Equipment Check-Out

1.8.8 CERCLA/RCRA Site Map Requests

1.8.9 Requests for Analytical Data Summary Tables

1.9 BRANCH PROCEDURES FOR OBTAINING ANALYTICAL SUPPORT

1.9.1 General

1.9.2 Specific Procedures

1.9.3 Definitions

1.9.4 Distribution of Analytical Data

1.10 QUALITY ASSURANCE PLAN

1.10.1 General

1.10.2 Corrective Actions

1.10.3 Peer Review

1.11 SAFETY PROGRAM

1.12 REFERENCES

SECTION 2 INVESTIGATIONS, INSPECTIONS, AND OVERVIEW ACTIVITIES

2.1 INTRODUCTION

2.2 SPECIAL PROVISIONS FOR INVESTIGATIONS INVOLVING POTABLE WATER SUPPLIES

2.3 ENFORCEMENT INVESTIGATIONS AND STUDIES

2.3.1 General Civil

2.2.2 General Criminal

2.4 NPDES COMPLIANCE MONITORING

2.4.1 General

2.4.2 Inspection Definitions

2.4.3 Municipal Wastewater Treatment Plant Technical Assistance (TA) Studies

2.4.4 NPDES Compliance Inspection Reports

2.4.5 Competition of NPDES Compliance Inspection Report Form (EPA Form 3560-3)

2.4.6 Inspection Notification

2.5 SUPERFUND INSPECTIONS, INVESTIGATIONS, AND OVERVIEW ACTIVITIES
2.5.1 General
2.5.2 Activity Definitions
2.6 RCRA INSPECTIONS, INVESTIGATIONS, AND OVERVIEW ACTIVITIES
2.6.1 General
2.6.2 Inspection Types
2.6.3 Requests for Studies
2.6.4 Investigation Study Plans
2.6.5 Investigation Reports
2.7 UNDERGROUND STORAGE TANK (UST) INVESTIGATIONS
2.7.1 General
2.7.2 Activity Definitions
2.8 AMBIENT AIR MONITORING EVALUATIONS AND AUDITS
2.8.1 NAMS/SLAMS Site Evaluations
2.8.2 State and Local QA Plan Reviews
2.8.3 Performance Audits
2.8.4 National Air Monitoring Audit System
2.8.5 National Performance Audit Program
2.9 REFERENCES

SECTION 3 SAMPLE CONTROL, FIELD RECORDS, AND DOCUMENT CONTROL
3.1 INTRODUCTION
3.2 SAMPLE AND EVIDENCE IDENTIFICATION
3.2.1 General
3.2.2 Sample Identification
3.2.3 Photograph Identification
3.2.4 Identification of Physical Evidence
3.3 CHAIN-OF-CUSTODY PROCEDURES
3.3.1 General
3.3.2 Sample Custody
3.3.3 Chain-of-Custody Record
3.3.4 Field Custody Procedures
3.3.5 Transfer of Custody and Shipment
3.4 RECEIPT FOR SAMPLES
3.4.1 General
4.4.2 Receipt for Samples Form
3.5 FIELD RECORDS
3.6 DISPOSAL OF SAMPLES OR OTHER PHYSICAL EVIDENCE
3.7 DOCUMENT CONTROL

SECTION 4 SAMPLING PROCEDURES
4.1 INTRODUCTION
4.2 GENERAL CONSIDERATIONS
4.2.1 Selection of Representative Sampling Sites
4.2.2 Selection and Proper Preparation of Sampling Equipment
4.2.3 Sampling Equipment Construction Material
4.2.4 Selection of Parameters to be Measured
4.2.5 Required Sample Volumes
4.2.6 Selection and Proper Preparation of Sample Containers
4.2.7 Sample Preservation
4.2.8 Sample Holding Times
4.2.9 Special Precautions for Trace Contaminant Sampling
4.2.10 Sample Handling and Mixing
4.2.11 Purgeable Organic Compounds Sampling (VOA)

4.2.12 Sample Identification ..
4.2.13 Procedures for Identifying Potentially Hazardous Samples
4.2.14 Collection of Auxiliary Data
4.2.15 Time Records
4.2.16 Transportation and Shipping of Samples
4.2.17 Sample Chain-Of-Custody
4.3 DEFINITIONS
4.3.1 Grab Sample
4.3.2 Composite Samples
4.3.3 Quality Control Samples
4.4 DATA QUALITY OBJECTIVES
4.4.1 DQO Level I
4.4.2 DQO Level II
4.4.3 DQO Level III
4.3.4 DQO Level IV
4.3.5 DQO Level V
4.5 INVESTIGATION DERIVED WASTE
4.5.1 General
4.6 SPECIFIC SAMPLE COLLECTION QUALITY CONTROL PROCEDURES
4.6.1 General
4.6.2 Experience Requirements
4.6.3 Traceability Requirements
4.6.4 Measurement of Relative Sampling Precision
4.6.5 Measurement of Sample Handling Effectiveness
4.6.6 Measurement of Sample Container, Sample Equipment, and Cleaning Procedure Integrity
4.6.7 Measurement of Field Generated Organic-Free Water
4.6.8 Special Quality Control Procedures for Water Samples for Extractable, Pesticide, or Herbicide Organic Compounds Analyses
4.6.9 Special Quality Control Procedures for EPA Contract Laboratories
4.6.10 Special Quality Assurance Procedures for Dioxin (2,3,7,8-TCDD or Other Isomers)
4.7 WASTEWATER SAMPLING
4.7.1 General Considerations
4.7.2 Site Selection
4.7.3 Sampling Techniques - General
4.7.4 Use of Automatic Samplers
4.7.5 Manual Sampling
4.7.6 Special Sample Collection Procedures
4.7.7 Special Process Control Samples and Tests
4.7.8 Auxiliary Data Collection
4.8 SURFACE WATER AND SEDIMENT SAMPLING
4.8.1 General
4.8.2 Sample Site Selection
4.8.3 Sampling Equipment and Techniques
4.8.4 Special Sample Collection Techniques
4.8.5 Auxiliary Data Collection
4.8.6 Specific Sampling Equipment Quality Assurance Procedures
4.9 GROUND WATER SAMPLING
4.9.1 General
4.9.2 Site Selection
4.9.3 Purging Equipment and Techniques
4.9.4 Sampling Equipment and Techniques
4.9.5 Special Sample Collection Procedures

7.5 BATHSYMETRY
7.5.1 Procedures
7.5.2 Equipment Available
7.5.3 Specific Equipment Quality Control Procedures
7.6 SURFACE WATER STAGE/TAPE DOWNS
7.6.1 Procedures
7.6.2 Equipment Available
7.6.3 Specific Equipment Quality Control Procedures
7.7 GROUND WATER LEVEL MEASUREMENT
7.7.1 General
7.7.2 Specific Ground Water Level Measuring Techniques
7.7.3 Total Well Depth Measurement Techniques
7.7.4 Equipment Available
7.7.5 Specific Quality Control Procedures
7.8 TIME OF TRAVEL
7.8.1 General
7.8.2 Procedures
7.8.3 Equipment Available
7.8.4 Specific Equipment Quality Control Procedures
7.9 DILUTION STUDIES
7.9.1 Procedures
7.9.2 Equipment Available
7.9.3 Specific Equipment Quality Control Procedures
7.10 GEOPHYSICAL STUDIES
7.10.1 General
7.10.2 Introduction
7.10.3 Specific Geophysical Study Methods
7.10.4 Specific Equipment Quality Control Procedures
7.11 REFERENCES

APPENDIX A RECOMMENDED SAMPLE CONTAINERS, SAMPLE PRESERVATION, SAMPLE HOLDING TIMES, AND PERMISSIBLE SAMPLE TYPE

APPENDIX B STANDARD CLEANING PROCEDURES
B.1 GENERAL
B.2 SPECIFIC QUALITY CONTROL PROCEDURES FOR CLEANING OPERATIONS
B.3 CLEANING PROCEDURES FOR TEFLON® OR GLASS FIELD SAMPLING EQUIPMENT USED FOR THE COLLECTION OF SAMPLES FOR TRACE ORGANIC COMPOUNDS AND/OR METALS ANALYSES
B.4 CLEANING PROCEDURES FOR STAINLESS STEEL OR METAL SAMPLING EQUIPMENT USED FOR THE COLLECTION OF SAMPLES FOR TRACE ORGANIC COMPOUNDS AND/OR METALS ANALYSES
B.5 CLEANING PROCEDURES FOR AUTOMATIC WASTEWATER SAMPLING EQUIPMENT
B.6 CLEANING PROCEDURES FOR SAMPLE TUBING
B.7 MISCELLANEOUS EQUIPMENT CLEANING PROCEDURES
B.8 FIELD EQUIPMENT CLEANING PROCEDURES
B.9 PREPARATION OF DISPOSABLE SAMPLE CONTAINERS
B.10 EMERGENCY DISPOSABLE SAMPLE CONTAINER CLEANING

APPENDIX C SAMPLE SHIPPING PROCEDURES
C.1 INTRODUCTION
C.2 SHIPMENT OF DANGEROUS GOODS
C.3 SHIPMENT OF ENVIRONMENTAL SAMPLES
C.4 REFERENCES

APPENDIX D STANDARD FIELD ANALYTICAL METHODS

D.1 TEMPERATURE
D.2 pH (HYDROGEN ION CONCENTRATION)
D.3 DISSOLVED OXYGEN (MODIFIED WINKLER, FULL BOTTLE TECHNIQUE)
D.4 DISSOLVED OXYGEN (MEMBRANE ELECTRODE)
D.5 SPECIFIC CONDUCTANCE
D.6 CHLORINE, TOTAL RESIDUAL (TITRIMETRIC, AMPEROMETRIC)
D.7 CHLORINE, TOTAL RESIDUAL (TITRIMETRIC, BACK-IODOMETRIC)
D.8 CHLORINE, TOTAL RESIDUAL (DPT COLORIMETRIC - HACH KIT)
D.9 FLUOROMETRIC DETERMINATION OF DYE TRACER
D.10 SALINITY

APPENDIX E DESIGN AND INSTALLATION FOR PERMANENT MONITORING WELLS

E.1 INTRODUCTION
E.2 DRILLING METHODS
E.2.1 Hollow-stem Auger
E.2.2 Solid-stem Auger
E.2.3 Rotary Method
E.2.4 Other Methods
E.3 BOREHOLE REQUIREMENTS
E.3.1 Annular Space
E.3.2 Overdrilling The Borehole
E.3.3 Filter Pack Placement
E.3.4 Filter Pack Seal-Bentonite Pellet Seal (Plug)
E.3.5 Grouting the Annular Space
E.3.6 Above Ground Riser Pipe and outer Protective Casing
E.3.7 Concrete Surface Pad
E.3.8 Surface Protection-Bumper Guards
E.4 CONSTRUCTION TECHNIQUES
E.4.1 Well Installation
E.4.2 Double Cased Wells
E.4.3 Bedrock Wells
E.5 WELL CONSTRUCTION MATERIALS
E.5.1 Well Screen And Casing Materials
E.5.2 Filter Pack Materials
E.5.3 Filter Pack And Well Screen Design
E.6 SAFETY PROCEDURES FOR DRILLING ACTIVITIES
E.7 WELL DEVELOPMENT
E.8 WELL ABANDONMENT
E.8.1 Abandonment Procedures
E.9 CLEANING AND DECONTAMINATION
E.10 DRILLING LOG

APPENDIX F PUMP OPERATING PROCEDURES

F.1 PERISTALTIC PUMP
F.2 FULTZ® PUMP
F.3 LARGE DIAMETER ELECTRIC SUBMERSIBLE PUMPS
F.4 QED® BLADDER AND PURGE PUMPS

APPENDIX G AIR MONITORING SAFETY EQUIPMENT CALIBRATION PROCEDURES

G.1 GENERAL
G.2 MSA MODEL 260 COMBUSTIBLE GAS AND OXYGEN ALARM
G.3 CENTURY MODEL OVA-128 ORGANIC VAPOR ANALYZER

4.9.6 Specific Sampling Equipment Quality Assurance Techniques
4.9.7 Auxiliary Data Collection
4.10 SAMPLING OF POTABLE WATER SUPPLIES
4.10.1 General
4.10.2 Sampling Site Selection/Sampling Techniques
4.10.3 Sampling Equipment/Specific Sampling Equipment Quality Assurance Techniques
4.11 SOIL SAMPLING
4.11.1 General
4.11.2 Sampling Location/Site Selection
4.11.3 Basic Considerations for Soil Sampling
4.11.4 Sampling Methodology
4.11.5 Special Techniques and Considerations
4.12 WASTE SAMPLING
4.12.1 General
4.12.2 Collection of Municipal Wastewater, Industrial Wastewater, and Municipal Water Treatment Plant Sludge Samples
4.12.3 Pits, Ponds, and Lagoons
4.12.4 Open and Closed Container Sampling
4.12.5 Waste Piles and Landfills
4.12.6 Contaminated Surfaces Sampling
4.12.7 Contaminated Documents Sampling
4.13 AIR TOXICS MONITORING
4.13.1 Formaldehyde Sampling Using Dinitrophenylhydrazine Cartridges Using Method TO-11
4.13.2 Volatile Organic Compound (VOC) Sampling With SUMMA Electropolished Stainless Steel Canisters Using Method TO-14
4.13.3 Semi-Volatile Organic Compounds (SVOC) Sampling With High Volume PUF Samplers Using Methods TO-4 & TO-13
4.13.4 Sampling For Metals Using The High Volume Sampler
4.13.5 Sampling And Analysis of Mercury In Ambient Air Using Arizona Instruments Mercury Dosimeter Tubes and The Model 511 Gold Film Mercury Vapor Analyzer
4.13.6 Dioxin and Dibenzofuran Sampling With High Volume PUF Samplers Using Method TO-9
4.14 CRITERIA POLLUTANT MONITORING (REFERENCE MONITORS)
4.14.1 Monitoring Ozone In Ambient Air
4.14.2 Sampling Of Total Suspended Particulate In Air Using The High Volume Sampler
4.14.2 Sampling Of Particulate Matter In Air As PM_{10}
4.15 SATURATION MONITORING (NON-REFERENCE MONITORS)
4.15.1 PM_{10} Saturation Monitoring Using Non-Reference Portable Monitors
4.15.2 Carbon Monoxide Saturation Monitoring
4.16 REFERENCES

SECTION 5 FLOW MEASUREMENT
5.1 INTRODUCTION
5.2 WASTEWATER FLOW MEASUREMENT
5.2.1 General
5.2.2 Site Selection
5.2.3 Flow Measurement Systems
5.2.4 Use of Existing Flow Measurement Systems
5.2.5 Specific Techniques
5.2.6 Closed Conduit Flow Measurements

5.3 SURFACE WATER FLOW MEASUREMENTS
5.3.1 General
5.3.2 Techniques
5.4 GENERAL QUALITY ASSURANCE PROCEDURES
5.5 EQUIPMENT AVAILABLE
5.6 SPECIFIC EQUIPMENT QUALITY CONTROL PROCEDURES
5.6.1 Stevens Model A-71 and Model F Stage Recorders
5.6.2 ISCO Model 1870 and 2870 Recording Flow Meters
5.6.3 Vertical Staff Gages and Tape Down Systems
5.6.4 Price AA and Price Pygmy Current Meters
5.6.5 Top Setting Wading Rod
5.6.6 Lee Au Tag Line
5.6.7 V-Notch and Rectangular Weir Plates
5.7 REFERENCES

SECTION 6 FIELD ANALYTICAL PROCEDURES
6.1 GENERAL
6.2 SPECIFIC ANALYTICAL TECHNIQUES
6.3 SPECIFIC QUALITY CONTROL PROCEDURES
6.3.1 Temperature
6.3.2 pH
6.3.3 Dissolved Oxygen (DO)
6.3.4 Specific Conductance
6.3.5 Total Chlorine Residual
6.3.6 Fluorescent Tracing
6.3.7 Salinity
6.4 SEMI-ANNUAL MAINTENANCE
6.5 SOURCES OF CHEMICALS AND STANDARDS
6.6 TRAINING
6.7 REFERENCES

SECTION 7 FIELD PHYSICAL MEASUREMENTS
7.1 GENERAL
7.2 SURVEYING (HORIZONTAL CONTROL)
7.2.1 General
7.2.2 Introduction
7.2.3 Equipment Available
7.2.4 Specific Equipment Quality Control Procedures
7.2.5 Procedures for Traversing
7.3 ELEVATION SURVEYS (VERTICAL CONTROL)
7.3.1 Introduction
7.2.2 Equipment Available
7.3.3 Specific Equipment Quality Control Procedures
7.3.4 Procedures for Differential Leveling
7.3.5 Procedures for Trigonometric Leveling
7.3.6 Procedures for Barometric Leveling
7.4 AERIAL IMAGERY
7.4.1 General
7.4.2 Litigation
7.4.3 Access
7.4.4 Funding
7.4.5 Environmental Procedures
7.4.6 Specific Quality Control Procedures for Aerial Imagery

G.4 PHOTOVAC TIP II PHOTOIONIZATION DETECTOR
G.5 HNU MODEL PI 101 PHOTOIONIZATION DETECTOR
G.6 LUDLUM MODEL 3 RADIATION SURVEY METER

APPENDIX H STANDARD WASTEWATER FIELD METHODOLOGY
H.1 GENERAL
H.2 PROCESS CONTROL TESTING
H-3 PROCESS CONTROL TESTS
H-4 REFERENCES

APPENDIX I SATURATION MONITORING
I.1 GENERAL DESCRIPTION
I.2 SAMPLING PROCEDURE
I.3 SAMPLE HANDLING PROCEDURE
I.4 CALIBRATION PROCEDURES

APPENDIX J PROCEDURES REGIONAL TECHNICAL SUPPORT FOR CRIMINAL INVESTIGATIONS

APPENDIX K BRANCH SAFETY PROTOCOLS
K.1 GENERAL
K.2 HAZARDOUS WASTE SECTION SAFETY PROTOCOLS
K.3 AIR AND WATER COMPLIANCE SECTION SAFETY PROTOCOLS

.. LIST OF TABLES

		Subsection
TABLE 1.8.1	ACTIVITY CODES	1.8
TABLE 1.9.1	OPTIMUM DETECTION LIMITS, ORGANIC COMPOUNDS, WATER AND SOIL/SEDIMENT SAMPLES	1.8
TABLE 1.9.2	OPTIMUM DETECTION LIMITS, INORGANIC CONSTITUENTS, WATER AND SOIL/SEDIMENT SAMPLES	1.8
TABLE 2.8.1	GUIDELINES FOR PM_{10} AND SO_2 NAMS NETWORK SITES	2.8
TABLE 2.8.2	POPULATION LEVELS FOR WHICH NAMS MONITORING OF POLLUTANTS OTHER THAN PM_{10} AND SO_2 IS REQUIRED	2.8
TABLE 2.8.3	SUMMARY OF SPATIAL SCALES USUALLY NEEDED FOR SLAMS AND NAMS	2.8
TABLE 2.8.4	SUMMARY OF PROBE SITING CRITERIA	2.8
TABLE 2.8.5	MINIMUM DISTANCE BETWEEN MONITORING STATIONS AND ROADWAYS	2.8
TABLE APP C.3.1	CHEMICALS LISTED IN THE DANGEROUS GOODS LIST (SECTION 4.2, IATA) USED BY ESD FOR PRESERVING SAMPLES	APP C

			Subsection	
FIGURE	1.2.1	STAFFING CHART	1.2	
FIGURE	1.8.1	TIME ACCOUNTING FORM	1.8	
FIGURE	1.8.2	PAYROLL DISTRIBUTION TIMESHEET	1.8	
FIGURE	1.8.3	REQUESTS FOR TRAVEL ORDERS	1.8	
FIGURE	1.8.4	OVERTIME/COMPENSATORY TIME/HAZARDOUS DUTY PAYROLL APPROVAL FORM	1.8	
FIGURE	1.8.5	HAZARDOUS WASTE SECTION LOAD OUT SHEET	1.8	
FIGURE	1.8.6	AUTOCAD REQUEST FORM	1.8	
FIGURE	1.8.7	DATA TABLE DEFINITION ENTRY SHEET	1.8	
FIGURE	3.2.1	SAMPLE TAG	3.2	
FIGURE	3.3.1	CHAIN-OF-CUSTODY RECORD	3.3	
FIGURE	3.3.2	CUSTODY SEAL	3.3	
FIGURE	3.4.1	RECEIPT FOR SAMPLES FORM	3.5	
FIGURE	7.2.1	HORIZONTAL ANGLE (map view)	7.2	
FIGURE	7.2.2	VERTICAL ANGLE (side view)	7.2	
FIGURE	7.2.3	BEARINGS AND AZIMUTHS	7.2	
FIGURE	7.2.4	TRAVERSE FIELD NOTATIONS	7.2	
FIGURE	7.2.5	EXAMPLE OF SITE MAP SHOWING TRAVERSE POINTS USED TO LOCATE MONITORING WELLS	7.2	
FIGURE	7.3.1	FIELD NOTATIONS FOR DIFFERENTIAL LEVELING	7.3	
FIGURE	7.3.2	ELEVATION OF POINT DESIRED IS ABOVE THE INSTRUMENT	7.3	
FIGURE	7.3.3	FIELD NOTATION FOR EXAMPLE 2	7.3	
FIGURE	7.3.4	ELEVATION OF POINT DESIRED IS BELOW THE INSTRUMENT	7.3	
FIGURE	7.3.5	FIELD NOTATION FOE EXAMPLE 3	7.3	
FIGURE	7.3.6	SPOT ELEVATION DIFFERENCES USING THE LAW OF SINES	7.3	
FIGURE	7.3.7	FACE OF AMERICAN PAULINS SYSTEM ALTIMETER	7.3	
FIGURE	7.3.8	FIELD NOTATION FOR THE SINGLE ALTIMETER METHOD	7.3	
FIGURE	I.1.1	SATURATION MONITORING CIRCUIT BOARD	APPENDIX	I.1
FIGURE	I.1.2	TIMER CONTROLS	APPENDIX	I.1
FIGURE	I.1.3	PROGRAMMING WEEKDAY OPERATIONS	APPENDIX	I.1
FIGURE	I.1.4	SATURDAY PROGRAMMING	APPENDIX	I.1
FIGURE	I.1.5	SUNDAY PROGRAM	APPENDIX	I.1
FIGURE	I.2.1	SATURATION MONITORING DATA SHEET	APPENDIX	I.2
FIGURE	K.2.1	SAFETY PLAN	APPENDIX	K.2
FIGURE	K.2.2	UNDERGROUND UTILITIES CHECKLIST	APPENDIX	K.2

LIST OF EXHIBITS

			Following Subsections
EXHIBIT	1	REGION IV ESD FIELD OVERVIEW CHECKLIST	2.9
EXHIBIT	2	EPA, REGION IV, ESD STATE/CONTRACTOR OVERVIEW - AUDIT CHECKLIST	2.9
EXHIBIT	3	STATE PROGRAM EVALUATION HAZARDOUS WASTE FIELD ACTIVITIES	2.9

1.0 STANDARD OPERATING POLICIES AND PROCEDURES

1.1 INTRODUCTION

This section presents the standard operating policies and procedures of the Environmental Compliance Branch (ECB) as well as a description of Branch activities. The basic objectives of this section are to present:

- the Branch functional statement and organization;
- how requests for field investigations and technical assistance are received, processed, and implemented;
- the basic flow of project activities, including the assignment of personnel to projects, preparation of study plans, report preparation, and peer review;
- basic rules for employee conduct and legal requirements for entry procedures during field investigations;
- Branch procedures for handling basic administrative functions such as travel, overtime, purchase requisitions, and typing requests;
- Branch procedures for obtaining analytical support;
- the Branch quality assurance plan; and
- the Branch basic safety program.

1.2 BRANCH ORGANIZATION

1.2.1 General

The Branch is organized into two sections: the Hazardous Waste Section and the Air and Water Compliance Section. The Hazardous Waste Section is composed of the RCRA Unit and the Superfund Unit. The Air and Water Compliance Section is composed of the Water Compliance Unit and the Air Compliance Unit. The staffing plan for these sections is presented in Section 1.2.2. The functional statements for the Branch and each Section are presented in the following section. The Branch structure is shown in Figure 1.2.1.

1.2.1.1 Environmental Compliance Branch -- Responsible for planning, coordinating, executing, and evaluating investigations of toxic and hazardous substances; pesticides; waste, air and wastewater management problems; water treatment facilities; UIC facilities and groundwater related problems; and related environmental studies within the Region. Provides technical assistance and multimedia overview to other federal agencies, states, local agencies, the private sector, and EPA contractors in municipal and industrial operations, field investigative procedures, and toxic and hazardous wastes investigations. Maintains expertise in air monitoring methodology. Develops and presents direct training courses. Reviews and comments on remedial investigations/feasibility study work plans, remedial investigation reports, RCRA facility investigations, Record of Decision documents, NPDES permits, UIC permits, State/local agency QA/SOP Plans, and federally licensed construction projects and provides requested field investigatory support of these programs.

1.2.1.2 Hazardous Waste Section -- Responsible for planning, directing, and conducting assessments and investigations for program and enforcement purposes (civil and criminal) related to hazardous substances, including: RCRA related sampling and non-sampling facility inspections (pre- and post-permit issuance), solid waste dumps and landfills, and Superfund remedial and pre-remedial investigations such as at abandoned hazardous waste sites and related multimedia environmental and technical assistance studies. Responds to requests for assistance with oil and hazardous material spill investigations, and related multimedia environmental and technical assistance studies. When required, provides support and technical assistance for TSCA and FIFRA inspections and investigations.

In conjunction with the Analytical Support Branch, manages the Regional Sample Control Center (RSCC) for the national Contract Laboratory Program (CLP) and provides logistical support and scheduling for all Superfund related field investigations conducted by the Section and program contractors. Provides overview (field and document related) and quality assurance of Superfund contractors in conjunction with the Waste Management Division.

Provides technical assistance, training, and multimedia and routine overview to other federal agencies, state agencies, local agencies, and EPA contractors in conducting multimedia hazardous waste inspections, toxic waste monitoring, and RCRA inspections.

Provides related input to permitting, enforcement, and other associated regional programs.

1.2.1.2.1 RCRA Unit -- The RCRA Unit has the primary responsibility for all Hazardous Waste Section RCRA activities, including the conduct of RCRA compliance inspections, sampling and non-sampling field investigations, technical support, technical assistance, and testimony for RCRA related facility and/or site related investigations in support of civil and/or criminal enforcement actions; overview of the state RCRA field program activities including on-site overview of state RCRA inspections as well as field program mid-year and end-of-year reviews; review of state RCRA grants and related documents; development of standard operating procedures and inspection protocols for RCRA field activities; as well as technical assistance and training for local, state, EPA program, and other federal personnel in the field aspects of RCRA investigations. The RCRA Unit has the primary responsibility for coordinating the training activities conducted by the Section and training received by Section personnel. When required, provides the primary Section support for TSCA and FIFRA inspections and investigations.

1.2.1.2.2 Superfund Unit -- The Superfund Unit has the primary responsibility for all Hazardous Waste Section Superfund activities including the conduct of abandoned hazardous waste site inspections and investigations, both sampling and geophysical; field investigations, technical assistance, and testimony in support of Superfund civil and criminal enforcement actions; responds to requests from the Waste Management Division for assistance in monitoring oil and hazardous material spill situations, as well as assistance in investigating potential immediate removal Superfund sites; and operation of the Section's portion of the RSCC. In conjunction with the Waste Management Division, schedules all Superfund investigations in the Region conducted by Section and EPA contractor personnel; conducts on-site field quality assurance overview of contractor field investigations and overviews contract related investigation documents (study plans, RI/FS work and site operation plans, study reports, etc.); overviews state hazardous waste programs that are Superfund related; participates in and develops specific Superfund related training and field standard operating procedures as well as participates in training courses for local, state, EPA programs, other federal field personnel, and contractors; and provides technical support for Superfund investigations and inspections to state and other federal programs. The Superfund Unit has the primary responsibility for the Branch's field health and safety program.

1.2.1.3 Air and Water Compliance Section -- Responsible for planning, coordinating, and executing investigations of municipal and industrial wastewater treatment facilities, and investigations in support of the Regional UIC and drinking water programs. Provides technical assistance and overview to states, local agencies, and other federal agencies in municipal and industrial wastewater operations, and air monitoring studies. Develops and presents direct training courses; reviews and comments on NPDES permits, and federally licensed construction permits; and provides expert testimony.

1.2.1.3.1 Water Compliance Unit -- Responsible for planning, directing, and conducting assessments and investigations including data interpretation and

investigative reports related to municipal and industrial wastewater treatment facilities.

Responsible for studies relating to facility operations, including their impact upon receiving waters as well as the persistence and fate of their contaminants in the aquatic environment and ground water. Provides related input to permitting, enforcement, and other associated regional programs.

Overviews and provides technical assistance and troubleshooting to state, local, and other federal agencies and the private sector concerning municipal operations in order to correct operational problems at existing facilities.

Conducts in-depth diagnostic evaluations of wastewater treatment facilities to provide technical details for enforcement actions, consent decrees, etc., in support of the Water Management Division.

Monitors and overviews NPDES delegated states as well as conducts independent studies of municipal and industrial facilities including CSIs, CEIs, PAIs, etc. Reviews and suggests corrections for self-monitoring techniques at municipal and industrial facilities and provides input to enforcement actions.

Provides technical assistance, training, and overview to state, local, and other federal agencies concerning municipal and industrial facility investigative techniques, operational control techniques, and data interpretation.

At the request of the Water Management Division, responsible for conducting field investigations of water treatment facilities and field investigations in support of the UIC, Drinking Water, UST and the Regional ground water monitoring program including associated water quality investigations.

1.2.1.3.2 Air Compliance Unit -- Responsible for conducting state and local agency Performance Audits; Quality Assurance Plan (QA/SOP) reviews and approvals; conducting National Air Monitoring (NAMS), State and Local Air Monitoring (SLAMS), and Special Purpose Monitoring (SPM), and National Performance Audit Program (NPAP) participation including the distribution of particulate filters; conducting data validations; tracking and submitting Precision and Accuracy (PARS) data submittals; conducting an annual state/local agency training workshop; and conducting special studies.

Responsible for maintaining the Region's expertise in air toxics monitoring methodology, which includes conducting, planning, and arranging air toxics studies. Provides technical assistance to federal, state, and local agencies on air monitoring and analytical methods for both toxics and criteria air pollutants.

Conducts air monitoring in support of CERCLA and RCRA site ranking studies, and performs air sampling for specific pollutants in response to emergency response requests from the Waste Management Division. Reviews hazardous waste site clean-up and remedial action plans for air toxics monitoring activities and overviews contractor air monitoring activities.

Maintains an air monitoring laboratory equipped with sophisticated air monitoring instrumentation, air toxics screening instrumentation, air toxics sampling equipment, calibration equipment, computerized data acquisition equipment, and a NBS Standard Reference Photometer in condition ready to produce valid air quality data. Some air monitoring equipment is maintained for use by state and local agencies for special studies or emergencies.

Provides assistance to the Air, Pesticides and Toxics Management Division by arranging, planning and conducting regional studies; reviewing state and local agency workplans; and conducting National Ambient Air System (NAAS) Audits.

Verifies that state/local Hi-Vol orifices meet regulatory specifications and certifies ozone photometers and calibration systems.

1.2.2 Line of Authority

The purpose of this section is to establish the line of authority, in the Branch and in each Section, in the event of the absence of the Branch or respective Section Chiefs.

Branch:

John Marlar
Mike Carter
Bill Bokey
Steve Hall
Ron Barrow
Herb Barden
Bill Cosgrove

Hazardous Waste Section:

Bill Bokey
Steve Hall
Bill Cosgrove
Rod Davis
Bruce Ferguson
Dan Thoman
Charles Till
Don Hunter
Jim Gray
Fred Sloan
Sharon Matthews
Pat Boyle
John Trudell
Roger Carlton
John Vail
Terry Thomas
Laura Childs

Air and Water Compliance Section:

Mike Carter
Ron Barrow
Herb Barden
Danny France
Joe Compton
Louis Salguero
Jerry Burger
Mike Bowden
Chuck Padgett
Tim Slagle
Jeff Lovell

FIGURE 1.2.1
STAFFING CHART
U. S. ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL SERVICES DIVISION
ENVIRONMENTAL COMPLIANCE BRANCH
COLLEGE STATION ROAD
ATHENS, GEORGIA 30613
FTS Access - 250

BRANCH CHIEF
John Marlar (404) 546-3117

HAZARDOUS WASTE SECTION
Bill Bokey - Chief (404) 546-3300 (3351)
Cathy Murphy - Secretary
Sandy McClain - Clerk Typist

AIR AND WATER COMPLIANCE SECTION
Michael R. Carter - Chief (404) 546-3317
Linda Kidd - Secretary

SUPERFUND UNIT
Steve Hall, Chief
Roger Carlton
Gray
Don Hunter
Fred Sloan
Dan Thoman
Charles Till
John Vail
ESAT Field Staff

RCRA UNIT
Bill Cosgrove, Chief
Pat Boyle
Rod Davis
Bruce Ferguson
Sharon Matthews
Terry Thomas
John Trudell
Laura Childs
Pat Thomas - Warehouse
Chuck Zimmerman - Warehouse
Milton Henderson - Warehouse
ESAT Warehouse Staff

WATER COMPLIANCE UNIT
Ron Barrow, Chief
Mike Bowden
Joe Compton
Louis Salguero
John Williams
Jeff Lovell

AIR COMPLIANCE UNIT
Herb Barden, Chief
Jerry Burger
Jim
Danny France
Richard Guillot
Margaret Hale
Chuck Padgett
Tim Slagle

1.3 PROJECT ACTIVITY FLOW

The Branch receives requests for field investigations and technical assistance activities from a variety of sources including federal, state, and local agencies; EPA Headquarters (including NEIC's Office of Criminal Investigations), EPA regional operating divisions (primarily the Water Management Division and the Waste Management Division); U.S. Department of Justice; as well as the private sector.

All requests for non-routine field studies or technical assistance activities shall be directed to the Director, Environmental Services Division with a copy to the appropriate Section Chief. Any request that is forwarded in any other manner shall be immediately routed to the Director's office. Requests for field studies that are received by Branch staff by telephone shall be discussed with the appropriate Unit Chief who will notify the Section Chief and/or the Branch Chief. All such requests shall be followed up by a memo or letter from the requestor. Non-supervisory Branch personnel are not to commit the Branch or the Division to field studies without the approval of the Division Director and Branch Chief (or appropriate Section Chief in his/her absence). All emergency requests for field studies shall be handled expeditiously, but all such requests shall be followed up by a written memo or letter from the requestor. All requests for routine field studies or technical assistance activities (i.e., those activities committed to in the annual work plan) shall be directed to the appropriate Section Chief who will assign the activity to the appropriate Unit.

The receipt of an investigation or technical assistance request shall be acknowledged as soon as possible. This is normally the responsibility of the Division Director, the Branch Chief, or the appropriate Section Chief. If the request is accepted, the requestor will be so notified, and the Branch Chief shall assign it to the appropriate Section. The Section Chief shall then assign the request to the appropriate Unit Chief who will log the request into the computerized project tracking system. The Unit Chief, in consultation with the Section Chief, shall select a tentative study date and assign a project leader or field investigator as appropriate.

The assigned project leader or field investigator shall discuss the technical merits of each project with his/her Unit Chief. The objectives and scope of each investigation or technical assistance project will be mutually agreed upon during this session. The project leader or field investigator will then contact the requestor and obtain necessary background information to formulate a study plan. A reconnaissance trip may be necessary in some cases. Trips to the EPA regional office or state and local regulatory agency offices may also be required. When the project leader has collected all of the relevant material, he/she shall prepare a study plan and, if appropriate, discuss the resource requirement of the project with his/her Unit Chief. When required, additional staff from other Units will be assigned by the Section Chief or Branch Chief. In studies involving more than one Branch, appropriate staff will be assigned by the Branch Chiefs or Division Director/Deputy Division Director. Concurrently, the Unit Chief and/or project leader shall discuss the analytical requirements with appropriate Analytical Support Branch

personnel. Draft study plans and final study plans shall be prepared as outlined in Section 1.5 and shall be reviewed in accordance with the Regional peer review policy.

After the study plan has been prepared, the project leader/field investigator shall prepare a request for travel orders and overtime/compensatory time and submit them to the appropriate Section Secretary. This request should be submitted at least 10 working days in advance of routine studies. Concurrently, the project leader shall coordinate equipment and vehicle needs with the Branch warehouse staff coordinator and procure any needed special equipment.

After the field study has been conducted, the project leader/field investigator shall prepare an outline or draft of the study report for review and concurrence of the appropriate Unit Chief (not required for routine inspections). If samples were collected during the study or investigation, the Analytical Support Branch will submit data to the appropriate Section Chief. The Section Chief will distribute the analytical data, through the appropriate Unit Chief, as soon as possible to the project leader/field investigator. The project leader shall prepare a draft of the final report (not required for routine inspections) for review by the Unit Chief and Section Chief. Once the report has been cleared by the appropriate Unit Chief and Section Chief, it shall then be reviewed in accordance with the Regional peer review policy. The review comments shall be considered and incorporated where appropriate. A final report shall then be prepared and distributed as outlined in Section 1.6. Routine inspection reports shall be prepared in final form for review by the Unit Chief and the Section Chief or his/her designee and shall be promptly transmitted (Section 2).

After the final report has been transmitted, the project leader/field investigator shall collect all relevant material including the report, etc., as outlined in Section 3, place it in the project file, and submit it to the appropriate Section Secretary for filing. Completion of the project shall be entered by the appropriate Section Chief or Unit Chief into the appropriate computerized project log.

1.4 PROJECT LEADER RESPONSIBILITIES

The project leader has overall responsibility for seeing that field operations are carried out expeditiously and that the project objectives are met. Specifically, these responsibilities include:

- study plan preparation and coordination;
- logistical arrangements including the submission of travel and purchase order requests;
- overall technical supervision of assigned project personnel during field operations and assurance that standard field operating procedures are followed (any deviations shall be documented in the field log book as well as in the final report);
- overall responsibility for project field safety;
- overall responsibility for making study plan modifications in the field as required;
- certifying and keeping accurate records of all overtime, compensatory time, and hazardous duty time earned by project personnel in the field;
- project data interpretation and final report preparation; and
- coordinating any necessary project follow-up activities such as attending show-cause hearings, presenting testimony, etc.

1.5 STUDY PLANS

Study plans shall be prepared and issued for all investigations, inspections, and field studies conducted by Branch personnel. The responsibility for preparing study plans rests with the assigned project leader or field investigator. Study plans shall be issued at least 10 working days in advance of the study for routine inspections and investigations and at agreed upon time frames (agreed upon with the requestor) for more complex studies. The only exceptions are those investigations and inspections that are conducted in response to emergency episodes and spills. No specific requirements for study plans for emergency episodes or spills shall be made. However, if time permits, a study plan should be prepared.

Study plans for routine inspections such as compliance sampling (CSI), case development investigation evaluations (CDIE), performance audit inspections (PAI), etc., shall consist of a notification that the inspection will be conducted, who will conduct it, the inspection dates, the number and types of samples to be collected (if appropriate), analyses required (if appropriate) and a statement that the procedures outlined in this SOPQAM will be followed. These study plans shall be prepared as one or two page memorandums. These standard study plans shall be distributed to appropriate Regional staff as well as the appropriate state regulatory agency (if appropriate). Where required, safety plans should be prepared for routine investigations (Appendix K).

Study plans for non-routine investigations and field studies need to be more detailed. In general, these study plans should contain the following elements:

- Introduction -- a brief history and statement of the problem to be investigated.
- Objectives -- a statement as to what the investigation is to accomplish and how the information is to be used.
- Scope -- a definition of the limits of the study.
- Time Schedule -- a statement outlining when the study will be conducted, analytical results will be available, the draft report will be written, and the final report will be available.
- Study Procedure -- the specific plan to collect the required information (not field methodology).
- Methodology -- specific field techniques to be employed. A statement that the techniques in this SOPQAM will be employed shall be included. The use of any techniques not included in this SOPQAM shall be justified.
- Analytical Requirements -- a complete listing of all samples to be collected, required analyses, and which laboratory(s) will analyze the samples.

- Logistics -- a complete listing of the manpower requirements and specific functions of all project personnel, special equipment and vehicles to be used, use of mobile laboratories, how samples are to be transported to the laboratory, etc.

- Safety Plan -- where required, a safety contingency plan will be included (Appendix K).

Draft study plans for the non-routine investigations shall be prepared and reviewed in accordance with the Regional peer review policy. Information copies of the draft study plan should be sent to all relevant program staff and to the Analytical Support Branch staff. If significant changes are made to the draft study plan, it shall be rewritten and reviewed again in accordance with the Regional Peer Review Policy. A final study plan will be prepared and transmitted to appropriate Regional, OCI, and/or Headquarters staff as well as appropriate state regulatory agency staff utilizing a transmittal memorandum.

1.6 STUDY REPORTS

Almost all investigations, inspections, and field studies conducted by Branch personnel will result in the issuance of a technical report. The project leader/field investigator is responsible for the preparation of the report.

Routine inspection reports such as CSI's, CDIE's, PAI's, etc., shall include the completion of any appropriate standard forms along with a transmittal memo detailing the significant findings of the inspection. Specific requirements for routine inspection reports are given in Section 2. The reports shall be distributed to appropriate Regional or Headquarters personnel utilizing a transmittal memorandum. Reports distributed to state or local personnel will be by use of an official EPA letter.

No firm format is given for non-routine technical reports. The following report outline shall be used as a guide and modified as necessary. Generally, report formats should include:

- Introduction -- should include a statement of the problem, who requested the study, when the study was conducted, who conducted the study, the objectives of the study, and any necessary acknowledgements.
- Study Area -- a description of the area studied.
- Study Findings -- a brief summary of study findings, results, and any relevant conclusions.
- Recommendations -- any recommendations resulting from study findings.
- Study Methodology -- field and analytical methods employed during the study.
- Appendices -- a listing of all relevant data collected during the study.

As a general rule, reports prepared for enforcement purposes, or reports prepared in anticipation of possible enforcement actions, should contain only factual information. These reports shall not contain conclusions, recommendations, or personal opinions. Conclusions, recommendations, and personal opinions for these investigations may be included in a separate memorandum with the concurrence of the Branch or appropriate Section Chief. When this is done, the transmittal memorandum should be stamped "Confidential - This document is prepared in anticipation of enforcement litigation. It is not subject to discovery."

The draft study report shall be reviewed in accordance with the Regional peer review policy. Although the Regional peer review policy excludes enforcement related reports, the Regional Quality Assurance Officer shall be sent a copy of all draft enforcement related reports for peer review with the exception of criminal investigative reports. The final report shall be distributed to appropriate Regional or Headquarters personnel utilizing a transmittal memo.

1.7 EMPLOYEE CONDUCT

1.7.1 General

EPA employees are required to perform their duties in a professional and responsible manner, refraining from any use of official position for private gain. Branch employees are also required to collect and report the facts of an investigation or inspection completely, accurately, and objectively. They must conduct themselves at all times in accordance with the Environmental Protection Agency Regulation on Employee Responsibilities and Conduct (1) and shall adhere to the Code of Ethics for Government Service. The following paragraphs review some topics in the regulations especially applicable to the work of Branch employees.

Employees shall avoid conflicts of interest through outside employment or other private interests. A conflict of interest may exist whenever an EPA employee has a personal or private interest in a matter which is related to his/her official duties and responsibilities. It is important to avoid even the appearance of a conflict of interest because the appearance of a conflict damages the integrity of the Agency and its employees in the eyes of the public. All employees must, therefore, avoid situations which are, or give the appearance of, conflicts of interest when dealing with others in or outside the government.

Good public relations and common sense dictate that employees dress appropriately for the activity in which they are engaged.

It is important that cooperation be obtained and good working relations established when working with the public. This can best be accomplished by using diplomacy, tact, and persuasion. Employees should not speak of any person (including other regulatory agency or facility personnel) in a derogatory manner, and should use discretion when asked to give a professional opinion on specific products. All information acquired during an employee's duties is for official use only.

An employee is forbidden to solicit or accept any gift, gratuity, entertainment, favors, loans, or any other thing of monetary value from any person, corporation, or group which has a contractual or financial relationship with EPA; which has interests that may be substantially affected by such employee's official actions; or which conducts operations regulated by EPA.

1.7.2 Entering A Facility

1.7.2.1 Authority -- Various federal environmental statutes grant EPA enforcement personnel authority to enter and inspect facilities. The authority granted in each statute is similar to that stated below in Section 308 of the Clean Water Act:

> "(a)(B) the Administrator or his authorized representative, upon presentation of his credentials (i) shall have a right of entry to, upon, or through any premises in which an effluent source is located or in which any records required to be maintained. . .are located, and

(ii) may at reasonable times have access to and copy any records, inspect any monitoring equipment or method required. . . , and sample any effluents which the owner or operator of such source is required to sample. . ."

For the specific requirements on conducting inspections and collecting data pursuant to a particular Act, see: Section 308 of the Clean Water Act; Section 9 of the Federal Insecticide, Fungicide, and Rodenticide Act; Section 3007 of the Resource Conservation and Recovery Act; Section 8 of the Toxic Substances Control Act; Section 1445 of the Safe Drinking Water Act; Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund); and Titles I, III, and IV of the Clean Air Act.

1.7.2.2 Unreasonable Search and Seizure -- EPA authority under the various Acts is subject to the "unreasonable search and seizure" provisions of the Fourth Amendment to the Constitution. The prohibition is not against all searches and seizures, but only those which are unreasonable or to which valid consent, if required, has not been given. Consent, in this context, means the intentional foregoing of right to privacy which is not the result of either fear, ignorance, or trickery.

To comply with the Acts and avoid any "unreasonable search" and procedural problems, a facility should be entered in the following manner:

1. The facility premises should be entered through the main gate or through the entrance designated by the source if in response to an inspection notification letter (a 308 letter for example).

2. The employee shall introduce herself/himself in a dignified, courteous manner to a responsible plant official. A responsible plant official may be the owner, operator, officer, or agent in charge for the facility, including the plant environmental engineer. Identification credentials shall always be shown.

3. If only a guard is present at the entrance, the employee shall present her/his credentials and suggest that the guard call his superior on the phone. If the inspector knows the name of the responsible official he/she is to see, he/she shall request the guard to call him/her directly.

4. If the company provides a general sign-in sheet, it is acceptable to sign it. Branch employees shall not sign a release of liability (waiver) when entering a facility under the authority of Federal law.

5. If entry is refused, the employee shall not contest the issue with the facility representative, but will immediately do the following:

   - obtain name and position of individual denying entry to the facility, and record the date and time;

   - cite the appropriate EPA-administered legislation, ask

if he/she heard and understood the reason for your presence, and record the answer and any reasons given for denial of entry; and

- leave the premises immediately.

After leaving the facility, the employee shall, at the earliest possible time, inform their immediate supervisor and the Office of Regional Counsel, by telephone of the events which took place and seek guidance on how to proceed.

1.7.3 Requesting Information

The various laws and statutes under which EPA operates address the protection of trade secrets and confidential information. As a general policy, Branch staff should not accept confidential information unless it is necessary for carrying out Agency functions under a particular Act. As a matter of Branch policy, request for confidential information can only be signed by a responsible party in one of the operating Divisions or by an attorney in the Office of Regional Counsel.

In compliance with EPA regulations, an EPA request for company information, pursuant to statutory authority, will contain a statement allowing the facility to designate all or part of the information requested by the Agency as confidential by marking it according to: Code of Federal Regulations, Title 40, Part 2, Section 203.41; or Federal Register, 41 FR 36902. In addition to citing the appropriate regulations, the request for confidential information will state that:

(1) The business may, if it desires, assert a business confidentiality claim covering part or all of the information in the manner described by [the applicable regulation], and that information covered by such a claim will be disclosed by EPA only to the extent, and by means of the procedures, set forth in [the applicable regulations]; and that

(2) If no such claim accompanies the information when it is received by EPA, it may be made available to the public by EPA without further notice to the business.

If the collection of confidential information is required to carry out the responsibility of the Branch, personnel should consult carefully with the appropriate operating Division staff and the Office of Regional Counsel attorneys. In general, when such information is needed by Branch personnel, the request should state that this information will be transmitted directly to the Office of Regional Counsel.

In general, Branch personnel shall not accept confidential information when conducting a plant evaluation, inspection, or reconnaissance. When Branch personnel must collect or observe confidential information, a separate logbook shall be maintained. When confidential information is entered into an inspector's logbook, the entire logbook and each page containing confidential information shall be marked "CONFIDENTIALITY CLAIM." Upon return to the EPA Region

IV, ESD facility, all such information shall be maintained in a locked filing cabinet and the Office of Regional Counsel shall be notified for ultimate disposition of the material.

1.7.4 Disclosure of Official Information

It is EPA policy to make information about EPA and its work available, freely and equally, to all individuals, groups, and organizations. This policy, however, does not extend to confidential information or to investigatory information and evidence relating to the suspicion of a violation of federal environmental laws.

Any Branch employee who receives a request, written or oral, for inspection or disclosure of EPA investigatory records, whether made under judicial discovery procedures or the Freedom of Information Act, shall immediately advise the Division's Freedom of Information (FOI) Act Coordinator and/or the Regional FOI Coordinator of the request. Such records shall not be released without the specific concurrence of the Regional FOI coordinator. RCRA, Superfund, and TSCA program offices will make all third party distribution of data and investigative reports.

1.8 BASIC ADMINISTRATIVE FUNCTIONS

1.8.1 Timekeeping

Each Section Secretary is that particular Section's timekeeper. The timekeeper shall be kept informed of all leave taken as well as the overtime and compensatory time earned and taken by each employee. Branch employees shall obtain approval from their respective Unit, Section, or Branch Chief before taking annual leave. A leave request form (SF-71) must be completed when more than 40 hours of annual leave is taken or whenever any leave is taken and the employee anticipates being unavailable to initial his/her timecard. All Branch employees shall utilize the appropriate Section roster, located on the bulletin board in their respective Section Secretary's office, to post leave taken. If an employee is too sick to report for duty, the employee shall notify the respective Section Secretary by telephone as soon as possible. The appropriate Section Secretary, as well as the employee's immediate supervisor, shall always be kept informed of all travel plans (even those made to the regional office). The appropriate Section Secretary is responsible for notifying the Division Director's Secretary in writing of any scheduled travel by COB on Thursday prior to the following week's travel. Emergency or unscheduled travel will be reported via telephone to the Division Director's Secretary by the appropriate Section Secretary once the travel is known. All employee's time must be charged to appropriate specific account numbers. This is accomplished by having each Branch employee utilize the form shown in Figure 1.8.1 to account for all work hours. This form shall be filled out by each Branch employee to the nearest whole hour. For the Activity Code in Figure 1.8.1, each employee shall use the most relevant Activity Code from Table 1.8.1. The form shall be submitted to the appropriate Section Timekeeper no later than close of business on the first Monday of each pay period. All leave, compensatory time, and overtime, whether earned or taken, must be turned in to the appropriate Section Timekeeper by 0900 on the second Thursday of each pay period. These times/days may vary on holidays. A notice will be posted in each Section Secretary's office if leave should be turned in earlier.

Each employee with either a fixed Superfund account number or any employee who works on any Superfund activity during a pay period shall also complete the EPA Payroll Distribution Timesheet (Figure 1.8.2). This form shall be filled out to the nearest hour for regular hours worked and to the nearest quarter hour for overtime. The report shall be signed and dated by each employee prior to turning it in to their Section Timekeeper on the first day of each pay period. The Timekeeper gives the supervisor the form to review, sign, and date. By noon on the second day of each pay period, the Supervisor returns the form to the Section Timekeeper.

All requests for compensatory time and overtime must be submitted in advance of projects and approved before it can be earned. Overtime/compensatory time requests should be submitted to the appropriate Section Secretary on the bottom of the Request for Travel Order Form (Figure 1.8.3). These requests should be submitted at least two weeks in advance of projects, and shall be initialed by the employee's immediate supervisor. The appropriate Section Secretary shall complete the Request for Authorization of Overtime Work (EPA Form 2560-7) for approval by the Division Director.

All overtime and compensatory time earned shall be submitted to the appropriate Section Timekeeper utilizing the form shown in Figure 1.8.4. This form should be signed by the project leader/field investigator, initialed by the appropriate Unit Chief, and signed by the appropriate Section Chief. When field operations are conducted during the second week of the pay period, the project leader or field investigator shall call the appropriate Section Timekeeper by 0900 on Thursday and report any overtime and compensatory time earned by project personnel.

Blanket authorization for hazardous duty pay is approved on an annual basis for Hazardous Waste Section personnel. The Overtime/Compensatory Time/ Hazardous Duty Pay Approval Form (Figure 1.8.4) must be completed for all approved personnel earning hazardous duty pay. The form shall be completed upon return from the field investigation for approval by the Chief, Hazardous Waste Section. The justification for hazardous duty pay shall be signed by the Project Officer, the Section Safety Officer, and the Chief of the Hazardous Waste Section.

1.8.2 Purchase Requisitions

All purchase requests shall be submitted on EPA Form 1980-8 (Procurement Request/Requisition). This form shall be routed through the appropriate Unit Chief to the Section Chief. All purchase requests shall contain a specific written justification on a separate sheet of paper attached to EPA Form 1980-8 as to why the purchase is necessary (if the request is for Superfund, it should be so noted below the written justification). This form and written justification shall also be used when purchases are made utilizing petty cash.

1.8.3 Travel Authorization Requests

All travel requests shall be made on the Request for Travel Orders Form (Figure 1.8.3), initialed by the immediate supervisor, and (if possible) shall be submitted to the appropriate Section Secretary at least 10 working days in advance of the scheduled travel.

1.8.4 Word Processing Procedures

To minimize risks of multiple copies, all reports and memos will be finalized through the clerical staff. The clerical staff will be responsible for proper formatting, editing, and final distribution of each document. Once a document has been submitted for finalization, no further editing should occur to the document unless it is on the "official working copy" which has been submitted to the clerical staff.

1.8.5 Report and Correspondence Distribution

After report distribution memos and correspondence have been signed, these items will be returned to the appropriate Section Secretary or Clerk-Typist for distribution. In general, other Branch employees <u>will not</u> make distribution of such items. Memos or correspondence for the Division Director (or higher level authority) must be initialed by the originator, the Unit Chief, the Section Chief, and the Branch Chief prior to submittal to the Division Director's

Secretary. The appropriate Section Secretary will carry all correspondence for the Division Director's signature directly to the Division Director's Secretary.

1.8.6 Vehicle Use and Check-Out

The keys for Branch sedans are kept in the Air and Water Compliance Section Secretary's office in a locked box, and the keys for Branch field vehicles are kept in the Hazardous Waste Section Secretaries's office in a locked box. All vehicles shall be checked out by Branch personnel utilizing the check-out sheet located in the appropriate Section Secretary's office. Any needed repairs shall be noted on the check-out sheet along with the ending vehicle mileage at the conclusion of a trip when the keys are returned. The gas tank for all vehicles shall be at least three quarters full when returned to the Athens facility.

1.8.7 Field Equipment Check-Out

Branch field personnel shall use the current field equipment load-out form (Figure 1.8.5) to specify the field equipment needed for specific field studies. All requested information (including account number, project number, and activity code for which the investigation is charged) shall be completed prior to submittal to the warehouse staff. The load-out form should be submitted to the warehouse staff at least five working days prior to the time the equipment is needed (except in an emergency).

1.8.8 CERCLA/RCRA Site Map Requests

Requests for hardcopy production of site maps and other graphic output to be produced by the Hazardous Waste Section AutoCAD/Mapping workstation should be completed using the form shown in Figure 1.8.6 or equivalent. Requests for non-CERCLA/RCRA work as well as requests by non-HWS Section personnel require approval by the HWS Chief.

1.8.9 Requests for Analytical Data Summary Tables

The Hazardous Waste Section has developed computer programs that produce tables summarizing ESD/ASB and CLP laboratory analytical data results. Since these programs require direct access to the ESD/ASB computer databases and appropriate accounts and access rights on the laboratory's computer, requests should be made to the HWS using the form shown in Figure 1.8.7 or equivalent.

FIGURE 1.8.3
REQUESTS FOR TRAVEL ORDERS

Names_____

_____

Dates of Travel_____

Site Name(s)_____

Site Location(s)_____

Site Account Number(s)_____

Purpose of Trip_____

_____

****

LODGING

City/County_____Hotel_____

Cost_____Actual Expenses_____

****

DO YOU NEED FLIGHT RESERVATIONS? Yes ( ) No ( )

Beginning Date_____LV_____Time_____Flight #_____

AR_____Time_____

Returning Date_____LV_____Time_____Flight #_____

AR_____Time_____

****

DO YOU NEED A RENTAL CAR? Yes ( ) No ( )

Confirmation #_____Agency_____

Rate_____Size_____

****

REQUEST FOR OVERTIME/COMP TIME

No. of Hrs_____

_____

Submitted By:_____

Approved By:_____Unit Chief

_____Section Chief

FIGURE 1.8.4

OVERTIME/COMPENSATORY TIME/HAZARDOUS DUTY PAY APPROVAL FORM

USE ONE FORM FOR EACH PROJECT

PROJECT NAME:_____PROJECT NUMBER:_____

ACCOUNT NUMBER_____PROGRAM ELEMENT:_____

NAME	DATE	OVERTIME	COMP TIME	HD PAY

PROJECT LEADER:_____ APPROVAL/DATE _____

CHIEF, HWS_____ APPROVAL/DATE_____

_____

HAZARDOUS DUTY PAY JUSTIFICATION

_____

_____

_____

SAFETY OFFICER: _____APPROVAL/DATE_____

CHIEF, HWS:_____APPROVAL/DATE_____

FIGURE 1.8.5
HAZARDOUS WASTE SECTION
LOAD OUT SHEET

Project Leader_____EXT._____ Activity Code_____ Loadout Date
Study(s)_____ST._____ Project No. _____ __/__/__
Account No(s)_____RCRA? CERCLA? Vehicles(s) _____
_____
_____

SOIL/SEDIMENT/WASTE

__S. S. Shovels

__Hand Augers 4" heads
__Extensions
__Pins (jar)
__Handles

__(L) S.S. Spoons
__(S)

__(L) Glass Pans
__(S)

__Scoops
__Scoop Brackets
__Conduit Pipe

__(L) S.S. Ponar Dredge
__(S)
__3/8" Rope (ft)

Miscellaneous
__Glass Tube
__Bacon Bomb
__Coliwasa Tubes
__S.S. Push Head (ea)
__Shelby Tube/pushhead(ea)

WATER
__Well Sounder #_____
__2" Teflon® Bailers
__Bailer Rope (spool)
__Phase Detector #_____
__Graduated Cylinder

GLOVES
__Surgical (latex) (Box)
__Neoprene Rubber (Box)
__Butyl Rubber (ea)
__PVC (ea)
__Cotton Work (ea)
__Silver Shields

WELL INSTALLATION
__Lil' Beaver®
__Auger Points
__Auger Flights
__2" Sand Points
__2" Well Casings

PUMPS

__Peristaltic Pump(s)#___
__Silastic Tubing (coil)
__Teflon® Tubing (25'roll)
__Vacuum Inserts (jar)
__M. Flex Cables (set)

__Fultz® Pump(s)#_____
#_____#_____
__Extra Fultz Heads (S/L)
__Power pack
__24v Cables (set)
__Charging Units (ea)
__24v Generator

__Goulds Pump #_____
__Extension Cord
__110v Generator
__Hose (ft)
__3/8" Rope (ft)
__Tripod

__Geo Guard #_____
__Geo Guard Control Box
__Geo Guard Compressor

__Well Wizard #_____
__3011 Controller (elect.)
__3111 Controller (gas)
__Air Connector
__12v Connector

BATTERIES
__12 volt
__ _____

SURVEYING EQUIPMENT
__Transit #_____
__Level #_____
__Rod #_____
__Altimeter
__Steel Tape (ea)
__Fiberglass Tape (ea)
__Aerial Targets (ea)
__Flagging (ea)
__Cloth Tape (ea)
__Tacks
__Wood Stakes (ea)
__Sledge Hammer (ea)
__Hammer (ea)
__Orange Vests
__Plumb Bob

TOPCON

__Topcon#_____
__Prisms
__Prism Tripods
__Thermometer
__Barometer
__Field Book

GEOPHYSICAL
__Magnetometer #__
__Metal Det. (L),(S)#
__EM-31#_____
__EM-34 #_____
__Wadi

LIQUID CONTAINERS

Liquid
__1Gal.(Ext/Pest)
__1L Poly Met/Cyanide
__40-ml VOAs-3/sample
____Chlorinated
____Non-Chlorinated
__500ml Glass(Phenol)

Soil/Sed/Sludge
__8oz Ext/Pest/Cyan
__2oz VOAs

Miscellaneous
__1 Gal Plastic
__4oz white-cap jars
__500-ml Polyeth.
__1/2 Gal Plastic
__1 L. W/M Clr. Glass

Concentrated Waste
__8oz Glass (jar)

REAGENTS

__HNO_3 (500ml)
__NaOH (bottle)
__H^2SO_4 (500ml)
__Thiosulfate
__Zinc Acetate
__KCL
__Ascorbic Acid

FIGURE 1.8.5 (CON'T)

FIELD ANALYSES

___pH Paper
___pH Meter (old)_____
___pH Meter (new)_____
___pH Buffer (set)
___Storemore jars
___Cond. Meter#_____
___D.O. Meter#_____
#_____
#_____

___ICE CHESTS (L,S, 6pck)

__ __ __ __ __ __
___Plastic Crates (L,S)

Plastic Bags
___Large
___Medium
___Small
___Whirl-Paks®

TAPE
___Fiber (ea)
___Duct (ea)
___Electrical (ea)
___Masking (ea)

SAMPLE SHIPPING
___Vermiculite (Bag)
___Dust Masks (Box)

Sample Cans w/ Clips
___Gallon (ea)
___Quart (ea)

Shipping Boxes/
Styrofoam Inserts
___1 Quart (ea)
___4 Quart (ea)
___1 Gallon (ea)

SAFETY EQUIPMENT

	XL	L	M	S
___Tyvek	___	___	___	___

___Green One Piece Suit
___Yellow Splash Suit (ea)
___Disposable Booties (pr)
___Tent (ea)
___Drink Cooler (ea)
___Chair(s) (ea)
___Tables (ea)
___Cooling Vests
___Brass Tools (set)
___Rangers (set)
___Extra Air Tanks (ea)
___Ultra Twin Canist.(set)
___Cascade System
___Boundary Tape-Excl Zone
___Boundary Tape-Supp Zone
___Boundary Tape-Cont Zone
___Eye Wash System
___Cooling Vest & Batteries

SAFETY MONITORING

___Air Monitoring Box#____
___OVA#_____
___Tip II #_____#_____

FIELD CLEANING
___Wash Tubs (ea)
___Pump Sprayer (ea)
___Distilled Water (gal)
___Organic Free Water (gal)
___Milli-Q Water System
___Isopropanol (gal)
___Liquinox (bott)
___Graduated Bucket (ea)
___Brushes (ea)
___Aluminum Foil (box)
___Garbage Bags (ea)
___Oil Wipes (ea)
___Saw Horses (pr)
___Plastic Sheets (box)

PROJECT LEADER

___Tags (bundle)
___Custody Seals (box)
___Custody Sheets
___Sample Receipt
___Travel Orders
___Hotel RSVP
___Topo/Quad/Photo
___Hand Radios
___Hand Rad. Charger
___Safety Bag(s)
___Camera
___Film
___Instruction Manuals
___Notebook(s)
___Traffic Reports
___Air Bill(s)
___Hazardous Manifest

MISCELLANEOUS
___Extension Cord
___Trailer (large)
___Trailer (small)
___Trailer (H) Hearse)
___Bungi Cord (ea)
___Gas Can (ea)
___Boat
___Life Vest(s) (ea)
___Oar(s) (ea)
___Waders (pr)
___Flashlight (ea)
___Machete (ea)
___Whizz Witch
___Jumper Cables (set)
___Safety Harness (ea)
___Fluorescent Paint
___12v Floodlights
___Tool Box (ea)
___Paper Towels (pks)
___Garden Hose
___Gator Aid (pks)
#CHECK PAGE ONE
__*__Reagents
__*__Lit' Beaver®
__*__24v Generator
__*__110v Generator
__*__PUMPS

Special Requests _____

_____

_____

Released By: _____ Date: _____ Returned To: _____ Date: _____
Released To: _____ Date: _____ Returned To: _____ Date: _____

FIGURE 1.8.6
AUTOCAD REQUEST FORM

REQUESTOR'S NAME:_____

TYPE OF REQUEST: CERCLA_____ RCRA_____ OTHER_____

DATE OF REQUEST:_____ DATE REQUIRED:_____

PROJECT NUMBER:_____ ACCOUNT NUMBER:_____

PROGRAM ELEMENT:_____ FIGURE NUMBER:_____

NAME OF OLD DRAWING TO USE AS TEMPLATE:_____
(IF APPLICABLE)

HAZARDOUS WASTE SECTION CHIEF SIGNATURE:_____
(REQUIRED FOR ALL NON-CERCLA/RCRA OR NON-HWS REQUESTS)

COMMENTS:

_____

_____

_____

_____

_____

_____

_____

_____

_____

COMPLETED BY:_____ DATE:_____

FIGURE 1.8.7

DATA TABLE .. DEFINITION ENTRY SHEET

FIRST and LAST INITIALS: _ _

PROJECT NUMBER: ____ - _____

TABLE ID: (1 or 2 char): _ _

YOUR LAST NAME: _____

(computer will assign the DBNAME based on info at left, WRITE IT DOWN!)

DBNAME = _ _ _ _ _ _ _ _

DATE TO RUN: _ _ / _ _ /_ _
M M D D Y Y

INCLUDE NONDETECTABLES (Y or N)? __ ("Y"es will give all "U" values)
SORT COMPOUNDS ALPHABETICALLY? (Y or N)? __ ("N"o is the default)

****

* ANALYSES TO PULL (Answer Y or N):

ALL __ VOAORG __ EXTORG __ PEST/PCB __ METALS __ SPECIFIED (CN) __

****

* (You may enter up to 5 titles, up to 40 characters each) EXAMPLE:

TABLE TITLE #1: _____

TABLE TITLE #2: _____

TABLE TITLE #3: _____

TABLE TITLE #4: _____

TABLE TITLE #5: _____

TABLE 1
ANALYTICAL DATA SUMMARY
BOZO'S TOXIC WASTE, INC
FUME CITY, NEW JERSEY
JANUARY, 1988

****

	SAMP 1	SAMP 2	SAMP 3	SAMP 4	SAMP 5	SAMP 6	SAMP 7	SAMP 8
SAD #1:	____	____	____	____	____	____	____	____
SAD #2: (optional)	____	____	____	____	____	____	____	____
STATION: (8 char)	____	____	____	____	____	____	____	____
DESCRIP: (8 char)	____	____	____	____	____	____	____	____
DESCRIP: (8 char)	____	____	____	____	____	____	____	____

	SAMP 9	SAMP 10	SAMP 11	SAMP 12	SAMP 13	SAMP 14	SAMP 15	SAMP 16
SAD #1:	____	____	____	____	____	____	____	____
SAD #2: (optional)	____	____	____	____	____	____	____	____
STATION: (8 char)	____	____	____	____	____	____	____	____
DESCRIP: (8 char)	____	____	____	____	____	____	____	____
DESCRIP: (8 char)	____	____	____	____	____	____	____	____

TABLE 1.8.1
ACTIVITIES CODES

RESOURCE.. TRACKING SYSTEM
GENERAL (USE APPROPRIATE ACCOUNT)

Program Element	Activity
	General Administrative
010	Administrative - Personnel, Performance, Travel, Etc.
012	Timekeeping
013	Training Attended
014	Safety Training
015	Training Plan Development
016	Property Inventory
017	Procurement
018	Clerical
020	Equipment Maintenance
021	Vehicle Maintenance
023	Equipment Repair
	Leave
051	Annual
052	Sick
053	Holiday
054	Administrative
055	Hazardous Weather
056	Jury
057	LWOP
058	Compensatory Time (Taken)
	Management/Supervision
100	General
101	Review of National Guidance
102	Work Plan Development/Review
103	Regional Program Reviews
104	Regional Program Planning
106	Literature Review
107	Workload Model Review/Input
108	End of Year Review (Personnel)
109	Mid-Year/End-Of-Year Review (Personnel)
110	SPMS/STAR Report/Preparation
111	Study/Project Plan Review
112	Peer Review Reports
113	Report Preparation
120	Office/Lab Cleanup/Move
121	Employee Physical
122	Attendance at Conference, Seminars, Conventions, Etc.
123	Staff Meetings
124	Health and Safety Meetings
125	FOI Requests
126	Committee Meetings
127	Program Meetings
128	General Meetings
133	Congressional Response/Inquiry

AIR MONITORING (A2304P009)

Program Element	Activity
	Technical Assistance
201	Develop State/Local Agency Capabilities
202	TA to EPA Program Personnel
203	TA to State/Local Agency Personnel
204	TA to HQ Personnel
205	TA to Other Federal Agency Personnel
206	On-site TA
207	General TA
208	Assistance to State/Local Agencies - Acid Rain
209	Assistance to State/Local Agencies - Air Toxics
211	Training Conducted
282	Trends Analysis
551	QA/SOP Plan Reviews including Branch SOPQAM Revisions
	Evaluations
251	Project/Study Plan Review and Preparation
252	State/Local Agency Lab Evaluations
254	Site Evaluations
255	NAMS (New Sites)
256	NAMS (Existing Sites)
257	SLAMS (New Sites)
258	SLAMS (Existing Sites)
261	NAMS Documentation
262	SLAMS Documentation
263	QAMS Audit
264	EMSL Audit
265	NAAS System Audits
266	Pre-audit Preparation
267	Audit Report Preparation
268	Performance Audits
	Precision & Accuracy and Data Submittals/Retrievals
259	P&A Reports
260	P&A Evaluations
287	SAROAD Retrieval/System Support
	Air Toxics Monitoring/Special Studies
269	Air Toxics Monitoring Studies - Ambient
270	Air Toxics Monitoring Studies - Superfund
283	Air Monitoring Policy Manual
	Criteria Monitoring
284	Orifice Calibration/Certification
285	Ozone Calibrator/Monitor Certification
286	CO Saturation Monitoring
287	PM_{10} Saturation Monitoring

Network Design/Redesign		Special Enforcement Activity	
271	Ozone Network Redesign		271 Criminal Investigations
272	CO Network Redesign	272	Civil Investigations
273	TSP, SO_2, & Pb Network Redesign	273	Admin. Enf. Actions

WATER QUALITY ENFORCEMENT (AFE04P000)

Program Element	Activity
	Technical Assistance
202	TA to EPA Program Personnel
203	TA to State Agency Personnel
204	TA to HQ Personnel
205	TA to Federal Agency Personnel
207	On-site TA
211	Training Conducted
551	QA/SOPQAM Activities/Updates
101	Review of National Guidance
	Inspections
301	PAI - Major Municipal
302	PAI - Minor Municipal
303	PAI - Major Industrial
304	PAI - Minor Industrial
305	PAI - Federal Facility
306	CSI - Major Municipal
307	CSI - Minor Municipal
308	CSI - Major Industrial
309	CSI - Minor Industrial
310	CSI - Toxics
311	CSI - Federal Facility
312	CEI - Major Municipal
313	CEI - Minor Municipal
314	CEI - Major Industrial
315	CEI - Minor Industrial
316	CEI - Federal Facilities
318	RI - Major Municipal
319	RI - Minor Municipal
320	RI - Major Industrial
321	RI - Minor Industrial
322	RI - Federal Facilities
323	LSI - Major Municipal
324	LSI - Minor Municipal
325	LSI - Major Industrial
326	LSI - Minor Industrial
327	LSI - Federal Facilities
328	DE - Major Municipal
329	DE - Minor Municipal
330	DE - Major Industrial
331	DE - Minor Industrial
336	DE - Federal Facilities
400	DE (MWPP)
401	DE (Tech Transfer)
341	Biomonitoring
337	Toxicity Study
357	Toxic Sludge

Program Element	Activity
	State Overview
250	General
	Special Enf. Activities
409	Show Cause Hearings
402	Consent Decree
403	AO
404	Attorney Consultation
372	Criminal Investigations
373	Civil Investigations
	Pretreatment Inspections
360	Pretreatment Compl Insp.
361	Pretreatment Check
362	Pretreatment Audit
	Underground Injection
368	UIC
	Special Water Quality Studies
347	Water Qual Monitoring
348	Toxicity Studies
363	Support Permit Activities
364	NPDES Enforcement
	Wetlands/Oceans
338	Field Investigation
	Miscellaneous
279	EIS Review

Program Element	Activity
	Technical Assistance
101	Review of National Guidance
105	Review of Water Monitoring Strategy
211	Training Conducted
280	Review of Annual Workplans
551	QA/SOPQAM Review/Update
	Program Evaluation
103	Regional Program Review
280	State Program Review
	Technical Assistance to States
201	Developing State Capabilities
207	General TA
210	Multimedia Geographical Area Assessments
	Water Quality Technical Assessments
202	Review of Regional Documents
203	Review of State Prepared Documents/Reports
250	Emerging Problems
274	Success Stories/PR
282	Trend Analysis
	Technical Assistance to HQ
366	Field Investigations
204	Other Assistance
	Technical Assistance to Region
366	Field Investigations
	Special Monitoring for States
366	Field Investigations
	Estuarine/Marine Program
103	Program Review
207	Technical Assistance
251	Overview of Work Plans and Work Products

HAZARDOUS WASTE MANAGEMENT (A8004P009)

Program Element	Activity
	Technical Assistance
101	Review of Program Guidance (Not Enforcement Related)
211	Training Conducted
551	QA Activities Including SOPQAM Revisions
207	**Technical Review of Waste Analysis Plans**
	State Program Reviews, Training, Technical Assistance
201	Review of State Grant Package
280	Review of State Program Plan
281	Mid-Year or End-of-Year Program Reviews
203	Technical Assistance for State or Local Agencies
211	Training Presented to State or Local Agencies
	Program Planning, Training, Technical Assistance
104	Program Planning
211	Training Presented to EPA Program Personnel
202	Technical Assistance for EPA Program Personnel
211	Training Presented to Other Federal Agency Personnel
205	Technical Assistance for Other Federal Agency Personnel

HAZARDOUS WASTE ENFORCEMENT (AGD04P009)

Program Element	Activity
	Technical Assistance
101	Review of National Enforcement Guidance
211	Training Conducted
551	QA Activities Including SOPQAM Revision
202	Technical Assistance to Program Staff - Civil/Criminal/Admin.
203	Technical Assistance to State Personnel
206	On-Site Technical Assistance
289	State/Contractor Field Overview
295	Document Review
	Investigations and Inspections
350	Comprehensive Groundwater Monitoring Evaluations - TSD - Major
352	Comprehensive Groundwater Monitoring Evaluations - Federal Fac.
353	Comprehensive Groundwater Monitoring Evaluations - State Facility
354	Case Development Investigations/Evaluations - TSD - Major
356	Case Development Investigations/Evaluations - Federal Facility
357	Case Development Investigations/Evaluations - State Facility
	Field Support
372	Field Investigative Support for Civil Enforcement Actions
373	Field Investigative Support for Criminal Enforcement Actions
366	Field Investigative Support for Administrative Enforcement Actions
	Litigation Support
407	Litigation Support for Civil Enforcement Actions
408	Litigation Support for Criminal Enforcement Actions
403	Litigation support for Administrative Enforcement Actions
	State Program Oversight/Technical Assistance
280	State Program Review

HAZARDOUS SUBSTANCE SPILL AND SITE RESPONSE (TFA04P700)

Program Element	Activity
	Technical Assistance
101	Review of National Guidance (Not Enforcement Related)
211	Training Conducted
551	QA Activities Including SOPQAM Revisions
	Sample Control Center
538	Operation of the Sample Control Center (RSCC)
369	Scheduling ESD Field Inspections
	Contractor Overview
295	Review of EPA Fund-Lead RI/FS Contractor Documents
289	On-Site Overview of Fund-Lead RI/FS Contractor Field Activity
296	Review of EPA Enforcement Lead RI/FS PRP Contractor Document
290	Review of EPA Enforcement Lead RI/FS PRP Contractor Field Activity
297	Review of State or State Contractor Prepared RI/FS Documents
292	On-Site Overview of State or State Contractor RI/FS Field Activity
298	Review of State Enf. Lead PRP Contractor Prepared RI/FS Doc.
291	Review of State Enf. Lead PRP Contractor RI/FS Field Activity
295	Review of FIT Study Plans
293	Review of FIT Reports
294	On-Site Overview of FIT Field Activity
	State Overview Activity
278	On-Site OV of State or State Contractor Screening Site Inspections (SSI)
281	Mid-Year Evaluation of State Superfund Grant Program
	Technical Assistance and Training
202	Technical Assistance to EPA Personnel
203	Technical Assistance to State Agency Personnel
211	Training Presented

HAZARDOUS SUBSTANCE RESPONSE AND ENFORCEMENT (TGB04P009)

Program Element	Activity
	Technical Assistance
101	Review of National Enforcement Guidance
211	Training Conducted
551	QA Activities Including SOPQAM Revisions
	Field Investigations in Support of Enforcement Activities
373	Field Investigations in Support of Civil Enforcement Actions
372	Field Investigations in Support of Criminal Enforcement Actions
366	Field Investigations in Support of Adm Enforcement Actions
374	Field Investigations in Support of State Enforcement Actions
	Litigation Support or Technical Assistance for Enf. Actions
407	Litigation or Technical Support for EPA Civil Enf. Actions
410	Support for EPA Superfund Cost Recovery Program
408	Litigation or Technical Support for EPA Criminal Enf. Actions
403	Litigation or Technical Support for EPA Adm. Enf. Actions
406	Litigation or Technical Support for State Enf. Actions
	Contractor Overview
296	Review of EPA Enf. Lead Contractor Prepared RI/FS Documents
290	On-Site Overview of EPA Enf. Lead PRP RI/FS Field Activity
297	Review of State Agency Enf. Lead PRP Contractor Prepared RI/FS Doc
291	On-Site OV of State Agency Lead PRP Contractor RI/FS Field Act.
294	On-Site OV of EPA Enforcement Contractor Field Activity

DREDGE AND FILL (AGM04P009)

Program Element	Activity
	Program Assistance
207	Desk-Top Environmental Assessment
206	On-Site Technical Advice
413	Expert Witness/Consultant for Litigation/Settlement
366	Field Investigation
279	EIS Review

DRINKING WATER (A7004P009)

Program Element	Activity
366	Field Investigation
202	Technical Assistance to EPA Personnel
203	Technical Assistance to State Agency Personnel
204	Technical Assistance to HQ

UNDERGROUND STORAGE TANKS (A4E05G0SL)

Program Element	Activity
101	Review of National Guidance
202	Technical Assistance to EPA Personnel
203	Technical Assistance to State Personnel
366	Field Investigation

1.9 BRANCH PROCEDURES FOR OBTAINING ANALYTICAL SUPPORT

1.9.1 General

Analytical support for Branch field investigations is available from a number of sources including in-house analytical support from the Analytical Support Branch (ASB), other EPA laboratories, the National Contract Laboratory Program (CLP), or other private contract laboratories. Procedures to be followed for obtaining this support are contained in the following paragraphs.

1.9.2 Specific Procedures

All arrangements for analytical support are ultimately channeled to the Analytical Support Branch (ASB). All requests for in-house (ASB) analytical support, or for contract laboratory support other than from the National Contract Laboratory Program (CLP), are handled directly by the ASB. Requests for CLP support (Superfund) are normally directed to the Regional Sample Control Center (RSCC - i.e., Chief, Hazardous Waste Section).

In either case, the ASB Sample Custodian assigns project numbers for all projects as they are received. Requests for analytical support should be submitted as far in advance as possible to insure that the support can be obtained and the analytical capacities of the analytical laboratories are not exceeded. The ASB will not accept samples without a project number, except in an emergency.

The Sample Custodian requires the following information to assign a project number:

- project name/facility name;
- location of project/facility (city and state);
- type of study, activity, and program element;
- date of study and sample shipping dates;
- number of samples by media;
- analyses required by media and analysis type; and
- the analytical turn-around time required.

Branch personnel should not routinely request quick turn-around for analyses unless it is absolutely required.

Blind spike and blank samples for inclusion with CLP sample shipments or for other purposes are obtained from the ASB (see Section 4.6).

1.9.3 Definitions

1.9.3.1 National Contract Laboratory Program (CLP) -- The CLP generally supports the Superfund Program. The program can be used for regional laboratory support by contacting either the Regional Sample Control Center (RSCC, Chief, Hazardous Waste Section) or the Technical Project Officer (TPO, Chief, Organic Chemistry Section). All aspects of the CLP including the proper completion of CLP forms and shipping procedures are given in the Users Guide to the Contract Laboratory Program (2).

1.9.3.2 Routine Analytical Service (RAS) -- Analysis conducted by the CLP which includes volatile organic compounds, semivolatile organic compounds, pesticides, metals, and cyanide. These individual parameters are listed on the Target Compound List (TCL) and the Target Analyte List (TAL).

1.9.3.3 Target Compound List and Target Analyte List -- The list of organic (TCL) and inorganic (TAL) parameters normally analyzed for by both the ASB and the CLP. These compounds/analytes are included in the Users Guide to the Contract Laboratory Program (2).

1.9.3.4 Special Analytical Services (SAS) -- Analyses that can be conducted by the CLP other than those included in the TCL/TAL. These need to be requested through the ASB as soon as possible since protocols for analyses have to be developed for the CLP.

1.9.3.5 Detection Limits -- The optimum detection limits for organic and inorganic constituents in water and soil/sediments by both the ASB and the CLP are listed in Tables 1.9.1 and 1.9.2. Optimum detection limits for organic and inorganic compounds for other media, i.e., concentrated waste, aquatic organisms, etc., can be obtained from the ASB on request. The detection limits for other standardized analytical procedures are contained in the Analytical Support Branch, Operation and Quality Control Manual (3).

1.9.3.6 Regional Sample Control Center (RSCC) -- The RSCC coordinates all aspects of the scheduling of Superfund investigations and analytical support (ASB and CLP) that involve sampling activities. The RSCC is accessed through the Chief, Hazardous Waste Section. The information required to obtain analytical support is the same as outlined in Section 1.9.2. Normally, analytical support for samples to be collected by EPA contractors is coordinated with the RSCC for Superfund projects through the Environmental Services Assistance Team (ESAT), Sample Control Coordinator located in the Waste Management Division (WD). Support for Environmental Services Division Superfund activities is coordinated by the Hazardous Waste Section's, Superfund Unit Chief.

In addition to coordinating the scheduling of Superfund sampling activities, the RSCC is responsible for estimating the needed regional CLP support for the National Superfund Program.

The RSCC is also responsible for obtaining sample containers for Branch Superfund and RCRA activities conducted by Branch personnel.

1.9.4 Distribution of Analytical Data

1.9.4.1 ASB Laboratory Reports -- Normally, two copies of the results of analysis will be sent to the Chief, Hazardous Waste Section for all Superfund and RCRA projects and to the Chief, Air and Water Compliance Section for all municipal and industrial investigations. Analytical data will be reported as it is completed. When all project data have been submitted, the ASB will notify the data requestor that the analyses are complete and request that disposal of the unused portion of samples be approved.

1.9.4.2 CLP Laboratory Reports -- Normally, two copies of the results of analyses for Branch projects will be distributed as outlined in Section 1.9.4.1.

TABLE 1.9.1
OPTIMUM DETECTION LIMITS
ORGANIC COMPOUNDS
WATER AND SOIL/SEDIMENT SAMPLES
(BASED ON CLEAN SAMPLES)

Concentration Description	Reported As	ASB Detection Limits	CLP Detection Limits
		Purgeables	Purgeables
Low Water	NA	5-20 ug/l	10 ug/l
Low Soil/Sediment	Dry Weight	10-20 ug/kg	10 ug/kg
Medium Water	NA	5-21 ug/l	10 ug/l
Medium Soil/Sediment	Dry Weight	10,000-50,000 ug/kg	1200 ug/kg
		Extractables	Extractables
Low Water	NA	10-20 ug/l	10-50 ug/kg
Low Soil/Sediment	Dry Weight	2,000-4,000 ug/kg	1,700-3,000 ug/kg
Medium Water	NA	10-20 ug/l	10-50 ug/l
Medium Soil/Sediment	Dry Weight	10,000-20,000 ug/kg	10,000-50,000 ug/kg
		Pesticides (PCB's)	Pesticides (PCB's)
Low Water	NA	0.05-5.0 ug/l (1.0-3.0 ug/l)	0.05-5.0 ug/l (1.0-2.0 ug/l)
Soil/Sediment	Dry Weight	50-5,000 ug/l (500-1500 ug/kg)	1.7-170 ug/l (33-67 ug/kg)
Medium Water	NA	0.05-5.0 ug/l (1.0-3.0 ug/l)	0.05-5.0 ug/l (1.0-2.0 ug/l)
Medium Soil/Sediment	Dry Weight	50-25,000 ug/kg (2500-7500 ug/kg)	1.7-170 ug/l (33-67 ug/kg)

1 - Detection limits may increase because of varying sample size and/or interferences requiring dilutions.

Note: Soil/Sediment Extracting Methods, Medium Level Versus low Level: The primary difference in the methods is the size of sample used for extraction. The low level method uses 30 gm (wet weight) of sample, whereas the medium level method uses 2-3 gm (wet weight) of sample. The negative aspects of the medium level method are (1) the quantitation limit is higher and (2) the smaller sample size is less representative of the sample. The positive aspect is the much simpler and faster sample extraction time. It takes less than an hour to extract a medium level sample and four hours to prepare a low level sample while the difference in quantitation limit is only a factor of five (1000 ug/kg for low level extractable organics and 5000 ug/kg for medium level). This is very significant with the increasing work load and also considering the lack of information on whether this factor of five increase in quantitation limit is necessary.

TABLE 1.9.2

OPTIMUM DETECTION LIMITS

INORGANIC CONSTITUENTS

WATER AND SOIL/SEDIMENT SAMPLES

	Water (ug/l)		Soil (Dry Weight) (mg/kg)	
	ASB	CLP	ASB	CLP
Silver	10	10	1	5
Arsenic	30	10	3	5
Barium	20	200	2	100
Beryllium	10	5	1	2.5
Cadmium	10	5	1	2.5
Cobalt	20	50	2	25
Chromium	10	10	1	5
Copper	10	25	1	12.5
Molybdenum	20	--	2	--
Nickel	20	40	2	20
Lead	30	5	3	2.5
Antimony	30	60	3	30
Selenium	40	5	4	2.5
Tin	100	40	10	20
Strontium	10	--	1	--
Tellurium	40	--	4	--
Titanium	10	--	1	--
Thallium	--	10	--	5
Vanadium	10	50	1	25
Yttrium	10	--	1	--
Zinc	10	20	1	10
Mercury	0.2	0.2	0.05	0.05
Aluminum	100	200	10	100
Manganese	25	15	2.5	7.5
Calcium	1000	5000	100	2500
Magnesium	100	5000	10	2500
Iron	100	100	10	50
Sodium	1000	5000	100	2500
Potassium	--	5000	--	2500

NOTE: -- Indicates that the constituent is not analyzed for.

1.10 QUALITY ASSURANCE PLAN

1.10.1 General

The procedures outlined in this manual are the basis of the Branch Quality Assurance Plan. Where appropriate, each section within this SOPQAM addresses the specific quality control aspects of the subjects covered by that section. The Branch Chief shall designate the Branch Quality Assurance Coordinator for the Branch. The current Quality Assurance Coordinator is the Chief, Hazardous Waste Section. The Quality Assurance Coordinator is responsible for: seeing that the specific quality control procedures as outlined in this SOPQAM are followed, and for tracking and recording the results of specific quality control (QC) programs (such as that outlined in Section 4 - Sampling Procedures). The Branch Quality Assurance Coordinator is responsible for the field analysis QC program, periodically checking the equipment logbooks, and notifying the appropriate Section Chiefs, Unit Chiefs, and Branch Chief of any observed problems.

The Branch and Section Chiefs are responsible for seeing that Branch personnel receive adequate training in order to provide the required quality control for Branch operations. In addition, the Section Chiefs and/or Unit Chiefs may periodically observe the professional and paraprofessional employees, in their respective sections, under actual field operating conditions to insure that the Standard Operating Procedures, as outlined in this manual, are being followed.

1.10.2 Corrective Actions

Corrective actions will be taken any time when deemed necessary. Problems with field quality control may result from contamination of field blanks or contamination of field equipment and supplies either from the vendor, during the cleaning/loadout process, or during field operations. Corrective actions must be taken immediately when data or field procedures are of questionable quality. These corrections may range from modifying certain procedures to reconducting an entire field investigation. The Regional QA Officer (QAO) shall be notified (through the Branch and appropriate Section Chief) of any suspected problems. A Corrective Action Plan shall be developed in cooperation with the QAO.

1.10.3 Peer Review

All non-routine reports and study plans generated by the Branch shall be peer reviewed in accordance with Region IV Order R2200.1 - Review and Clearance of Materials for Public Distribution. The appropriate Section secretary shall be responsible for distribution of documents for peer review after the Peer Review Clearance Form has been signed by the Division Director. All comments from reviewers shall be considered by the project leader. If the document receives a nonconcurrence, the Branch and appropriate Section Chief shall be immediately notified. Appropriate changes/corrections shall be made and the entire document shall be resubmitted for peer review.

1.11 SAFETY PROGRAM

The Branch safety program includes the following regulations and policies in addition to safety practices specified in Appendix N of this SOPQAM:

- Safety and Health Manual, United States Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia, 1990 (4).

  This manual covers safety practices and rules governing activities at the EPA facilities in Athens, Georgia. Included in its contents are accident reporting procedures, procedures for natural and manmade emergencies, safety guidelines for offices and laboratories, and special rules for storage of equipment and wastes.

- Field Health and Safety Manual, USEPA, Region IV, 1990 (5).

  This manual covers safety involved in all field activities performed in Region IV. It includes regional policy regarding training requirements, medical monitoring, and personal protection.

- 29 CFR, Part 1910, Hazardous Waste Operations and Emergency Response; Final Rule, March 1989 (6).

  This is the title for the Department of Labor, Occupational Safety and Health Administration (OSHA) regulations governing workers at hazardous waste sites. It covers requirements for training, equipment, and practices involved in specific hazardous waste activities.

1.12 REFERENCES

1. Ethics In A Nutshell...Ethical Conduct for EPA Employees...in Brief, US-EPA, Office of Inspector General, Washington, D.C., March 1988 (or 40 CFR, Part 3, Chapter 1, Subchapter A, pp. 71-95, July 1, 1989).

2. EPA Users Guide to the Contract Laboratory Program, Us-EPA, Office of Emergency and Remedial Response, Washington, D. C. 20460, December 1988.

3. Analytical Support Branch Operation and Quality Control Manual, Region IV, US-EPA, ESD, September 1990 (and subsequent revisions).

4. Safety and Health Manual, United States Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia, 1990.

5. Field Health and Safety Manual, United States Environmental Protection Agency, Region IV, 1990.

6. 29 CFR, Part 1910, Hazardous Waste Operations and Emergency Response; Final Rule, March 1989.

Facility/Site Name_____

Address_____

Project No._____ EPA ID No._____

Facility Contact_____ Phone No.(_____)-_____

Overview Personnel_____ Date_____

State/Contractor Project Leader_____

Affiliation_____ Phone No.(_____)-_____

Address_____

_____

Sampling Personnel_____

_____

Other Personnel & Affiliation_____

_____

_____

Type of study?_____

Study plan issued?_____ Date issued?_____

Study plan reviewed by ESD? Yes_____ No_____ Acceptable? Yes_____ No_____

Was study plan followed? Yes_____ No_____

Comments_____

Was a safety plan prepared for the study? Yes_____ No_____

Was the safety plan adequate? Yes_____ No_____

Comments_____

Was the safety plan followed? Yes_____ No_____

Comments_____

Additional Comments or Information_____

_____

Checklist sections completed for this overview: 1_____2_____3_____4_____5_____6_____
KEY: 1 General Procedures; 2 Ground Water Sampling; 3 Soil, Sediment Sampling
4 Surface Water Sampling; 5 Waste Sampling; 6 Monitoring Well Installation

SECTION 1 - GENERAL PROCEDURES - SAFETY, RECORDS, QA/QC, CUSTODY, ETC.

1) Type samples collected?_____

2) Were sampling locations properly selected? Yes_____ No_____

Comments_____

3) Were sampling locations adequately documented in a bound field log book using indelible ink? Yes_____ No_____

Comments_____

4) Were photos taken and a photolog maintained? Yes_____ No_____

5) What field instruments were used during this study?_____

_____

_____

6) Were field instruments properly calibrated and calibrations recorded in a bound field log book? Yes_____ No_____

Comments_____

7) Was sampling equipment properly wrapped and protected from possible contamination prior to sample collection? Yes_____ No_____

Comments_____

8) Was sampling equipment constructed of Teflon®, glass, or stainless steel?

_____

9) Were samples collected in proper order? (least suspected contamination to most contaminated?) Yes_____ No_____

Comments_____

10) Were clean disposable latex or vinyl gloves worn during sampling? Yes_____ No_____

Comments_____

11) Were gloves changed for each sample station? Yes_____ No_____

Comments_____

12) Was any equipment field cleaned? Yes_____ No_____

13) Type of equipment cleaned?_____

14) Were proper field cleaning procedures used? Yes_____ No_____

Comments_____

15) Were equipment rinse blanks collected after field cleaning?
Yes_____ No_____

Comments_____

16) Were proper sample containers used for samples? Yes_____ No_____

Comments_____

17) Were split samples offered to the facility owner or his representative?
Yes_____ No_____

Comments_____

18) Was a receipt for samples form given to facility representative?
Yes_____ No_____

19) Were any duplicate samples collected? Yes_____ No_____

Comments_____

20) Were samples properly field preserved? Yes_____ No_____

Comments_____

21) Were preservative blanks utilized? Yes_____ No_____

Comments_____

22) Were field and/or trip blanks utilized? Yes_____ No_____

Comments_____

23) Were samples adequately identified with labels or tags? Yes_____ No_____

Comments_____

24) Were samples sealed with custody seals after collection? Yes_____ No_____

Comments_____

25) What security measures were taken to insure custody of the samples after collection?

_____

26) Were chain-of-custody and receipt for samples forms properly completed?
Yes_____ No_____

Comments_____

27) Were any samples shipped to a laboratory? Yes_____ No_____

28) If yes to No. 27, were samples properly packed? Yes_____ No_____

Comments_____

29) If shipped to a CLP lab, were Traffic Report Forms properly completed?
Yes_____ No_____

Comments_____

30) What safety monitoring equipment, protection, and procedures were used prior to and during sampling?_____

_____

31) Was safety monitoring equipment properly calibrated and calibrations recorded in a bound field log book? Yes_____ No_____

Comments_____

SECTION 2 - SAMPLING - GROUND WATER WELLS

1) Type of wells sampled? (monitoring, potable, industrial,etc.)_____

_____

2) Were wells locked and protected? Yes_____ No_____

Comments_____

3) Were identification marks and measurement points affixed to the wells? Yes_____ No_____

Comments_____

4) What were the sizes and construction materials of the well casings?

_____

5) Were the boreholes sealed with a concrete pad to prevent surface infiltration? Yes_____ No_____

Comments_____

6) Was there a dedicated pump in the well? Yes_____ No_____

7) Was clean plastic sheeting placed around the wells to prevent contamination of sampling equipment and containers? Yes_____ No_____

8) Were total depths and depths to water determined before purging? Yes_____ No_____

9) What device was used to determine depths?_____

10) Were measurements made to the nearest 0.01 ft? Yes_____ No_____

11) Was the measuring device properly cleaned between wells? Yes_____ No_____

Comments_____

12) Was the standing water volume in each well determined? Yes_____ No_____

13) How was the volume determined?_____

14) Was a sufficient volume purged prior to sampling? Yes_____ No_____

Comments_____

15) How many volumes?_____

16) How was the purged volume measured?_____

8) Were total depths and depths to water determined before purging?
Yes_____ No_____

9) What device was used to determine depths?_____

10) Were measurements made to the nearest 0.01 ft? Yes_____ No_____

11) Was the measuring device properly cleaned between wells?
Yes_____ No_____

Comments_____

12) Was the standing water volume in each well determined?
Yes_____ No_____

13) How was the volume determined?_____

14) Was a sufficient volume purged prior to sampling? Yes_____ No_____

Comments_____

15) How many volumes?_____

16) How was the purged volume measured?_____

17) What was the method of purging?_____

_____

18) Were pH, conductivity, and temperature measurements taken and recorded at least once during each well volume purged? Yes_____ No_____

Comments_____

19) Were pH, conductivity, and temperature readings stable prior to sampling? Yes_____ No_____

Comments_____

20) How many wells were sampled?_____Upgradient?_____Downgradient?_____

21) How were the samples collected? Bailer_____Pump_____Other_____

Comments_____

22) If pump was used, what type?_____

23) If a pump was used, was it properly cleaned before and/or between wells?
Yes_____ No_____

Comments_____

24) What were the cleaning procedures?_____

_____

25) Did bailers have Teflon® coated wire leaders to prevent rope from coming into contact with water? Yes_____ No_____

26) Were bailers open or closed top?_____

27) Was a clean bailer and new rope used at each well? Yes_____ No_____

Comments_____

28) Were samples properly transferred from the sampling device to the sample containers? (i.e., purgeable sample first - not aerated, etc.)
Yes_____ No_____

Comments_____

29) Was pH of preserved samples checked to insure proper preservation?
Yes_____ No_____

Comments_____

30) Were samples iced immediately after collection? Yes_____ No_____

31) For what analyses were the samples collected?_____

_____

32) If samples were split, what were the sample/station numbers for these?

_____

_____

Other comments or observations_____

_____

_____

_____

SECTION 3 - SAMPLING - SOIL, SEDIMENT, SLUDGE, ETC. (Non-containerized)

1) Type of samples collected?_____

2) General description of samples?_____

_____

3) How many samples were collected?_____

4) Were background and/or control samples collected? Yes_____ No_____

Comments_____

5) Were representative samples collected? Yes_____ No_____

Comments_____

6) Were grab or composite samples collected?_____

7) Were composite samples areal or vertical?_____

8) How many aliquots were taken for the composite sample?_____

9) What procedures and equipment were used to collect samples?_____

_____

_____

10) Were samples thoroughly mixed prior to putting them into the sample containers? Yes_____ No_____

Comments_____

11) Were samples properly placed into sample containers? Yes_____ No_____

Comments_____

12) Were samples iced immediately after collection? Yes_____ No_____

13) For what analyses were the samples collected?_____

14) If samples were split, what were the sample/station numbers for these?

_____

15) Was a drilling rig, back hoe, etc., used to collect soil samples? _____

16) Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site? Yes_____ No_____

Comments _____

17) What was the condition of the drilling and sampling equipment when it arrived on site?_____

_____

18) Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment? Yes_____ No_____

Comments_____

19) Was clean equipment properly wrapped and stored in a clean area?
Yes_____ No_____

Comments_____

20) Was the drilling rig(s) properly cleaned between well borings?
Yes_____ No_____

Comments_____

21) Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP? Yes_____ No_____

Comments_____

22) Other comments or observations_____

_____

_____

SECTION 4 - SAMPLING - SURFACE WATER (Pond, Stream, River, Leachate, Etc.)

1) Type of samples collected?_____

2) General description of samples?_____

3) How many samples were collected?_____

4) Were background and/or control samples collected? Yes_____ No_____

Comments_____

5) Were grab or composite samples collected?_____

6) How many aliquots were taken for the composite sample?_____

7) What procedures and equipment were used to collect the samples?

_____

_____

8) Were samples collected directly into sample containers? Yes_____ No_____

Comments_____

9) Did the sampler wade in the stream to collect the samples? Yes_____ No_____

Comments_____

10) Were the samples collected upstream from the sampler? Yes_____ No_____

Comments_____

11) Did the sampler insure that roiled sediments were not collected along with the water samples? Yes_____ No_____

Comments_____

12) Were representative samples collected? Yes_____ No_____

Comments_____

13) Was the pH of preserved samples checked to insure proper preservation? Yes_____ No_____

Comments_____

14) Were samples iced immediately after collection? Yes_____ No_____

15) For what analyses were the samples collected?_____

_____

16) If samples were split, what were the sample/station numbers for these?

_____

_____

Other comments or observations_____

SECTION 5 - OTHER SAMPLING - DRUMS, TANKS, BARRELS, ETC. (Containerized)

1) Type of samples collected? (Oil, sludge, waste?)_____

_____

2) Description of containers or sources sampled?_____

_____

3) How many samples were collected?_____

4) What type of equipment was used to collect the samples?_____

_____

5) What procedures were used to collect the samples?_____

_____

6) For what analyses were the samples collected?_____

_____

7) If samples were split, what were the sample/station numbers for these?

_____

_____

_____

8) Were any special safety measures taken during collection of the samples?

_____

9) What level of safety protection was required for collection of the samples?

_____

Other comments or observations_____

_____

_____

_____

_____

SECTION 6 - MONITORING WELL INSTALLATION

General

1) Were the wells installed in the proper locations in accordance with the study plan and/or project operations plan (POP)? Yes_____ No_____

Comments_____

2) Were the wells installed starting in the least contaminated area and proceeding to the most contaminated area? Yes_____ No_____

Comments_____

3) Were proper safety protocols employed during the well installations? Yes_____ No_____

Comments_____

4) Were samples of the drilling mud, water, bentonite pellets, filter pack materials, etc., collected for quality control analyses? Yes_____ No_____

Comments_____

Equipment Decontamination

5) Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site? Yes_____ No_____

Comments_____

6) What was the condition of the drilling and sampling equipment when it arrived on site?_____

_____

7) Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment? Yes_____ No_____

Comments_____

8) Was clean equipment properly wrapped and stored in a clean area? Yes_____ No_____

Comments_____

9) Was the drilling rig(s) properly cleaned between well borings? Yes_____ No_____

Comments_____

10) Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP? Yes_____ No_____

Comments_____

Drilling

11) What type of drilling method(s) was used to install the wells? _____

_____

12) Was this drilling method(s) the same as proposed in the study plan and/or POP? Yes_____ No_____

Comments_____

13) Were soil samples collected for logging and analyses as the wells were installed? Yes_____ No_____

14) If yes to 13, at what intervals and by what method?_____

_____

15) If air rotary was used:
Was an in-line organic air filter employed? Yes_____ No_____
Was a cyclone velocity dissipator used? Yes_____ No_____

Comments_____

16) What diameter borehole(s) were installed?_____

17) Were surface outer casings used? Yes_____ No_____

18) If yes to 17, what size and to what depth?_____

_____

19) Were the wells double cased? Yes_____ No_____

20) If yes to 19, explain procedure._____

_____

Well Installation

21) What type of well casing(s) and screen(s) were used?_____

_____

22) What diameter were the well casing(s)?_____screen(s)?_____

23) Was there a minimum two inch annulus around the casing (between casing and borehole wall or inside augers)? Yes_____ No_____

Comments_____

24) What was the length of the well screen(s)?_____

25) What was the slot size of the well screen(s)?_____

26) Was the well screen(s) commercially manufactured? Yes_____ No_____

If yes, by whom?_____

27) Was the bottom of the well screen(s) plugged or capped? Yes_____ No_____

Comments_____

28) Were sand and/or gravel (filter) packs installed? Yes_____ No_____

Comments_____

29) Specify type of materials in 28 [(play sand, Ottawa sand, etc.) and grain size (20/30, 20/40, etc.)], if known._____

_____

30) Was a sieve analysis conducted to determine well screen slot size and filter pack grain size? Yes_____ No_____

Comments_____

31) Were the wells installed to the proper depths? Yes_____ No_____

Comments_____

32) Were well screens placed at the proper intervals? Yes_____ No_____

Comments_____

33) Were the filter packs placed a minimum of two feet above the well screens? Yes_____ No_____

Comments_____

34) Was the tremie tube method used to place the filter packs? Yes_____No_____

Comments_____

35) Were seals placed above the filter packs? Yes_____ No_____

36) If yes to 35, what material was used for the seals?_____

37) Was the vertical thickness of the seals a minimum of two feet? Yes_____ No_____

Comments_____

38) If bentonite pellets were used for the seals above the filter packs, were they allowed to hydrate a minimum of 8 hours? Yes_____ No_____

Comments_____

39) Did contractor/driller have documentation from manufacturer stating recommended hydration time? Yes_____ No_____

Comments_____

40) Was the tremie tube method used to place the bentonite pellets? Yes_____ No_____

Comments_____

41) Was the annulus grouted from the seal to within two feet of the ground surface, or below the frost line? Yes_____ No_____

Comments_____

42) Was the tremie tube method used to place the grout in the annulus? Yes_____ No_____

43) If no to 42, what method was used?_____

44) What type of grout was used to seal the annulus (neat cement, cement/bentonite, cement/sand, etc.)?

_____

45) What grout mix ratio was used? (should be stated in the POP)_____

_____

46) What was the density of the grout? (lb./gal., etc.)_____

47) If bentonite grout was used, was the density at least 9.4 lb./gal.? Yes_____ No_____

48) Was the density determined using a mud balance? Yes_____ No_____

49) Was the grout allowed to set a minimum of 24 hours before the surface pad was installed? Yes_____ No_____

Comments_____

50) Was a concrete surface pad installed with an outer protective casing and locking cap? Yes_____ No_____

Comments_____

51) How far below the ground surface did the concrete pad extend?_____

52) What were the dimensions of the concrete pads?_____

53) Did the well casings extend to a minimum of 2.5 feet above the ground surface? Yes_____ No_____

Comments_____

54) How far above the ground surface did the outer protective casings extend?

_____

55) Did the outer protective casings have weep holes? Yes_____ No_____

Comments_____

56) Were the wells properly developed? Yes_____ No_____

Comments_____

57) Describe method of development._____

_____

58) Give a general evaluation of the activities observed during the installation of the wells.

_____

_____

_____

_____

_____

51) How far below the ground surface did the concrete pad extend?_____

52) What were the dimensions of the concrete pads?_____

53) Did the well casings extend to a minimum of 2.5 feet above the ground surface? Yes_____ No_____

Comments_____

54) How far above the ground surface did the outer protective casings extend?

_____

55) Did the outer protective casings have weep holes? Yes_____ No_____

Comments_____

56) Were the wells properly developed? Yes_____ No_____

Comments_____

57) Describe method of development._____

_____

58) Give a general evaluation of the activities observed during the installation of the wells.

_____

_____

_____

_____

_____

3.0 SAMPLE CONTROL, FIELD RECORDS, AND DOCUMENT CONTROL

3.1 INTRODUCTION

The objectives of this section are to present the Branch standard operating procedures for sample identification, sample control and chain-of-custody, maintenance of field records, and document control.

A sample is defined as physical evidence collected from a facility, site, or the environment. For the purposes of this section, the term "physical evidence" also includes photographs, records, or any other tangible article collected from the environment, facility, or site.

All sample identification, field records, and chain-of-custody records shall be recorded in waterproof, non-erasable ink. If errors are made in any of these documents, Branch personnel will make corrections by simply crossing a single line through the error and entering the correct information. All corrections shall be initialed and dated by the investigator. If possible, all corrections should be made by the individual making the error.

If information is entered onto sample tags, logbooks, or sample containers utilizing stick-on labels, these labels should not be capable of removal later without leaving obvious indications of the attempt. Labels should never be placed over previously recorded information Corrections to information recorded on stick-on labels should be made as stated in the previous paragraph.

3.2 SAMPLE AND EVIDENCE IDENTIFICATION

3.2.1 General

The method of sample identification utilized depends on the type of sample collected. Samples collected for in-situ field analyses are those collected for specific field analyses or measurements where the data are recorded directly in bound field logbooks or recorded directly on the Chain-of-Custody Record, with identifying information, while in the custody of the sampling team. Examples of such in-situ field measurements and analyses include pH, temperature, and conductivity. Also included in this category are those field measurements or analyses such as flow measurements, geophysical measurements, surveying measurements, etc. that are made with field instruments or analyzers, where no sample is actually collected.

3.2.2 Sample Identification

Samples, other than those collected for in-situ field measurements or analyses, are identified by using a standard sample tag (Figure 3.2.1) which is attached to the sample container. In some cases, particularly with biological samples, the sample tag may have to be included with or wrapped around the sample. The sample tags are sequentially numbered and are accountable documents after they are completed and attached to a sample or other physical evidence. The following information shall be included on the sample tag:

- ESD project number;
- field identification or sample station number;
- date and time of sample collection;
- designation of the sample as a grab or composite;
- type of sample (water, wastewater, leachate, soil, sediment, etc.) and a very brief description of the sampling location;
- the signature(s) of the sampler(s) or of the designated sampling team leader (a team leader is a field investigator assigned by the project leader to be present during the collection of a specific sample and to be responsible and knowledgeable of all activities directly related to the collection of that sample).
- whether the sample is preserved or unpreserved;
- the general types of analyses to be conducted (checked on front of tag); and
- any relevant comments (such as readily detectable or identifiable odor, color, or known toxic properties).

Samples or other physical evidence collected by Branch personnel during criminal investigations are to be identified by using the "criminal sample tag."

This tag is identical to the standard sample tag shown in Figure 3.2.1, except that it has a red border around the front and a red background on the back of the tag.

The field sample station number is assigned by the project leader or field investigator. This number is ordinarily an alpha-numeric code, designed for a particular inspection or investigation. For example, if a sample is collected from a monitoring well installed during a site screening investigation conducted at the Abercrombie Widget Company, the alpha-numeric sample number code could be AW-001W. A surface soil sample from this facility might be identified as AW-002S. Each separate monitoring location should have a different numerical designation. Frequently, water and sediment samples are collected from the same sampling station and could have the same numerical designation. For example, water and sediment samples collected from the same location in the Oconee River at Station 001 would be identified as OR-001W and OR-001S, respectively. The project leader or field investigator shall exercise due caution to insure that sample station numbers are not duplicated during studies. The exact description of all sampling stations associated with field identification or sample station numbers shall be documented in the bound field logbooks.

If a sample is split with a facility, state regulatory agency, or other party representative, sample tags or labels with identical information should be attached to each of the sample containers by the party receiving the split sample. Also, all tags for blank or duplicate samples will be marked "blank" or "duplicate," respectively. This requirement does not apply to "blind" spiked or blank samples which are to be submitted for laboratory quality control purposes. "Blind" spiked or blank samples shall not be identified as such, but will be submitted as outlined in Section 4.6.9. This identifying information shall also be recorded in the bound field logbooks and on the Chain-Of-Custody Record as outlined in Section 4.4.

3.2.3 Photograph Identification

All photographs taken by Branch personnel shall be identified on the back of the print with the following information:

- an accurate description of what the photograph shows, including the name of the facility or site and the location.
- date, time and the location that the photograph was taken;
- the orientation of the photograph (i.e., looking northeast, etc.);
- the signature of the photographer.

If the photograph was taken with a Polaroid camera, the information shall be entered on the back of each photograph as soon as it is taken. If a 35 mm camera is used, a serial type record of each frame exposed shall be kept in the bound field logbook along with the information required for each photograph. The film shall be developed with the negatives supplied uncut. The field investigator shall then enter the required information on the prints, using the serialized photographic record from the bound field logbook, to identify each

photograph. For criminal investigations, the negatives must be maintained with the bound field logbook in the project file and stored in the secured file cabinet.

3.2.4 Identification of Physical Evidence

Physical evidence, other than samples, shall be identified by utilizing a sample tag or recording the necessary information on the evidence. When samples are collected from vessels or containers which can be moved (barrels for example), the field investigator shall mark the vessel or container with the field identification or sample station number for future identification, if necessary. The vessel or container shall be marked by utilizing a sharp instrument or spray paint. The vessel or container need not be marked if it already has a unique marking or serial number; however, these numbers shall be recorded on the sample tag and in the bound field logbooks. In addition, it is suggested that photographs of any physical evidence (markings, etc.) be taken and the necessary information recorded in the field logbook.

Occasionally, it is necessary to obtain recorder and/or instrument charts from facility owned analytical equipment, flow recorders, etc., during field investigations and inspections. Field investigators should mark the charts and write the following information on these charts while they are still in the instrument or recorder (along with the field investigators initials):

- if possible, starting and ending time(s) and date(s) for the chart;
- if possible, the field investigator shall take an instantaneous measurement of the media being measured by the recorder. The instantaneous measurement shall be entered at the appropriate location on the chart. The field investigator shall enter the date and time of the measurement and then enter his/her initials;
- a description of the location being monitored and any other information required to interpret the data such as type of flow device, chart units, factors, etc.

After the chart has been removed, the field investigator shall indicate on the chart who the chart (or copy of the chart) was received from and enter the date and time, as well as the investigator's initials.

Documents such as technical reports, laboratory reports, etc., should be marked with the field investigator's signature, the date, the number of pages, and from whom they were received. Branch personnel shall not accept confidential documents, except in special circumstances such as process audits, hazardous waste site investigations, etc.

FIGURE 3.2.1
SAMPLE TAG

FRONT

BACK

3.3 CHAIN-OF-CUSTODY PROCEDURES

3.3.1 General

The possession of samples or other physical evidence shall be traceable from the time they are obtained until they are introduced as evidence in legal proceedings. This section covers only that portion of the Environmental Services Division chain-of-custody procedures that are the responsibility of Branch personnel.

3.3.2 Sample Custody

A sample or other physical evidence is in custody if:

- it is in the field investigator's or the transferee's actual possession; or
- it is in the field investigator's or the transferee's view, after being in his/her physical possession; or
- it was in the field investigator's or the transferee's physical possession and then he/she secured it to prevent tampering; or
- it is placed in a designated secure area.

3.3.3 Chain-of-Custody Record

The field Chain-Of-Custody Record (Figure 3.3.1) is used to record the custody of all samples or other physical evidence collected and maintained by Branch personnel. This form shall not be used to document the collection of split or duplicate samples where there is a legal requirement to provide a receipt for samples (see Section 3.4). The Chain-Of-Custody Record also serves as a sample logging mechanism for the Analytical Support Branch (ASB) sample custodian.

The following information must be supplied in the indicated spaces (Figure 3.3.1) in detail to complete the field Chain-Of-Custody Record.

- The ESD project number.
- The project name.
- All samplers and /or sampling team leader must sign in the designated signature block.
- The sampling station number, date, and time of sample collection, grab or composite sample designation, and a brief description of the type of sample and the sampling location must be included on each line (each line shall contain only those samples collected at a specific location).

- The sampling team leader's name should be recorded in the right or left margin of the Chain-Of-Custody Record when samples collected by more than one sampling team are included on the same form. The sampling team leader is an individual designated by the project leader to be responsible for all activities related to the collection of samples by a specific team of sampling personnel.

- The total number of sample containers must be listed in the indicated space for each sample. The total number of individual containers must also be listed for each type of analysis under the indicated media or miscellaneous columns. Note that it is impossible to have more than one media type per sample. The type of container and required analyses should be circled as indicated on the Record.

- The tag numbers for each sample and any needed remarks are to be supplied in the indicated column.

- The field investigator and subsequent transferee(s) must document the transfer of the samples listed on the Record in the spaces provided at the bottom of the Record. One of the samplers documented under the sampler(s) section must be the person that originally relinquished the samples or evidence or a designated field sample custodian who receives secured samples from sampling teams and maintains these samples under secure conditions. Both the person relinquishing the samples and the person receiving them must sign the form; the date and time that this occurred must be documented in the proper space on the Record. Usually, the last person receiving the samples or evidence should be a laboratory sample custodian or other evidence clerk.

- The remarks column at the bottom of the Record is used to record airbill numbers or registered or certified mail serial numbers.

The Chain-Of-Custody Record is a serialized document. Once the Record is completed, it becomes an accountable document and must be maintained in the project file. The suitability of any other form for chain-of-custody should be evaluated based upon its inclusion of all of the above information in a legible format.

3.3.4 Field Custody Procedures

- To simplify the Chain-Of-Custody Record and eliminate potential litigation problems, as few people as possible should handle the sample or physical evidence during the investigation or inspection.

- The field investigator is responsible for the proper handling and custody of the samples collected (Section 3.3.2) until they are properly and formally transferred to another person or facility.

- Sample tags (Figure 3.2.1) shall be completed for each sample, using waterproof, non-erasable ink as specified in Section 3.3.2.

- All samples shall be sealed immediately upon collection utilizing the EPA custody seal (EPA Form 7500-(R7-75)) shown in Figure 3.3.2. The field investigator may write the date and his/her signature on the seal. This requirement shall be waived if the field investigator keeps the samples in his/her continuous custody from the time of collection until they are delivered to the laboratory analyzing the samples.

- All samples must be documented in bound field logbooks.

- A Chain-Of-Custody Record will be completed for all samples or physical evidence collected as specified in Section 3.3.3. A separate Chain-Of-Custody Record will be utilized for each final destination or laboratory utilized during the inspection or investigation.

- If chain-of-custody is required for documents received during investigations, they should be placed in large envelopes, and the contents should be noted on the envelope. The envelope shall be sealed and an EPA custody seal placed on the envelope such that it cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for the envelope. Any time the EPA seal is broken, that fact shall be noted on the Chain-Of-Custody Record and a new seal affixed. The information on the seal shall include the field investigator's signature, as well as the date and time of sealing.

- Other physical evidence such as video tapes or other small items shall be placed in Zip-Loc® type bags or envelopes and an EPA custody seal should be affixed so that they cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for these items. Any time the seal is broken, a new seal shall be affixed. The information on the seal shall include the field investigator's signature, as well as the date and time of sealing.

- In general, Branch personnel shall not accept samples from other sources unless the sample collection procedures used are known to be acceptable, can be documented, and the sample chain-of-custody can be established. If such samples are accepted by Branch personnel, a standard sample tag containing all relevant information and the Chain-Of-Custody Record, shall be completed for each set of samples.

- EPA custody seals can be used to maintain custody on other items when necessary by using similar procedures as those outlined previously in this section.

3.3.5 Transfer of Custody and Shipment

- All physical evidence or sample sets shall be accompanied by a Chain-Of-Custody Record. When transferring the possession of samples, the individual receiving the samples shall sign, date, and note the time that he/she received the samples on the Chain-Of-Custody Record. This Chain-Of-Custody Record documents transfer of custody of samples from the field investigator to another person, to the ASB, other laboratories, or other organizational elements.

- Samples shall be properly packaged for shipment (Appendix C) and delivered or shipped to the ASB or other designated laboratory for analyses. Shipping containers shall be secured by using nylon strapping tape and EPA custody seals. The custody seals shall be placed on the container so that it cannot be opened without breaking the seals. The seal shall be signed and dated by the field investigator.

- When samples are split with a facility, state regulatory agency, or other government agency, the facility, state regulatory agency, or other government agency representative should sign the Chain-Of-Custody Record. The only exception is that a Receipt For Samples Form will be used for RCRA, TSCA, and CERCLA samples as required by the appropriate regulations (Section 3.4).

- All samples shall be accompanied by the Chain-Of-Custody Record. The original and one copy of the Record will be placed in a plastic bag inside the secured shipping container if samples are shipped. One copy of the Record will be retained by the field investigator or project leader. The original Record will be transmitted to the field investigator or project leader after samples are accepted by the laboratory. This copy will become a part of the project file.

- If sent by mail, the package shall be registered with return receipt requested. If sent by common carrier, a Government Bill of Lading (GBL) or Air Bill should be used. Receipts from post offices, copies of GBL's, and Air Bills shall be retained as part of the documentation of the chain-of-custody. The Air Bill number, GBL number, or registered mail serial number shall be recorded in the remarks section of the Chain-Of-Custody Record or in another designated area if using a form other than that shown in Figure 3.3.1.

3.4 RECEIPT FOR SAMPLES

3.4.1 General

Section 3007 of the Resource Conservation and Recovery Act (RCRA) of 1976 and Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) of 1980 require that a "receipt" for all facility samples collected during inspections and investigations be given to the owner/operator of each facility before the field investigator departs the premises. The Toxic Substances Control Act (TSCA) contains similar provisions.

3.4.2 Receipt for Samples Form

The Receipt For Samples Form (Figure 3.4.1) is to be used by Branch personnel to satisfy the receipt for samples provisions of RCRA, CERCLA, and TSCA. The form also documents that split samples were offered and accepted or rejected by the owner/operator of the facility or site being investigated. The following information must be supplied and entered on the Receipt For Samples Form.

- The ESD project number, project name, name of facility or site, and location of the facility or site must be entered at the top of the form in the indicated locations.
- The sampler(s) must sign the form in the indicated location.
- The facility/site owner/operator's acceptance or rejection of split samples must be checked in the appropriate place in the Split Samples Offered section of the form. The owner/operator should be requested to initial his acceptance or rejection by the check mark and to sign his name in this block indicating that he has been offered this choice if the offer is refused.
- Each sample collected from the facility or site must be documented in the sample record portion of the form. The sample station number, date and time of sample collection, composite or grab sample designation, whether or not split samples were collected (yes or no should be entered under the split sample column), the tag numbers of samples collected which will be removed from the site, a brief description of each sampling location, and the total number of sample containers for each sample must be given. If EPA sample tags are used for split samples, these tag numbers should be recorded under the remarks column.
- The bottom portion of the form is used to document the receipt of split samples by the owner/operator of the facility or site. One of the samplers must be requested to sign and complete the information in the "transferred by" section (date and time must be entered). The owner/ operator of the site must sign the "received by" section of the form (the owner/operator must give his title, and telephone number and give the date and time he/she signed the form). If the owner/operator refuses to sign the form, the sampler(s) should note

this fact in the owner/operator's signature block and initial this entry.

The copy of the form is to be given to the facility or site owner/operator. The Receipt for Samples Form is serialized and becomes an accountable document after it is completed. The original copy of this form must be maintained in project files.

3.5 FIELD RECORDS

Branch personnel shall use only bound field logbooks for the maintenance of field records. The standard field logbooks utilized by Branch personnel are those obtained from the General Services Administration federal supply schedule numbers 7530-00-274-5494 and 7530-00-222-3525. Other bound logbooks such as bound surveyors logbooks are acceptable so long as pages cannot be removed without tearing them out.

Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project code should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and initial indicating the conclusion of the entry or the days activity.

All aspects of sample collection and handling as well as visual observations shall be documented in the field logbooks. All sample collection equipment (where appropriate), field analytical equipment, and equipment utilized to make physical measurements shall be identified in the field logbooks as outlined in Sections 4, 5, 6, and 7 of this SOPQAM. All calculations, results, and calibration data for field sampling, field analytical, and field physical measurement equipment shall also be recorded in the field logbooks. All field analyses and measurements must be traceable to the specific piece of field equipment utilized and to the field investigator collecting the sample, making the measurement, or analyses.

All entries in field logbooks shall be dated, shall be legible, and shall contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and must be maintained as part of project files.

3.6 DISPOSAL OF SAMPLES OR OTHER PHYSICAL EVIDENCE

Disposal of samples or other physical evidence obtained during Branch investigations is conducted on a case-by-case basis. Before any samples analyzed by the ASB are disposed, ASB personnel shall contact the Branch field investigator or Branch or Section Chief, in writing, requesting permission to dispose of the samples. The samples will not be disposed until the Branch field investigator or Branch or Section Chief completes the appropriate portions of the ASB memo, signs and returns the memo to the ASB, specifically giving them permission to dispose of the samples. Branch personnel should check with the EPA Program Office requesting the inspection or investigation before granting permission to dispose of samples or other physical evidence. The following general guidance is offered for the disposal of samples or other physical evidence:

- No samples, physical evidence, or any other document associated with a criminal investigation shall be disposed without written permission from EPA's Office of Criminal Investigation, the Office of Regional Counsel, or the Department of Justice.

- Quality assurance samples are routinely disposed after the analytical results are reported. ASB does not advise the Branch on the disposal of these samples.

- Samples associated with routine Branch inspections may be routinely disposed.

After samples are disposed, the ASB shall send the sample tags to the Branch field investigator. These sample tags are accountable and must be placed and maintained in the project files.

3.7 DOCUMENT CONTROL

The term document control, as it applies to Branch inspections and investigations, refers to the maintenance of inspection and investigation project files. All project files shall be maintained by the appropriate Section Secretary. All documents as outlined below shall be kept in project files. Branch personnel may keep their own files, however, all official and original documents relating to Branch inspections and investigations shall be placed in the official project files. The following documents shall be placed in the project file:

- a copy of the study plan;
- original Chain-Of-Custody Records and bound field logbooks;
- a copy of the Receipt For Sample Forms;
- all records obtained during the investigation;
- a complete copy of the analytical data and memorandums transmitting analytical data;
- sample tags from samples that have been disposed of by the ASB;
- all official correspondence received by or issued by the Branch relating to the investigation including records of telephone calls;
- one copy of the draft report (without review comments; however, peer review clearance forms shall be included);
- one copy of the final report and transmittal memorandum(s); and
- any other relevant documents related to the original investigation/ inspection or follow-up activities related to the investigation/ inspection.

Under no circumstances are any personal observations or irrelevant information to be filed in the official project files. The project leader or field investigator shall review the file at the conclusion of the project to insure that it is complete.

4.0 SAMPLING PROCEDURES

4.1 INTRODUCTION

This section discusses the standard practices and procedures utilized by Branch personnel during field operations to ensure the collection of representative samples. All sampling activities conducted by Branch personnel are conducted with the expectation that they will be used for enforcement purposes, unless specifically stated to the contrary in advance of the field investigation. Therefore, the use of proper sampling procedures cannot be over emphasized. The collection of representative samples depends upon:

- ensuring that the sample taken is representative of the material or medium being sampled;
- using proper sampling, sample handling, preservation, and quality control techniques;
- properly identifying the collected samples and documenting their collection in permanent field records (field log books, Chain-Of-Custody Records); and
- maintaining sample chain-of-custody.

The objectives of this section are to present:

- general considerations that must be incorporated in all sampling operations conducted by the Branch;
- Branch sampling site selection and collection procedures for an individual medium;
- Branch sampling quality assurance procedures; and
- equipment calibration and maintenance requirements for Branch sampling equipment.

4.2 GENERAL CONSIDERATIONS

The following factors and procedures shall be considered and implemented in planning and conducting all Branch sampling operations. All these factors and procedures must be considered in view of specific objectives and scope of each individual field investigation.

4.2.1 Selection of Representative Sampling Sites

Representative sampling sites are dependent on the type of investigation undertaken and are discussed under type of sample procedures for each medium later in this section.

4.2.2 Selection and Proper Preparation of Sampling Equipment

The type of sampling equipment to be used is dictated by the investigation and is discussed for each medium later in this section. Appendix B describes the standard equipment cleaning procedures.

4.2.3 Sampling Equipment Construction Material

The material that sampling equipment is constructed of can affect sample analytical results. Materials used must not contaminate the sample being collected and must be readily cleaned so that samples are not cross-contaminated. The standard materials for sampling equipment used to collect samples for trace organic compounds or metals analyses are, in order of decreasing desirability; Teflon®, glass, stainless steel, and steel.

4.2.4 Selection of Parameters to be Measured

Parameters to be measured are usually dictated by the purpose of an investigation and should be based on required monitoring conditions (NPDES or RCRA permits for example) or on the field investigator's or requestor's knowledge of the problem being investigated.

4.2.5 Required Sample Volumes

The volume of sample obtained should be sufficient to perform all required analyses with an additional amount collected to provide for quality control needs, split samples, or repeat examinations. When using a peristaltic pump, individual aliquots of a composite sample should be at least 100 milliliters in order to minimize sample solids bias.

Although the volume of sample required by contract laboratories depends on the analyses to be performed, the amount of sample required for a complete water or wastewater analysis is normally two gallons (7.6 liters) for each laboratory receiving a sample. The amount of soil/sediment required for a complete analysis is approximately 16 ounces. However, the laboratory receiving the sample should be consulted for any specific volume requirements.

The volumes of samples collected from waste sources at hazardous waste sites or samples from sources which are known to be toxic should be kept to an absolute minimum.

Sample volumes to be collected by Branch personnel for routine analyses by the Environmental Services Division (ESD), Analytical Support Branch (ASB) laboratory are in Appendix A. The sample volume required for each analysis is the volume of the standard container less ullage (empty space) required for sample mixing by laboratory personnel and safe shipment of samples to the laboratory. Branch personnel shall allow a minimum of ten percent ullage in every sample container for this purpose. The only exception is samples collected for purgeable organic analyses (VOA) or dissolved gases such as sulfides for which sample containers must be completely filled.

4.2.6 Selection and Proper Preparation of Sample Containers

The type of sample container is dictated by the analyses required. Standard sample containers used by Branch personnel are presented in Appendix A. Special sample container preparation requirements are in Appendix B.

4.2.7 Sample Preservation

Samples for some analyses must be preserved in order to maintain their integrity. Preservatives required for routine analyses of samples collected by Branch personnel are given in Appendix A. All chemical preservatives used by Branch personnel will be supplied by the ASB. All samples requiring preservation should be preserved immediately upon collection in the field. Samples that should not be preserved in the field are:

- Samples collected within a hazardous waste site that are known or thought to be highly contaminated with toxic materials. Barrel, drum, closed container, spillage, or other source samples from hazardous waste sites are not to be preserved with any chemical. These samples may be preserved by placing the sample container on ice, if necessary.
- Samples that have extremely low or high pH or samples that may generate potentially dangerous gases if they were preserved using the procedures given in Appendix A.
- Samples for metals analyses which are shipped by air shall not be preserved with nitric acid in excess of the amount specified in Appendix C.
- Samples for purgeable organic compounds analyses which are shipped by air shall not be preserved with hydrochloric acid in excess of the amount specified in Appendix C.

All samples preserved with chemicals shall be clearly identified by indicating on the sample tag that the sample is preserved. If samples normally requiring preservation were not preserved, field records shall indicate why.

4.2.8 Sample Holding Times

The elapsed time between sample collection and initiation of laboratory analyses must be within a prescribed time frame for each individual analysis to be performed. Sample holding times for all routine samples collected by Branch personnel are shown in Appendix A.

4.2.9 Special Precautions for Trace Contaminant Sampling

Some contaminants can be detected in the parts per billion and/or parts per trillion range. Extreme care must be taken to prevent cross-contamination of these samples. The following precautions shall be taken when trace contaminants are of concern:

- A clean pair of new, disposable gloves will be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.
- Sample containers for source samples or samples suspected of containing high concentrations of contaminants shall be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.
- If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples shall be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples shall never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants shall be lined with new, clean, plastic bags.
- If possible, one member of the field team should take all the notes, fill out tags, etc., while the other members collect all of the samples.
- When sampling surface waters, the water sample should always be collected before the sediment sample is collected.
- Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.
- Branch personnel should use equipment constructed of Teflon®, stainless steel, or glass that has been properly precleaned (Appendix B) for collecting samples for trace metals or organic compounds analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern. Equipment constructed of

plastic or PVC shall not be used to collect samples for trace organic compounds analyses.

4.2.10 Sample Handling and Mixing

After collection, all sample handling should be minimized. Branch personnel should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, personnel should ensure that melted ice cannot cause sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock® bags, should be used when small sample containers (e.g., VOA's or bacterial samples) are placed in ice chests to prevent cross-contamination.

Once a sample has been collected, it may have to be split into separate containers for different analyses. The best way to split liquid samples is to continually stir the sample contents with a clean pipette or precleaned Teflon® rod and allow the contents to be alternately siphoned into respective sample containers using Teflon® or PVC (Tygon® type) tubing. Teflon® must be used when analyses for organic compounds or trace metals are to be conducted. Any device used for stirring, or tubing used for siphoning, must be cleaned in the same manner as other equipment (Appendix B). However, samples collected for purgeables organic compounds analyses may not be split using this procedure.

A true split of soil, sediment, or sludge samples is almost impossible to accomplish under field conditions. The higher the moisture content, the more difficult it is to split the sample.

It is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. The most common method of mixing is referred to as quartering. The soil in the sample pan is divided into quarters. Each quarter is mixed, then all quarters are mixed into the center of the pan. This procedure is followed several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material over. Soil and sediment samples collected for purgeable organic compounds analyses should not be mixed. The 2-ounce (60-ml) sample container should be filled completely; no head space should remain in the sample containers.

4.2.11 Purgeable Organic Compounds Sampling (VOA)

Water samples to be analyzed for purgeable organic compounds should be stored in 40-ml septum vials with screw cap and Teflon®-silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

The vials (40-ml) should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule,

it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the procedure. Since the VOA vials are pre-preserved, extreme caution should be exercised when the vials are used as the collection device for surface water samples in order to prevent the loss of the preservative. When collecting water samples for purgeable organic compounds, triplicate samples should always be collected from each location. Three 40-ml vials containing four drops of concentrated HCl should be filled the with sample.

4.2.12 Sample Identification

All samples will be fully documented, as outlined in Section 3, in the field records, on the field sample Chain-Of-Custody Record, and on the sample tags.

4.2.13 Procedures for Identifying Potentially Hazardous Samples

Any sample either known or thought to be hazardous should be so identified on both the sample tag and the field sample Chain-Of-Custody Record. Information explaining the hazard, i.e., corrosive, flammable, poison, etc., shall also be listed.

4.2.14 Collection of Auxiliary Data

All auxiliary data such as flow measurements, photographs of sampling sites, meteorological conditions, and other observations shall be entered onto the field records when the auxiliary data are collected. Auxiliary data relative to a particular sampling location should be collected as close to the sample collection time as possible. Specific types of auxiliary data to collect for each medium sampled are discussed later in this section.

4.2.15 Time Records

All records of time shall be kept using local time in the 2400 hour time format and shall be recorded to the nearest minute.

4.2.16 Transporting and Shipping of Samples

Samples may be hand delivered to the laboratory using government owned (or rented) vehicles or they may be shipped by common carrier. All Branch personnel must be aware that certain samples are hazardous materials and, as such, are regulated by the U. S. Department of Transportation under the Transportation Safety Act of 1974. These regulations are contained in Title 49, CFR, Parts 110-119. Shipment of dangerous goods by air cargo is also regulated by the United Nations/International Civil Aviation Organization (UN/ICAO). The Dangerous Goods Regulations promulgated by the International Air Transport Association (IATA) meet or exceed DOT and UN/ICAO requirements and should be used for shipment of dangerous goods via air cargo. Shipment of samples by EPA employees is also governed by EPA Order No. 1000.18 (1). The standard Branch procedure for

shipping environmental samples is in Appendix C. All Branch employees shall meet the intent of the Transportation Safety Act of 1974 when shipping samples by common carrier.

4.2.17 Sample Chain-of-Custody

Branch employees shall maintain sample chain-of-custody during all field investigations for all samples collected. The standard sample chain-of-custody procedures used by Branch employees are given in Section 3.3.

4.3 DEFINITIONS

4.3.1 Grab Sample

An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes. Grab samples are associated with surface water, groundwater, wastewater, waste, contaminated surfaces, soil, and sediment sampling. Grab samples are typically used to characterize the media at a particular instant in time. See Appendix A for additional guidance concerning parameters requiring a grab sample and for monitoring that indicates that grab samples must be collected.

4.3.2 Composite Samples

A sample collected over time that typically consists of a series of discrete samples which are combined or "composited". Four types of composite samples are listed below:

- Time Composite (TC): A sample comprised of a varying number of discrete samples collected at equal time intervals during the compositing period. The TC sample is typically used to sample wastewater or streams.

- Flow Proportioned Composite (FPC): A sample collected proportional to the flow rate during the compositing period by either a time-varying/constant volume (TVCV) or time-constant/varying volume (TCVV) method. The TVCV method is typically used with automatic samplers that are paced by a flow meter. The TCVV method is a manual method that individually proportions a series of discretely collected samples. The FPC is typically used when sampling wastewater.

- Areal Composite: A sample collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from grid points.

- Vertical Composite: A sample collected from individual grab samples collected from a vertical cross section. Vertical composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes and estuaries.

4.3.3 Quality Control Samples

The majority of ECB field studies require the collection of additional samples for various quality control purposes. These include the isolation of site effects (control samples), define background conditions (background sample), evaluate field/laboratory methodology (spikes and blanks, trip blanks, duplicate samples), or to assess sampling equipment (sampler blanks and equipment rinse

blanks). In addition, it may be necessary to provide split or duplicate samples to assess field sampling procedures.

Miscellaneous sampling definitions are listed below:

- Sample Aliquot: A portion of a sample that is representative of the entire sample.
- Split Sample: A sample which has been portioned into two or more containers from a single sample container or sample mixing container.
- Duplicate Sample: Two or more samples collected simultaneously into separate containers from the same source under identical conditions.
- Control Sample: A sample collected upstream or upgradient from a source or site to isolate the effects of the source or site on the particular ambient medium being sampled.
- Background Sample: A sample collected from an area, water body, or site similar to the one being studied, but located in an area known or thought to be free from pollutants of concern.
- Biased Sample: A sample which is known to be non-representative of the entire site being studied. An example is samples collected during Superfund Site Screening Investigations that are intentionally biased towards suspected areas of contamination.
- Trip Blanks: Trip blanks are prepared prior to the sampling event in the actual sample container and are kept with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they reach the laboratory. ESD utilizes volatile organic trip blanks to determine if samples were contaminated during storage and transportation back to the laboratory. If samples are to be shipped, trip blanks are to be provided per shipment but not per cooler.
- Equipment Blanks: Equipment field blanks are defined as samples which are obtained by running organic-free water over/through sample collection equipment after it has been cleaned. These samples will be used to determine if cleaning procedures were adequate. (The equipment could have been cleaned in the field or prior to the field operation.)
- Pre and Post Preservative Blanks: To determine if the preservative used during field operations were contaminated, pre and post preservative blanks are prepared. On small studies, usually only a post preservative sample will be prepared. These samples are prepared by putting analyte-free/organic-free water in the container and then preserving the sample with the appropriate preservative.

- Field Blanks: Organic-free water is taken to the field in sealed containers and poured into the appropriate sample containers at pre-designated locations. This is done to determine if any contaminants present in the area may have an affect on the sample integrity. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.

4.4 DATA QUALITY OBJECTIVES

As defined in Data Quality Objectives for Remedial Response Activities (29), "Data Quality Objectives (DQO's) are qualitative and quantitative statements which specify the quality of the data required to support Agency decisions during remedial response activities". DQO's should be considered when planning any study. DQO's provide information on the limits of the data, which in turn dictate the proper uses of the data. DQO's were originally developed to guide the analytical program of Superfund (29), but the concept also has application for other field sampling efforts. Data collected in the field include samples and site information. The methods by which samples are collected may limit the uses of the subsequent analytical data. The methods by which site information, such as physical measurements, photographs, field notes, etc., are collected, may reduce their accuracy. The manner in which sampling equipment is cleaned will also affect the DQO level of the data. The various DQO levels are numbered I through V, with I being the lowest and IV the highest quality data. Level V data are collected using special or non-standard methods. Higher quality methods may be substituted for lower level work.

4.4.1 DQO Level I

Sampling equipment and sample containers must be cleaned using soap and tap water, visibly free of contamination, and free of detectable analytes using the analytical screening methods specified for the study. Use of organic vapor survey methods to determine locations or media fractions for higher level analysis is an example of DQO Level I field work. However, this technique is not appropriate for compounds that are not volatile or produce low instrument response. Data produced from such samples may not be used for other than the stated purpose.

4.4.2 DQO Level II

Field methods, decontamination procedures, and sampling equipment construction materials for DQO Level II analyses are as specified elsewhere in this document. The construction materials for sampling equipment may vary if rinse blanks analyzed using the field analytical procedures show that the substituted equipment does not contribute detectable analytes, and the materials would not reasonably be expected to contribute detectable analytes. For example, it may be acceptable to use PVC sampling equipment to collect samples that are only being analyzed for metals, or to use equipment made of chrome plated material for samples being analyzed only for organic compounds. Field cleaning procedures for sampling equipment used to collect samples that will be analyzed at this DQO level may consist of:

- Soap and potable water wash with brush (steam may also be used), followed by potable water rinse.
- Water rinse. The quality of the water is determined by the contaminants of concern and the minimum quantitation limits of the analytical methods used. For example, if an atomic absorption (AA) unit is being used to analyze water samples for lead only, and the

minimum quantitation limit is 20 ug/l, water containing up to 10 ug/l lead (one-half the minimum quantitation limit) may be used as decontamination water.

A minimum of five percent of samples collected for DQO Level II analyses should be split for DQO Level IV analysis. These samples must be representative of all samples submitted to the field laboratory.

4.3.3 DQO Level III

Field methods, decontamination procedures, and sampling equipment construction materials for DQO Level III analyses are as specified elsewhere in this document. Some modifications of these specifications are allowable in certain limited instances, as specified below.

If DQO Level III analytical services are being used in support of drilling or excavation operations, the cleaning procedures for the down-hole drilling or excavation equipment only may be cleaned as specified in Appendix E.9, with the omission of steps 3, 4, and 5. All other cleaning and decontamination procedures specified in that appendix apply.

When wells are constructed using materials that are not inert with respect to the contaminants being analyzed, data collected from those wells are DQO Level III or lower for those incompatible analytes, even if DQO Level IV analytical procedures are used.

A minimum of one equipment rinse blank per week for each week sampling equipment is field cleaned is required to be analyzed. If samples are preserved, a preservative blank must be collected and analyzed in the field at the beginning and end of the study. A blank of the rinse water must be collected and analyzed prior to beginning the study and at the end of each week sampling equipment is field cleaned.

A minimum of five percent of samples collected for DQO Level III analysis should be split for DQO Level IV analysis. These samples must be representative of all samples submitted to the field laboratory.

4.4.4 DQO Level IV

Field methods and equipment decontamination procedures described in this document are considered to be level IV methods. These are the standard methods to be used on all studies requiring DQO Level IV quality data. Any deviations from these methods must be documented in the field logbook or the approved study plan. The sampler must be aware that such deviations in the field work may reduce the DQO level of the data, with a subsequent reduction in the data uses. The field notes are always collected as specified in Section 3.5. Photographs are always logged as specified in Section 3.2.3.

4.4.5 DQO Level V

Because DQO Level V procedures are by definition non-standard, they are not discussed in detail. The project leader must be aware that special analytical procedures may require specialized field procedures and equipment. These must be specified in the approved study plan prior to beginning the study.

4.5 INVESTIGATION DERIVED WASTE

4.5.1 General

Many field investigations conducted by the Branch generate waste materials. These waste materials are known as investigation derived waste (IDW) (30). Some of these waste materials may be hazardous wastes which must be properly disposed in accordance with EPA regulations. Most, but not all, of these hazardous wastes will be associated with investigations of hazardous waste sites.

4.5.1.1 Types of IDW -- Materials which may become IDW requiring proper treatment, storage and disposal are:

- Personnel protective equipment (PPE). This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.
- Disposable equipment (DE). This includes plastic ground and equipment covers, aluminum foil, conduit pipe, coliwasa samplers, Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.
- Soil cuttings from drilling or hand auguring.
- Drilling mud or water used for water rotary drilling.
- Groundwater obtained through well development or well purging.
- Cleaning fluids such as spent solvent and washwater.

4.5.1.2 Management of Non-Hazardous IDW -- Disposal of non-hazardous IDW from hazardous waste sites should be addressed in the study plan. Non-hazardous IDW such as PPE and DE may be double-bagged and brought back to the Branch warehouse for disposal in the warehouse trash containers. To reduce volume for transportation back to the warehouse, it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum. If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE and DE IDW into the facilities dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a permitted landfill local to the site. On larger studies, waste hauling services may be obtained and a dumpster located at the study site. They may also be buried on site near the contamination source, with the burial location noted in the field logbook.

Disposal of non-hazardous IDW such as drill cuttings, purge or development water, decontamination fluids, drilling muds, etc., should be specified in the approved study plan. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place the liquid IDW into the facilities treatment system. It may be feasible to spread drill cuttings around the borehole, or if the well is temporary, to replace the cuttings back into the borehole. Cuttings, purge

water, or development water may also be placed in a pit in or near the source area. Monitoring well purge or development water may also be poured onto the ground downgradient of the monitoring well. Purge water from private potable wells which are in use may be discharged to the ground surface.

4.5.1.3 Management of Hazardous IDW -- Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan. Hazardous IDW must be disposed as specified in USEPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed of in the source area from which they originated, if doing so does not endanger human health and the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to permit arrangements for proper containerization, labelling, transportation, and disposal/treatment in accordance with USEPA regulations.

Hazardous investigation derived waste should be kept to a minimum to conserve Branch resources. Most of the routine studies conducted by the Branch should not produce any IDW that are hazardous, with the possible exception of purged groundwater. Many of the above PPE and DE wastes can be deposited in municipal dumpsters if care is taken to keep them segregated from hazardous waste contaminated materials. Disposable equipment can often be cleaned to render it non-hazardous, as can some PPE, such as splash suits. The volume of spent solvent waste produced during equipment decontamination can be reduced or eliminated by applying only the minimum amount of solvent necessary.

4.6 SPECIFIC SAMPLE COLLECTION QUALITY CONTROL PROCEDURES

4.6.1 General

This subsection provides guidelines for establishing quality control procedures for Branch sampling activities. Specific guidelines for sample site selection, selection of sampling equipment, types of samples to be collected, standard sample collection procedures, specific maintenance and calibration procedures for sampling equipment, and other considerations are presented for each medium later in this Section. Specific requirements for all sampling activities are presented in Section 4.2. Strict adherence to all of the standard operating procedures outlined in this chapter form the basis for the Branch sampling quality assurance program.

4.6.2 Experience Requirements

There is no substitute for field experience. Therefore, all professional and paraprofessional Branch employees shall have the equivalent of six months field experience before they are permitted to select sampling sites on their own initiative. This field experience shall be gained by on-the-job training using the "buddy" system. Each new Branch field employee shall accompany an experienced employee on as many different types of field studies as possible. During this training period, the new employee will be permitted to perform all facets of field investigations, including sampling, under the direction and supervision of senior Branch technical staff.

4.6.3 Traceability Requirements

All sample collection activities shall be traceable through field records to the person collecting the sample and to the specific piece of sampling equipment (where appropriate) used to collect that sample. All maintenance and calibration records for sampling equipment (where appropriate) shall be kept so that they are similarly traceable.

4.6.4 Measurement of Relative Sampling Precision

The following duplicate sampling procedures shall be used during the collection of Branch samples as a relative measure of the precision of the sample collection process. Duplicate grab and/or composite samples shall be collected during all major investigations and studies (more than 20 samples) conducted by the Branch. No more than ten percent of all samples shall be collected in duplicate. These samples shall be collected at the same time, using the same procedures, the same equipment, and in the same types of containers as the required samples. They shall also be preserved in the same manner and submitted for the same analyses as the required samples. The collection of duplicate composite samples shall require the installation of duplicate automatic sampler setups if automatic samplers are used for sample collection.

These data will be examined by the project leader to determine if any problems are evident with specific types of media samples or with the procedures used by specific Branch personnel. The project leader will advise the Branch Quality Assurance Officer who will in turn advise the Branch and appropriate

Section Chiefs of any problems encountered so that corrective action can be taken.

4.6.5 Measurement of Sample Handling Effectiveness

The effectiveness of Branch personnel sample handling techniques will be monitored by utilizing field blank samples. For routine studies these blank samples will be prepared by ASB personnel. Branch personnel shall request that these samples be provided at least one week in advance of scheduled field investigations and inspections and never (except in emergency situations) less than two days in advance of scheduled field investigations and inspections. These samples should not be picked up by Branch personnel earlier than the morning of departure for the scheduled inspection/investigation. On larger studies, where organic-free water is generated in the field, these blank samples may be made in the field. The following field blank samples are required:

- Water Sample VOA Trip Blank -- A water sample VOA trip blank is required for every study where water samples are collected for VOA analysis. Two sealed preserved (or unpreserved if appropriate) 40-ml VOA vials will be transported to the field. These field blanks will be handled and treated by Branch personnel in the same manner as the water samples collected for purgeable organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-Of-Custody Records as trip blanks.

- Soil Sample VOA Trip Blank -- A soil sample VOA trip blank is required for every study where soil samples are collected for purgeable organic compounds analysis. One 2-oz. soil VOA vial will be transported to the field. This field blank will be handled and treated by Branch personnel in the same manner as the soil samples collected for purgeable organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-Of-Custody Records as trip blanks.

The following blanks are prepared in the field:

- Inorganic Sample Preservative Blanks -- Metals and general inorganics sample containers filled with blank water will be transported to the field and preserved and submitted for the same analyses as the other inorganic samples collected. These samples will be clearly identified as preservatives blanks on sample tags and in the Chain-Of-Custody Record(s). At least one preservative blank for each type of preserved sample should be collected at the end of routine field investigations. A minimum of one preservative blank should be prepared at the beginning and end of all major Branch field investigations (20 samples or more).

- Automatic Sampler Blanks -- The procedure for collecting automatic sampler blanks is given in Section 4.5.4. In general, cleaning procedures outlined in Appendix B should be adequate to insure sample integrity. However, it is the standard practice of the

Branch to submit automatic sampler blanks for analyses when automatic samplers are used to collect samples for organic compounds analyses. Automatic sampler blanks for other standard analyses shall be submitted at least once per quarter.

The ASB will advise the Branch Quality Assurance Officer when trip blanks or preservative blanks are unacceptably contaminated. The Branch Quality Assurance Officer will immediately initiate an investigation to determine the cause of the problem. The results of this investigation will be promptly reported to the Branch and appropriate Section Chief so that corrective action can be initiated.

4.6.6 Measurement of Sample Container, Sample Equipment, and Cleaning Procedure Integrity

Specific quality control procedures are outlined in Appendix B.

4.6.7 Measurement of Field Generated Organic-Free Water

On larger studies, organic-free water may be prepared in the field. When this is done, a system blank should be collected prior to use and at the end of the study. If the study lasts more than one week, at least one sample per week shall be collected. Blank samples should be analyzed for all analytes of interest.

4.6.8 Special Quality Control Procedures for Water Samples for Extractable, Pesticide, or Herbicide Organic Compounds Analyses

Branch personnel shall submit duplicate water samples for extractable, pesticide, and/or herbicide organic compounds analyses from at least one sampling location per project and laboratory used. This sample should be collected from a location expected to be relatively free from contamination, since this sample will be used for laboratory quality control purposes. The duplicate sample should be clearly identified as "Duplicate Sample for Matrix Spike" on the sample tag, Chain-Of-Custody Record, in the field logbook, and on the Contract Laboratory Program (CLP) Traffic Report Form (if appropriate). This procedure shall be followed for all Branch projects where water samples are collected for the indicated organic compounds analyses, whether the samples are submitted to the ASB or the EPA CLP.

4.6.9 Special Quality Control Procedures for EPA Contract Laboratories

Special quality control procedures are used when samples are submitted to the EPA CLP. A series of blank and spiked samples are provided by ASB personnel that are to be submitted along with the regular samples to each contract laboratory utilized. These samples will be provided by the ASB along with the necessary CLP Traffic Report Forms for each blank and spike sample. These samples shall be submitted to the respective contract laboratories on a blind basis. Fictitious station numbers will be used on the Traffic Report Forms; the contract laboratories are <u>not</u> to know which samples are spikes and blanks. These samples are identified as spikes or blanks only on the copy of the Traffic Report Forms that are returned to the ASB.

These spike and blank samples are to be obtained from the ASB utilizing the procedures outlined in Section 4.4.5.

The ASB TPO (See Section 1.9.3.1) may request, on a case-by-case basis, that Branch personnel collect split samples (or duplicate samples if appropriate) for analysis by both the ASB and contract laboratories. The split samples are to be submitted to the ASB using established procedures. The contract laboratory involved shall not be notified in any way that samples were split, i.e., there should be no indication on Chain-Of-Custody Records or CLP Traffic Report Forms submitted to the contract laboratories that these samples were split with the ASB.

4.6.10 Special Quality Assurance Procedures for Dioxin (2,3,7,8-TCDD or Other Isomers)

All samples collected for dioxin (2,3,7,8-TCDD or isomers) analyses are analyzed by other EPA laboratories or through contract laboratories. The ASB does not conduct in-house analyses for dioxin. The ASB maintains a package that outlines all current quality control procedures to be used by Branch personnel when collecting samples for dioxin (2,3,7,8-TCDD or other isomers) analyses. The ASB must be consulted before any such samples are collected.

4.7 WASTEWATER SAMPLING

4.7.1 General Considerations

The variety of conditions at different sampling locations require that considerable judgment be made regarding the methodologies and procedures for collection of representative samples of wastewater. Each sampling point warrants attention commensurate with its complexity. There are, however, basic rules and precautions generally applicable to sample collection. The procedures used by the Branch are generally those outlined in the NPDES Compliance Inspection Manual (2). Additional guidance is given in the agency's handbook, Monitoring Industrial Wastewater (3). Some important considerations for obtaining a representative wastewater sample include:

- The sample should be collected where the wastewater is well mixed. Therefore, the sample should be collected near the center of the flow channel, where the turbulence is at a maximum and the possibility of solids settling is minimized. Skimming the water surface or dragging the channel bottom should be avoided; however, allowances should be made for fluctuations in water depth due to flow variations.

- In sampling from wide conduits, cross-sectional sampling should be considered. Rhodamine WT dye (See Section 7.8.2.3 for procedures) may be used as an aid in determining the most representative sampling point(s); and

- If manual compositing is employed, the individual sample bottles must be thoroughly mixed before pouring the individual aliquots into the composite container.

4.7.2 Site Selection

Where applicable, wastewater samples should be collected at the location specified in the NPDES permit (if the source has such a permit). In some instances the sampling location specified in the permit, or the location chosen by the permittee, may not be acceptable for the collection of a representative wastewater sample. In such instances, the project leader or field investigator is not limited by permit specifications from collecting a sample at a more representative location. When a conflict exists between the permittee and the regulatory agency regarding the most representative sampling location, both sites should be sampled, and the reason for the conflict should be noted in the inspection or study report and field notes. Recommendations and reasons for a change in sampling location should be given to the appropriate permitting authority.

4.7.2.1 Influent -- Influent wastewaters are preferably sampled at points of highly turbulent flow in order to ensure good mixing; however, in many instances the most desirable location is not accessible. Preferable influent wastewater sampling points include: (1) the upflow siphon following a comminutor (in absence of grit chamber); (2) the upflow distribution box following pumping from main plant wet well; (3) aerated grit chamber; (4) flume throat; or (5) pump

wet well when the pump is operating. When possible, raw wastewater samples should be collected upstream from sidestream returns.

4.7.2.2 Effluent -- Effluent samples should be collected at the site specified in the permit, or if no site is specified in the permit, at the most representative site downstream from all entering wastewater streams prior to discharge into the receiving waters. If a conflict exists between the permittee and inspector regarding the source being sampled or the location of the most representative site, follow the procedure outlined in Section 4.7.2.

4.7.2.3 Pond and Lagoon Sampling -- Generally, composite effluent wastewater samples should be collected from ponds and lagoons. Even if the ponds or lagoons have long retention times, composite sampling is necessary because of the tendency of ponds and lagoons to have flow paths that short circuit the detention time. However, if dye studies or facility data indicate a homogeneous discharge, a grab sample may be taken as representative of the waste stream.

4.7.3 Sampling Techniques - General

Sampling and flow measuring are mutually dependent for a complete evaluation of a wastewater treatment plant. The investigator must know the wastewater flow variability before a sampling program can be initiated.

The choice of a flow proportional or time composite sampling scheme depends on the variability of the wastewater flow or concentration, equipment availability, and sampling location. If an investigator knows or suspects that there is significant variability in the wastewater flow or if the investigator knows nothing about the facility, a flow proportional sample should be collected. Otherwise a time composite sample would be acceptable.

Prior to sampling, the flow measuring system (primary flow device, totalizer, and recorder) should be examined (methods described in Section 5). If the flow measuring system is unacceptable, the investigator may have to install flow measurement instrumentation (Section 5). If the flow measuring system is acceptable, samples can be collected by the appropriate method.

Time composite samples collected by the Branch are based on a constant time interval between samples. A time composite sample can be collected either manually or with an automatic sampler.

Flow proportional samples can be collected automatically with an automatic sampler and a compatible pacing flow measuring device, semi-automatically with a flow chart and an automatic sampler capable of collecting discrete samples, or manually. Refer to Appendix E for procedures describing the first method and to the NPDES Compliance Inspection Manual (2) for details on the latter two methods.

4.7.4 Use of Automatic Samplers

4.7.4.1 General -- Automatic samplers may be used when several points are to be sampled at frequent intervals or when a continuous sample is required. Automatic samplers used by the Branch must meet the following requirements:

- Sampling equipment must be properly cleaned to avoid cross-contamination which could result from prior use (see Appendix B for cleaning procedures).

- No plastic or metal parts of the sampler shall come in contact with the water or wastewater stream when parameters to be analyzed could be impacted by these materials (See Section 4.7.6).

- The automatic sampler must be able to provide adequate refrigeration during the sampling period. This can be accomplished in the field by using ice.

- The automatic sampler must be able to collect a large enough sample for all parameter analyses (see Appendix A for required sample volumes).

- A minimum of 100 mls should be collected each time the sampler is activated if a peristaltic pump is used.

- The automatic sampler should provide a lift of at least 20 feet and the sampler should be adjustable so that the volume is not be a function of the pumping head.

- Pumping velocity must be adequate to transport solids and not allow solids to settle.

- The intake line leading to the pump must be purged before each sample is collected.

- The minimum inside diameter of the intake line should be 1/4 inch.

- An adequate power source should be available to operate the sampler for 48 hours at a 30-minute sampling interval.

- Facility electrical outlets may be used if available.

- Facility automatic samplers may be used for conventional parameters if they meets SOP criteria.

Specific operating instructions, capabilities, capacities, and other pertinent information for automatic samplers presently used by the Branch are included in the respective operating manuals and are not presented here.

4.7.4.2 Equipment Installation

4.7.4.2.1 Conventional Sampling -- Automatic samplers may be used to collect time composite or flow proportional samples. In the flow proportional mode, the samplers are activated by a compatible flow meter. Flow proportional samples can also be collected using a discrete sampler and a flow recorder and manually compositing the individual aliquots in flow proportional amounts (2).

All new tubing (Dow® Corning Medical Grade Silastic, or equal, in the pump and either Teflon® or Tygon®, or equal, in the sample train) will be used for each sampler installation.

Installation procedures include cutting the proper length of tubing, positioning it in the wastewater stream, and sampler programming.

For a time composite sample, the sampler should be programmed to collect 200 mls at 30-minute intervals or 100 mls at 15-minute intervals into a refrigerated 3-gallon glass jug. For a 5-gallon compositing container, the volume should be increased

For a flow proportional sample, the sampler should be programmed to collect a minimum of 100 mls for each sample interval, with the interval predetermined based on the flow of the waste stream.

At the end of each 24-hour sampling period, the contents of the glass compositing container with the sample should be stirred and siphoned (poured if there are no visible solids) into the respective containers, followed by immediate preservation, if required.

4.7.4.3 Automatic Sampler Security -- EPA owned equipment is assumed to be in the custody of the permittee as long as it is on their property. This assumption should be made known to permittees whenever equipment is left unattended. A lock or seal may be placed on the sampler to detect tampering. However, this does not prevent tampering with the sample collection tubing. If necessary, seals may be placed on the sampling pole and tubing line to further reduce tampering possibilities.

4.7.4.4 Automatic Sampler Maintenance, Calibration, and Quality Control - To insure proper operation of automatic samplers, and thus the collection of representative samples, the procedures outlined in this section shall be used to maintain and calibrate Branch automatic samplers.

The following maintenance and calibration procedures shall be used; any differences from those prescribed procedures will be documented.

Prior to each field trip, the sampler operation will be checked by warehouse personnel. This includes operation (forward, reverse, automatic) through three cycles of purge-pump-purge; checking desiccant and replacing if necessary; checking 12-volt batteries to be used with the sampler; and repairing any item if necessary.

During each field trip, prior to initiating sampling, the purge-pump-purge cycle shall be checked at least once. The constant pumping volume using a graduated cylinder or other calibrated container will be checked at least twice, and the flow pacer that activates the sampler shall be checked to be sure it operates properly.

Upon return from a field trip, the sampler shall be examined for holes, dents, etc., and repaired, if necessary. The desiccant will be checked and replaced if appropriate. The operation (forward, reverse, automatic, etc.) will

be checked and any required repairs will be made and documented. The sampler will then be cleaned as outlined in Appendix B.

The automatic sampler's pumping rate at multiple heads, the timing mechanisms, the multiplexer, or the flow pacer will be checked against the manufacturer's specifications and documented whenever one or more of these functions appears to be operating improperly.

Automatic sampler blanks must be collected for organic compounds and metals analyses when collecting samples for trace organic compounds analyses as described in section 4.7.6.1.

4.7.5 Manual Sampling

Manual sampling is normally used for collecting grab samples and/or for immediate in-situ field analyses. However, it can also be used in lieu of automatic equipment over extended periods of time for composite sampling, especially when it is necessary to evaluate unusual waste stream conditions.

The best method to manually collect a sample is to use the actual sample container which will be used to transport the sample to the laboratory. This eliminates the possibility of contaminating the sample with an intermediate collection container. The actual sample container must always be used for collecting samples for oil and grease and bacterial analyses.

A separate collection container can be used to collect the sample, from which the sample can be redistributed to other containers. If this is done, however, the container used to collect the sample must be properly cleaned (Appendix B) and must be made of a material that meets the requirements of the parameter(s) being investigated. Also, a separate container will be used at each sampling station. This will prevent cross contamination between sampling station.

If the water or wastewater stream cannot be physically reached by the sampling personnel or it is not safe to reach for the sample, an intermediate collection container may be used. The sample is collected by lowering a properly cleaned Teflon®, plastic, glass, or stainless steel collection vessel (type of collection vessel used depends on the parameter being investigated) into the material to be sampled. The collection vessel may be lowered by hand or attached to a pole or rope and then lowered into the stream.

In some cases it may be best to use a pump, either power or hand operated, to withdraw a sample from the water or wastewater stream. If a pump is used, it is imperative that all components of the pump that come in contact with the liquid are properly cleaned (Appendix B) to insure the integrity of the sample.

Samples are manually collected by tipping the collection container in the water or wastewater stream so the mouth of the container faces upstream. The container should be rinsed with this procedure at least twice before the sample is collected (exceptions to this rinsing procedure exist if preservatives are present in the sampling container and for certain analyses such as oil and grease and bacteria).

4.7.6 Special Sample Collection Procedures

4.7.6.1 Trace Organic Compounds and Metals -- Trace organic compounds and metals detection limits are usually in the parts per billion range, so extreme care must be exercised to insure sample integrity.

All containers, composite bottles, tubing, etc., used in sample collection for trace organic compounds and metals analyses should be prepared as described in Appendix B.

When possible, the sample should be collected directly into the appropriate sample container. If the material to be sampled cannot be physically reached, an intermediate collection device may be used. This should be a Teflon®, glass, or stainless steel vessel on a pole or rope or Teflon® tubing via a peristaltic type pump and a Teflon® vacuum container attachment which converts a sample container into a vacuum container. The device which is used should be cleaned as described in Appendix B.

Personnel handling the sample should always wear a new pair of disposable surgical gloves with each set of samples collected and change as often as needed. This is necessary to prevent cross-contamination. A more detailed discussion is given in Section 4.2.10 under special precautions for trace contaminant sampling.

When an automatic sampler is used for collecting samples for trace organic compounds and metals analyses, the installation procedures include cutting the proper length of new Teflon® tubing, water rinsing of the entire collection system with a minimum of two gallons of Milli-Q® water, and blank collection for organics and metals. In the Milli-Q® water rinse, approximately one-half gallon is initially pumped into the composite sampler container and discarded. An additional one and one-half gallons are then pumped into the composite sampler container for distribution into the appropriate blank container. Nitric acid must be added to the metals blank container. Finally the collection tubing should then be positioned in the wastewater stream and sampler programming initiated.

4.7.6.2 Bacterial -- Samples for bacterial analysis will always be collected directly into the prepared glass or plastic sample bottle. The sample bottle should be kept unopened until it is to be filled. When the cap is removed, care should be taken not to contaminate the cap or the inside of the bottle. The bottle should be held near the base and filled to within about one inch of the top without rinsing and recapped immediately. The bottle should be plunged, neck downward, below the surface and turned until the neck points slightly upward. The mouth should be directed toward the current (4, 5). Appendix A presents preservation procedures and holding times.

When the sample bottle must be lowered into the waste stream, either because of safety or impracticality (manhole, slippery effluent area, etc.), care must be taken to avoid contamination.

4.7.6.3 Immiscible Liquids/Oil and Grease -- Oil and grease may be present in wastewater as a surface film, an emulsion, a solution, or as a combination of

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these forms. Since it is very difficult to collect a representative sample for oil and grease analysis, the inspector must carefully evaluate the location of the sampling point. The most desirable sampling location is the point of greatest mixing. Quiescent areas should be avoided. Because losses of oil and grease will occur on sampling equipment, the collection of a composite sample is impractical. Individual portions collected at prescribed time intervals must be analyzed separately to obtain the average concentrations over an extended period.

4.7.6.4 Purgeable Organic Compounds Analyses (VOA) -- Samples to be analyzed for purgeable organic compounds should be collected in 40-ml septum vials with screw caps with a Teflon® lined silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

When sampling for purgeable organic compounds, triplicate samples should always be collected from each location. The investigator should determine if the water to be sampled contains chlorine. If the water contains no chlorine, three 40-ml vials containing four drops of concentrated HCl should be filled with the sample. The samples may be held up to 14 days before analysis. When preservation (HCl) is not feasible, samples can be held up to 7 days before analysis for purgeable aromatic hydrocarbons and 14 days for purgeable hydrocarbons compounds.

If the water contains chlorine, the following sampling and preservation procedure should be followed:

> Fill an 8-ounce VOA sampling container with 8 drops of a 25% ascorbic acid solution and the water sample. Cap and mix thoroughly but gently by swirling to eliminate residual chlorine. Transfer the sample to three 40-ml VOA vials containing four drops of concentrated HCl*. Label each 40-ml vial with "P" (preserved/ascorbic acid).
>
> * The ascorbic acid and acid preservatives must be added in this order and in two separate steps.

The purgeable organics vials (40-ml) should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles; if any are present, repeat the procedure using a new 40-ml vial.

Sampling containers with preservatives should be prelabeled (i.e., P) prior to any field activities. This will reduce the chances of confusion during sampling activities by the investigation team. Sample preservation, containers, holding times, and sample volumes are listed in Appendix A.

4.7.7 Special Process Control Samples and Tests

Special process control samples collected and field tests performed on these samples are given in Appendix H.

4.7.8 Auxiliary Data Collection

While conducting wastewater sampling, the following information will also be obtained (if applicable):

- Field measurements - pH, DO, conductivity, temperature (see Section 6 and Appendix D for standard field analytical techniques);
- Flows associated with the samples collected -- continuous flows with composite samples and instantaneous flows with grab samples (Section 5);
- Diagrams and/or written descriptions of the wastewater treatment systems (if available);
- Photographs of pertinent wastewater associated equipment, such as flow measuring devices, treatment units, etc. (keep photolog as specified in section 3.2.3);
- Process control information on the wastewater treatment process (if applicable); and
- Completion of applicable forms required during specific investigations.

All observations, measurements, diagrams, etc., will be entered in bound field logbooks or attached thereto (where applicable as specified in Section 3.5).

4.8 SURFACE WATER AND SEDIMENT SAMPLING

4.8.1 General

Selection of a surface water sampling location for water quality studies is based on many factors, including: study objective, water use, point source discharges, nonpoint source discharges, tributaries, changes in stream characteristics, types of stream bed, stream depth, turbulence, presence of structures (weirs, dams, etc.), accessibility, personnel available, etc. When sampling in estuarine systems, tidal effects must be considered in selecting sampling locations.

If the study objective is to investigate a specific location as a source of water supply, recreation, or other discrete use, then considerations such as accessibility, flow, velocity, physical characteristics, etc., are not as critical from a water quality investigation standpoint.

If the objective of a water quality study is to determine patterns of pollution, provide data for mathematical modeling purposes, conduct assimilative capacity studies, etc., where more than a single sampling location is to be investigated, then several factors become interrelated and need to be considered in sampling location selection. An excellent guide to conducting surface water stream studies is F. W. Kittrells, "A Practical Guide to Water Quality Studies" (6).

4.8.2 Sample Site Selection

Before any sampling is conducted, an initial reconnaissance should be made to locate suitable sampling locations. Bridges and piers are normally good choices as sites since they provide ready access and permit water sampling at any point across the width of the water body. However, these structures may alter the nature of water flow and thus influence sediment deposition or scouring. Additionally, bridges and piers are not always located in desirable locations with reference to waste sources, tributaries, etc. Wading for water samples in lakes, ponds, and slow-moving rivers and streams must be done with caution since bottom deposits are easily disturbed, thereby resulting in increased sediment in the overlying water column. On the other hand, wadeable areas may be best for sediment sampling. In slow-moving or deep water, a boat is usually required for sampling.

Sampling station locations can be chosen without regard to other means of access if the stream is navigable by boat, especially in estuarine systems where boats frequently provide the only access to critical sampling locations.

Wading to collect samples may be feasible in some cases, but this method usually will be chosen for only very small streams. A field investigator usually has to carry a considerable amount of sampling equipment, field analytical instruments, and water samples. When it also is necessary to wear rubber boots to walk the streambed or to wade out to the main current, the physical effort involved often makes this method too difficult to be practical.

Fresh water environments are commonly separated into two types: (1) rivers, streams, and creeks; and (2) lakes, ponds, and impoundments. Since these waterways differ considerably in general characteristics, site selection must be adapted to each. Estuarine environments are a special case and are discussed separately.

4.8.2.1 Rivers, Streams, and Creeks -- In the selection of a surface water sampling site on rivers, streams, and creeks, areas that exhibit the greatest degree of cross-sectional homogeneity shall be located. When available, previously collected data may indicate if potential sampling locations are well mixed or vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately downstream of a riffle area will insure good vertical mixing. These locations are also likely areas for deposition of sediment since the greatest deposition occurs where stream velocity slows down. Horizontal (cross-channel) mixing occurs in constrictions in the channel, but because of velocity increases, the stream bottom may be scoured, and therefore, a constriction is a poor sediment sample location. In the absence of turbulent areas, the selection of a site that is clear of immediate point sources, such as tributaries and industrial and municipal effluents, is preferred for the collection of water samples.

Typical sediment depositional areas are located inside of river bends, downstream of islands, and downstream of obstructions in the water. Sites that are located immediately upstream or downstream from the confluence of two streams or rivers should generally be avoided since flows from two tributaries may not immediately mix, and at times due to possible backflow can upset the normal flow patterns.

When several stations along a stream reach are to be sampled, they should be strategically located:

- They shall be spaced at intervals based on time-of-water-travel, not distance. For example, sampling stations may be located about one-half day time-of-water-travel for the first three days downstream of a waste source (the first six stations) and then approximately one day through the remaining distance.

- If the study is to be compared to a previous study, the same sampling stations should be used, if possible, for comparison purposes.

- A station should be located whenever a marked physical change occurs in the stream channel. Example: A stream reach between two adjacent stations should not include both a long rapids section of swift shallow water with a rocky bottom, and a long section of deep, slow-moving water with a muddy bottom. Stations at each end of the combined reach would yield data on certain rates of change, such as reaeration, that would be an unrealistic average of two widely different rates. Much more would be learned of the actual natural characteristics of the stream by inserting a third sampling station within the reach, between the rapids and the quiet water sections.

- Station locations should be selected to isolate major discharges as well as major tributaries.

Dams and weirs cause changes in physical characteristics of a stream. They usually create quiet, deep pools in river reaches that, historically were swift and shallow. Such impoundments should be bracketed. When times of water travel through them are long, stations should be established within the impoundments.

Some stream structures, such as dams, permit overflow that accomplishes significant reaeration of oxygen deficient water. In such cases, stations should be located short distances upstream and downstream from the structures to measure the rapid, artificial increase in dissolved oxygen (DO), which is not representative of natural reaeration.

A minimum of three stations located between any two points of major change in a stream is a desirable precaution, when feasible, even when the time-of-travel between the points of change is short. Major changes may consist of a waste discharge, a tributary inflow, or a significant difference in channel characteristics. The use of three stations is especially important when rates of change of unstable constituents are being determined. If results from one of only two stations in a subreach are in error for some unforeseen reason, it may not be possible to judge which of the two sets of results indicate the actual rate of change. Results from at least two of three stations, on the other hand, will probably support each other and indicate the true pattern of water quality in the subreach.

If there is interest in the effects of certain discharges or tributary streams on ambient water quality, sites should be located both upstream and downstream from the tributaries or discharges.

Unless a stream is extremely turbulent, it is nearly impossible to measure the effect of a waste discharge or tributary immediately downstream of the source. Inflow frequently "hugs" the stream bank with very little horizontal (cross-channel) mixing for some distance. This is a major consideration in estuarine environments. Samples from quarter points may miss the wastes altogether and reflect only the quality of water above the waste source. Samples taken directly in the portion of the cross section containing the wastes would indicate excessive effects of the wastes with respect to the river as a whole.

Tributaries should be sampled as near the mouth as is feasible. This may be a bridge some distance upstream from the mouth. Frequently, the mouths of tributaries may be entered from the main stream for sampling by boat. Care should be exercised to avoid collecting water from the main stream that may flow into the mouth of the tributary on either the surface or bottom because of differences in density resulting from temperature, dissolved salts, or turbidity.

Actual sampling locations will vary with the size of the water body and the amount of turbulence in the stream or river. Generally, with small streams less than 20 feet wide, a sampling site can be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth at the center of the channel is adequate to represent the entire cross-section. A sediment sample can

also be collected at the center of the channel. For slightly larger streams, at least one vertical composite should be taken from mid-stream, with samples taken just below the surface, at mid-depth, and just above the bottom. Of course, DO, pH, temperature, conductivity, etc. should be measured on each aliquot of the vertical composite. For large rivers, several locations across the channel width should be sampled. Vertical composites across the channel width should be located in a manner that is roughly proportional to flow, i.e., they should be closer together toward mid-channel, where most of the flow travels, than toward the banks, where the proportion of total flow is smaller. The number of vertical composites required and the number of depths sampled for each are usually determined in the field by the sampling crew. This determination is based on a reasonable balance between the following two considerations.

1. The larger the number of subsamples, the more nearly the composite sample will represent the water body.

2. Taking subsamples is time-consuming and expensive, and increases the chance of contamination.

In most circumstances, a number of sediment samples should be collected along a cross-section of a river or stream in order to adequately characterize the bed material. A common procedure is to sample at quarter points along the cross-section of the site selected. When the sampling technique or equipment requires that the samples be extruded or transferred at the site, they can be combined into a single composite sample. However, samples of dissimilar composition should not be combined but should be stored for separate analysis in the laboratory. To insure representative samples, the preferred method is diver deployed coring tubes.

4.8.2.2 Lakes, Ponds, and Impoundments -- Lakes, ponds, and impoundments have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained. Occasionally, an extreme turbidity difference may occur vertically where a highly turbid river enters a lake, and each layer of the stratified water column needs to be considered. Since the stratification is caused by water temperature differences, the cooler, heavier river water is beneath the warmer lake water. A temperature profile of the water column as well as visual observation of lake samples can detect the different layers and they can be sampled separately.

The number of water sampling sites on a lake, pond, or impoundment will vary with the purpose of the investigation as well as the size and shape of the basin. In ponds and small impoundments, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is to be conducted on each vertical composite aliquot. In naturally-formed ponds, the deepest point is usually near the center; in impoundments, the deepest point is usually near the dam.

In lakes and larger impoundments, several vertical subsamples should be composited to form a single sample. These vertical sampling locations are often taken along a transect or grid. Again, the number of vertical subsamples and the depths at which subsamples are taken are usually at the discretion of the

sampling crew. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones, but normally a composite shall consist of several vertical subsamples collected at various depths.

In lakes with irregular shape and with several bays and coves that are protected from the wind, additional separate composite samples may be needed to adequately represent water quality. Similarly, additional samples should be taken where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

When collecting sediment samples in lakes, pond, and reservoirs, the site selected should be approximately at the center of water mass. This is particularly true for reservoirs that are formed by the impoundment of rivers or streams. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir, and the bed sediments near the center of the water mass will be composed of fine-grained materials. The shape, inflow pattern, bathymetry, and circulation must be considered when selecting sediment sampling sites in lakes or reservoirs.

4.8.2.3 Estuarine Waters -- Estuarine areas are zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types, dependent upon freshwater inflow and mixing properties (7, 8, 9, and 10):

- Mixed estuary -- Characterized by an absence of vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is found in major freshwater sheetflow areas, featuring shallow depths.

- Salt wedge estuary -- Characterized by a sharp vertical increase in salinity and channelized freshwater inflow into a deep estuary. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase.

- Oceanic estuary -- Characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh saline water mixing occurring near, or at, the vegetated shore line.

A reconnaissance investigation should be conducted for each estuarine study unless prior knowledge of the estuarine type is available. The reconnaissance should focus upon the freshwater and oceanic water dynamics with respect to the study objective. In this regard, National Oceanic Atmospheric Administration tide tables and USGS freshwater surface water flow records provide perspective to the estuary dynamics. The basic in-situ measurement tools for reconnaissance are: a boat, recording fathometer, salinometer, and dissolved oxygen meter. These instruments coupled with the study objective or pollution source location, whether it is a point or nonpoint source problem, provide the focus for setting

sampling locations. More often than not, preplanned sampling locations in estuarine areas are changed during the actual study period. Because of the dynamics of estuaries, initial sampling often reveals that the study objective could be better served by relocating, adding, or deleting sampling locations.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (11).

All estuarine sampling programs conducted by Branch personnel shall include vertical salinity measurements at one- to five-foot increments coupled with vertical DO and temperature profiles. A variety of water sampling devices are used, but in general, the Van Dorn (or similar type) horizontal sampler is employed.

Samples are normally collected at mid-depth in areas where the depths are less than 10 feet, unless the salinity profile indicates the presence of a halocline (salinity stratification). In that case, samples are collected from each stratum. Depending upon the study objective, when depths are greater than 10 feet, water samples may be collected at the one-foot depth, mid-depth, and one-foot from the bottom.

In general, estuarine investigations are two phased, with study investigations conducted during wet and dry periods. Depending upon the freshwater inflow sources, estuarine water quality dynamics cannot normally be determined by a single season study.

For a complete discussion of estuarine systems, refer to references 7, 8, 9, and 10.

4.8.2.4 Control Stations -- In order to have a basis of comparison of water quality, the collection of samples from control stations is always necessary. A control station above the source of waste is fully as important as are stations below, and should be chosen with equal care to ensure representative results. At times it may be desirable to locate two or three stations above the waste inflow to establish the rate at which the unstable material is changing. The time of travel between the stations should be sufficient to permit accurate measurement of the change in the constituent under consideration.

4.8.3 Sampling Equipment and Techniques

4.8.3.1 General -- Any equipment or sampling techniques used to collect a sample are acceptable as long as they do not cause the integrity of the sample to be violated and which provide a sample which is representative of the stream being sampled.

4.8.3.2 Water Sampling Equipment/Techniques -- The physical location of the investigator when collecting a sample may dictate the equipment to be used. If surface water samples are required, direct dipping of the sample container into the stream is desirable. This is possible, however, only from a small boat, a pier, etc., or by wading in the stream. Wading, however, may cause bottom deposits to rise and bias the sample. Wading is acceptable if the stream has a noticeable current (is not impounded), and the samples are collected directly

into the bottle while pointed upstream. If the stream is too deep to wade or if the sample must be collected from more than one water depth or from a bridge, etc., supplemental sampling equipment must be used.

Teflon® bailers may be used for surface water sampling, if the data requirements do not necessitate a sample from a strictly discrete interval of the water column. A closed top bailer with a bottom check-valve is sufficient for many studies. As the bailer is lowered through the water column, water is continually displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. This technique may not be successful where strong currents are found, or where a discrete sample at a specific depth is required.

If discrete samples are desired at a specific depth, and the parameters to be measured do not require a Teflon® coated sampler, a standard Kemmerer or Van Dorn sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends of the sampler open while being lowered in a vertical position to allow free passage of water through the cylinder. The Van Dorn sampler is plastic and is lowered in a horizontal position. In each case, a messenger is sent down a rope when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill respective sample bottles. With a rubber tube attached to the valve, DO sample bottles can be properly filled by allowing an overflow. With multiple depth samples, care should be taken not to stir up the bottom sediment and thus bias the sample.

A plastic bucket can be used to collect samples if the parameters to be analyzed do not preclude it. However, the bucket should be rinsed twice with the sample water prior to collection of the sample. All field equipment should follow standard cleaning procedures.

4.8.3.3 Sediment Sampling Equipment/Techniques -- To collect a sediment sample from a streambed, a variety of methods can be used. Dredging (Peterson, Eckman, Ponar), coring, and scooping (BMH-60) are available. Regardless of the method used, precautions shall be taken to insure that the sample collected is representative of the streambed. These methods are discussed in the following paragraphs.

4.8.3.3.1 Dredging -- For routine analyses, the Peterson dredge can be used when the bottom is rocky, in very deep water, or when the stream velocity is high. The dredge should be lowered very slowly as it approaches bottom, because it can displace and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high velocities. It should not be used from a bridge more than a few feet above the water, because the spring mechanism which activates the sampler can be damaged by the messenger if dropped from too great a height.

The Ponar dredge is a modification of the Peterson dredge and is similar in size and weight. It has been modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

4.8.3.3.2 Corers -- Core samplers are used to sample vertical columns of sediment. They are particularly useful when a historical approach to sediment deposition is desired for they preserve the sequential layering of the deposit. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand push tubes to weight or gravity driven devices.

Coring devices are particularly useful in pollutant monitoring because the "shock wave" created by descent is minimal, thus the fines of the sediment-water interface are only minimally disturbed; the sample is withdrawn intact permitting the removal of only those layers of interest; core liners manufactured of glass or Teflon® can be purchased, thus reducing possible sample contamination; and the samples are easily delivered to the lab for analysis in the tube in which they were collected. The disadvantage of coring devices is that a relatively small surface area and sample size is obtained often necessitating repetitive sampling in order to obtain the required amount for analysis. Because it is felt that this disadvantage is offset by the advantages, coring devices are recommended in sampling sediments for trace organic compounds or metals analyses.

In shallow, wadeable waters, the direct use of a core liner or tube manufactured of Teflon® or glass is recommended for the collection of sediment samples. Their use can also be extended to deep waters when SCUBA equipment is available. Teflon® is preferred to avoid glass breakage and possible sample loss. Stainless steel push tubes are also acceptable and provide a better cutting edge and higher strength than Teflon®. The use of the glass or Teflon® tube by itself eliminates any possible metal contamination from core barrels, cutting heads, and retainers. The tube should be approximately 12 inches if only recently deposited sediments (8 inches or less) are to be sampled. Longer tubes should be used when the depth of the substrate exceeds eight inches. Soft or semi-consolidated sediments such as mud and clays have a greater adherence to the inside of the tube and thus can be sampled with larger diameter tubes. Because coarse or unconsolidated sediments such as sands and gravel tend to fall out of the tube, a small diameter is required for them. A tube about two inches in diameter is usually the best size. The wall thickness of the tube should be about 1/3 inch for either Teflon® or glass. The inside wall may be filed down at the bottom of the tube to facilitate entry of the liner into the substrate.

Caution should be exercised not to disturb the area to be sampled when the sample is obtained by wading in shallow water. The core tube is pushed into the substrate until only four inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is pushed will facilitate greater penetration and cut down on core

compaction. The tube is then capped with a Teflon® plug or a sheet of Teflon® held in place by a rubber stopper or cork. After capping, the tube is slowly extracted, the negative pressure and adherence of the sediment keeping the sample in the tube. Before pulling the bottom part of the core above the water surface, it too is capped.

For a detailed description of several types of coring devices, refer to "Sampling Protocols for Analysis of Toxic Pollutants in Ambient Water, Bed Sediment and Fish" (12).

4.8.3.3.3 Scooping -- If the water is wadeable, the easiest way to collect a sediment sample is to scoop the sediment using a stainless steel spoon or scoop. This reduces the potential for cross-contamination. This can be accomplished by wading into the stream, and while facing upstream (into the current), scooping the sample along the stream bottom in the upstream direction. If the stream is too deep to wade but less than eight feet deep, a stainless steel scoop attached to a piece of conduit can be used either from the banks if the stream is narrow or from a boat.

If the stream has a significant flow and is too deep to wade, a BMH-60 sampler may be used. It is not particularly efficient in mud or other soft substrates because its weight will cause penetration to deeper sediments, which are not desired when sampling for priority pollutants. It is also difficult to release secured samples in an undisturbed fashion that would readily permit subsampling. The BMH-60 may be used for priority pollutant sampling provided that caution is exercised by only taking subsamples that have not been in contact with the metal walls of the sampler.

4.8.3.3.4 Mixing -- Regardless of the method of collection, sediment samples collected for chemical analysis should be thoroughly mixed (except for purgeable organic compounds analysis) before being placed in the appropriate sample containers, as specified in Section 4.2.10.

4.8.4 Special Sample Collection Techniques

4.8.4.1 Trace Organic Compounds and Metals -- Since trace organic compounds and metals are usually found in extremely low concentrations in ambient waters, the possibility of contamination is greater than with sediment or fish. Precautions must be taken with sampling equipment and preservatives to ensure that contamination does not occur.

Direct dipping of the sample containers is the preferred method of collecting surface water sample for trace levels pollutants analyses. If samples are to be split for enforcement or quality control purposes, and duplicate samples will not suffice, a sufficient volume for all sample containers should be collected in a large glass compositing container and then, with mixing, be alternately siphoned or poured into the respective sample bottles. This technique is not to be used for samples collected for purgeable organic compounds analysis.

Many contaminants are partitioned more strongly to sediments than water; thus, if these contaminants have been deposited recently and are not quickly degraded or desorbed, they are evident in the sediment analysis. Ideally, only Teflon®, stainless steel, or glass should be used in sediment sampling for trace level contaminant analyses. The method using glass or Teflon® coring tubes, was discussed previously, is the preferred technique.

In many situations when the water is deep, divers are not available, or the only sampling location is from a bridge, a dredge may be used. In these cases, a high grade stainless steel Ponar dredge (properly cleaned, Appendix B) shall be used to collect the sediment samples. Direct scooping of the streambed sediment as described earlier is acceptable.

4.8.4.2 Bacterial -- Samples for bacteriological examination must be collected in bottles properly sterilized and protected against contamination. The preferable method is to scoop up the water with the open bottle just below the surface. This method usually is used when sampling by boat. While the bottle is open, both bottle and stopper must be protected against contamination. A small amount of water should be poured from the bottle after filling to leave an air space for subsequent shaking in the laboratory. The bottle should be closed at once.

When sampling from a bridge, the sterilized sample bottle can be placed in a weighted frame, opened, and then lowered to the water with a string or rope. The bottle can also be lowered by attaching twine directly to it. Care should be taken not to dislodge dirt or other material from the bridge that will fall into the open bottle. The mouth of the bottle may be faced upstream by swinging the bottle downstream under the bridge and dropping it quickly but without excessive slack in the rope. The bottle is then pulled upstream and out of the water.

Special equipment for collecting sterile samples at various depths is available. The JZ sampler, for example, includes a metal frame to hold the sample bottle, two sterile glass tubes connected by a rubber tube and inserted through the sterile bottle stopper, and a messenger. One of the glass tubes is bent so that the upper portion is horizontal. This portion is positioned next to a rope. The messenger breaks the tube, which allows the bottle to fill. The bottle, glass tube and rubber tube must be properly sterilized before use. Additional guidance for collecting samples for bacterial analyses is given in References 4 and 5.

4.8.5 Auxiliary Data Collection

A bound field log book will be used to record daily activities, describe sampling locations and techniques, list photographs taken, etc., as specified in Section 3.5. Visual observations are particularly significant and may prove invaluable in interpreting water quality study results. These visual observations, including weather and stream conditions (including tide stage) during the investigation should also be recorded in field records.

4.8.6 Specific Sampling Equipment Quality Assurance Procedures

All water and sediment sampling equipment shall be cleaned as outlined in Appendix B after field use and before being stored. This equipment shall be inspected and tested before being issued for each field study. Any repairs necessary shall be made and recorded.

During field studies, this equipment shall be cleaned as outlined in Appendix B and all such cleaning procedures shall be documented in field records.

4.9 GROUND WATER SAMPLING

4.9.1 General

Ground-water sampling may be required for a variety of reasons, such as examining potable or industrial water supplies, checking for and/or tracking contaminant plume movement in the vicinity of a land disposal or spill site, RCRA compliance monitoring, or examining a site where historical information is minimal or non-existent but where it is thought ground water contamination could have occurred.

Ground water is usually sampled through an in-place well, either temporarily or permanently installed. However, it can also be sampled anywhere ground water is present, as in a pit or a dug or drilled hole.

Occasionally, a well will not be in the ideal location to obtain the sample needed (for example, to track a contaminant plume). In that case, a well will have to be installed, and it may be either a temporary or permanently installed well. An experienced and knowledgeable person will need to locate the well and supervise its installation so that the samples ultimately collected will be representative of the ground water.

The procedures covered in this section are those used by the Branch. Additional guidance is given in the "RCRA Ground Water Monitoring Technical Enforcement Guidance Document" (TEGD) (13); the ground water sampling procedures used by Branch personnel will meet or exceed the requirements of this document.

4.9.2 Site Selection

The relationship of the following factors to potential pollution sources shall be considered and evaluated when selecting ground-water sampling sites:

- the direction of ground-water flow, depth to ground water, thickness of the aquifer (if applicable);
- type of stratigraphy;
- presence of perched water tables;
- types of soils;
- depth to bedrock;
- type of vegetation;
- surface drainage patterns;
- type of topography;
- general land use;

- and surface features such as rock outcrops, seeps, springs, streams, rivers, and wet areas (14).

The area of interest should be located on an aerial photograph, a USGS 7.5 minute quadrangle map, a USDA soils map, and/or any other appropriate map that shows topography and general relationships between surface features. Aerial photographs can usually be obtained at the local Agricultural Stabilization Conservation Service (ASCS) office or the local county tax office. USGS 7.5 minute quadrangle maps can be acquired from the State Geological Survey or from the USGS, and soils maps from the USDA-SCS (Soil Conservation Service). A visual inspection of the area may be sufficient to evaluate and determine the surface conditions and their relationship to the subsurface conditions (14). In some cases, surface conditions and subsurface conditions cannot be correlated by site inspection or reconnaissance. When this occurs, a more detailed study, possibly involving test drilling, will have to be conducted.

It is extremely important to sample the unconfined or surficial aquifer downgradient of potential pollution sources or spills to determine if it (the most easily contaminated aquifer) has been affected. Generally the direction of ground-water flow can be estimated by two vectors - one in the direction of surface water flow (i.e., downstream) and another toward the nearest surface water stream or river, if present. The relative magnitude of these vectors will vary according to site conditions and in some instances both direction and magnitude may be changed by construction activities. If both a shallow and a deep aquifer are involved in the zone of interest, a screening study will reveal whether or not the deep aquifer should be sampled and a more detailed study is required. To adequately assess subsurface conditions, a minimum of three wells is required; one in the upgradient portion of the area of interest, one in the middle portion, and one in the downgradient portion. In some cases, a more complex system of wells may be needed to define the subsurface conditions, especially in establishing the depth to the shallow ground-water aquifer and the direction of ground-water movement. Site conditions and the scope of the project will determine the total number of wells required. Existing wells should be used when possible. Where permanent well installation is necessary, the wells should be installed according to the procedures in Appendix E.

4.9.3 Purging Equipment and Techniques

4.9.3.1 General -- Wells shall be purged before taking samples in order to clear the well of stagnant water which is not representative of aquifer conditions. The method of purging is to pump the well until three to five times the volume of standing water in the well has been removed and until the specific conductance, temperature, and pH of the ground water stabilizes. Normally, a combination of the two methods is employed (i.e., specific conductance, temperature, and pH are measured at intervals and three to five volumes are purged). If a well is pumped dry, this constitutes an adequate purge and the well can be sampled following recovery (15, 17). However, if possible, monitoring wells should not be pumped dry. If the well is pumped dry, water that has been trapped in the sandpack may be sampled. In addition, as water re-enters the well it may cascade down the well screen and strip volatile contaminants.

4.9.3.2 Equipment Available -- Monitoring well purging is accomplished by using in-place plumbing/pumps or when in-place pumps are not available, by using EPA equipment; either a peristaltic, turbine, bladder, centrifugal, or other appropriate pump, depending on well depth. A Teflon®, closed top bailer may be used for purging; however, bailing may stir up sediment in the well if conducted improperly.

Other monitoring equipment used during purging includes water level indicators, pH meters, thermometers, and conductivity bridges (See Section 6, Field Analytical Procedures).

4.9.3.3 Purging Techniques (Wells Without Plumbing or In Place Pumps)

4.9.3.3.1 General -- For permanently installed wells, the depth of water shall be determined (if possible) before purging. This can be accomplished by attaching a weight on the end of a tape and lowering it into the well until it touches the water, or by use of a mechanical or electrical water level indicator (see Ground-Water Level Measurement Techniques, Section 7.7). Branch personnel shall exercise extreme caution during this procedure to prevent contamination of the ground water. This is a critical concern when samples for trace organic compounds or metals analyses are collected.

4.9.3.3.2 Using Pumps to Purge -- When suction lift or centrifugal pumps are used, only the intake line is placed into the water column. To minimize contamination, the line placed into the water is either standard cleaned (see Appendix B) Teflon®, in the case of the suction lift pumps, or standard cleaned stainless steel pipe attached to a hose, when centrifugal pumps are used.

When submersible pumps (bladder, turbine, displacement, etc.) are used, the pump itself is lowered into the water column. The pump must be cleaned as specified in Appendix B.

4.9.3.3.3 Using Bailers to Purge -- Standard cleaned (Appendix B) closed-top Teflon® bailers with Teflon® leaders and new nylon rope are lowered into top of the water column, allowed to fill, and removed and then the water is discarded.

4.9.3.3.4 Field Care of Purging Equipment -- Regardless of which method is used for purging, new plastic sheeting shall be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they need to be placed on the ground during the purging or they accidentally come into contact with the ground surface. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool, both during transporting and during field use, to further minimize contamination from the transporting vehicle or ground surface.

4.9.3.3.5 Purging Entire Water Column -- The pump/hose assembly or bailer used in purging should be lowered into the top of the standing water column and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. If the pump is placed deep into

the water column, the water above the pump may not be removed, and the subsequent samples collected may not be representative of the ground water.

To minimize cross contamination between wells, no more than three to five feet of hose should be lowered into the water column. If the recovery rate of the well is faster than the pump rate, the pump may be left hanging at the initial level until an adequate volume has been purged. If the pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the drawdown.

After the pump is removed from the well, all wetted portions of the hose and the pump shall be cleaned as outlined in Appendix B.

Careful consideration shall be given to using pumps to purge wells which are excessively contaminated with oily compounds, because it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When these type wells are encountered, alternative purging methods, such as bailers, should be considered.

4.9.3.4 Purging Techniques - Wells With In Place Plumbing

4.9.3.4.1 General -- In-place plumbing is found at water treatment plants, industrial water supply wells, private residences, etc. The objective of purging is the same as with monitoring wells without in place pumps, i.e., to ultimately collect a sample representative of the ground water.

The volume to be purged depends on several factors: whether the pumps are running continuously or intermittently; how close to the source the sample can be collected; and the presence of any storage/pressure tanks between the sampling point and the pump. If storage/pressure tanks are present, an adequate volume must be purged to totally exchange the volume of water in the tank.

4.9.3.4.2 Continuously Running Pumps -- If the pump runs continuously, and the sample can be collected prior to a storage/pressure tank, no purge, other than opening a valve and allowing it to flush for a few minutes, is necessary.

4.9.5.4.3 Intermittently Running Pumps -- If the pump runs intermittently, it is necessary to determine the volume to be purged, including storage/pressure tanks that are located prior to the sampling location. The pump should then be run continuously until the required volume has been purged.

4.9.4 Sampling Equipment and Techniques

4.9.4.1 Equipment Available -- Sampling equipment used by the Branch includes closed-top Teflon® bailers and the peristaltic pump/vacuum jug assembly.

Other monitoring equipment used during sampling includes water level indicators, pH meters, thermometers, and conductivity bridges (see Sections 6 and 7).

4.9.4.2 Sampling Techniques -- Wells With In Place Plumbing -- Samples should be collected following purging from a valve or cold water tap as near to

the well as possible. Samples should be collected directly into the appropriate containers (see Standard Sample Containers, Appendix A). Also, refer to the Potable Water Supply discussion in Section 4.10.

4.9.4.3 Sampling Techniques -- Wells Without Plumbing -- Following purging, samples should be collected using a peristaltic pump/vacuum jug procedure, if possible, or with a closed top Teflon® bailer. The pump used for purging generally should not be used for sampling. When the peristaltic pump is used, samples for purgeable organic compounds analyses should be collected using a bailer or by allowing the Teflon® tube to fill and then allowing the water to drain into the sample vials. All equipment shall be cleaned using the procedures described in Appendix B. Also, refer to the Potable Water Supply discussion, Section 4.10, for additional information.

When bailing, new plastic sheeting should be placed on the ground around each well to provide a clean working area. The nylon rope should be attached to the bailer via a Teflon® coated stainless steel wire. This coated wire is attached to the bailer semi-permanently and is decontaminated for reuse as the bailer is cleaned.

4.9.5 Special Sample Collection Procedures

4.9.5.1 Trace Organic Compounds and Metals -- Special sample handling procedures shall be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which come into contact with the water in the well must be cleaned in accordance with the cleaning procedures described in Appendix B. Pumps shall not be used for sampling, unless the interior and exterior portions of the pump and discharge hoses can be thoroughly cleaned. Blanks should be collected to determine the adequacy of cleaning prior to collection of any sample using a pump. Peristaltic pumps using Teflon® tubing and a Teflon® insert can be used to collect samples without the sample coming into contact with the pump. This is accomplished by placing the Teflon® insert into the opening of a standard cleaned 4-liter glass container. The Teflon® tubing connects the container to the pump and sample source. The pump creates a vacuum in the container, thereby drawing the sample into the container without coming into contact with the pump tubing. Samples for purgeable organic compounds analyses shall be collected with well bailers. The procedures given in the General Considerations, Special Precautions for Trace Contaminant Sampling (Section 4.2.9) shall be followed.

4.9.5.2 Filtering -- As a standard Branch policy, ground-water samples will not be filtered. However, if samples are filtered, then both filtered and non-filtered samples will be submitted for analyses. Proper well installation and development (Appendix E) as well as proper well purging techniques should be utilized to minimize the turbidity of samples. If filtered samples for metals analyses must be collected, an additional unfiltered sample will also be collected for metals analyses. Samples for organic compounds analyses shall not be filtered.

4.9.5.3 Bacterial Sampling -- Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in Sampling for Organic Chemicals and Microorganisms in the Subsurface (19) as well as References 4 and 5. Additional information on bacterial sampling is also included in Section 4.10 (Potable Water Supplies), Section 4.7 (Wastewater Sampling), and Section 4.8 (Surface Water Sampling).

4.9.6 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground-water samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of field studies. Cleaning procedures conducted in the field (Appendix B), or field repairs shall be thoroughly documented in field records.

4.9.7 Auxiliary Data Collection

Water table measurements from the top of the well casings (referenced to National Geodetic Vertical Datum) in permanent wells, and ground surface elevations in temporary wells should be made to determine the general direction of ground-water flow and gradient. The methodology to be used to determine well water levels are given in Section 7. Tracer dyes and radioactive and thermal detection methods can be used to determine direction and velocities of flow (14). Also, a study of the general topography and drainage patterns will generally indicate direction of ground-water flow.

Water table measurements shall not be taken until the water table has stabilized, preferably 24 hours after well installation for permanent wells (20). The ground surface elevation at the wells should be determined by standard engineering survey practices as outlined in Section 7.

In addition to water level measurements, the pumping rate used to purge a well, the volume of water in wells, and drillers' logs are examples of auxiliary data that should be collected during ground-water sampling activities. This information should be documented in field records. Methodology for obtaining these data are given in the following sections.

Temperature, specific conductance, and pH shall be measured each time a well is sampled. Stabilization of these parameters is measured during the purging process to evaluate the adequacy of the purging procedure. In this situation, the final measurements for these parameters prior to sampling shall be considered the measurement of record for the well. If these parameters were not evaluated during purging, they shall be obtained prior to sampling. Methodology for obtaining these data are given in Section 6.

4.9.7.1 Well Pumping Rate - Bucket/Stop Watch Method -- The pumping rate of a pump can be determined by collecting the flow of water from the pump in a bucket of known volume and timing how long it takes to fill the bucket. The pumping rate should be in gallons per minute. This method shall be used only with pumps with a constant pump rate, such as gasoline powered or electric

submersible pumps. It should not be used with battery powered pumps. As the batteries lose their charge, the pump rate decreases so that pumping rate calculations using initial, high pump rates are erroneously high.

4.9.7.2 Volume of Water in Wells -- In order to purge wells, the volume of water in the well should be known. To determine the volume, the following method should be used; measure the distance from the bottom of the well to the static water level, then measure the inside diameter of the well or casing. Obtain the volume of the well by the formula:

$$V = 0.041 \quad d^2h$$

Where h = depth of water in feet
d = diameter of well in inches
V = volume of water in gallons

If preferred, a quick reference nomograph or table may be used.

Additional ground-water related data can be obtained from most local, state, and federal agencies dealing with water resources. Some states require well drillers to be licensed, and all work performed on wells must be reported to the state on prescribed forms. These forms are available to the public, so a study of wells installed in the area of interest may provide background information as to the subsurface conditions. State geological surveys, as well as the USGS, have various types of water related papers and reports on all phases of ground-water studies in each state. City and county governments usually have departments that deal with water related projects that may provide data for the local area. Federal agencies such as the SCS, U. S. Army Corps of Engineers, the Bureau of Reclamation, U. S. Forest Service, Science and Education Administration, and the U. S. Public Health Service have water programs which may provide data. Other sources include the Bureau of Mines, colleges, universities, and technical societies such as American Association of Petroleum Geologists, American Institute of Mining and Metallurgical Engineers, American Water Well Association, Association of Engineering Geologists, and Geological Society of America (14, 21).

4.10 SAMPLING OF POTABLE WATER SUPPLIES

4.10.1 General

When sampling potable water supplies, utmost care must be taken to insure that samples are representative of the water supply being sampled. This is important not only from a technical and public health perspective, but also from a public relations standpoint. Poor sampling techniques may result in incorrect results (either not detecting a compound which is present or by contaminating the sample and falsely indicating a compound which is not present). If incorrect results are disclosed to the public, it may be impossible to change public opinion when correct results are reported.

4.10.2 Sampling Site Selection/Sampling Techniques

Even though the same care and techniques used in wastewater, ground-water, etc., sampling (including thorough documentation of location, date, time, etc.) are used by Branch personnel in potable water supply sampling, there are certain additional special procedures which shall be used.

When water samples are collected from wells, either by mechanical or hand pumping, the wells must be purged before the sample is collected (see Section 4.9 for ground-water sampling methods). This procedure insures that water representative of the formation is sampled, not the standing water in the well casing, pipes, or holding tank. As a rule of thumb, at least one volume of water in the well casing and storage tank should be evacuated (a 15-minute period is usually sufficient for residential wells). After purging for about 15 minutes, the pH, conductivity, and temperature should be measured until constant values are obtained. This procedure insures that any contaminants that might have entered the area of the tap from external sources have been removed (19).

Potable water samples shall be representative of the water quality within a given segment of the distribution network. Taps selected for sample collection should be supplied with water from a service pipe connected directly to a water main in the segment of interest and should not be separated from the segment of interest by a storage tank. The sampling tap must be protected from exterior contamination associated with being too close to the sink bottom or to the ground. Contaminated water or soil from the faucet exterior may enter the bottle during the collecting procedure since it is difficult to place a bottle under a low tap without grazing the neck interior against the outside faucet surface. Leaking taps that allow water to flow out from around the stem of the valve handle and down the outside of the faucet, or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations. Aerator, strainer, and hose attachments on the tap must be removed before sampling. These devices can harbor a bacterial population if they are not cleaned routinely or replaced when worn or cracked. Whenever a steady stream of water cannot be obtained from taps, after such devices are removed, a more suitable tap shall be sought. Taps where the water flow is not steady should be avoided because temporary fluctuation in line pressure may cause sheets of microbial growth that are lodged in some pipe section or faucet connection to break loose. The cold water tap should be opened for two or three minutes or for sufficient time to permit clearing the service line; a smooth-flowing water stream at moderate

pressure without splashing should be obtained. Then, without changing the water flow which could dislodge some particles in the faucet, the samples can be collected (19).

Occasionally, samples are collected to determine the contribution of transmission pipes, water coolers, water heaters, etc., to the quality of water in private residences, offices, etc. The purpose of these investigations may be to determine if metals, e.g., lead, are being dissolved into the water supply. In these cases, it may be necessary to insure that the water source has not been used for a specific time interval, e.g., over a weekend or a three- or four-day holiday period. Sample collection may consist of collecting a sample of the initial flush, collecting a sample after several minutes, and collecting another sample after the system being investigated has been completely purged.

Regardless of the type of sample bottle being used, the bottle cap should not be placed on the ground or in a pocket. Instead, hold the bottle in one hand and the cap in the other, using care not to touch the inside of the cap. Exercise care not to lose the Teflon® liner in certain bottle caps. Avoid contaminating the sample bottle with fingers or permitting the faucet to touch the inside of the bottle. When sampling for bacterial content, the bottle should not be rinsed before use. This may not only contaminate the bottle but also remove the thiosulfate dechlorinating agent (if used). When filling any container, care should be taken so splashing drops of water from the ground or sink do not enter into either the bottle or cap. In order to avoid dislodging particles in the pipe or valve, do not adjust the stream flow while sampling.

When sampling at a water treatment plant, samples should be collected both from the raw water supply and after chlorination.

Triplicate samples will always be collected for purgeable organic compounds analyses and duplicate samples for bacterial analyses. Single samples may be collected for extractable organic compounds, metals, phenol, cyanide, and conventional parameter analyses. The procedures given in Section 4.2.11 (Special Precautions for Trace Contamination Sampling) and in Section 4.7.6.4 (Purgeable Organic Compounds Sample Collection) shall always be followed when potable water supplies are sampled.

Branch personnel shall always obtain the name(s) of the resident or water supply owner/operator and the resident's exact mailing address, as well as the resident's home and work telephone numbers. The information is required so that the residents or water supply owner/operators can be informed of the results of the sampling program.

4.10.3 Sampling Equipment/Specific Sampling Equipment Quality Assurance Techniques

Sampling equipment and specific equipment quality assurance techniques are contained in Section 4.8 (Surface Water Sampling) and Section 4.9 (Groundwater Sampling).

4.11 SOIL SAMPLING

4.11.1 General

Soil sampling at hazardous waste sites will typically be approached in a totally different manner than sampling of other media. Sampling locations and rationale for other media are usually easily defined. For example, ground water samples may be collected at existing monitoring wells; surface water and sediment samples are usually collected from well defined surface drainage patterns at easily rationalized locations with respect to the suspected problem; and waste sources, such as drums, tanks, and piles, are easily identified sampling targets. Occasionally, surface soils may be stained or show evidence of vegetative stress, indicating that a contaminant may be present, but in many cases there may not be any direct evidence to suggest that a particular location is a candidate for soil sampling. The sampler may, in fact, be faced with investigating a virtually invisible contaminant distribution pattern, both in the surficial material, as well as in the subsurface region.

4.11.2 Sampling Location/Site Selection

Areas selected for soil sampling shall be strategically located in order to collect a representative fraction of the soils with the minimum number of samples. Although it is not always feasible to conduct a site reconnaissance prior to an investigation, a site reconnaissance can eliminate many uncertainties with respect to site characteristics and result in more complete and successful soil sampling studies. A surface inspection of the subject area should be made to locate pertinent features (e.g., rock outcrops, drainage patterns, surface runoff, ponds, lakes, wet areas, seeps, springs, permanent structures, fill areas, erosional areas, depositional areas, etc.) and to evaluate the relationship between these features and potential sources of pollution. A knowledge of these relationships and conditions, particularly soil conditions (type and thickness of soil overburden) and water table conditions are extremely important in developing sampling plans.

In addition to what is normally considered soil, i.e., in situ weathered rock overburden, soil samples may also consist of what is more correctly considered sediment, which has been deposited by both overland sheet runoff, as well as flow in normally dry wet-weather swales. The location of sediment sampling locations in these types of depositional areas is a useful screening tool, providing an indication of the presence of contaminants from the larger area contributing the sediment.

Initial investigations at most sites will consist of "screening-type" studies. Sampling for these investigations will generally be confined to a small number of surface or shallow subsurface samples. Typically, samples would be collected from depositional areas within and around the periphery of the site, as well as from obviously contaminated areas. Based on the results of the initial site-screening studies, more detailed studies, involving considerably more samples and with a greater emphasis on subsurface sampling, are usually required to fully characterize soil contamination at a site.

Study plans or work plans for soil sampling investigations must be carefully conceived with respect to the study objectives. This, in turn, requires a careful consideration of the types of samples to be collected, as well as the sampling methods to be employed. These areas are discussed below.

4.11.3 Basic Considerations for Soil Sampling

Three basic considerations, with respect to sample type, should be evaluated when developing a soil sampling plan and establishing investigation objectives. Should the samples be random, biased, or grid-based? Will they be collected from the surface or subsurface? Will a particular sample be a grab sample or a composite sample? When all of these questions are answered, it will be found that many investigations will involve the collection of most combinations of the above types of samples. A discussion of these considerations is found in the following sections.

4.11.3.1 Random, Biased and Grid-Based Sampling -- Generally, unless there is a strong indication of contamination, such as staining, or there are distinct depositional areas which provide excellent screening samples, soil samples collected for small investigations with limited areal extent, such as screening site investigations, must be randomly selected from several areas within the suspected area of contamination. Random in this sense is synonymous with casual, i.e., locations are often subjectively selected based purely on personal judgement.

If any areas show evidence of contamination, such as staining or vegetative stress, biased samples should be collected from each of the areas to characterize the contamination present in each area. If surface drainage patterns such as dry washes or swales are discernable, soil/sediment samples may be collected from the deposits in these features to characterize the immediate areas. Background and control samples are also biased, since they are collected in locations dictated by expected clean conditions or by anticipated impact from adjacent off-site areas.

When soil sampling investigations involve large areas, measured in acres for example, a systematic approach must be taken, not necessarily to the exclusion of other approaches, to characterize the presence and distribution of contaminants. In these situations, a grid-based soil sampling program is employed. There is no single grid size that is appropriate for all sites; however, in most cases, the smaller the site, the smaller the grid size. Common grid sizes are developed on 50-foot and 100-foot centers, although other sizes may be appropriate in given situations. It may be appropriate and acceptable to integrate several different grid sizes in a single investigation.

When the site is extremely large, over several acres for example, it may be impossible to consider sampling every grid and it will be necessary to statistically select a sub-set of the total number of grids in order to reduce the number of samples collected for the study. On the other hand, it may sometimes be appropriate to sample every grid and use relatively inexpensive and quick screening-level analytical techniques to define the areas which must be sampled and analyzed for a higher level of data quality. Because the screening level

analysis is relatively quick, the second phase sampling can sometimes be conducted during the same investigation. In all cases, however, the grid centers should be located using a site survey and semi-permanently marked to facilitate relocating the sample locations for subsequent sampling.

4.11.3.2 Surface and/or Subsurface Soil Samples -- In most initial investigations, particularly site screening-type studies, surface soil samples may comprise the great majority of soil samples collected. These are collected to look for the possible presence and distribution of contaminants in surficial materials. Subsurface soil sampling may be limited during initial investigations, but it may comprise the major portion of the soil sampling effort during subsequent phases of the investigation where the vertical extent of contamination in identified areas of surface contamination is the major objective.

4.11.3.3 Grab versus Composite Samples -- When a sample is needed to identify and quantify compounds at a specific location or interval, a grab sample is collected. Grab samples are limited in areal extent (for surface samples) or vertical extent (for subsurface samples). The sample should be comprised of no more than the minimum amount of soil necessary to make up the volume of sample dictated by the required sample containers. Composite samples are a mixture of a given number of subsamples and are collected to characterize the average composition of a given surface area or vertical interval. Areal composites are comprised of subsamples collected from the surface within the selected area. The number of subsamples forming a composite should remain consistent within the context of the study, i.e., a number and pattern for collection of subsamples within a grid should be selected and, for a given grid size, should not be changed. Likewise, if one of the objectives of the study is to determine if any contamination is present within a particular vertical interval, a vertical composite sample, comprised of vertically discrete samples collected over the selected interval may be collected. As with the areal composites, the number of subsamples is dependent on the objectives of the study. With the low analytical detection limits available today, compositing can usually be used to determine the presence or absence of compounds in the area or interval sampled.

There are two potential problems associated with compositing for which the sampler must be aware. Even though modern analytical detection limits allow for qualitative screening in many cases using compositing techniques, the risk still remains that low concentrations, present in individual composite aliquots, may be diluted to the extent that the total composite concentration is below the minimum quantification limit. Also, if the subsamples are predominantly moist and clayey, it will be very difficult to produce a homogenous mixture. The resulting sample, as represented by the portion selected by the analytical chemist, may not be representative, either qualitatively or quantitatively, of an average of all of the subsamples.

4.11.4 Sampling Methodology

This discussion of soil sampling methodology reflects both the equipment used (required/needed) to collect the sample, as well as how the sample is handled and processed after retrieval. Selection of equipment is usually based

on the depth of samples, but it is also controlled, to a certain extent, by the characteristics of the material. Simple, manual techniques and equipment, such as hand augers, are usually selected for surface or shallow, subsurface soil sampling. As the depth of the sampling interval becomes greater, some type of powered sampling equipment is usually needed to overcome torque induced by soil resistance and depth. The following is an overview of the various sample collection methods employed over three general depth classifications: surface, shallow subsurface, and deep subsurface. Any of the deep collection methods described may be used to collect samples from the shallower intervals. See Section 4.2.10 for special sampling considerations for purgeable organic compounds analyses.

4.11.4.1 Manual (Hand Operated) Collection Techniques and Equipment -- These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual, i.e., hand-powered, methods becomes impractical.

4.11.4.2 Surface Soils -- Surface soils may be collected with a wide variety of equipment. Spoons, shovels, hand-augers, push tubes, and post-hole diggers, made of the appropriate material, may be used to collect surface soil samples. As discussed in the section on powered equipment, surface soil samples may also be collected in conjunction with the use of heavy equipment.

Surface samples are removed from the ground and placed in pans, where mixing, as appropriate (Section 4.2.10), occurs prior to filling of sample containers. Section 4.11.5 contains specific procedures for handling samples for purgeable organic compounds analyses. If a thick, matted root zone is encountered at the surface, it should be removed before the sample is collected.

4.11.4.3 Subsurface Soils -- Hand-augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger-buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand-auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand-augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand-auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required. Some powered methods, discussed later, are not acceptable for actual sample collection, but are used solely to gain easier access to the required sample depth, where hand-augers or push tubes are generally used to collect the sample.

When a vertical sampling interval has been established, one auger-bucket is used to advance the auger hole to the first desired sampling depth. If the

sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a new bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole. Section 4.11.5 contains additional sample handling procedures.

Another hand-operated piece of soil sampling equipment commonly used to collect shallow subsurface soil samples is the Shelby or "push tube". This is simply a thin-walled tube, generally of stainless steel construction and having a beveled leading edge, which is twisted and pushed directly into the soil. This type of sampling device is particularly useful if a relatively undisturbed sample is required. The sampling device is removed from the push-head, then the sample is extruded from the tube into the pan with a spoon or special extruder. Even though the push-head is equipped with a check valve to help retain samples, the Shelby tube will generally not retain loose and watery soils, particularly if collected at lower depths.

4.11.4.3.1 Powered Sampling Devices -- Powered sampling devices and sampling aids may be used to acquire samples from any depth but they are generally limited to depths of 20 feet or less. Among the common types of powered equipment used to collect or aid in the collection of subsurface soil samples are Little Beaver®-type two-man power augers; split-spoon samplers driven with a drill rig drive-weight assembly or hydraulically pushed using drill rig hydraulics; continuous split-spoon samplers; specialized hydraulic cone penetrometer rigs; and back-hoes. The use of each of these is described below.

4.11.4.3.2 Power Augers -- Two-man power augers of the Little Beaver® variety, are commonly used to aid in the collection of subsurface soil samples at depths where hand augering is impractical. This type of equipment is technically a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range for this equipment. It is used to advance a hole to the required sampling depth, at which point a hand auger is usually used to collect the sample.

4.11.4.3.3 Drill Rigs -- Drill rigs offer the capability of collecting soil samples from greater depths. For all practical purposes, the depth of investigation achievable by this method is controlled only by the depth of soil overlying bedrock, which may be in excess of 100 feet.

When used in conjunction with drilling, split-spoon samplers are usually driven either inside a hollow-stem auger or inside an open borehole after rotary drilling equipment has been temporarily removed. The spoon is driven with a 140-pound hammer through a distance of up to 24 inches and removed. If geotechnical data are also required, the number of blows with the hammer for each six-inch interval is also recorded.

Continuous split-spoon samplers may be used to obtain five-foot long, continuous samples approximately 3 to 5 inches in diameter. These devices are

located inside a five-foot section of hollow-stem auger and advanced with the auger during drilling. As the auger advances, the central core of soil moves into the sampler and is retained until retrieval.

4.11.4.3.4 Cone Penetrometer Rigs -- A recent innovation is now available, which involves the modification of a standard split-spoon. The spoon has been modified with a releasable tip which keeps the spoon closed during the sampling push. Upon arrival at the desired depth, the tip can be remotely released and the push continued. During the subsequent push, the released tip floats freely up the inside of the spoon as the soil core displaces it. Split-spoon soil samples, therefore, can be collected without drilling, as has historically been required, by simply pushing the device to the desired depth. This technique is particularly beneficial at highly contaminated sites, because cuttings are not produced as with drill rigs. The push rods are generally retrieved with very little residue. This results in minimal exposure to sampling personnel and very little contaminated residue is produced as a result of equipment cleaning.

4.11.4.3.5 Back-Hoes -- Back-hoes are often utilized in shallow subsurface soil sampling programs. Samples may either be collected directly from the back-hoe bucket or they may be collected from the trench wall if proper safety protocols are followed. Trenches offer the ability to collect samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. Prior to collecting samples from trench walls, the wall surface must be dressed with a stainless steel shovel, spatula, knife, or spoon to remove the surface layer of soil which was smeared across the trench wall as the bucket passed. If back-hoe buckets are not cleaned according to the procedures described in Section B.8.3 of this manual, samples must be collected from material which has not been in contact with the bucket surface.

4.11.5 Special Techniques and Considerations

4.11.5.1 Collection of Soil Samples for Purgeable Organic Compound (VOA) Analyses -- These samples should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with a hand auger, the VOA sample may be collected directly from the auger bucket or immediately after an auger bucket is emptied into the pan. The sample should be placed in the appropriate container with no head-space, if possible, as is the practice with water samples. Samples for VOA analysis are not mixed (Section 4.2.10).

4.11.5.2 Dressing Soil Surfaces -- Any time a vertical or near vertical surface, such as is achieved when shovels or back-hoes are used for subsurface sampling, is sampled, the surface should be dressed to remove smeared soil. This is necessary to minimize the effects of cross-contamination due to smearing of material from other levels.

4.11.5.3 Sample Mixing -- It is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is representative of the interval sampled. Soil samples should be mixed as specified in Section 4.2.10.

4.11.5.4 Special Precautions for Trace Contaminant Soil Sampling - The procedures outlined in Section 4.2.9 shall be followed. All soil sampling equipment used for sampling for trace contaminants should be constructed of stainless steel where possible. Pans used for mixing shall be made of Pyrex®, or equivalent, glass. In no case will chromium, cadmium, or galvanized plated or coated equipment be used for soil sampling operations. Similarly, no painted or plastic equipment shall be used. All paint and primer must be removed from soil sampling equipment by sandblasting or other means before such equipment can be used for collecting soil samples.

4.11.5.5 Specific Sampling Equipment Quality Assurance Techniques - Drilling rigs and other major equipment used to collect soil samples shall be identified so that this equipment can be traced through field records. A log book shall be established for this equipment so that all cleaning, maintenance and repair procedures can be traced to the person performing these procedures and to the specific repairs made. Sampling spoons, hand augers, Shelby tubes, and other minor disposable type equipment are exempted from this equipment identification requirement.

- All equipment used to collect soil samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of field studies.
- Any cleaning conducted in the field (Appendix B) or field repairs should be thoroughly documented in field records.

4.11.5.6 Auxiliary Data Collection - In addition to information pertaining to an area or specific site/location that may be available in EPA files from previous investigations (i.e., site screenings, water quality, well monitoring studies, etc.), information and data may be obtained from various city, county, state, and other federal agencies.

Samples should be accurately tagged and labeled with all pertinent site information at the time of sampling. See Section 3 for sample labeling and field recording procedures. The latitude and longitude shall be obtained for each site for future STORET data entry.

4.12 WASTE SAMPLING

4.12.1 General

Waste sampling as discussed in this section includes the collection of sludge samples from municipal and industrial wastewater treatment facilities; samples of liquid waste and sludge from pits, ponds, and lagoons; waste samples from open or closed containers such as drums, tank trucks, and storage tanks: and samples of waste piles and landfills.

Generally, the collection of sludge samples from municipal and industrial wastewater treatment plants is a low risk operation. However, the collection of liquid waste and sludge samples from open containers and liquid waste from pits, ponds, or lagoons and solid waste from waste piles may involve sampling operations that are inherently dangerous to the personnel involved. Sampling of closed containers (drums, storage tanks, etc.) shall be considered a high hazard operation by all Branch personnel. The procedures outlined in the Region IV Field Health and Safety Manual (23) will be strictly observed during all potentially hazardous sampling operations. Additional safety guidance is included in the draft EPA Safety Manual for Hazardous Waste Site Investigations (23). Branch specific safety protocols for these types of operations are included in Appendix K.

4.12.1.1 Specific Quality Control Procedures for Sampling Equipment

Sampling equipment contaminated during waste sampling must be cleaned as specified in Appendix B, Section B.1.5 before being returned from the field.

Contaminated disposable equipment and sampling equipment that is to be discarded must be properly disposed of as specified in the site-specific field sampling plan (Section 4.5).

All equipment used to collect waste samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of a field study. In some instances, special decontamination procedures in excess of the cleaning procedures outlined in Appendix B will be necessary. These procedures will be developed on a case-by-case basis according to the specific material encountered (26).

All air monitoring and field analytical equipment shall be tested before being issued for field studies, as specified in Section 6.0, and Appendix G.

Any cleaning procedures conducted in the field deviating from those specified in Appendix. B, and all field repairs, shall be thoroughly documented in the field logbooks.

4.12.1.2 Collection of Auxiliary Information and Data -- The collection of auxiliary information and data is particularly important when collecting waste samples. Any field analyses, including those conducted with safety equipment such as photoionizers, explosion meters or approximate analyses such as those obtained with Ph indicator paper shall be recorded in field logbooks, as outlined in Section 3.5. Sketches of sampling locations, valving arrangements of tank

trucks and storage tanks, markings on drums, tanks, etc., should be thoroughly documented in the logbooks. Photographs are particularly useful for recording this information and they should be used extensively during waste sampling operations. A field log of the photographs taken should be maintained as outlined in Section 3.2.3.

4.12.2 Collection of Municipal Wastewater, Industrial Wastewater, and Municipal Water Treatment Plant Sludge Samples

4.12.2.1 Sampling Equipment -- Branch equipment available for the collection of sludge samples includes: sample containers; stainless steel spoons and shovels; stainless steel ponar dredges; stainless steel scoops attached to a conduit pipe; stainless steel push tubes; and Peterson and Eckman dredges.

4.12.2.2 Sampling Technique -- If the sampling technique involves multiple aliquots or if the final sample will consist of aliquots from several locations, all aliquots should be placed into a Pyrex® dish, or another suitable container, and mixed thoroughly before containerization, as specified in Section 4.2.10. The sample is containerized as specified in Appendix A.

If the sludge layer is shallow or if only the surface is to be sampled, samples can be collected directly into the sample container.

If depth samples are required, the methods described in Section 4.12.3.4.2 may be used.

Regardless of the method used, special care must be taken when collecting sludge sample to minimize the loss of fine materials by the excess water flowing out of the sampling device, thus biasing the sample.

4.12.2.3 Sampling Locations -- Sampling locations must be carefully selected to insure that the samples are truly representative of the material being sampled. The following are suggested locations for different sampling conditions.

4.12.2.3.1 Municipal Sludge Being Drawn to a Drying Bed -- Collect samples from the pipe flowing to the bed or at the discharge into the bed. Take three or more sample aliquots during the draw period to insure that variations in the sludge concentrations and consistency are accounted for.

4.12.2.3.2 Sludge From an Anaerobic Digester -- It is difficult to insure that the contents of these units are well mixed. Samples can be taken from sample ports in the recirculation lines if so equipped. Otherwise, samples can be taken from "thief holes" in the floating top of the digester.

4.12.2.3.3 Sludge From an Aerobic Digester -- It is much easier to sample these units because of the clear view of the contents. Samples should be taken while the contents are being mixed and from between 1/3 and 2/3 of the total depth of the digester.

4.12.2.3.4 Sludge From a Quiescent Holding Basin (Water or Wastewater) -
One sample cannot be collected which will be representative of the total contents

of the basin since the material is generally stratified. Near bottom samples can be collected from the upper, relatively clear liquid layer as one would collect any water sample. Generally, a minimum of 3 to 5 grab sludge samples should be collected from the basin. These grab samples should be as representative of the sludge contents as possible. Samples should be collected near the inlet and discharge structures as well as from the open pond area. Samples may be analyzed individually or composited into a single sample. Sludge samples should be collected from the basin from a boat or a platform. Sediment sampling devices are required to collect these samples.

4.12.2.3.5 Sludge From Drying Beds -- After sludge is partially dried and cracked, samples can be collected with a stainless steel spoon, shovel, or similar device. Samples should be collected from three or four locations in the bed and composited to insure a representative sample. The sample should be collected to the full depth of sludge on the bed.

4.12.2.4 Special Precautions for Trace Contaminant Sampling -- See Section 4.7.6.1.

4.12.2.5 Sludge Samples Collected for Purgeable Organic Compounds Analyses See Section 4.7.6.4.

4.12.3 Pits, Ponds, and Lagoons

4.12.3.1 General -- For the purposes of this subsection, pits, ponds, and lagoons refer to any basin, pit, or open tank (lined or unlined) which contains or is suspected of containing unknown concentrated liquid, solid, or sludge chemical wastes. This discussion does not include municipal and industrial treatment ponds or natural or man-made surface water impoundments (discussed in Section 4.8.2).

4.12.3.2 Sampling Locations -- Sampling locations within pits, ponds, and lagoons should yield samples which are representative of that section, or of the entire pit, pond, or lagoon being sampled. All phases (floating solids, all liquid phases, and sludge) in the pit, pond, or lagoon should be sampled. The only exception is situations where representative samples cannot be safely collected or where the investigative team is attempting to determine worst case conditions.

Because of the inherent danger with sampling known or unknown concentrated waste, sampling personnel should never attempt to sample pits, ponds, or lagoons from a boat. All sampling should be accomplished from the banks of pits, ponds, or lagoons or from piers. Any exception must be approved by the appropriate Branch and/or Section Chief.

4.12.3.3 Sampling Equipment -- The following Branch equipment is available for field use in collecting liquid waste samples from pits, ponds, and lagoons: sampling containers; sampling containers affixed to a piece of conduit pipe, stainless steel scoop affixed to a piece of conduit pipe with a scoop bracket, stainless steel spoon affixed to a conduit pipe, peristaltic pump and vacuum jug arrangement, and Bacon-Bomb samplers. For sludge sampling of pits, ponds, and

lagoons; stainless steel ponar dredges, stainless steel scoops attached to conduit pipe, and stainless steel push tubes are available.

4.12.3.4 Sampling Techniques

4.12.3.4.1 Liquid Waste Sampling -- If the sampling technique utilized requires multiple aliquots, or if the final sample will consist of aliquots from several different locations in the pit, pond, or lagoon, all aliquots should be placed into a Pyrex® dish or a large glass sample container, or other suitable compositing container, and mixed thoroughly before containerization (Section 4.2.10).

The presence of individual liquid phases can be determined by using a peristaltic pump. The Teflon® tubing attached to the pump is strapped to a piece of conduit pipe and slowly lowered to the bottom of the unit to be sampled. The pump discharge (and the intake tubing) is examined to determine if phases are present. If phases are present, the top liquid phase can be sampled by direct dipping with the sample container, or dipping with the sample container attached to the conduit pipe - either directly or by way of a fishing pole type arrangement, or dipping the sample with a stainless steel scoop attached directly to conduit pipe with a scoop bracket. Alternatively, all liquid phases can be sampled with a peristaltic pump/vacuum jug arrangement with the Teflon® tubing attached to a conduit pipe and held at the desired depth or with the Bacon-Bomb sampler opened at the desired depth. The Bacon-Bomb sampler can be operated directly from the banks of pits, ponds, and lagoons; from piers; or operated by way of a fishing pole type arrangement using a piece of conduit pipe.

Floating solids can be sampled directly or with a stainless steel scoop or spoon attached to a piece of conduit pipe.

4.12.3.4.2 Sludge Sampling -- If the sampling technique involves multiple aliquots, or if the final sample will consist of aliquots from several different locations in the pit, pond, or lagoon, all aliquots should be placed into a Pyrex® dish or other suitable container and mixed thoroughly before containerization, as specified in Section 4.2.10. The sample is containerized as specified in Appendix A.

Sludge samples may be collected by pushing a stainless steel push tube into the sludge and emptying the tube contents into a Pyrex® dish or other suitable container. "Emptying" may include shaking to remove sludge or extrusion of thick or gummy sludges with a new wooden dowel. A disadvantage of this technique is the need for multiple insertions of the tube into the sludge to collect sufficient sample volume.

Sludge samples can also be collected with a stainless steel ponar dredge. An advantage of this technique is that one operation of the dredge usually yields sufficient sample volume for most sampling efforts.

One of the easiest methods of collecting a sludge sample consists of attaching a stainless steel scoop to a piece of conduit pipe with a scoop bracket, and inserting the scoop into the sludge. The scoop bracket has a

decided advantage in that it allows sampling personnel to adjust the angle between the scoop and the conduit pipe.

4.12.4 Open and Closed Container Sampling

4.12.4.1 General -- Sampling of closed containers (drums, storage tanks, etc.) should be conducted only when absolutely necessary. Whenever container sampling is necessary, the first priority should be the collection of samples from open containers since they generally present less hazard to the sampling personnel than closed containers (i.e., volatile organic components have already evaporated, extreme acute toxicity would probably be evident from dead animals or vegetation around the site, etc.). Closed containers must be considered as extremely hazardous from either the toxicity, explosion, or fire potential. Acute toxicity may pose a danger in both open or closed containers. Because of the dangers involved with container sampling, the sampling of drums or other containers containing either unknown materials or known hazardous materials shall be considered a hazardous duty assignment. Additional information regarding container sampling is available in the draft EPA Safety Manual for Hazardous Waste Site Inspections (24).

Safety procedures for container sampling will be in accordance with the Region IV Field Health and Safety Manual (23) and Appendix N.

A problem which often arises in container sampling is stratification and/or phase separation of the container contents. When this condition occurs, or is suspected, care must be taken to insure that the sample collected is representative of the container contents. If only one layer or phase is sampled, this should be noted and taken into account when interpreting analytical results. For example, if a large tank is being sampled for PCB's and the only valve or access port available for sampling is at the bottom of the tank, it should be noted that the concentration of PCB's might be biased on the high side, since PCB's are heavy and tend to settle near the bottom of containers.

If stratification is not present, samples may be composited by depth (i.e., collected throughout the entire depth of the container or at several different depths) to provide a representative sample. When a drum or cylindrical container is standing vertically, depth compositing provides a good quantitative estimate of the containers contents. In other cases where such containers are tipped, horizontal, deformed, etc., and stratification is not present, vertical compositing will provide a representative sample at least on a qualitative basis. (Note: a quantitatively representative sample could be collected, but would require sophisticated sampling methodology involving multilayer sampling and volume measurements; this is not recommended unless initial screening indicates it is absolutely necessary). Samples may not be composited across containers.

4.12.4.2 Sampling Equipment -- The following Branch equipment is available for use in collecting waste samples from open and closed containers: a complete set of spark-resistant (beryllium-brass) tools including barrel bung wrenches, adjustable wrenches, etc.; a remote barrel opening device; coliwasa samplers for drum sampling; glass tubes for drum sampling; glass profile tubes for container sampling; Bacon-Bomb samplers for container sampling; and peristaltic pumps and vacuum bottle arrangements for liquid waste sampling from containers.

4.12.4.3 Sampling Techniques -- Closed drums, or other containers (including storage tanks) containing unknown materials or known hazardous materials shall be opened using only spark proof opening devices and while the container is grounded. A remotely controlled device may be used when deemed necessary. Such a device involves the use of a remotely operated pneumatic wrench along with a brass pressure fitted bung socket (25).

The most commonly used Branch sampling device for 55-gallon drums is the coliwasa sampler. The coliwasa sampler is a single use glass sampler, consisting of an outer glass tube with one end tapered, and a separate inner glass tube with a small bulb on one end. In use, the outer tube is slowly lowered into the drum, tapered end first. This must be done slowly for two reasons. One, the drum may contain solid material which might break the tube and injure the sampler. Second, slowly lowering the tube allows the liquid phases in the drum to stay in equilibrium with the coliwasa sampler, ensuring a representative sample. The inner glass tube is inserted (bulb end first) into the outer tube. This may be done very slowly after the outer tube is fully inserted into the drum, or the inner tube may be inserted prior to immersing the outer tube. In the latter case, the bulb tip of the outer tube must be pulled back several inches from the tapered end of the outer tube. After both inner and outer tubes are inserted into the drum to be sampled, the inner tube bulb end is pressed gently against the tapered end of the outer tube, forming a seal. Both tubes are withdrawn from the drum and the ends of the tubes are held over the sample container. By manipulating the inner tube, the sampler can control the rate of flow of the sampled liquid into the sample container.

Samples from drums can also be collected using a four-foot length of glass tube. In most instances, glass tubes with a 1/2-inch or less inside diameter work best. The tube is inserted into the opening of the drum or barrel as far as possible. The open end is then sealed either with the thumb or a rubber stopper to hold the sample in the tube while removing the tube from the container. The sample is then placed in the appropriate container, and the procedure is repeated until an adequate amount of sample is collected. Sample volume shall be held to the absolute minimum required for analysis.

An optional method involves the use of a piercer valve which is inserted into the drum or barrel by use of a remotely operated hydraulic jack (24); however, this method should be used only as a last resort (24). The sample is collected directly from the valve. Several valves may be required at different depths on the drum or barrel if stratification has occurred.

Other sampling procedures including the use of automatic samplers, pumps, siphons, multiple valves and ports, etc., may be used depending on the specific container involved. These procedures should not be used unless it can be established that their use will not constitute a fire or explosion hazard. This determination shall be made only after field reconnaissance, collection of appropriate field data (explosion meter, photoionizer, etc.), and consideration of available file information on the site.

Tank trucks and storage tanks containing liquid wastes present a unique problem. Samples may be collected from access ports on top of these tanks or trucks using the techniques outlined above. Tank trucks are often compartment-

alized, and the investigator should insure that all compartments of the tank truck are sampled. Sampling from discharge valves usually found on tank trucks is not recommended due to potential stratification of the tank contents and the possibility of sticking or broken valves causing a release. However, if the investigator must sample from a tank truck discharge valve, the valving arrangement of the particular tank truck being sampled must be clearly understood to insure that the contents of the compartments of interest are sampled. The same precautions apply to sampling from storage tank valves. In either case, the investigator must realize that samples obtained from valves (particularly those at or near the bottom of tank trucks and storage tanks) may not yield representative samples. Sampling personnel should not utilize valves on tank trucks or bulk storage devices unless they are operated by the owner or operator of the facility, or a containment plan is in place should the valve stick or break.

4.12.5 Waste Piles and Landfills

4.12.5.1 General -- Waste piles consist of sludges and other solid waste, liquid waste mixed with soil, slag, or any type of waste mixed with construction debris, household garbage, etc. Each situation presents a unique challenge to the sampler in the selection of an appropriate sampling location and technique. Sampling at landfills is generally considered a routine operation. However, the sampling personnel must be aware that, in the past, landfills were not selective in the types of waste materials accepted. Therefore, sampling at landfills known or suspected to contain hazardous wastes could involve sampling operations that are inherently dangerous to the personnel involved.

4.12.5.2 Sampling Locations -- Sampling locations should be selected which will yield a sample which is representative of the waste pile or landfill being investigated. The only exception is situations in which representative samples cannot be collected safely or where the investigative team is attempting to determine worst case conditions.

4.12.5.2.1 Waste Piles -- A representative sample from a small waste pile can often be obtained by collecting a single sample. The collection of representative sample from large waste piles presents problems with both the number and locations of samples. For a sample to be truly representative, a statistical approach should be used in selecting both the numbers of samples and the location where they are to be collected. A discussion of statistical methods which can be utilized is given in the Test Methods for Evaluating Solid Waste (SW-846) issued by the EPA Office of Solid Waste and Emergency Response (28).

4.12.5.2.2 Landfills -- Representative samples from landfills are often difficult to obtain because of the heterogenous nature of the wastes deposited. Geophysical instruments may occasionally be useful in locating buried drums and tanks, but the signal is often lost in the background noise of waste ferrous materials. As with samples from waste piles, for a sample to be truly representative, a statistical approach should be used in selecting both the number of samples and the location where they are to be collected. A discussion of statistical methods which can be utilized is given in the Test Methods for Evaluating Solid Waste (SW-846) issued by the EPA Office of Solid Waste and Emergency Response (28). The sampler should be aware that landfills often generate leachate at one or more locations downgradient of the fill material.

Leachate samples can provide a limited overview of materials deposited in a landfill which are migrating via groundwater.

4.12.5.3 Sampling Equipment -- The following Branch equipment is available for field use in collecting samples from waste piles and landfills: stainless steel hand augers, stainless steel push tubes, stainless steel shovels, stainless steel scoops, stainless steel slag hammer/slag pan, drill rig, and stainless steel spoons.

4.12.5.4 Sampling Techniques -- All samples collected should be placed into a Pyrex® dish and mixed thoroughly before containerization, as specified in Section 4.2.10. Samples for volatile organic compounds analyses may not be composited and must not be mixed. Stainless steel shovels, spoons, or scoops should be used to clear away surface materials before samples are collected. Near surface samples can then be collected with a clean stainless steel spoon. Depth samples can be collected from the cleared location by forcing a stainless steel push tube into the waste pile or by augering to the desired depth in the landfill or waste pile with a stainless steel hand auger. When the desired depth is reached with a hand auger, a clean auger head should be used for collecting the sample. An alternate method for collecting depth samples is to dig to the desired depth with a stainless steel shovel or scoop and collecting the sample with a stainless steel spoon.

Sometimes the waste material is too hard to mix in a Pyrex® dish or the sample material retrieved is too large to contain in the sample container (for example slag wastes). This refractory material may be sampled by crushing representative portions of the waste material with the stainless steel slag pan and hammer. Once crushed, the material may be thoroughly mixed and containerized for analysis. Mixing is done as specified in Section 4.2.10 and the sample is containerized as specified in Appendix A. Any remaining waste materials must be properly disposed of, in accordance with the waste handling procedures for that process.

4.12.6 Contaminated Surfaces Sampling

4.12.6.1 General -- Sampling may be required to determine whether or not various surfaces are contaminated, or to evaluate the effectiveness of decontamination procedures. The procedures outlined below are intended for non-absorbent surfaces e.g., metal, concrete, glass, plastic, etc. These types of surfaces may be sampled using wipes or swabs that are purchased commercially. The wipe or swab material must be compatible with the solvent used and the analyses to be performed, and should not come apart in use. The wipes are saturated with either methylene chloride, hexane, or deionized water depending upon the parameters to be analyzed. Sampling personnel should be aware of this and take the proper precautions against skin contact and inhalation of these solvents as outlined in Appendix N. For routine scheduled wipe sampling, ASB requests two weeks notice to prepare the wipes. ASB must be notified as to what analyses are required. ECB should provide sufficient precleaned 8-oz sampling jars to ASB for storage of the prepared wipes. Wipe samples should not be collected for volatile organic compounds analysis.

4.12.6.2 Sampling Locations -- Surfaces contaminated by hazardous wastes may include walls, ceilings, floors, exposed beams, inner walls of tanks, equipment, furniture, etc. Sampling locations will often be dictated by the surface to be sampled. If possible, however, the surface sampled should be horizontal and facing up. Surfaces in this position are generally the most likely to become contaminated by spills, splashing, settling dust, etc.

4.12.6.3 Sampling Equipment -- Branch sampling equipment consists of specially prepared wipes in sample jars. A sufficient number of wipes for each sample are kept in separate containers. These containers are precleaned 8-oz sample jars.

4.12.6.4 Sampling Techniques -- The sample jar containing the prepared wipes is opened and a prepared wipe is removed. Wipes may be handled either with stainless steel tongs, tweezers, or gloves. Gloves may be used only if the contaminants of interest are not present in the glove. The entire area to be sampled is wiped with firm strokes using only one side of the wipe. The wipe is then returned to the sample jar from which it was taken. This process is repeated until the area is visibly free of contamination or no more wipes are left in the jar. Care should be taken to keep the sample jar tightly sealed to prevent evaporation of the solvent. Samplers must also take care to not touch the used side of the wipe, to prevent loss of the contaminants. Unused wipes should not be removed. All wipes in the jar will analyzed by the laboratory.

If surface contamination is to be quantified (e.g., ug/cm^2) the surface area that is to be wiped must be measured. This can often be accomplished using a template made of decontaminated aluminum foil with an opening of the desired size, generally 10 cm by 10 cm.

4.12.7 Contaminated Documents Sampling

4.12.7.1 General -- Contaminated documents that require sampling are usually business records that are suspected to be contaminated with hazardous materials. If business records are to be sampled (files, file folders, correspondence, receipts, etc.), care must be taken that no evidentiary materials are destroyed in the sampling process.

4.12.7.2 Sampling Locations -- Blank letterhead, unused receipts, unlabeled file folders, etc., should receive first consideration. If these are not present in sufficient quantity, it may be necessary to collect the sample by removing material from the unused portions of the documents.

4.12.7.3 Sampling Equipment -- A Pyrex® pan and a pair of scissors decontaminated as specified in Appendix B. The handles of the scissors should not be painted or constructed of plastic.

4.12.7.4 Sampling Techniques -- The material selected for sampling should be as representative as possible. Once the sample material has been removed, it must be reduced in size and mixed prior to containerization. This can be accomplished by cutting the paper into small pieces with a pair of scissors and mixing the pieces in a glass pan. The shredded material is then placed into a precleaned 8-oz glass jar.

duration of the non-refrigerated period shall be kept to a minimum but absolutely not more than two days.

4.13.1.4 Analytical Support Branch -- Upon arrival of the metal container at the Athens laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

4.13.2 Volatile Organic Compounds (VOC) Sampling With SUMMA® Electropolished Stainless Steel Canisters Using Method TO-14

4.13.2.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the cleanup and use of Summa® canisters in sampling air for Volatile Organic Compounds (VOC). This summary is adapted from Method TO-14 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following procedures must be followed in the preparation and use of Summa® canisters for sampling VOC.

- All new Summa® canisters must be individually checked for contamination by the ESD laboratory before use. One of each batch of 10 Summa® canisters that are subsequently cleaned must be analyzed to check for contamination.
- All sampler tubing, fittings, and wetted parts of valves must be solvent washed in hexane and heated to >100° C. These parts should then be assembled and flushed with nitrogen for at least 8 hours prior to use in the sample train or in the canister cleanup apparatus.
- Each canister's valve and fitting will be inspected for damage before cleaning. Any damaged valve will be replaced with a previously cleaned (see procedure above) valve. After replacing any valve, the canister will be cleaned and analyzed to verify that it is free of contamination.
- If any canister is used to sample a high concentration source, it must be cleaned and analyzed to verify it is free of contamination before it can be used again.
- Chain-of-custody must be maintained for all samples.

4.13.2.2 SUMMA® Canister Cleanup -- The following cleanup procedure will be followed for the preparation of all Summa® canisters:

- The canisters should initially be pressurized to >2 atm with humidified nitrogen[1] then evacuated to 1 atm. This filling and evacuation sequence shall be repeated five times to dilute any residual contaminants. The addition of the water from the humidified nitrogen may also displace some of the more reactive contaminants that could adhere to active sites on the wall of the canister. After the fifth evacuation to 1 atm, the vacuum pump will

be valved on and left on for a minimum of 3 hours or until a vacuum of <150 millitorr is reached. The identification number of the canister, the date and the final vacuum will be recorded in the canister cleanup logbook. After cleaning, the canister's valve should be capped with a Swagelok® plug. A label will then be affixed to the canister denoting the date it was cleaned and the name of the person who performed the cleaning.

1. (The nitrogen should be certified 99.999% pure by the manufacturer. A molecular sieve scrubber should be attached to the nitrogen line after the regulator to remove any trace impurities).

4.13.2.3 Sample Collection -- Two types of VOC samples can be collected with Summa® canisters. The canister can be opened and allowed to fill rapidly to obtain a grab sample or filled slowly by using a flow controller to collect a time integrated sample. With either type of sample, the following general procedures should be followed:

- An EPA, pre-numbered sample tag should be tied to the handle of the Summa® canister prior to sampling.
- A Chain-Of-Custody Record should be completed detailing time of sampling, sampling interval, and signed by the person taking the sample.
- After the sample has been collected, the Summa® canister should be capped, the pre-numbered EPA tag should be completed, and the canister should be placed in a shipping container with a copy of the Chain-Of-Custody Record and sealed with EPA sample custody tape.

4.13.2.4 Grab Sample Collection -- Before a grab sample for VOC analysis is collected in a Summa® canister, the canister inlet valve should be fitted with a pre-cleaned (Section 4.13.2.2) stainless steel particulate filter. At the sample collection location, the main valve should be opened and the canister allowed to fill. After about one minute (when no audible sound of rushing gas can be heard), close and cap the main valve of the Summa® canister.

4.13.2.5 Time Integrated Sample Collection -- This sample collection method involves the use of a flow controller or a sampler containing a flow controller to slowly meter the flow of air entering a Summa® canister. With this method, a sample is collected over a longer period of time than with a grab sample. If a constant flowrate was maintained, the resulting sample will have a VOC content that is the average of the VOC concentrations for the sampling interval (a time integrated sample).

The following procedures should be followed to collect time integrated samples:

- All sampler systems should be checked for contamination prior to use or after any major repair. This is accomplished by metering zero air or nitrogen[1] to the inlet of the sampler. Excess zero air or nitrogen flow should be vented with a Swagelok® tee from the sampler

4.13 AIR TOXICS MONITORING

4.13.1 Formaldehyde Sampling Using Dinitrophenylhydrazine Cartridges Using Method TO-11

4.13.1.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the handling and field use of dinitrophenylhydrazine (DNPH) cartridges for formaldehyde sampling. This is from METHOD TO-11 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following generic procedures should be adhered to at all times.

- Polyethylene or Nylon gloves must be worn whenever handling any of the DNPH cartridges (in the extraction laboratory, during preparation for shipment, during field set-up, in field during preparation for return shipment, and in the laboratory during preparation for analysis and during analysis).
- Coated DNPH cartridge which have been prepared for longer than 90 days shall not be used.
- All padding material shall be either clean tissue paper or polyethylene-air bubble padding. Never use polyurethane foam, cardboard, or newspaper as padding material. DNPH cartridges which have been properly prepared for shipment may be shipped in cardboard containers or preferably in coolers with eutectic salt (Blue Ice) packs.
- Chain-of-custody shall be maintained for all samples.
- A minimum of one trip blank shall be transported per one to ten samples collected.

4.13.1.2 Extraction Laboratory -- Upon completion of preparation of the DNPH cartridges, both ends shall be plugged with polypropylene Luer® male plugs and each DNPH cartridge placed in a borosilicate glass culture tube with polypropylene screw caps (tightened). A serial number, expiration date and a lot number label will be placed on each glass culture tube. The batches of culture tubes shall be placed in sealed friction-top metal containers which contain 1-2 inches of granular activated charcoal (or a pouch filled with a similar amount of charcoal) for storage in the refrigerator in the Air Laboratory. The culture tubes should be enclosed in two Zip-Lock® bags to prevent contamination from charcoal dust.

4.13.1.3 Air Compliance Unit -- The Air Compliance Unit will notify and keep the Extraction Unit informed as to the anticipated number of prepared DNPH cartridges needed for field use. On routine studies, the Air Compliance Unit will notify the Extraction Unit of needs at least two weeks in advance of needed pick-up date. Only the number of DNPH cartridges needed for a maximum of 60 days (including trip blanks and extra DNPH cartridges for breakage) will be requested.

- On the date of shipment or when loading out for a study, the Air Compliance Unit will remove the sealed cans (which contain the DNPH cartridges sealed in glass culture tubes) from the refrigerator in the Air Laboratory. If only a small number of tubes are needed for a particular study, the correct number of tubes will be transferred to another, smaller, solvent-washed shipping can.

- An appropriate amount of packing material shall be placed in the metal container to prevent breakage of the glass culture tubes. A label shall be affixed onto each metal container listing the number of DNPH cartridges in the container. The metal containers should be shipped in coolers containing eutectic salt packs (such as Blue Ice) to maintain a temperature of approximately 4°C. The DNPH cartridges shall be shipped the same day they are packed.

- On each sampling date, the metal container(s) will be removed from the refrigerator or cooler for transport to the field. At each sampling location the metal container will be opened and one glass culture tube will be removed (wearing clean polyethylene or nylon gloves) and allowed to warm to ambient temperature (before removing the DNPH cartridge from the glass culture tube). The plugged DNPH cartridge will be removed from the culture tube and the two Luer® end plugs will be removed from each end of the DNPH cartridge which will be immediately placed on the sampling train. The Luer® end plugs will be placed back into the glass culture tube and the cap placed on the tube and tightened. The culture tube will be left in the sampler enclosure at the site. The same procedure will be adhered to at each sampling location. A trip blank (in a sealed culture tube) will be placed in a sampler enclosure at one on the sites for the duration of a sampling event.

The sampler will be manually turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

- The operator should collect the sample as soon as possible after the sampling period ends. The sampler should manually be turned on and allowed to run for two minutes and a final flowrate and elapsed time from the elapsed time meter should be recorded on the sample data sheet. The exposed DNPH cartridge will then be removed from the sampling train (wearing clean polyethylene or nylon gloves). The two Luer® end caps will be removed from the glass culture tube and placed on the ends of the DNPH cartridge. The DNPH cartridge will be placed back into the glass culture tube, the lid tightened and placed back into the metal container. The same procedure is to be followed at each sampling site.

- At the end of the day on which the samples are collected, the sealed metal can (which contains the exposed DNPH cartridges) shall be either placed in a refrigerator for storage overnight or placed in a cooler. The cooler will be used to transport the samples to the EPA, Region IV, Analytical Support Branch in Athens, GA. The

inlet to atmosphere. The evacuated canister should then be filled at the normal sampling rate with the zero gas.

- Initial flowrates will be determined with a mass flow meter. The initial flowrate and initial vacuum (at least 29 inches of Hg) should be recorded on the sample data sheet. Adjust the flowrate so that at the end of the sampling interval the ending pressure of the canister is approximately 0.9 atm.

- Final flowrates should also be determined with a mass flow meter. Final flowrate and final vacuum should be recorded on the sample data sheets. The final vacuum should be between 5 inches and 1 inch of Hg. The final flowrate should be at least 1 scc/min.

After sample collection, all canisters should be double checked to verify that each has an EPA pre-numbered tag with all information filled out. Place the canister in a shipping container and seal the container with EPA sample custody tape.

4.13.3 Semi-Volatile Organic Compounds (SVOC) Sampling With High Volume PUF Samplers Using Methods TO-4 & TO-13

4.13.3.1 General -- The following is a synopsis of procedures which should be strictly adhered to for use of the High Volume Polyurethane Foam (PUF) sampling method for sampling semi-volatile organic compounds (SVOC) including pesticides and polychlorinated biphenyls. This summary is adapted from Method TO-4 (pesticides and PCBs) and TO-13 (polynuclear aromatic compounds) of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following procedures must be followed in preparation of PUF sampling media and using the High Volume PUF method for sampling for SVOCs:

- All PUF sampling media should be pre-cleaned, loaded into High Volume PUF sample cartridges and sealed in solvent washed cans by the extraction lab prior to use.

- Chain-of-custody shall be maintained for all samples.

4.13.3.2 PUF Cleaning -- The Air Compliance Unit has responsibility for buying the PUF media and cutting the PUF plugs. PUF media should be specified as not containing any fire retardants. It should be stored in the dark to prevent photo-oxidation. It should be less than two years old, and should be stored in a pesticide free environment.

Care should be exercised in cutting the PUF. It should be thoroughly wet with tap water prior to cutting. A drill press and stainless steel PUF cutting die should be used. The drill press area should be free of oil and a polyethylene cutting block should be used to stop the die at the bottom of the drill press stroke (do not use wood). Water should be sprayed on the die as the PUF is cut to help prevent snagging. After the plugs are cut, they should be

rinsed with tap water and followed by a rinse with deionized water. Finally, the excess water should be squeezed out.

The rinsed PUF plugs should be placed in a polyethylene plastic bag and delivered to the Analytical Support Branch extraction laboratory for preparation of the PUF/XAD-2 cartridges. The extraction laboratory will be given a minimum of three weeks notice for cleaning and checking the PUF/XAD-2 cartridges. The cleaned PUF/XAD-2 cartridges should be wrapped in aluminum foil and packed in metal cans cushioned by cleaned polyurethane foam to prevent breakage during shipment. Prepared PUF/XAD-2 sample cartridges that are pre-packed in solvent washed metal cans will be obtained from the extraction laboratory prior to sampling. The cans should be packed inside coolers which are lined with polyurethane foam for shipment.

4.13.3.3 Sample Collection -- The following procedures will be followed for all High Volume PUF sampling.

Nylon gloves will be used when handling all PUF cartridges and quartz particulate pre-filters. Assure that the red silicon upper and lower gaskets, located in the cartridge housing, are in place. Then remove the PUF cartridge from the shipping can, remove from the foil and insert the cartridge into the High Volume PUF Sampler's chamber. The pre-filter should be installed in the filter holder using caution not to over tighten the fittings. The foil should be sealed back in the shipping can. The can should be labeled with site ID, operators name, and sample date, and placed in the High Volume PUF sampler enclosure until the sample is collected.

The High Volume PUF sampler should be turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

The operator should collect the sample as soon as possible after the sampling period ends. The sampler should be manually turned on and allowed to run for two minutes. A final flowrate should be recorded on the sample data sheet. The final flowrate should be at least 150 liters per minute. The PUF cartridge should be removed, and the quartz pre-filter folded and placed in the top of the PUF cartridge. The PUF cartridge and pre-filter should be re-wrapped in the original aluminum foil and placed back in the shipping can. The can should be tightly sealed. Complete the sample data sheet and Chain-Of-Custody Record and seal the shipping can with a sample custody seal. Finally, the shipping can containing the sample should be placed in a cooler containing frozen eutectic salt packs (at a nominal temperature of - 4° C). When all samples are collected from all sites, the cooler should be sealed with sample custody tape for transport back to the ASB.

4.13.3.4 Analytical Support Branch -- Upon arrival of the metal container at the Athens ASB laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

4.13.4 Sampling For Metals Using The High Volume Sampler

4.13.4.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the sampling of metals in air. This summary is adapted from 40 CFR, PART 50, APPENDIX B - Reference Method For The Determination Of Suspended Particulate Matter In The Atmosphere (High Volume Method), and 40 CFR, PART 50, APPENDIX G - Reference Method For The Determination Of Lead In Suspended Particulate Matter Collected From Ambient Air.

The following procedures must be followed in preparation for collecting samples for metals analyses with the High Volume sampler.

- All filters used will be supplied by the EPA National Filter Distribution Program, and of the same quality as supplied to the State and Local Agency Air Monitoring Stations.
- Prior to use, all filters will be checked for pinholes, and desiccated at 15°C - 30°C, ± 3°C, and less than 50 percent relative humidity, ± 5 percent, for at least 24 hours.
- A filter field blank will be taken to the field, but not exposed. Filter field blanks will be analyzed by the Analytical Support Branch (ASB) to determine the background concentration of metals. The number of filter blanks will be determined based on the number of samples collected, or one blank for each ten samples collected.
- Chain-of-custody must be maintained for all samples.

4.13.3.4 Sample Collection Procedures -- Samples will be collected using the High Volume sampler as described, and operated in accordance with 40 CFR, PART 50, APPENDIX B:

- All flow calibration orifices will be traceable to a Primary Standard Rootsmeter. Flows will be corrected to EPA Standard Temperature and Pressure (25°C and 760 mm Hg).
- Digital manometers used to determine flow rates will be checked against a U-Tube water manometer prior to use in each study.
- Air Compliance Unit personnel will remove a 2-inch strip of the exposed filter from one end and discard it. Two 1-inch strips will be cut from the same end and transported to the ASB for analysis.

4.13.4.3 Integrated Sample Collection -- The following procedures should be followed to collect time integrated samples:

- Initial and final flow rates will be determined with a calibrated orifice and a digital manometer.
- After the sample has been collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.

- A Chain-Of-Custody Record should be completed which contains the time of sampling, the sampling interval, and the signature of the person taking the sample.

After sample collection, all sample envelopes will be placed in an appropriate container. An EPA chain-of-custody seal will be placed on the container. Filters will be cut by the Analytical Support Branch and transported to the ASB for analysis.

4.13.5 Sampling and Analysis of Mercury In Ambient Air Using Arizona Instrument® Mercury Dosimeter Tubes and the Model 511 Gold Film Mercury Vapor Analyzer

4.13.5.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the sampling and analysis of mercury (Hg) in ambient air. This summary is adapted from the Arizona Instruments® (AZI), Model 511, Gold Film Mercury Vapor Analyzer Manual.

The following generic procedures should be adhered to at all times:

- Chain-of-custody shall be maintained for all samples
- A minimum of one trip blank shall be transported per one to ten samples collected.
- All mercury dosimeter tubes shall be cleaned and analyzed each sample day prior to use.

4.13.5.2 Dosimeter Cleanup -- Each dosimeter tube should be connected to the AZI® model 412 dosimeter controller and AZI® Gold Film Mercury Analyzer as shown in Figure 1 of the AZI® model 511 Mercury Analyzer Operation Manual. The mercury analyzer analysis cycle should be started and immediately afterward the dosimeter controller's START button should be depressed. This will cause the gold plated wire inside the dosimeter tube to heat up and liberate any elemental mercury that forms an amalgam on the gold plated wire inside the dosimeter. Continue this cycle until less than 2 ng of Hg is detected from the dosimeter tube. Remove the clean dosimeter tube from the dosimeter controller, tag it with the cleanup date and operators name, and connect the inlet and outlet dosimeter ports together with a clean 8-inch section of 3/16" ID x 1/16" wall Tygon® tubing (this effectively caps the dosimeter tube).

4.13.5.3 Sample Collection -- Each sampling pump will be calibrated with a mass flow meter before and after each sampling event. Connected the dosimeter to the battery powered sampling pump with Tygon® tubing. Adjust the sampling pump to obtain a flowrate of 50 cc/min. The sampling interval should not extend beyond 8 hours. The following steps should be followed to collect each sample.

- Disconnect one end of the Tygon® tubing from the dosimeter tube and connect it to the battery powered sampling pump.

- Program the pump to run the desired number of hours. Position the dosimeter tube inlet so that there is no obstruction of flow. Record the dosimeter tube number, site ID, sample date, start time, and initial flowrate on the sample data form.

- As soon as possible after the sampling event, disconnect the Tygon® tubing from the sample pump and connect the loose end to the inlet of dosimeter tube. Record the elapsed time from the pump display. Check the ending flowrate with a mass flow meter and record it on the sample data form.

4.13.5.4 Sample Analysis -- Before any mercury analysis of dosimeter tubes, the AZI® model 511 should be calibrated. The AZI® model 511 should only be used under laboratory conditions. All glassware should be scrupulously cleaned and used exclusively for mercury analysis. All tygon tubing that is used should be new. The following calibration procedure is adapted from the AZI® model 511 operation manual:

Calibration

- Calibration of the AZI® model 511 is accomplished by the reaction of a mercuric chloride standard solution with stannous chloride which liberates elemental mercury. The elemental mercury is sparged from an impinger for analysis in the mercury analyzer.

- Before calibration, a film heat cycle should be initiated to clean the mercury analyzer sensor.

- Fresh working 100 ng/ml mercuric chloride standards should be prepared daily from a 1000 ug/ml stock solution. From the 100 ng/ml working standard, calibration standards of 10 ng/ml, 20 ng/ml, and 40 ng/ml should be prepared. Use the procedure outlined in the AZI® operation manual to introduce the stannous chloride solution into the impinger containing the 40 ng/ml standard. IMMEDIATELY depress the SAMPLE START button on the analyzer. Use the calibration potentiometer to adjust the analyzer to read 40. Analyze the 10, 20, and 40 ng/ml standards to verify that the calibration curve is linear. All analyzer readings should be within 2 ng of the actual values of the standards. Record the readings in the logbook.

- Once the mercury analyzer is calibrated, connect an exposed dosimeter tube to the model 412 dosimeter controller. Connect a zero filter to the inlet of the dosimeter tube. Simultaneously press the mercury analyzer SAMPLE START button and the dosimeter controller START button. Record the analyzer reading (in ng) in the logbook. Repeat this sequence three times and sum the values. This value is the total ng of mercury that was captured on the dosimeter tube.

- Divide the sum of the mercury analyzer readings (in ng) by the total volume of air sampled (in liters) to give the concentration of mercury present in ug/M^3.

4.13.6 Dioxin and Dibenzofuran Sampling With High Volume PUF Samplers Using Method TO-9

4.13.6.1 General -- The following is a synopsis of procedures which should be strictly adhered to for use of the High Volume Polyurethane Foam (PUF) sampling method for sampling for polychlorinated dibenzo-p-dioxins and dibenzofurans. This summary is adapted from Method TO-9 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

Since this method requires High-Resolution Mass Spectrometry which ESD does not have, all sample media preparation and analysis will have to be contracted. At least one months notice prior to sampling should be given to the Analytical Support Branch to obtain a contract laboratory program (CLP) contract for any dioxin and dibenzofuran analysis. It is important that the contract specify a number of details to assure accurate results:

- All of the PUF media and a representative number of each batch of quartz pre-filters should be checked by the contract laboratory to assure that there is no contamination. Each PUF plug should be pre-spiked by the contract laboratory with dioxin and dibenzofuran surrogates as a check of the accuracy of the method.

- Each set of PUF plugs and quartz filters should be securely packed in sealed containers and in coolers to prevent damage during shipment. The sampling media should be shipped air freight to minimize the time between cleanup and sampling.

- Chain-of-custody shall be maintained for all samples.

4.13.6.2 Sample Collection -- The following procedure will be followed for all High Volume PUF sampling for dioxins and dibenzofurans.

Nylon gloves will be used when handling all PUF cartridges and quartz particulate pre-filters. Assure that the red silicon upper and lower gaskets are in place in the PUF cartridge housing. Remove the PUF cartridge from the shipping can. Unwrap and insert the PUF cartridge into the High Volume (Hi-Vol) PUF sampler's chamber. Install the pre-filter in the filter holder using caution not to over tighten the fittings. The removed aluminum foil should be sealed in the shipping container. The container should be labeled with the site ID, the operators name, and the sample date, and placed in the Hi-Vol PUF sampler enclosure until the sample is collected. The Hi-Vol PUF sampler should be turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

The operator should collect the sample as soon as possible after the sampling period ends. The sampler should be manually turned on and allowed to run for two minutes and a final flowrate recorded on the sample data sheet. The final flowrate should be at least 150 liters/minute. The PUF cartridge should be removed, and the quartz pre-filter folded and placed in the top of the PUF cartridge. The PUF cartridge and pre-filter should be re-wrapped in the original aluminum foil and placed back in the shipping container and the container should

be tightly sealed. Complete the sample data and sample custody sheets. Each shipping container should have a sample custody seal. Finally, the shipping container containing the sample should be placed in a cooler containing frozen eutectic salt packs (at a nominal temperature of ~ 4° C). When all samples are collected from all sites, the cooler should be sealed with sample custody tape for shipment to the contract laboratory.

4.13.6.3 Contract Laboratory -- Upon arrival of the metal container at the contract laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

4.14 CRITERIA POLLUTANT MONITORING (REFERENCE MONITORS)

4.14.1 Monitoring Ozone In Ambient Air

4.14.1.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the monitoring of ozone in air. This summary is adapted from 40 CFR 50, APPENDIX D - Measurement Principle and Calibration Procedure For The Measurement Of Ozone In The Atmosphere, and the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.7 (EPA-600/4-77-027a).

The following procedures must be followed in monitoring for Ozone in ambient air:

- Calibration systems will meet 40 CFR, Part 50, Appendix D specifications for a Primary Standard Calibration Photometer.
- Calibration systems will be verified against the National Bureau of Standards (NBS) Standard Reference Photometer #10 before use.
- Monitor enclosures will meet the specifications of monitor reference/equivalent designation for temperature control.
- Probes must meet the requirements stated in 40 CFR, Part 58 for materials and sample residence time.
- All flow calibrations will be traceable to a Primary Standard. Flows will be corrected to EPA Standard Temperature and Pressure (25°C and 760 mm Hg).
- Chain-of-custody must be maintained at all times.

4.14.1.2 Monitoring Procedure -- Measurements will be made using the procedure as described, and operated in accordance with 40 CFR, PART 50, APPENDIX D:

- Monitors will be calibrated at the beginning and end of each study, and at least quarterly during the study.
- Monitors will be calibrated after major maintenance or when a quality assurance (QA) check shows an out-of-control condition exists.
- A zero/span check will be conducted daily on all monitors.
- Precision checks of all monitors will be conducted at least weekly.
- Quality assurance audits as specified in 40 CFR, Part 58, Appendix A will be conducted quarterly, or at least once for short duration studies.

controllers. Flow rate look-up tables will be verified using a calibrated orifice on a routine basis, or at least annually.

4.14.2.3 Integrated Sample Collection -- The following procedures should be followed to collect time integrated samples:

- Initial and final flow rate will be determined with a digital manometer based on the manufacturer's flow rate look-up table.
- After the sample is collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.
- A Chain-Of-Custody Record should be completed detailing the time of sampling and the sampling interval, and the signature of the person taking the sample.

After the sample are collected, all sample envelopes will be placed in an appropriate container. An EPA chain-of-custody seal will be placed on the container and the container transported to the Athens, Georgia facility for final weighing of filters.

4.14.3 Sampling Of Particulate Matter In Air As PM_{10}

4.14.3.1 General -- The following is a synopsis of procedures which should be strictly adhered to for the sampling of particulate matter as PM_{10} in air. This summary is adapted from 40 CFR, PART 50, APPENDIX J - Reference Method For The Determination Of Particulate Matter as PM_{10} In The Atmosphere , and the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.11 (EPA-600/4-77-027a).

The following procedures must be followed in sampling for particulate matter as PM_{10}:

- All filters used will be supplied by the EPA National Filter Distribution Program, and of the same quality as supplied to the State and Local Agency Air Monitoring Stations.
- Prior to use, all filters will be checked for pinholes, and desiccated at 15°C - 30°C ± 3°C, and less than 50 percent relative humidity ± 5 percent, for at least 24 hours.
- Initial and final (exposed) filter weights will be determined by the Air Compliance Unit. One of ten filters will be reweighed as a quality assurance check. For batches less than ten, one filter will be reweighed.
- After sampling, filters will be desiccated as described above.
- Chain-of-custody must be maintained for all samples.

4.14.3.2 Sample Collection -- Samples will be collected using the High Volume sampler as described, and operated in accordance with, 40 CFR, PART 50, APPENDIX J:

- All flow calibration orifices will be traceable to a Primary Standard Rootsmeter. Flows will be corrected to EPA Standard Temperature and Pressure (25°C and 760 mm Hg).
- Digital manometers used for flow rate determination will be checked against a U-Tube water manometer prior to use in each study.
- Volumetric flow controllers will be used on all PM_{10} samplers. Flows will be determined using the manufacturer's flow rate look-up table supplied with the controllers (Section No. 4.14.2.2). Flow rate look-up tables will be verified using a calibrated orifice on a routine basis, or at least annually.

4.14.3.3 Integrated Sample Collection -- The following procedures should be followed to collect time integrated samples:

- Initial flow rate will be determined with a digital manometer based on the manufacturer's flow rate look-up table.
- Final flow rate will be determined with the same method.
- After the sample is collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.
- A Chain-Of-Custody Record should be completed detailing the time of sampling and the sampling interval, and the signature of the person taking the sample.

After sample collection all sample envelopes will be placed in an appropriate container. An EPA chain-of-custody seal will be placed on the container and the container transported to the Athens, Georgia facility for final weighing of filters.

4.15 SATURATION MONITORING (NON-REFERENCE MONITORS)

4.15.1 Pm_{10} Saturation Monitoring Using Non-Reference Portable Monitors

4.15.1.1 Introduction -- This document gives procedures for use of the PM_{10} Saturation Monitors constructed by Lane Regional Air Pollution Control Authority located in Springfield, Oregon. These monitors are not referenced by the U.S. EPA.

4.15.1.2 General Description -- Each monitor is shipped with the following items:

Description	Qty
Sampler Body	1
PM_{10} Head	1
Filter Holders	2
Rechargeable Battery Packs	2
Battery Charger	1
Sampler Hanger	1
Storage Boxes	2

Procedures for siting requirements, monitor calibration, filter media inspection and preparation, sampler preparation, and battery pack preparation and changing are discussed in Appendix O of the manufacturers Operations Manual.

4.15.1.3 Calibrations -- Calibrations will be performed before and after each study for each sampler. Recalibration will be performed before field use on units which require major maintenance. Detailed calibration procedures are given in Appendix O of the manufacturers Operation Manual.

4.15.1.4 Sampling Procedure -- This sampling technique does not comply with EPA's ambient air monitoring regulations for PM_{10} sampling. The method has been shown to represent effective and efficient means for the collection of quality PM_{10} data.

Sample Preparation:

- Filters will be kept in protective cassettes. Prior to use, all filters will be visually inspected for defects.
- Each filter will have an ID number assigned to it.
- Each battery will be checked before load-out.

Sample Collection:

- Record information on Data Sheets.
- Install clean filter, and start system to check for leaks.
- Set initial flow to 5 L/min, and stop system.

- Input timer program, and verify.
- Input pulse factor into calculator, and start system.

Sample Retrieval:

- Start system, and record the ending flow rate.
- Note the ending sampling conditions, and record any problems on Data Sheets.
- Remove and replace sample filter following the double bag procedure.

Sample Preservation:

- Extreme care must be taken in removing exposed filters and reloading of filter heads.
- Filters will be returned to the original sample cassettes, and the ID number verified.
- Complete data sheets and store them and the filter samples in a container sealed with custody tape.

4.15.1.5 Sample Custody -- Chain-of-custody will be followed at all times during the sampling study. Chain-of-custody procedures can be found in Section 3.3, of this manual.

4.15.2 Carbon Monoxide Saturation Monitoring

RESERVED

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5.0 FLOW MEASUREMENT

5.1 INTRODUCTION

The measurement of flow with surface water and wastewater sampling is essential to almost all water pollution control activities. Activities such as water quality enforcement studies, NPDES permit compliance monitoring, water quality monitoring, municipal operation and maintenance investigations, planning, and research rely on accurate flow measurement data. The importance of obtaining accurate flow data cannot be overemphasized, particularly with respect to enforcement investigations since these data will be used as evidence in enforcement case preparation. NPDES permits often limit the quantity (mass loading) of a particular pollutant that may be discharged, and the calculation of mass loadings are also frequently necessary for water quality studies and other purposes. As much attention and care should be given to flow measurement in the design of a sampling program as to the collection of samples and their subsequent laboratory analysis.

The basic objectives of this section are to:

- outline standard practices for Branch personnel with respect to wastewater flow measurements during water enforcement and NPDES compliance monitoring activities and other studies where wastewater flow measurements are required;
- outline standard practices for obtaining surface water flow during water quality surveys;
- present acceptable, commonly used flow measurement techniques; and
- present general and specific quality assurance procedures for Branch flow measurement equipment and techniques.

A complete discussion of all available flow measurement techniques and the theory behind them is beyond the scope of this manual. However, most of the common techniques currently in use are covered in general terms. A comprehensive list of references is included at the end of this section and a detailed discussion of flow measurement techniques may be found in the references.

5.2 WASTEWATER FLOW MEASUREMENT

5.2.1 General

The USDI Water Measurement Manual (1) is the standard Branch reference for details on checking the installation of primary open channel flow devices. Basic guidance for making wastewater flow measurements and a basic description of all common wastewater flow measurement systems are given in the EPA Compliance Inspection Manual, May 1988 (2). This manual shall be used as Branch guidance for such measurements.

5.2.2 Site Selection

It is the field investigator's responsibility to insure that the wastewater flow measurement system or technique used measures the total wastewater discharged (described by the NPDES permit, if applicable). All recycled waters must be accounted for so that any reported flows accurately reflect the volume of wastewaters discharged. The actual location of wastewater flow measurement is not important so long as these criteria are met, and the location chosen is suitable for the technique or flow measurement system utilized to actually measure flow.

5.2.3 Flow Measurement Systems

Flow may be measured on an instantaneous or a continuous basis. A typical continuous system consists of a primary flow device, a flow sensor, transmitting equipment, a recorder, and possibly a totalizer. Instantaneous flow measurements can be obtained without using such a system.

The heart of a typical continuous flow measurement system is the primary flow device. This device is constructed to produce predictable hydraulic responses which are related to the flow rate of water or wastewater through it. Examples of such devices include weirs and flumes which relate water depth (head) to flow, Venturi and orifice type meters which relate differential pressure to flow, and magnetic flow meters which relate induced electric voltage to flow. Standard primary flow devices have undergone detailed testing and experimentation, and their accuracy has been verified.

A flow sensor is required to measure the particular hydraulic responses of the primary flow measurement device and transmit them to the recording system. Typically, sensors include floats, pressure transducers, capacitance probes, differential pressure cells, electromagnetic cells, etc.

The sensor signal is generally converted using mechanical, electromechanical, or electronic systems into units of flow which are recorded directly on a chart or transmitted into a data system. Systems which utilize a recorder are generally equipped with a flow totalizer which displays the total flow on a real time basis.

Studies that necessitate continuous flow measurements require a complete system. Instantaneous flow measurements do not necessarily dictate the use of any portion of such a system. Techniques which are described later in this Section are available for measuring instantaneous flows with portable equipment.

An important consideration during wastewater studies is that the investigator may want to obtain continuous flow data at a facility where only instantaneous flow data are being measured. If an open channel primary flow device is utilized for making instantaneous measurements, only the installation of a portable field sensor and recorder is necessary. If, on the other hand, the facility being investigated does not utilize a primary flow device, and a continuous flow record is desired, a portable primary flow device will have to be installed. ESD investigators have both open channel equipment and closed conduit flow meters available for field use. This chapter does not cover in detail the installation of primary flow devices, but many of the references cited treat this area quite adequately.

Wastewater flow measurement systems are generally very accurate. The total error inherent in a flow measuring system is the sum of each component part of the system. However, any system that cannot measure the wastewater flow within ± 10 percent of the actual flow is considered unacceptable for use in measuring wastewater flow.

5.2.4 Use of Existing Flow Measurement Systems

The installation of systems to measure wastewater flows can be a time consuming task, particularly if a primary device is not available. Therefore, Branch field personnel shall always use existing facility primary flow devices and flow measurement systems when the accuracy of these devices and the system can be verified. The objective of this section is to outline the responsibilities of Branch field personnel in verifying the accuracy of existing primary flow devices and systems.

The field investigator must verify that any existing flow measurement system (including primary flow device) utilized to measure wastewater flows conforms with recognized design and installation standards, and any deviation from standard conditions shall be thoroughly documented. The accuracy of the primary flow device should be checked by making an independent "calibration" or flow measurement. If there is no usable or existing primary flow measuring device or if the device has been mislocated, the investigator shall attempt to install a portable primary flow device.

If the discharger's flow measurement system is accurate within ± 10 percent of the actual flow, the investigator can use the installed system. The accuracy of flow sensors and recorders can be easily checked for open channel flow devices by making an instantaneous measurement utilizing the primary flow device and comparing this against the recorder reading. The accuracy of the recorder time trace shall be checked by actually marking times on the flow chart and comparing these to the correct time. It is necessary to make an independent flow measurement when closed conduit systems must be checked, although ESD inspectors have a closed conduit system (Polysonics) available. If the existing equipment cannot be calibrated in a timely manner, the investigator should install a portable flow sensor and recorder for the duration of the investigation. The installation and use of such equipment is preferred over attempts to correct erroneous flow measurement systems. The investigator should note the action taken in the study or inspection report and inform the discharger that the equipment should be calibrated as soon as possible if flow is required for calculating mass loadings or is itself a permit monitoring requirement. If non-standard primary flow devices are being used, data supporting the accuracy and precision of the methods being employed should be provided by the discharger.

5.2.5 Specific Techniques

This section outlines and familiarizes the field investigator with the most commonly used methods for wastewater flow measurements and the primary devices that will be encountered during field studies. Volumetric and dilution techniques are presented at the beginning of this section, since they are applicable to both open channel and closed conduit flow situations. The remaining methods are grouped under categories dealing with open channels and closed con-

duits. The general method of checking individual primary flow devices is given, where applicable. Several estimation techniques are presented. However, it should be recognized that flow estimates do not satisfy NPDES permit monitoring requirements unless the permit specifically states that this is permissible. The following methods are included only to enable the field investigator to make accurate flow estimates when necessary.

5.2.5.1 Volumetric Techniques -- Volumetric flow measurement techniques are among the simplest and most accurate methods for measuring flow. These techniques basically involve the measurement of volume and/or the measurement of time required to fill a container of known size.

5.2.5.1.1 Vessel Volumes -- The measurement of vessel volumes to obtain flow data is particularly applicable to batch wastewater discharges. Accurate measurements of the vessel volumes and the frequency that they are dumped are all that is required. An accurate tape to verify vessel dimensions and a stop watch are the only required field equipment. The NPDES Compliance Inspection Manual (2) is a useful reference on the equations for calculating volumes of various containers.

5.2.5.1.2 Sump Pumps -- This measurement is made by observing the sump levels at which the pumps cut on and off and calculating the volume contained between these levels. This volume, along with the number of pump cycles, will give a good estimate of the daily wastewater flow. The inspector must also account for the quantity of wastewater that flows into the sump during the pumping cycle.

5.2.5.1.3 Bucket and Stop Watch -- The bucket and stop watch technique is particularly useful for the measurement of small wastewater flows. It is accurate and easy to use. The only equipment required to make this measurement is a calibrated container (bucket, drum, tank, etc.) and a stop watch. A minimum of 10 seconds to fill the container is recommended. Three consecutive measurements should be made, and the results should be averaged.

5.2.5.2 Dilution Methods -- Dilution methods for water and wastewater flow measurements are based on the color, conductivity, fluorescence, or other quantifiable property of an injected tracer. The dilution methods require specialized equipment, special attention to detail by the investigator, and are time consuming. However, these techniques offer the investigator:

- a method for making instantaneous flow measurements where other methods are inappropriate or impossible to use;
- a reference procedure of high accuracy to check in-situ those primary flow devices and flow measurement systems that are non-standard or are improperly installed; and
- a procedure to verify the accuracy of closed conduit flow measuring systems.

The Turner Designs nomograph (3), the NPDES Compliance Inspection Manual (2), and the Geological Survey publication (4) outline recommended reference

procedures. The dilution method utilizing Rhodamine WT dye is the preferred reference procedure to be utilized by Branch personnel when verifying the accuracy of flow measurement systems.

5.2.5.3 Open Channel Flow Measurements -- The measurement of wastewater flow in open channels is the most frequently encountered situation in field investigations. An open channel is defined as any open conduit, such as a channel or flume, or any closed conduit, such as a pipe, which is not flowing full. The most commonly encountered methods and primary flow devices used in measuring open channel wastewater flows are described in this section. Several flow estimation techniques are also presented.

The measurement accuracies quoted in this section apply only to the specific method or to the primary flow device being discussed. The total error involved in a continuous flow measurement system, which is the sum of the errors of each component, is beyond the scope of this discussion. The reader is referred to the list of references at the end of this chapter for such a discussion.

5.2.5.3.1 Weirs -- A weir is basically defined as an overflow structure built according to specific design standards across an open channel to measure the flow of water. The theory of flow measurements utilizing weirs involve the release of potential static energy to kinetic energy. Equations can be derived for weirs of specific geometry which relate static head to water flow (discharge). Weirs are generally classified into two general categories; broad crested and sharp crested.

Broad crested weirs take the following form; $Q=CLH^{3/2}$. Values for the coefficient C are given in hydraulic handbooks (5, 6). Unless such weirs have been independently calibrated, they are usually not accurate enough for wastewater flow measurements.

Sharp crested weirs are constructed in a wide variety of shapes; the most commonly encountered are: V-notch, rectangular, and Cipolletti weirs. If such weirs are constructed as outlined in the USDI Water Measurement Manual (1), they are considered standard primary flow devices.

All weirs should be inspected to determine if the weir installation and construction conform to the conditions given in the USDI Water Measurement Manual (1) and provide a uniform influent flow distribution, and the weir is placed squarely across the channel perpendicular to the direction of flow. Useful tools for checking weir construction and installation include a carpenter's level, a framing square, a measuring tape, and a staff gage. Any problems observed during the inspection or study should be noted in the field log book.

A set of weir tables is necessary for calculating flows. The USDI Water Measurement Manual (1), the Stevens Water Resource Data Book (7), and the ISCO Open Channel Flow Measurement Handbook (8) contain a complete set of tables.

5.2.5.3.2 Flumes -- The conditions that must be met in a flume are similar to those that occur at a weir or spillway crest since water passing through the throat should not be impeded by downstream conditions (constrictions, bends in

channel, obstructions). There are several types of flumes, Palmer-Bowlus, Cutthroat, H, and Trapezoidal, but the most widely used is the Parshall flume. The Parshall flume is considered a standard primary flow device when constructed and installed as outlined in the USDI Water Measurement Manual (1). A complete discussion of other types of flumes is given in references 9, 10, 11, and 12.

All flumes should be inspected to determine if entrance conditions provide a uniform influent flow distribution, the flume dimensions conform to those given in the USDI Water Measurement Manual (1), the flume converging throat section is level, and the throat section walls are vertical. Useful tools for checking the construction and installation of Parshall (and other) flumes include a carpenter's level, a framing square, and a measuring tape. The flume should be closely examined to determine if it is discharging freely. If there is any question about free discharge, the downstream head (Hb) should be measured and compared to the head at the proper location (Ha) in the converging section. A staff gage is useful for making head measurements. Any problems observed during the inspection or study should be noted in the field log book.

A set of flume tables is necessary for calculating flows. The USDI Water Measurement Manual (1), the Stevens Water Resources Data Book (7), and the ISCO Open Channel Flow Measurement Handbook (8) contain a complete set of tables. The explanatory material accompanying these tables should be read and understood before they are used. In many cases, tabulated flow values are given for measured heads that are not within the usable measurement range.

5.2.5.3.3 Open Flow Nozzles -- Open flow nozzles such as parabolic or Kennison nozzles are factory calibrated and are ordinarily supplied as part of a flow measurement system. Calibration and installation information for each nozzle should be supplied by or obtained from the manufacturer. The accuracy of these devices is reported to be often better than ± 5 percent of the indicated flow (10). A framing square is useful for checking the installation. A volumetric flow measurement may be used to check accuracy of this device if flow volumes are not excessive.

5.2.5.3.4 Velocity-Area Method -- The basic principal of this method is that the flow in a channel (cubic feet/second) is equal to the average velocity (feet/second) times the cross sectional area (square feet) of the channel. The velocity of the water or wastewater is determined with a current meter; the area of the channel is either measured or calculated using an approximation technique in conjunction with a series of velocity measurements. The USGS mid-section method and the stream gaging techniques described in the USGS publication, Discharge Measurements at Gaging Stations (9) shall be the standard practice of the Branch. This technique shall be used (where appropriate) as an independent flow measurement to verify the accuracy of existing flow measurement systems.

5.2.5.3.5 Slope-Area Method -- The slope-area method consists of using the slope of the water surface, in a uniform reach of channel, and the average cross-sectional area of that reach, to estimate the flow rate of an open channel. The flow rate is estimated from the Manning formula (5, 6). This method is an estimation technique.

5.2.6 Closed Conduit Flow Measurements

The accuracy of closed conduit flow measuring devices shall be checked when necessary, by making an independent flow measurement, preferably using a dilution technique.

5.2.6.1 Venturi Meter -- The Venturi meter employs a conversion of static head to velocity head whereby a differential is created that is proportional to flow. The typical accuracy of a Venturi meter is given at 1 to 2 percent (10, 11, 12, and 13).

5.2.6.2 Orifice Meter -- The Orifice meter is a pressure differential device that measures flow by the difference in static head. Orifice meters require from 40 to 60 pipe diameters of straight pipe upstream of the installation. They can be quite accurate, i.e., within 0.5 percent, although their usable range is limited (10).

5.2.6.3 Flow Nozzle -- The basic principle of operation is the same as that of the Venturi meter. The flow nozzle has an entrance section and a throat, but lacks the diverging section of the Venturi. Flow nozzle accuracies can approach those of Venturi meters (10).

5.2.6.4 Electromagnetic Flow Meter -- The electromagnetic flow meter operates according to Faraday's Law of Induction where the conductor is the liquid stream, and the field is produced by a set of electromagnetic coils. The accuracy of the device is within ± 1 percent of full scale (10).

5.2.6.5 Other Closed Conduct Devices -- References for other closed conduit flow measurement methods such as acoustic flow meters, trajectory methods, pump curves, and water meters can be found in the NPDES Compliance Inspection Manual (2).

5.3 SURFACE WATER FLOW MEASUREMENTS

5.3.1 General

Surface waters are considered to be open channel for flow measurement purposes. All of the techniques utilized by Branch personnel to measure open channel flows have been discussed in the wastewater flow measurement portion of this section. Except for very small surface streams, the installation of primary flow devices is not practical. Most surface water flow measurements are made utilizing classical stream gaging techniques. These techniques involve the use of the velocity-area open channel technique which was discussed in the wastewater portion of this section. Branch personnel shall use the techniques outlined in the USGS publication Discharge Measurements at Gaging Stations (9) to:

- select the flow measuring site;
- perform stream gaging; and
- calculate flow.

5.3.2 Techniques

Where possible Branch stream studies shall be conducted utilizing existing permanent stream gaging stations operated by the USGS, the U. S. Army COE, or other federal or state agencies. These permanent gaging stations have established water stage - discharge relationships that permit the flow to be obtained from water stage measurements. Staff gage or recorder readings of water stage at these stations may be converted to flow by using the rating curve for that gaging station. The rating curve is available from the operator of the permanent gaging station. An additional benefit of utilizing these permanent gaging stations is that long-term flow records are generally available. These long-term flow records are invaluable in planning water quality studies and assessing data trends.

Where permanent gaging stations are not present, surface water flow will have to be measured utilizing classical stream gaging techniques. If a station is to be used more than one time during a water quality survey, a rating curve should be developed for that station. This may be done by making a series of independent flow measurements and simultaneous tape down or staff gage measurements for that station (see Section 7) at different water levels. The rating curve is developed utilizing the same measurement section each time; at least two, preferably three, flow measurement - tape downs should be made. The flow measurements used to develop the rating curve must bracket the lowest and highest flows encountered during the study. A tape-down rating curve is constructed by plotting the tape-down measurements verses flows on a piece of semi-log graph paper.

5.4 GENERAL QUALITY ASSURANCE PROCEDURES

All Branch personnel shall use the techniques and procedures for making wastewater and surface water flow measurements outlined in this section. The USDI Water Measurement Manual (1), the USGS publication Discharge Measurements at Gaging Stations (9), the EPA NPDES Compliance Inspection Manual (2) and a set of weir and flume tables shall be supplied to all Branch field employees. However, the measurements of wastewater and water flows require considerable experience. Therefore, no Branch employee shall make flow measurements until he/she has at least six months of actual field experience and has performed these measurements under the supervision of a senior member of the Branch staff.

Wastewater flow shall be expressed in million gallons per day (mgd) or the metric equivalent (m^3/day); stream flow shall be expressed in cubic feet per second (second feet) or the metric equivalent (m^3/sec). Time records associated with flow measurements shall be kept in local time, shall be made in the 2400 hour military time format, and shall be recorded to the nearest five minutes.

All flow measurements conducted by Branch personnel shall be thoroughly documented in field records. All measurements shall be traceable both to the individual making the measurements and the equipment utilized.

A log of all maintenance, calibration, and repair for each piece of flow measuring equipment shall be established. The log shall be kept in such a manner that all maintenance and calibrations performed on the equipment are traceable to the person performing them and to the calibration standard utilized. All equipment shall be numbered, or the US-EPA property or serial number shall be

used to facilitate identification.

5.5 EQUIPMENT AVAILABLE

The equipment available to Branch personnel for the measurement of surface water or wastewater flows is categorized as follows: water level/stage hardware and recorders, velocity measuring equipment and assemblies, and direct flow measurement equipment and instrumentation.

The hardware available to Branch personnel to determine the rise and fall of a water surface with time (the water stage) includes the following recording devices: Stevens Model F horizontal drum recorders and Stevens Model A-71 continuous strip chart recorders, ISCO Model 1870 recording flow meters used in the linear head mode, and ISCO Model 2870 recording flow meters that have programmable functions. Non-recording equipment available includes vertical staff gages and tape-down systems (see Section 7).

Instruments and equipment available to make velocity cross-sectional area measurements include current meters and sounding (depth) equipment. The current meters available to Branch personnel are the vertical-axis mounted Price AA and Price pygmy meters (including direct readout meters), and ENDECO solid state memory current meters. Sounding (determination of depth) is accomplished using Ratheon recording fathometers or with a standard top setting wading rod. Width measurements are made by Branch personnel using a Lee-Au galvanized steel tag line which is segmented into equal divisions of length by metal beads.

The equipment available for direct flow measurement includes the following primary devices available for installation by Branch personnel: V-notch weir plates and rectangular weir plates. The corresponding conversion of water level to flow rate can be accomplished instantaneously from stage/staff gage readings corresponding to the primary flow device in use, or by instantaneous readings of the available recording flow meter systems. The continuous recording systems presently available are the ISCO Model 1870 and 2870 recording flow meters.

The Polysonics Ultrasonic Flowmeter (Model UFM84P) is available for measuring flow in closed pipes. The pipe must be flowing completely full and not contain large amounts of air pockets. A coupling jelly is spread on the face of two transducers, and the transducers are mounted opposite each other on the outside of the pipe. The meter must then be calibrated according to the manufacturer's instructions.

5.6 SPECIFIC EQUIPMENT QUALITY CONTROL PROCEDURES

A log book shall be kept of all equipment utilized for measuring water flows, water stage/tape downs, velocity measurements, flow recordings, etc. The following maintenance and calibration procedures shall be implemented.

5.6.1 Stevens Model A-71 and Model F Stage Recorders

See specific equipment and quality control procedures in Section 7.

5.6.2 ISCO Model 1870 and 2870 Recording Flow Meters

The recording flow meter shall be thoroughly tested annually to insure that the accuracy, resolution, and precision are within the technical specifications as established by the manufacturer. This shall be accomplished by operating the instruments in a controlled test environment for a period not less than 24 hours. The test environment shall consist of a controlled atmospheric temperature, power source, and water level/head. Operation during the testing period shall be according to the manufacturer's instruction manual. The functions that shall be tested include: flow meter totalizer accuracy, flow recorder tracing accuracy, and chart speed accuracy.

In addition to the above annual testing program, an abbreviated testing procedure will be conducted on the flow meters and recorders which will include a check on the following functions: flow meter and recorder response to changing heads as shown on the meter's liquid level indicator and the recorder's flow indicator, bubble rate adjust response, flow recorder accuracy, full scale span sensitivity, sample signal initiation response, zero adjust response, and chart speed response. The flow meters and recorders shall be checked through the abbreviated procedure whenever they are scheduled for field use.

The following routine maintenance procedures shall apply whenever the equipment is returned from the field: the exterior of the meter and recorder case will be cleaned with soapy water (Appendix B), the front panel desiccant and external desiccant cartridges will be reactivated, and the bubble line will be inspected and cleaned.

5.6.3 Vertical Staff Gages and Tape Down Systems

See specific equipment and quality control procedures in Section 7.

5.6.4 Price AA and Price Pygmy Current Meters

All meters shall be sent to the USGS for recalibration once every five years. All meters shall be examined before and after each discharge measurement. The examination shall include the meter cups or vanes, pivot and bearing, and shaft for damage, wear, or faulty alignment. Meter balance and alignment shall be checked prior to each use in the field (9). Meters shall be cleaned and oiled daily when in use. Surfaces that shall be cleaned and oiled on a yearly basis are the pivot bearing, pentagear teeth and shaft, cylindrical shaft bearing, and thrust bearing at the cap.

5.6.5 Top Setting Wading Rod

This equipment shall be cleaned and examined before and after each discharge measurement. The examination shall include a check on the sliding rod and lock set mechanism.

5.6.6 Lee Au Tag Line

This equipment shall be inspected for damage and cleaned before and after each discharge measurement. The accuracy of the tag line will be checked initially and then once per year utilizing the Invar steel surveyors chain. The tag

line(s) shall be accurate to 0.1 foot per 100 feet. Any tag lines that do not conform to this accuracy specification shall be repaired, recalibrated, or discarded. Yearly maintenance shall include an inspection for potential breaks, a thorough washing, and a finish oiling.

5.6.7 V-Notch and Rectangular Weir Plates

These plates shall be cleaned and examined before and after each field installation. Construction and condition of weir plates shall conform to recognized standards (2). The plates shall be cleaned with a soapy wash water, followed by a distilled water rinse. The weir plates will be inspected to insure that the upstream edge of the plate remains sharp.

5.7 REFERENCES

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6.0 FIELD ANALYTICAL PROCEDURES

6.1 GENERAL

Field analytical equipment used by Branch personnel should be suitable for the analysis to be accomplished and properly calibrated. In addition to being accurate, field analyses must be conducted on a sample which is representative of the source from which it was collected. Therefore, the type of sample and location of the sampling site are critical. A detailed discussion of sample type and sample site selection is given in Section 4 for the various media investigated by Branch personnel.

The objectives of this section are to:

- list the specific field analytical techniques that shall be used by Branch personnel;
- list the specific quality control procedures and calibration techniques for each piece of field analytical equipment used by Branch personnel;
- list the source of all reagents and standards used to perform field analyses and/or calibrate field analytical equipment; and
- specify the training required of Branch personnel to perform the listed field analyses.

Specific field analytical methodology for each parameter is given in Appendix D.

6.2 SPECIFIC ANALYTICAL TECHNIQUES

The specific field analytical techniques used by Branch personnel are listed below and the specific procedures for each analytical technique and field test are presented in Appendix D.

Analytical Parameter	Method	Reference	Equipment
Temperature	Calibrated glass (mercury), dial (mechanical), or electrometric thermometer	1	Mercury filled glass, mechanical dial type thermometer, or thermistor with electronic readout
pH	Electrometrically using a glass electrode in combination with a reference potential or a combination electrode	1	Portable field pH meter
Dissolved Oxygen (DO)	Modified Winkler or membrane electrode	1	Standard DO kit with fresh sodium thiosul-

			fate, or membrane electrode and electronic readout
Specific Conductance	Wheatstone bridge type or equivalent meter corrected to 25_oC	1	Self-contained conductivity meter, Wheatstone bridge type, or equivalent with automatic temperature compensation to 25_oC or "dial in" temperature compensation
Total Chlorine Residual	Back titration, iodometric with starch or amperometric end-point or DPD colorimetric	1	Iodometric backtitration kit with fresh reagents, or amperometric titrator with fresh reagents, or DPD kit with color standards
Tracer-Fluorescence	Analysis of fluorescent dyes using a fluorometer	2	Rhodamine WT dye and Turner fluorometer
Salinity	Electrodeless Inductive Conductivity Cell Salinometer	3	Beckman RS5-3 Portable Salinometer and Hydrolab Surveyor II Meter

6.3 SPECIFIC QUALITY CONTROL PROCEDURES

Quality assurance procedures for field analysis, and field analytical and test instrumentation calibration are an essential part of these standard operating procedures. All field analytical procedures shall be conducted in duplicate at least 10 percent of the time. A record of these duplicate analyses shall be kept in field logbooks. A significant difference in the replicate analyses (greater than specified in the following sections) shall result in recalibration of the instruments used, re-examination of the analytical methodology being used, or re-examination of the sampling location.

All field analyses must be traceable to the specific individual performing the analyses. Time records shall be kept in local time using the military 2400 hour format and shall be recorded to the minute. This information shall be entered into the field logbooks for all field analyses performed by Branch personnel.

A specific calibration and/or standardization plan for all field analytical equipment is presented in this subsection. Included in this plan are: calibration and maintenance intervals; listing of required calibration standards and conditions requiring recalibration.

6.3.1 Temperature

6.3.1.1 Initial Calibration -- All thermometers shall be initially calibrated against a National Bureau of Standards (NBS) certified thermometer or one traceable to NBS certification.

6.3.1.2 Inspection and Calibration -- Each glass mercury filled thermometer shall be inspected before each field trip to see that it is not cracked and has no air space in the mercury column. If a mechanical dial-type thermometer is used, it should not have a broken face cover or otherwise show damage. A cross-check with a calibrated NBS certified thermometer shall be made at least semi-annually. Thermistors and electronic readout units should be calibrated in the same manner. Recording thermometers shall be checked for recording accuracy before each use. The recorder time scale accuracy shall be checked semi-annually. Before using a thermometer in the field, a visual observation shall be made to assure that it has not been damaged. If a thermistor is used, the instrument shall be checked against a thermometer before field use. Cross-checks and duplicate field analyses should agree within $\pm 0.5^{o}C$.

6.3.1.3 Calibration Records -- A logbook shall be maintained with each thermometer number and/or equipment property number recorded. All calibration information including individuals making the calibrations and dates of calibration shall be recorded.

6.3.1.4 Reporting Units -- Report all temperature data to the nearest $0.5^{0}C$.

6.3.2 pH

6.3.2.1 Equipment -- Only electronic (portable) pH meters with automatic temperature compensation (ATC) should be used. Temperature resistant, combination electrodes should be employed in conjunction with the meters. pH test paper will be used only for determining pH ranges, for determining approximate pH values, or for concentrated hazardous waste samples which would damage the instrument.

6.3.2.2 Equipment Inspection and Calibration -- The pH meter shall be checked before each field trip for any mechanical or electrical failures, weak batteries, and cracked or fouled electrodes. The slope of the meter shall also be checked initially with three fresh standard buffer solutions (e.g., 4, 7, and 10). All pH recorders shall be checked for recording accuracy and time scale accuracy. While in the field, the meter shall be calibrated daily before use with two buffers bracketing the expected sample pH. Thereafter, the meter shall be checked against two buffers when moving to a new sample location. Fresh buffer solutions shall be used for each field trip. In case of an apparent pH violation, the electrode shall be checked with pH 7.0 buffer and recalibrated to the closest reference buffer. Then the sample shall be retested. Duplicate tests should agree within 0.1 standard unit.

6.3.2.3 Reporting Units -- Report pH to the nearest 0.1 standard unit.

6.3.3 Dissolved Oxygen (DO)

6.3.3.1 Equipment -- Modified Winkler kits and membrane electrode DO meters should be used.

6.3.3.2 Equipment Inspection and Calibration -- DO meters shall be checked before each field trip by inspecting the membrane for air bubbles and holes. If the membrane is dry, it shall be replaced and soaked in water before calibrating. Calibration should be made against the modified Winkler test.

DO kits shall be refilled with new standardized sodium thiosulfate before each field trip. Each solution shall be checked for clarity and volume.

Before using the DO meter each day, duplicate deionized or known clean water samples shall be collected by siphoning water from a bucket into two DO bottles. These duplicate samples shall be analyzed by the modified Winkler test for DO content. The DO meter shall be calibrated against the DO content measured by the Winkler test by placing the DO probe in the bucket containing the water used for the Winkler test.

While using the DO meter, the instrument shall be recalibrated at least twice per day or if a change in water quality is noted. If the sample temperature is 5^0C greater than the calibration temperature, the meter shall also be recalibrated.

Duplicate analyses should agree with $\pm$ 0.1 mg/l.

6.3.3.3 Reporting Units -- Results for the DO test should be reported to the nearest 0.1 mg/l.

6.3.4 Specific Conductance

6.3.4.1 Equipment -- A portable specific conductance meter, Wheatstone bridge type or equivalent should be used.

6.3.4.2 Inspection and Calibration -- Each conductivity meter shall be checked before each field trip. Batteries shall be checked, and conductivity cells shall be cleaned and checked against known conductivity standards (KCl).

6.3.4.3 Field Calibration -- Before using in the field, check instrument daily with known standards. Refer to the instrument instructions for temperature conductance calculations. Duplicate field analyses should agree within $\pm$ 10 percent.

6.3.4.4 Reporting Units -- Results should be expressed in micromhos/centimeter (umhos/cm) corrected to 25^0C. Results should be reported to the nearest ten units for readings under 1,000 umhos/cm and the nearest 100 units for readings over 1,000 umhos/cm.

6.3.5 Total Chlorine Residual

6.3.5.1 Equipment -- The iodimetric back titration method with a starch-iodide end point or amperometric end point or a Hach DR 100 colorimetric (DPD) kit may be used.

6.3.5.2 Inspection and Calibration -- Each titration kit or meter shall be checked before each field trip by inspecting the meter for battery strength and fresh reagents. The normality of the iodate should be checked with a distilled water blank to establish a correction factor for the titrant. This will also serve to check the response of the amperometric titrator. Duplicate chlorine residual analyses should agree within ± 0.01 mg/l.

If the Hach DR 100 colorimeter (DPD) kit is used, the method must agree with the requirements of Method 408E, "Standard Methods," 16th Edition, or Method 330.5 "Methods for Chemical Analysis of Water and Wastes," and calibration scales must be calibrated on site at a minimum of three points (blank and two standards) that bracket the expected sample concentration.

6.3.5.3 Reporting Units -- Results should be reported to the nearest 0.01 mg/l residual chlorine.

6.3.6 Fluorescent Tracing

6.3.6.1 Tracer -- Rhodamine WT dye is the standard tracer used by Branch personnel.

6.3.6.2 Fluorometer -- A filter fluorometer (fluorometer) is the instrument used to determine intensity of emitted light or concentration of dye in the sample.

6.3.6.3 Fluorometer Calibration and Calibration Standards -- Before a fluorometer is used in the field, it shall be checked against a set of standard dye solutions. All standard concentrations shall be made relative to the stated concentration of the manufacturer's solution.

All standard solutions shall be made with distilled water. Sufficient solution volumes shall be made to permit calibration checks. Calibration checks shall be conducted whenever the fluorometer has been turned off for an extended period of time.

The fluorometer and all associated equipment shall be thoroughly cleaned between uses.

6.3.6.4 Reporting Units -- Turner Design fluorometer results shall be reported as ± 1 percent of full scale concentration.

6.3.7 Salinity

6.3.7.1 Equipment -- A portable salinometer, electrical conductivity type shall be used.

6.3.7.2 Inspection and Calibration -- Each salinometer shall be checked before every field trip. Batteries shall be checked and the cell inspected to determine if it is free of marine growth and salt. The meter shall be checked against the resistor loop supplied with the meter.

6.3.7.3 Reporting Units -- Results should be reported to the nearest 0.1 part per thousand of salinity.

6.4 SEMI-ANNUAL MAINTENANCE

All analytical and test instruments and kits shall be inspected on a semiannual basis, whether used during the intervening period or not. The purpose of the semi-annual inspection is to maintain the equipment in a ready-to-use condition. This inspection shall consist of a general examination of the electrical system (including batteries) and a calibration against standards. Any expired reagents, broken glassware, or parts shall be replaced.

6.5 SOURCES OF CHEMICALS AND STANDARDS

All chemicals used in test kits and with field analytical instruments as reagents and standards shall be supplied and standardized by the Analytical Support Branch (ASB). Certified pH buffer solutions shall be purchased from chemical supply houses. All reagents and solutions shall have expiration dates attached to the containers. All out-of-date reagents, buffers, and chemical solutions shall be properly disposed of at their expiration date. All field reagent containers shall be identified with the chemical name, concentration, and date prepared.

Tracer-fluorescence standards will be prepared for each study using the actual tracer as outlined in Appendix D.9.

6.6 TRAINING

Each member of the Branch involved in field studies shall undergo an initial review of field analytical and test procedures and equipment. After the initial review, subsequent reviews shall take place annually. The Branch Quality Assurance Officer, in conjunction with personnel from the ASB, shall conduct the instruction. Any new instrumentation adopted by the Branch will be introduced to Branch personnel in a training session before it will be authorized for routine use.

6.7 REFERENCES

1. "Guidelines for Establishing Test Procedures for the Analysis of Pollutants," Federal Register, Volume 49, No. 209, 40 CFR 136, October 26, 1984, and any subsequent revisions.

2. Wilson, J. F., Fluorometric Procedures for Dye Tracing: USGS Techniques of Water-Resources Investigations, Book 3, Chapter A12, United States Department of Interior, Geological Survey, 1968.

3. Standard Methods for the Examination of Water and Wastewater, 1985, 16th Edition.

4. Methods for Chemical Analysis of Water and Wastes, EPA, 600/4-79-020, and all current revisions.

7.0 FIELD PHYSICAL MEASUREMENTS

7.1 GENERAL

Field measurements of topographic features, water levels, time of travel, geophysical parameters, and physical dimensions are frequently required during comprehensive water quality, groundwater, hazardous waste, wastewater treatment system, and related field investigations conducted by the Branch. The scope of such measurements obviously depends on the purpose of the particular investigation.

All sampling locations used during Branch field investigations shall be depicted on an accurate drawing or a topographic or other standard map, or be referenced in such a manner that their location(s) are firmly established. The Region IV library has a complete collection of 7.5 minute USGS (1:24,000 scale) topographic maps and a map copier available.

Each field measurement made by Branch personnel shall be traceable to the actual person making the measurement and to the field equipment used to make that measurement. All equipment maintenance and calibration records shall be kept in log books and field records so that all such procedures are traceable. All time records shall be kept in local time using the 2400 hour format, and time shall be recorded to the nearest minute.

New Branch employees shall perform each of the physical field measurements described in this section under the supervision of a senior technical staff member at least once before being permitted to make these measurements on their own.

The specific objectives of this section are to:

- present the standard practices used by the Branch to make physical field measurements;
- list the field equipment utilized to make such measurements; and
- present specific quality control procedures to insure that such measurements are accurate.

A. SURVEYING (HORIZONTAL CONTROL)

7.2.1 General

Surveying is described as the art and science of determining the area and configuration of portions of the earth's surface, and representing them on maps. Generally, surveying can be divided into two categories or classes: horizontal control surveying and vertical control surveying. Horizontal control surveying pertains to the measurement of the relative difference in the horizontal location of two or more control points. Vertical control surveying involves the measurement of the relative difference in vertical location, or elevation, of two or more control points and is treated separately in Section 7.3. This Section discusses the standard procedures and techniques used by the Branch to survey, or locate sample points or site features horizontally. Basic surveying and field geology textbooks should be consulted for more detailed information on this topic (1, 2, 3).

7.2.2 Introduction

Several field methods may be used to horizontally locate sample points or various site features during hazardous waste site investigations and/or other site investigations that may result in enforcement actions. Traverse methods used by the Branch utilize horizontal angle or direction (azimuth/bearing) measurements and calculated horizontal distances from a starting point to a second point, and from the second to the third, and so forth to the last point. The last point in a traverse is usually a return to the starting point, thus making a closed loop. During a traverse for site control, sample points or site features may be located by employing various techniques at the traverse control points, i.e., by angle (azimuth or bearing) and distance measurements from a control point, by angular intersection from two control points, by perpendicular offset from a line between two control points, by angle from one control point and distance from another control point, etc. (1).

Regardless of the method(s) used, surveying by the Branch should be based on established control points. A network of horizontally (and vertically) located control data points has been established and is continually maintained by the National Oceanic and Atmospheric Administration (NOAA) through its National Ocean Survey (formerly U. S. Coast and Geodetic Survey). The system of horizontal control points, or Triangulation Stations, have established latitude and longitude positions and provide the basis for the coordinate grid systems used by many States (1, 2).

When measuring horizontal angles, compensation must be made for the angle between true north and magnetic north. This angle is called the magnetic declination. Branch field surveying methods must be referenced to true north. The first step in this procedure is to determine from an isogonic map, the declination for the area of work. Isogonic maps may be found in basic surveying and field geology textbooks referenced above.

Sources of existing information on triangulation stations or coordinate grid data and their exact locations may be obtained from local, state or federal departments or agencies. Typically, the engineering or public works departments of counties, cities or towns may have data on file that is near the particular site being investigated. State or federal agencies which are good sources of useful data include: (1, 2, 3)

- State highway or transportation departments
- State geodetic or land surveying offices
- State natural or water resources bureaus
- State geological surveys
- NOAA/National Ocean Survey
- United States Geological Survey
- Corps of Engineers, Department of the Army
- Soil Conservation Service
- Tennessee Valley Authority
- Bureau of Land Management

When the exact locations of sampling points or other physical features at a site are needed, Branch surveying methods must be based on existing control data. In all cases, the site property boundary survey, description, and any physical property corners or monuments must be located by a professional Registered Land Surveyor (RLS). Often times, before or when the surveyor is at a site, the registered surveyor can be requested to set control data points for Branch use. At a minimum, the registered land surveyor will be asked to establish at least two control points upon which the elevation and Universal Transverse Mercator (UTM) coordinates are set. The data on control points shall be of at least third-order accuracy. The control points will be permanent markers set at locations that are unlikely to be disturbed by future site activities.

If no existing control data exists in the site vicinity, an arbitrary point may be established at a permanent location, e.g., set a nail or spike beneath the ground or set a nail and cap in asphalt or foundation. However, the coordinates for that point (and, therefore all other points) should be determined at a later

date. As with all Branch field work, the location of all control data used and all field measurements shall be recorded in the field logbook as outlined in Section 3.5.

7.2.3 Equipment Available

The following Branch equipment is available for field use in conducting surveying in support of site investigations:

- Topcon GTS-2, total station theodolite/electronic distance meter (EDM)
- tripod(s)
- reflector prism(s)
- range pole
- steel tape
- cloth tape
- optical tape measure
- Rola tape
- compass

7.2.4 Specific Equipment Quality Control Procedures

All field surveying methods using Branch equipment shall be made only by those Branch personnel who have been trained to use them. All Branch professional staff and field technicians must be trained and checked out in surveying procedures by qualified staff before using this equipment.

Each piece of field equipment (as appropriate) shall be numbered, and a log book shall be kept containing all maintenance and calibrations made on the equipment. The following specific maintenance and calibration procedures shall be used for all surveying equipment:

7.2.4.1 Theodolite -- This equipment shall:

- be serviced and calibrated by a qualified private service shop annually or sooner if damaged or suspected to be in error;
- be checked out using procedures outlined in basic surveying textbooks and appropriate users manuals before use (1, 2, 3); and
- be cleaned and maintained using procedures outlined in basic surveying textbooks and appropriate users manuals during field use and before being returned to storage (1, 2, 3).

7.2.4.2 Steel and Cloth Measuring Tapes, and Mechanical Rola-Tape -- The following procedures shall be used for all measuring tapes:

- All measuring tapes and the mechanical Rola-tape will be calibrated annually against an Invar steel surveyors chain or the theodolite/EDM both of which are traceable to the National Bureau of Standards (NBS). Those steel tapes that are not within 0.01 foot per 100 feet or cloth tapes not within 0.02 foot per 100 feet shall be discarded. The

7.2.4.2 Steel and Cloth Measuring Tapes, and Mechanical Rola-Tape -- The following procedures shall be used for all measuring tapes:

- All measuring tapes and the mechanical Rola-tape will be calibrated annually against an Invar steel surveyors chain or the theodolite/EDM both of which are traceable to the National Bureau of Standards (NBS). Those steel tapes that are not within 0.01 foot per 100 feet or cloth tapes not within 0.02 foot per 100 feet shall be discarded. The shorter carpenter-type steel tapes (6-12 feet) shall also check within 0.01 foot or they will be discarded.

- All tapes shall be checked to see that they are not damaged and are clean before and after use.

7.2.4.3 Optical Tape Measure -- Each Branch employee using the optical tape measure shall become proficient in its use by measuring known distances before using this equipment in the field.

7.2.4.4 Compass -- All compasses shall:

- be checked for proper movement of the compass meddle. If the compass needle movement is sluggish, the glass cover can be removed by prying a knife point under the spring washer. The copper wire on the needle is then moved until the needle lies level (3);

- be checked for proper alignment of clinometer level. The clinometer is checked by setting the clinometer to 0, and placing the compass on a surface that has been leveled exactly with either a carpenters level or a water tube level. If the horizontal level bubble on the clinometer does not rest at the center, the compass is opened as described above and the clinometer level vial is moved and rechecked as appropriate. If the level vial becomes broken, the compass must be sent to the manufacturer to be repaired (3); and

- be cleaned after use and before storage. If the compass should become wet, the compass is opened as previously described and the interior is dried using a toothpick and a piece of soft cloth or soft paper. They should not be used, exposed to or stored in strong electrical fields (3).

7.2.4.5 Range Poles and Reflector Prisms -- All of this equipment shall:

- be checked for warpage and/or damage before use by sighting through the theodolite/EDM while the poles/prisms are rotated in two planes at 90° intervals. The bullseye bubble will be reset as appropriate; and
- be cleaned daily after use and before being returned to storage.

7.2.5 Procedures for Traversing

When traverse methods are used, at least two stations or control points of known horizontal location (expressed in terms of UTM coordinates and/or the local State coordinate system) must be in the site vicinity. These control points can usually be set for the specific site by a governmental agency or registered land surveyor.

The total station theodolite, which measures horizontal angles, vertical angles, and slope distances, is set up over an existing control point. The theodolite is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads appropriately. Once the bullseye bubble is centered, the theodolite is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The instrument is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman has either a range pole equipped with a reflector prism (single or triple) or a tripod with the reflector prism. The prism is used to reflect the signal from the electronic distance meter in the total station theodolite. While located over the point(s) whose location is desired, the rodman holds the range pole vertically by means of centering the bullseye bubble, or sets up the tripod and reflector prism similarly as stated above. The instrument man sights through the telescope on the theodolite, lines up the horizontal and vertical cross-hairs on the center of the prism and records the horizontal angle (Ah), vertical angle (Av), and the slope distance (Ds) to the prism. The difference in location between the point where the theodolite is set up and the point where the prism is held is determined trigonometrically. A compass and measuring tape could also be used to reference field measurements to a map or vice versa.

The following examples depict some of the field measurements that must be considered and accounted for, the calculations that must be performed, and the conversions that must be made when the Branch uses traverse methods to horizontally locate sampling points or other site features.

EXAMPLE 1: Figure 7.2.1. Horizontal Angle (map view).

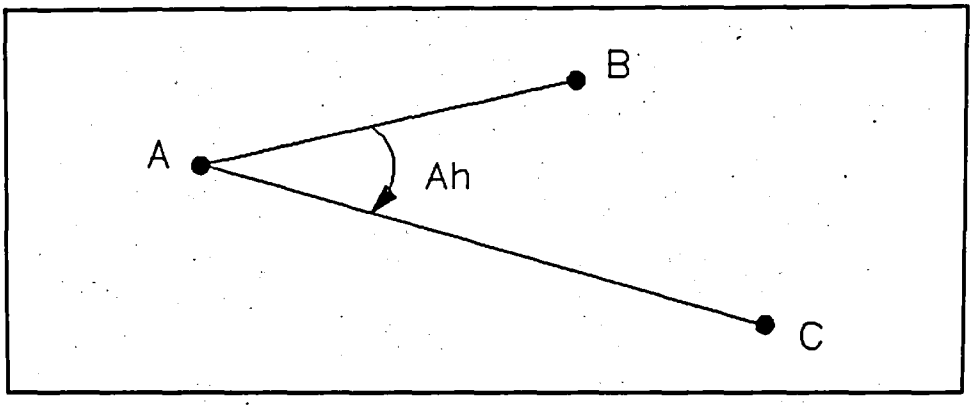
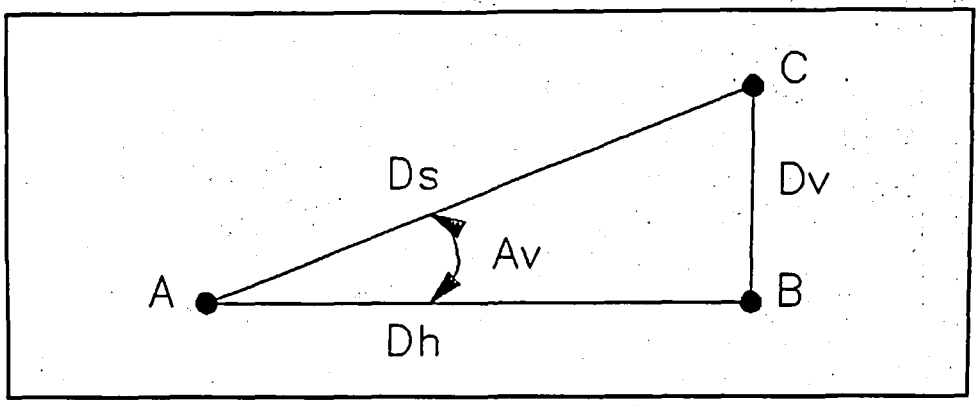


Figure 7.2.1 illustrates that while the instrument is at point A (a control point), one reads the backsight angle (azimuth or bearing) to point B, then turns and measures the foresight angle (azimuth or bearing) to point C. The difference between the two angles is the interior angle included at the intersection of line AB and line AC, or the horizontal angle (Ah).

The field notation for the measurement of the angle above would be represented as angle B-A-C. Typically, the first column to the left in the field book is labeled: (BS - ℄ - FS) or Station and the second column is labeled Ah (see Example 5 Field Notation).

EXAMPLE 2: Figure 7.2.2. Vertical Angle (side view).



After the horizontal angle is determined, the vertical angle (Av) is measured, in Figure 7.2.2, from point C to point B to determine the angle between the line of sight AC and the horizontal line AB. The vertical angle is the included angle between a line connecting two points of different elevations and a line horizontal to the earths gravity.

To determine the height of the point C, measure the slope distance (Ds) with the electronic distance meter from A to C. Using the theodolite or transit, measure the vertical angle between line AC and AB. The height of point C would be obtained by the formula:

$$Dv = (\sin Av)\ Ds$$

The horizontal distance (Dh), which is the distance used when drawing the map, would be obtained by the formula:

$$Dh = (\cos Av)\ Ds$$

If the vertical distance to be measured was to the top of a building, tree, or other point where the measurement of the slope distance is impractical, simply measure the horizontal distance and determine the height by:

$$Dv = (\tan Av)\ Dh$$

The field notation for the third column from the left in the field book is labeled: Av and the forth column is labeled Ds/Dh (see Example 5 Field Notation).

EXAMPLE 4: Coordinates.

When the local State rectangular grid coordinate points near a particular site are obtained, Branch personnel should be able to convert rectangular coordinates to polar coordinates. This is important since through this conversion, the azimuths and distances between each point can be obtained and then used as the starting control points for the site control traverse. Simple programmable or non-programmable calculators are extremely useful in providing precise results from the field surveying measurements. The following is an example of a conversion from rectangular to polar coordinates:

The instrument is set up at TP1, and given the rectangular coordinates:

Control Point	North (y)	East (x)
TP1	7935.07	6178.78
MCT3	7851.75	6209.99

The relative change in location between the north and east coordinates (from TP1 to MCT3), respectively, are:

$$\Delta N = -83.32, \quad \Delta E = 31.21$$

The negative symbol for ΔN indicates the relative movement from TP1 to MCT3 downward (-) along the y axis. The positive symbol for ΔE indicates relative movement from TP1 to MCT3 to the right (+) along the x axis. Solving for the formula (Pythagorean theorem):

$$c^2 = a^2 + b^2$$

The resulting distance between TP1 and MCT3 is c = 88.97'.

The azimuth is obtained by first computing the inverse tangent of the change in north divided by the change in east:

$$\tan^{-1} (\Delta N \div \Delta E) = -69.4651°$$

This is the negative angle, expressed in decimal degrees, and is measured from the (x) axis into the southeast quadrant. The azimuth from TP1 to MCT3 is obtained, in this case, by changing the sign (- to +) and adding 90° and then converting to degrees, minutes, and seconds. The resulting azimuth from TP1 to MCT3 is 159°27'54".

Note: The trigonometric formula above always gives the angle measured from the (x) axis. When using this procedure, it is wise to make a sketch showing the change in direction between the points relative to north. This will aid in visually and mentally seeing which geometric quadrant that the foresight angle falls in relation to the instrument.

EXAMPLE 5: Figure 7.2.4. Traverse Field Notation.

The following is an example of the field notation for a traverse to horizontally locate sampling points. Figure 7.2.5 shows some of the physical features, sampling points, and traverse control points that should be sketched on the right hand side of the field log book. The coordinates for each point are then determined and usually entered in red ink after the traverse is finished.

01/22/90 Project 90E-000
Region IV Site Name
City, State

Pg. 1 of 2
Landis Surveyor - T
Ben Chmark - ⊥
Weather: Clear; 0-5 mph N

-Set traverse points around property to locate the 5 monitoring wells that were recently installed.

Given: TP1: N=7935.07, E=6178.78
MCT2: N=8297.79, E=6598.14
MCT3: N=7851.75, E=6209.99

TP1 to MCT3 : ΔN=-83.32 ΔE=31.21

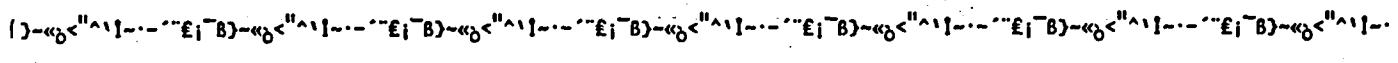
$c^2 = a^2 + b^2$, c = 88.97'

$\tan^{-1}$ (ΔN + ΔE) = -69.4651

∴ Azimuth TP1 to MCT3 = 159°27'54"

(BS - T - FS) Station	Ah	Av	Ds / Dh	Coordinates	Remarks/Comments
MCT3-TP1-	Set: Ah= 159°27'54"	90°45'24"	88.98' 88.97'	N=7935.07 E=6178.78	Notes: Instrument (T) is set up at TP1, back sight (BS) to MCT3 and set instrument to read 159°27'54".
MCT3-TP1-A	125°26'18"	89°44'06"	502.64' 502.635'	N=7643.63 E=6588.30	Set nail in ground for point A.
MCT3-TP1-MW5	124°09'12"	90°07'21"	375.58' 375.58'	N=7724.22 E=6489.59	Locate MW5.
TP1-A-	Set: Ah= 305°26'18"	--------			Instrument at A, back sight to TP1 and set the reciprocal azimuth, i.e. add 180°.
TP1-A-B	228°00'54"	90°32'54"	470.94' 470.94'	N=7328.60 E=6238.24	Set nail for point B.
A-B-	Set: Ah= 48°00'54"	--------			Reciprocal azimuth as above.
A-B-MW2	343°55'21"	90°21'54"	113.68' 113.68'	N=7437.83 E=6206.76	Locate MW2.
A-B-C	300°46'27"	89°59'54"	762.46' 762.46'	N=7718.72 E=5583.14	Set point C.

EXAMPLE 5: Figure 7.2.4. Traverse Field Notation (continued).



EXAMPLE 5: Figure 7.2.4. Traverse Field Notation (continued).

01/23/90 Project 90E-000 Pg. 2 of 2
Region IV Site Name Landis Surveyor - ⊤
City, State Ben Chmark - ⊦
Weather: Clear; 0-5 mph N

Station	Ah	Av	Ds / Dh	Coordinates	Remarks/Comments
B-C-	Set: Ah= 120°46'27"	--------			Reciprocal azimuth.
B-C-D	14°40'24"	89°49'39"	698.34' 698.34'	N=8394.28 E=5760.03	Set point D.
B-C-MW1	24°11'21"	90°21'12"	132.96' 132.96'	N=7840.01 E=5637.62	Locate MW1.
B-C-MW3	26°50'36"	89°44'45"	612.76' 612.754'	N=8265.45 E=5859.83	Locate MW3.
C-D-	Set: Ah= 194°40'24"	--------			Reciprocal azimuth.
C-D-E	67°36'15"	90°03'48"	715.66' 715.66'	N=8666.95 E=6421.71	Set point E.
C-D-MW3	142°17'51"	89°45'03"	163.14' 163.14'	N=8265.20 E=5859.80	Locate MW3 (again, just in case).
D-E-	Set: Ah= 247°36'15"	--------			Reciprocal azimuth.
D-E-MCT2	154°27'09"	90°04'33"	409.08' 409.08'	N=8297.87 E=6598.13	Actual: N=(8297.79), E=(6598.14).
E-MCT2	Set: Ah= 334°27'09"	--------			Reciprocal azimuth.
E-MCT2-A	180°51'42"	89°36'24"	654.28' 654.265'	N=7643.68 E=6588.30	Coordinates first computed to be: N=(7643.63), E=(6588.30).
E-MCT2-MW4	249°56'39"	88°32'48"	85.66' 85.63'	N=8268.50 E=6517.69	Locate MW4.
MCT2-A-	Set: Ah= 360°51'42"	--------			Reciprocal azimuth.
MCT2-A-TP1	305°26'18"	--------	------ (502.635')	N=7935.12 E=6178.78	Should have ended at: N=(7935.07), E=(6178.78).
MCT2-A-MW5	309°13'33"	91°10'36"	127.50' 127.47'	N=7724.29 E=6489.55	Locate MW5 (again, just in case).
					Closure: Σ Dh=4,716.015 N Dh=0.0466', E Dh=0.00'

Figure 7.2.3 - EXAMPLE OF SITE MAP SHOWING TRAVERSE POINTS USED TO LOCATE MONITORING WELLS

Figure available upon request.

7.3 ELEVATION SURVEYS (VERTICAL CONTROL)

7.3.1 Introduction

The field of surveying that pertains to measuring the relative differences in elevation of two or more points is called "running levels" or "Leveling". The two most commonly used methods are Differential Leveling and Trigonometric Leveling. Differential leveling is the most precise and easiest method because it utilizes "level" measurements with simple addition and subtraction. Trigonometric leveling is slightly less precise and more difficult as it uses vertical angle and distance measurements combined with the principles of trigonometry. Differences in elevation can also be determined from controlled altimeter measurements by the method called Barometric Leveling. However, the altitude (elevation) readings are not as precise as elevation measurements obtained from differential or trigonometric leveling since most altimeters permit readings to within about 5 feet of the actual elevation. This subsection discusses the standard procedures and techniques used by the Branch to obtain differences in elevation and are described in more detail in basic surveying and field geology textbooks (1, 2, 3).

Regardless of the method(s) used, elevation surveys by the Branch should be based on established control points. A network of vertically located control data points has been established and is continually maintained by the National Oceanic and Atmospheric Administration (NOAA) through its National Ocean Survey (formerly U. S. Coast and Geodetic Survey). The system of vertical control points, or Benchmarks (B.Ms.), are referenced to a surface of fixed and precisely known elevation above mean sea level and is referred to as the datum or datum plane. The datum for vertical control (elevation) is called the National Geodetic Vertical Datum (NGVD), formerly known as the 1929 sea level datum, established by the U. S. Coast and Geodetic Survey (1).

Sources of existing information on benchmark data and their locations may be obtained from local, state or federal departments or agencies. Typically, the engineering or public works departments of counties, cities or towns may have data on file that is near the particular site being investigated. State or federal agencies that are good sources of useful data include: (1, 2, 3)

- State highway or transportation departments
- State geodetic or land surveying offices
- State natural or water resources bureaus
- State geological surveys
- NOAA/National Ocean Survey
- United States Geological Survey
- Corps of Engineers, Department of the Army
- Soil Conservation Service
- Tennessee Valley Authority
- Bureau of Land Management

When the exact elevations of sampling locations or other physical features are needed, benchmarks of precisely known elevation should be used when leveling. At a minimum, during the course of a site investigation, a registered land surveyor will be asked to set at least two third-order accuracy vertical control points or benchmarks. The vertical control points shall have established Universal Transverse Mercator (UTM) coordinates (see section 7.2.2) and the elevations shall be referenced to NGVD.

If no benchmark is located in the site vicinity, an arbitrary temporary benchmark should be established on a permanent location, e.g., bridge wingwall, foundation, corner post, or a nail or spike in a tree or telephone pole. However, the elevation of the temporary benchmark (and, therefore all other points) should be determined at a later date. As with all Branch field work, the location of all benchmarks used shall be shown on the site sketch map and all field measurements shall be recorded in the field logbook as outlined in Section 3.5.

7.3.2 Equipment Available

The following Branch equipment is available for field use in conducting elevation surveys in support of site investigations:

Differential Leveling

- Lietz B2C, precision automatic level
- tripod
- telescoping level rod

Trigonometric Leveling

- Topcon GTS-2, total station theodolite/electronic distance meter (EDM)
- tripod(s)
- reflector prism(s)
- range pole
- steel tape
- compass

Barometric Leveling

- Micro M-1, American Pauli System altimeter

7.3.3 Specific Equipment Quality Control Procedures

All field surveying methods using Branch equipment shall be made only by those Branch personnel who have been trained to use them. All Branch professional staff and field technicians must be trained and checked out in surveying procedures by qualified staff before using this equipment.

Each piece of field equipment (as appropriate) shall be numbered, and a log book shall be kept containing all maintenance and calibrations made on the equipment. The following specific maintenance and calibration procedures shall be used for all surveying equipment:

7.3.3.1 Theodolite/EDM, Level and Altimeter -- This equipment shall:

- be serviced and calibrated by a qualified private service shop annually or sooner if damaged or suspected to be in error.
- be checked out using procedures outlined in basic surveying textbooks and appropriate users manuals before use (1, 2, 3).
- be cleaned and maintained using procedures outlined in basic surveying textbooks and appropriate users manuals during field use and before being returned to storage (1, 2, 3).

7.3.3.2 Level Rods, Range Poles, Reflector Prisms -- All of this equipment shall:

- be checked for warpage and/or damage before use by sighting through the theodolite/EDM and lining up the two vertical cross hairs on the rod(s). The poles/prisms are rotated at 90° intervals and the bullseye bubble is reset as appropriate.
- be checked for proper alignment of the reflector prism by comparing the measurement obtained with the EDM to the measurement obtained with an Invar steel surveyors chain (see Section 7.2.4.2).
- be cleaned daily after use and before being returned to storage. Level rods should be stored in carrying tubes or a cloth slip cover to protect markings.

7.3.3.3 Steel Tape -- The procedures found in Section 7.2.4.2 shall apply.

7.3.3.4 Compass -- All compasses shall:

- be checked for proper movement of the compass needle. If the compass needle movement is sluggish, the glass cover can be removed by prying a knife point under the spring washer. The copper wire on the needle is then moved until the needle lies level (3).
- be checked for proper alignment of the clinometer level. The clinometer is checked by setting the clinometer to 0, and placing the compass on a surface that has been leveled exactly with either a carpenters level or a water tube level. If the horizontal level bubble on the clinometer does not rest at the center, the compass is opened as described above and the clinometer level vial is moved and rechecked as appropriate. If the level vial becomes broken, the compass must be sent to the manufacturer to be repaired (3).
- be cleaned after use and before storage. If the compass should become wet, the compass is opened as described above and the interior is dried using a toothpick and a piece of soft cloth or soft paper. They should not be used, exposed to or stored in strong electrical fields (3).

7.3.4 Procedures for Differential Leveling

The level, or instrument, is set up by the instrument man at a location not more than 250 feet from the benchmark and at a height above the benchmark and the next point(s). The level is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads accordingly. Once the bullseye bubble is centered, the level is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The level is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman then holds the rod as plumb (vertical) as possible on the benchmark so the instrument man can read where the horizontal cross-hair in the telescope of the level intersects the graduations on the rod. The rodman "rocks" the rod in two planes, when instructed by the instrument man, to obtain a level reading. The rod is white with large red numbers which indicate the foot-marks and smaller black numbers which indicate the tenths of feet and has black graduations the entire length which indicate hundredths of feet. The instrument man sights through the telescope and takes the first rod reading which is called a backsight (denoted BS or + in the field log book). The backsight (+) reading added to the elevation of the benchmark gives the height of the level, or instrument, (denoted H.I. in the field log book). Next the rodman holds the rod on a point (called a turning point and denoted TP) of fixed but unknown elevation such as a nail in the ground, spike in a tree or telephone pole, or the top of a fire hydrant. The instrument man then takes his second rod reading which is called a foresight (denoted FS or - in the field log book). If the foresight (-) reading is subtracted from the H.I. the result is the elevation of the point. That is, the difference between the first reading obtained from the benchmark and the second reading obtained from the point is the difference in elevation between the point and the benchmark. Note that the distance between each sighted reading shall not ordinarily exceed 250 feet with turning point backsight and foresight distances deviating no more than 50 feet from one another.

The instrument man then goes ahead of the rodman, sets the level up as stated before and takes a rod reading (backsight) from the previous turning point. The rodman then moves ahead of the instrument man for a new turning point rod reading (foresight) and so forth until the desired final point is located vertically. Once the final point is located, the instrument man breaks the set up of the level (i.e., changes the H.I.) and relevels the level. The instrument man and rodman then run levels from the last or final point to the first point or benchmark. This is called making a closed circuit or closed level loop.

When practical, leveling should be conducted to form a closed circuit. That is, the level circuit or loop should close back in close agreement to a benchmark by within 0.02 foot of the original reading or third order accuracy whichever is greater. If the level circuit does not close within these limits of accuracy, then the level circuit must be repeated until this accuracy is attained. Third order accuracy is defined by the formula: 0.05 foot × ($\sqrt{}$number of miles run), which means for a one-mile level circuit, the closure should be within five hundredths of a foot. The following is an example of field notation for differential leveling:

EXAMPLE 1: Figure 7.3.1. Field notation for differential leveling.

01/22/90 Project 90E-000
Region IV Site Name
City, State

Landis Surveyor - ∓
Ben Chmark - ∤
Weather:60's overcast; 5-10mph NW

Station/ Point	+ or BS	H.I.	- or FS	ELEV.	Remarks
B.M. 523	6.13	25.69		19.560	Top of brass cap in concrete mon. marked B.M. 523 El.=19.560'
TP01	2.10	19.58	8.21	17.48	Set nail in ground
TP02			8.39	11.19	RR spike in tele. pole NW corn. Athens St. and Georgia Ave.
MW01			6.17	13.41	Top of casing for MW01
GS01			8.88	10.70	Ground shot at MW01
WSCS			12.13	7.45	Water surface of cyprus swamp
Weir 01			10.30	9.28	Invert of weir 01 south of plant
					(Break set up to run levels back)
TP02	7.89	19.08		11.19	RR spike in tele. pole NW corner Athens St. and Georgia Ave.
T.B.M.01	6.26	20.78	4.56	14.52	Set nail in 24" Oak for temporary bench mark 01
B.M. 523			1.23	19.55	Checked to BM 523 (Off -0.01')

7.3.5 Procedures for Trigonometric Leveling

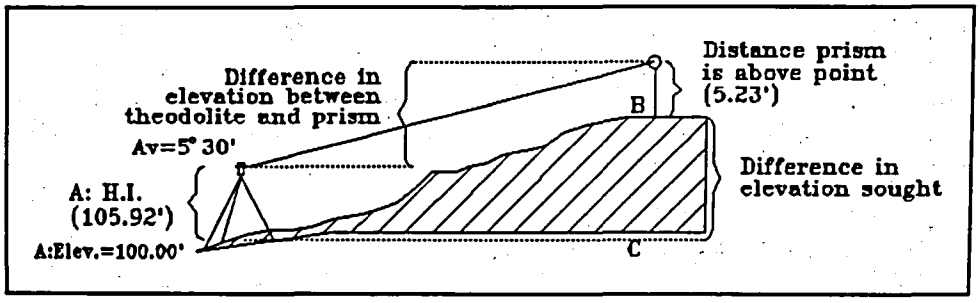
The total station theodolite, or instrument, is usually set up above a benchmark and the elevation of the instrument (H.I.) must be obtained. The theodolite is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads accordingly. Once the bullseye bubble is centered, the theodolite is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The instrument is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman has either a range pole equipped with a reflector prism (single or triple) or a tripod with the reflector prism. The prism is used to reflect the signal from the electronic distance meter in the total station theodolite. While located over the point(s) whose elevation is desired, the rodman holds the range pole level by means of centering the bullseye bubble, or sets up the tripod by means of centering the bullseye bubble with the three-screw leveling heads. The instrument man sights through the telescope on the theodolite, lines up the horizontal and vertical cross-hairs on the center of the prism and takes a reading of both the vertical angle (Av) and the distance to the prism. The difference in elevation between the theodolite and the prism is determined trigonometrically. A compass with a clinometer and a measuring tape could also be used for field measurements or as a map reference.

The following three examples graphically depict the distances that must be considered and accounted for when using the trigonometric leveling method to compute the vertical changes in elevation. The field notation for trigonometric leveling follows.

EXAMPLE 3: Figure 7.3.4. Elevation of point desired is below the instrument.

EXAMPLE 2: Figure 7.3.2. Elevation of point desired is above the instrument.



The elevation at point A in Figure 7.3.2 is 100.00 ft. The instrument is set up 5.92 ft. above point A which makes the height of the instrument (H.I.) 105.92 ft. Given a slope distance (Ds) shot to the prism (distance AB) of 323.88 ft. and a vertical angle (Av) of 5°30', the difference in elevation at point B is computed using the trigonometric formula:

elevation difference = distance AB × sin(Av)

The method described above only accounts for the relative difference in elevation between the theodolite (H.I.) and the center of the prism. The distance that the prism is held above the point in question must be subtracted from the resulting elevation of the prism to obtain the elevation of the point. Substituting in the trigonometric formula:

elevation difference = 323.88 ft. × sin(5°30') = 31.04 ft.

The elevation of point B is: 105.92 ft. + 31.04 ft. - 5.23 ft. = 131.73 ft.

Figure 7.3.3 Field notation for Example 2.

01/22/90 Project 90E-000
Region IV Site Name
City, State

Landis Surveyor - ∓
Ben Chmark - ∔
Weather:60's overcast; 5-10mph NW

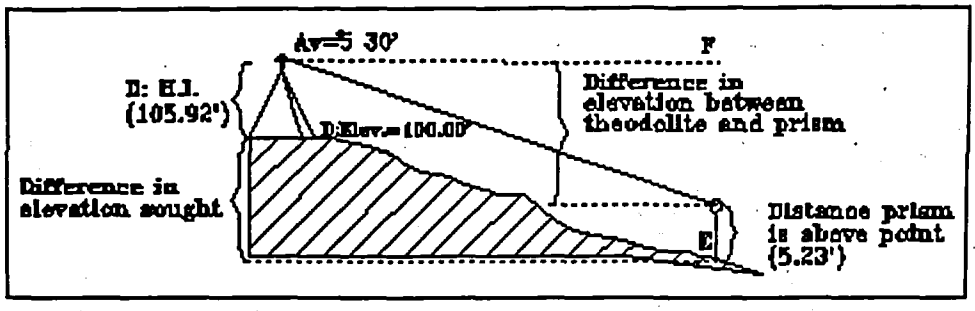
Station/ Point	+/Ds	H.I.	-/Av	ELEV.	Remarks
@ A	5.92	105.92		100.00	
Dist.A-B	323.88				
V. ∠BAC			5°30'		
@ B			5.23	131.73	

B
BC = AB × sin ∠BAC
= 323.88' × 0.0958
= 31.04'
A C

B=105.92'+ 31.04'- 5.23'= 131.73'

EXAMPLE 3: Figure 7.3.4. Elevation of point desired is below the instrument.

EXAMPLE 3: Figure 7.3.4. Elevation of point desired is below the instrument.



The elevation at point D in Figure 7.3.4 is 100.00 ft. The instrument is set up 5.92 ft. above point D which makes the height of the instrument (H.I.) 105.92 ft. Given a slope distance (Ds) shot to the prism (distance DE) of 323.88 ft. and a vertical angle (Av) of 5°30', the difference in elevation at point E is computed by substituting in the trigonometric formula:

elevation difference = 323.88 ft. × sin(5°30') = 31.04 ft.

The distance that the prism is held above the point in question must be subtracted from the resulting elevation of the prism to obtain the elevation of the point.

The elevation of point E is: 105.92 ft. - 31.04 ft. - 5.23 ft. = 69.65 ft.

Figure 7.3.5. Field notation for Example 3.

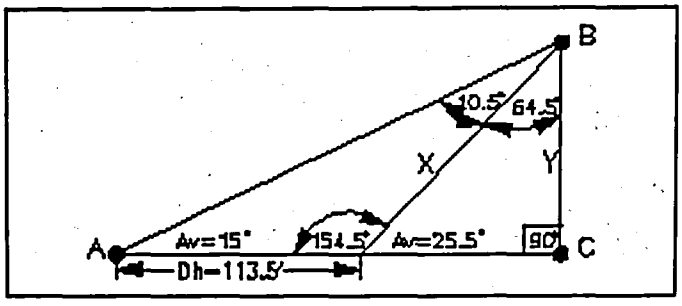
01/22/90 Project 90E-000
Region IV Site Name
City, State

Landis Surveyor - ⊤
Ben Chmark - ⊦
Weather:60's overcast; 5-10mph NW

Station/ Point	+/Ds	H.I.	-/Av	ELEV.	Remarks
@ D	5.92	105.92		100.00	D ——— F
Dist.D-E	323.88				EF = DE × sin ∠EDF
V. ∠EDF			5°30'		= 323.88' × 0.0958
					= 31.04'
@ E			5.23	69.65	E=105.92'- 31.04'- 5.23'= 69.65'

E

EXAMPLE 4: Figure 7.3.6. Spot elevation differences using the law of sines.



When the measurement of the slope distance is not possible, differences in elevation can be determined using the law of sines from trigonometry:

$$\frac{\sin\alpha}{a} = \frac{\sin\beta}{b} = \frac{\sin\gamma}{c} \quad \text{or} \quad \frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma}$$

Simple spot elevation differences can be determined by taking only a few measurements. The measurements can be obtained with the total station theodolite or by using a compass (equipped with a clinometer) and a measuring tape. In the above example (Figure 7.3.6), the vertical angle (Av) is measured at two locations and the horizontal distance (Dh) between those two measurements is also measured. Since the sum of the interior angles of each triangle should equal 180°, all the other interior angles are calculated. Substituting the measurements into the law of sines and solving for x and y shown in Figure

7.3.5.5:

$$\frac{x}{\sin 15^\circ} = \frac{113.5'}{\sin 10.5^\circ} \qquad \frac{y}{\sin 25.5^\circ} = \frac{161.36'}{\sin 90^\circ}$$

$$x = \frac{(\sin 15^\circ)\ 113.5'}{\sin 10.5^\circ} \qquad y = \frac{(\sin 25.5^\circ)\ 161.36'}{1}$$

$$x = 161.36' \qquad y = 69.4'$$

Note that the method described above only accounts for the relative difference in elevation between point A and the point in question, point B. If an instrument, such as a compass or theodolite, is used at point A, the H.I. at point A must be added to the resulting elevation of the point in question. The field notation would include the figure drawing, all field measurements, and all of the calculations.

7.3.6 Procedures for Barometric Leveling

An "aneroid barometer" or altimeter is an instrument that measures variations in atmospheric pressure. Because the pressure of the earth's atmosphere varies with height above sea level, a barometer could be used to measure the approximate differences in altitude or elevation. However, atmospheric pressure also varies with changes in temperature, humidity and regional or local pressure changes caused by weather conditions. The appropriate corrections for these changes in air column temperature, humidity, and barometric pressure must be applied where maximum accuracy is desired. Humidity corrections are normally negligible, and the additional readings to compensate for humidity are of questionable value. However, temperature and barometric corrections to the altimeter readings are necessary to obtain favorable results. A complete discussion of the altimeter observation corrections as well as the theory and general procedures used in reading the American Paulin System altimeter may be found in Precision Altimeter Survey Procedures - A Comprehensive and Authoritative Treatise on Modern Altimeter Surveys, by Dr. Robert A. Hodgson. The procedures contained herein have been paraphrased from this manual with permission from the American Paulin System.

There are two types of altimeters in common use for determining differences in elevation. They are the American Paulin System altimeter and the Wallace and Tiernan altimeter. The American Paulin System surveying altimeter, used by Branch personnel, offers excellent results when third order accuracy is not of prime importance. The Branch altimeter is graduated in one-foot increments and has an operating range of -1,000 feet to +5,000 feet of altitude. The altimeter is useful when it is desirable to measure differences in elevation on mountainous or wooded terrain; where the use of cumbersome surveying equipment is prohibitive; or, as a supplemental tool used in conjunction with other surveying equipment. The altimeter could also be useful when site specific geologic mapping is necessary. A compass could be used as a field measurement to map reference.

Although the altimeter is specially constructed for rugged field use, as with all sensitive Branch equipment, reasonable care should be exercised to prevent damage to the internal parts of the instrument. The following general procedures for the "single altimeter method with temperature and barometric corrections" should be followed when reading the altimeter and when recording and computing traverse data:

7.3.6.1 Reading the Altimeter

Procedure at the Base Station (See Figure 7.3.7.)

(1) Allow approximately 10 minutes for the altimeter to adjust to the ambient temperature. (Do not place altimeter in direct sunlight at any time. Use shading when possible.)

(2) Place altimeter on the base station (typically a benchmark or other point where the elevation has been previously determined).

(3) Level the altimeter by means of the bullseye bubble on the plastic window.

(4) Balance the altimeter by turning the large pointer knob at the center of the face of the altimeter. By using the reflecting mirror and reading directly above the Balance Indicator needle, the parallax in reading can be avoided.

Note: Always balance the instrument from the positive (+) side of the window. Make sure that the Balance Indicator needle covers its own image in the mirror.

(5) After the altimeter is balanced, the pointer may be set to the desired elevation (elevation of the base station benchmark) by raising and turning the Reset Control knob. While doing this, view the Pointer from directly above (a magnifying glass is provided) so that the sides of the knife edge are not visible when the pointer is directly above the engraved elevation mark.

(6) Record the elevation of the base station, temperature (to the nearest degree), and the time of the reading.

Procedure at Subsequent Stations

(1) Place altimeter at the next station point.

(2) Level the instrument (bullseye bubble).

(3) Balance the instrument using the large pointer knob. (Do not reset small knob).

(5) Record elevation, time, and temperature.

Note: (This procedure is continued at each station. The traverse is considered to be complete by returning to the base station or other benchmark).

7.3.6.2 Recording and Computing Altimeter Data

The American Paulin System altimeter is calibrated to measure true differences in altitude when used at a temperature of 50°F (assuming no change in barometric pressure). When the average temperature of two successive temperature readings fall above or below 50°F, it is necessary to apply a temperature correction to adjust the recorded differences in elevation that are a result of temperature change. The difference in altitude between two successive stations is recorded in the field book as positive when moving from a lower to a higher station (altitude) and negative when moving from a higher to a lower station (altitude). The temperature correction takes the same sign as the difference in altitude when the average temperature is above 50°F and will take the sign opposite the sign of the difference in altitude when the average temperature falls below 50°F.

Temperature corrections can be determined by referencing the tables or graph found in Dr. Hodgson's manual. The following formula may also be used to compute the percent adjustment due to temperature change:

$$\% = (T_1 + T_2 - 100) \times 0.102$$

Example: The temperatures recorded at two successive stations are 40°F and 41°F, respectively. The uncorrected difference in altitude between the two stations is 31 feet. Substituting in the percentage adjustment formula we get:

$$\% = (40 + 41 - 100) \times 0.102 = -1.938\%$$

By multiplying the uncorrected difference in altitude by the percentage factor, we get the temperature correction given in feet:

$$-0.0194 \times 31 \text{ ft.} = -0.6 \text{ ft. (temperature correction)}$$

After the altimeter readings are corrected for temperature, the change in barometric pressure that occurred during the time of the traverse must be applied. For Branch purposes, it will be assumed, that the rate of change of barometric pressure is constant. The change in barometric pressure that occurs

during the time of the traverse is taken to be the difference between the temperature corrected reading of the last station (benchmark or other point of known elevation) and the actual elevation of that last station or benchmark. To obtain the barometric correction (C_B) for each reading, the change in barometric pressure is divided by the number of minutes in the traverse. The barometric change per minute is obtained. By multiplying this factor by the number of minutes between each station, the amount of barometric change for each station is obtained.

Certain considerations should be taken into account when using the altimeter. A sudden change in weather conditions during the time of the traverse may affect the rate of change in the local barometric pressure which could lead to incorrect barometric corrections. A change in wind velocity and turbulence could also adversely affect the recording and, therefore, the barometric correction. Generally, good altimeter traverse results can be obtained during the early morning or late afternoon. Before starting the altimeter traverse, it is a good practice to check the altimeter at two or more base stations or bench marks. This is done to insure that the altimeter is in good working order, to be certain the proper procedures are being used, and to provide a background check on the local barometric conditions. The following is an example of field notation for the above described single altimeter method traverse:

EXAMPLE 5: Figure 7.3.8. Field notation for the single altimeter method.

01/22/90 Project 90E-000 | Landis Surveyor - ⊤
Region IV Site Name | Ben Chmark - ⊦
City, State | Weather: Clear; 0-5 mph NW

No.	Remarks	Time	Reading	T (°F)	▲ in Reading	Av. Σ of Temp.	Temp. %	Cor. Total	Adj. Reading	C_B	Elevation Comp.	Elevation Actual
▲-1	BM-ESD-IV Athens	07:30	747	40°								747
					+31	40.5°	-0.6					
◆-2	Top of waterfall	07:37	778	41°				-0.6	777.4	+2.9	780	
					+20	41.0°	-0.4					
◆-3	Invert culvert 4	07:45	798	41°				-1.0	797.0	+6.3	803	
					-93	41.5°	+1.6					
◆-4	Base of falls	07:55	705	42°				+0.6	705.6	+10.6	716	
					+27	42.5°	-0.4					
▲-1	BM-ESD-IV	08:05	732	43°				+0.2	732.2	+14.8		747
▲-1	BM-ESD-IV	08:15	747	45°								747
					-22	46°	+0.2					
◆-5	Epps Bridge	08:24	725	47°				+0.2	725.2	+2.2	727	
					-5	48°	+0.02					
◆-6	Weir W-2 invert	08:30	720	49°				+0.22	720.2	+3.6	724	
					+45	50°	0					
▲-4	BM-UGA-IV	08:37	765	51°				+0.22	765.2	+5.3	770	768
					+21	52°	+0.09					
◆-7	Athens airport 1	08:45	786	53°				+0.31	786.3	+7.2	793	
					-75	54°	-0.6					
◆-8	Oconee R. @ 441	08:56	711	55°				-0.29	710.7	+9.8	721	
					+24	55.5°	+0.3					
▲-9	BM-ESD-IV	09:05	735	56°				+0.01	735.0	+12.0		747

7.4 AERIAL IMAGERY

7.4.1 General

Aerial imagery is unique and distinct from the other field measurement tools and procedures discussed in this manual. However, it is frequently an invaluable supplement to field studies. It records a great deal of detail that can provide a guide for other field measurements as well as historical documentation of conditions at the time of acquisition.

Aerial imagery is obtained and interpreted using state-of-the-art techniques to the extent justifiable for the intended use. Photographic interpretation is by its nature, very subjective at times. When an interpretation is questionable, the opinions of several photographic analysts will be solicited. Environmental interpretation, where natural features have been slightly modified by man, is much more subjective than military interpretation, where definite, man-made features are sought out. Therefore, where environmental interpretations are not clear-cut, they should be used only as tentative findings to be further verified or modified by subsequent field investigations.

7.4.2 Litigation

Several limitations apply to photographic missions for the specific purpose of collecting evidence to be used in litigation.

- The military services cannot be used for such purposes (4).
- If a court injunction prohibiting trespassing is in effect against EPA, a search warrant must be obtained for the overflight.
- Even in the absence of a court injunction, if the case is in litigation or in the preparation for likely litigation, the Regional Counsel must be consulted for his/her recommendation on the need for a search warrant.

The following, more general-purpose imagery, can also be used in litigation, subject to the guidance of the Office of the Regional Counsel:

- Imagery or overlays prepared from imagery acquired by the military, or anyone else, for other purposes: i.e., for broad-area mapping or inventorying, routine missions clearly not connected with the litigation, etc.;
- Archival imagery antedating the litigation in question; and
- "Targets of opportunity," such as a stack putting up dense smoke, an unusual discharge from an outfall, etc., which are photographed while on a mission for another purpose or for general surveillance. (This is equivalent to stopping at the side of a road to photograph a suspected violation of any law.)

7.4.3 Access

All requests for aerial imagery and other remote sensing services shall be coordinated through the Regional Remote Sensing Coordinator as specified in the April 2, 1980, memorandum on this subject by the Deputy Regional Administrator (5). The coordinator shall make appropriate contacts with the Remote Sensing Branch, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada (EMSL-LV), with the Environmental Photographic Interpretation Center (EPIC), in Warrenton, Virginia, or with others as necessary; and the coordinator will arrange for direct follow-up contacts between the requestor and the group to provide the service if desired. All Enviropod activities will be under the administrative direction of the Regional Remote Sensing Coordinator. However, to the extent practical, efforts will be made to involve the user of the imagery in the missions for acquiring it.

Interpretation of photographs and other imagery within the Branch will be the responsibility of each individual program, although some limited assistance may be available from the Remote Sensing Coordinator. Requests for this service from groups outside the Region should be initiated as specified above.

7.4.4 Funding

In general, each program requesting remote sensing services will have to pay, from either national or regional funds, for necessary flight time, film and processing costs, and interpretation and preparation expenses. Costs can often be minimized by the Remote Sensing Coordinator by combining missions, locating archival imagery, and by using limited ORD support funds when available. The Remote Sensing Coordinator will arrange for cost estimates as needed.

7.4.5 Enviropod Procedures

The Enviropod will be installed and operated by personnel familiar with the detailed instructions prepared following the Enviropod Installation and Operations Course at EPIC (6). Mission planning will be done using appropriate nomograms supplied by EPIC or with the HP-97 Enviropod Program (7). All flight lines shall be logged on a data sheet. After exposure, film and log sheets should be promptly shipped to EPIC at Vint Hill Farms in Warrenton, VA, for processing.

7.4.6 Specific Quality Control Procedures for Aerial Imagery

All film is processed using the manufacturer's recommendations for temperature, time, and density of solutions. At the end of each Enviropod mission, approximately eight or ten frames will be exposed for trial development for EPIC to determine whether adjustments must be made in processing rates or temperatures to obtain a clear image. These will be noted on the log sheet with notes on lighting and weather conditions. Enviropod personnel at EPIC will be contacted before each mission (or monthly, whichever is less frequent) to determine current experience and recommend f-stop settings for various cloud covers and atmospheric conditions.

7.5 BATHYMETRY

7.5.1 Procedures

Recording fathometers are used to provide bathymetric traces of water depths. Because water depths are time dependent (especially in tidal areas), the date and time of all traces should be noted. Operation manuals provide operation and calibration procedures to be followed. In particular, tide and draft adjustments provide datum calibration in regard to the respective tidal amplitude and sensor probe depth. During the initial setup of each survey, the fathometer calibration should be checked against a field measurement of water depth made using a graduated sounding line. All traces should be noted with transect description, chart speed, direction of travel, and pertinent reference points and then indexed to a site map. When working in tidal areas, a water stage recorder (see Section 7.6) should be positioned to provide a histogram of water levels to correlate with the bathymetric trace.

7.5.2 Equipment Available

The following Branch equipment is available for bathymetric surveys:

- recording fathometers;
- water level recorder and/or referenced gaging station(s); and
- calibrated sounding line(s).

7.5.3 Specific Equipment Quality Control Procedures

All equipment used for bathymetric studies shall be numbered and a record shall be kept of all maintenance and calibration procedures. The following procedures shall be used to maintain and calibrate bathymetric measurement equipment.

7.5.3.1 Recording Fathometers -- These fathometers shall:

- Be calibrated and maintained according to the manufacturer's instructions before use. The chart speed should be checked against a reliable time source before the instrument is sent to the field;
- Be checked in the field against a field measurement of water depth utilizing a calibrated sounding line; and
- Be cleaned daily after use and prior to being stored.

7.5.3.2 Sounding Lines -- All sounding lines will be calibrated against a steel surveyors tape and shall be accurate ± 3 percent.

7.6 SURFACE WATER STAGE/TAPE DOWNS

7.6.1 Procedures

Water level recorders provide a time series record of water levels. Where possible, these instruments should be referenced to National Geodetic Vertical Datum (NGVD). All water level tracings should be noted with beginning and ending date and time, site location, stage scale, and time scale and initialed by the servicing Branch personnel. Standard USGS staff gages should be employed at each water level recorder site to provide a reference and check on the recorder trace. Water stage should be recorded to the nearest 0.01 foot where possible.

Tape downs provide instantaneous water stage as referenced to a known elevation. An engineering tape is fashioned with a plumb bob to measure from a bridge deck or other reference point to the water surface. The plumb bob provides weight for the tape as well as providing a discernible contact with the water surface. All measurements should be to the nearest 0.05 foot accompanied by a date, time, and station location. The exact reference or point from which a tape down is measured shall be permanently marked on the reference (wing wall or bridge rail by etching a reference with a chisel, etc.) and a complete description of the reference shall be made in the field records.

Both of these procedures (water stage and tape downs) are predicated upon accurate references to established measuring points. As mentioned above, the NGVD is an established datum that provides correlation of water surface recordings to engineering structures (bridge, wing walls, sea wall caps, clarifier cat walks, etc.). When recording water level dynamics in relation to a particular flow device, the datum is established in relation to the flow device reference point. Rectangular and V-notch weirs, for instance, are proportional to the water level referenced to the weir crest or, in the case of partially filled pipes, the flow rate is proportional to the depth of flow. Therefore, when employing a water level recorder or tape down on primary flow devices the reference or datum is the weir crest or in the case of pipes, the invert (see Section 5, Flow Measurement).

7.6.2 Equipment Available

The following Branch equipment is available for surface water stage/tape down measurements:

- Model F Stevens Stage Recorder(s);
- Model A-71 Stevens Stage Recorder(s);
- Model 1152 SSM ENDECO Stage Recorder(s);
- ISCO Flow Meter(s) and Recorder(s);
- USGS Staff Gage(s); and
- Weighted steel measuring tapes.

7.6.3 Specific Equipment Quality Control Procedures

A log book will be kept of all equipment used for making water stage/ tape down measurements. The following maintenance and calibration procedures shall be used and recorded in the log book for all equipment using for water stage and tape down measurements.

7.6.3.1 Stevens Model A-71 and Model F Stage Recorders -- These stage recorders shall:

- Be maintained according to the manufacturer's instructions. Once yearly, each unit shall be operated, and the time scale shall be adjusted to read within two percent of full scale. Once yearly, the recorders shall be bench checked by moving the recording mechanism vertically. The units must be accurate and record to within 0.01 foot of the Invar steel surveyor's chain.

- Be checked in the field by comparison with a staff gage. During field measurements, the vertical accuracy shall check within 0.05 foot, and

- Be cleaned and maintained before storage.

7.6.3.2 ENDECO Model 1152 SSM Stage Recorder(s) -- This instrument has no moving parts and uses solid state memory. In addition to water level data, the instrument also measures and stores conductivity and temperature data. The stage recorder shall:

- Be maintained according to manufacturer's instructions and checked in the field by comparison with a staff gage. The vertical accuracy shall check within 0.05 foot.

- Be within $\pm$ 0.55 m^2/cm and $\pm$ 0.2°C of prepared conductivity standards and an NBS thermometer, respectively.

- Be cleaned and maintained before storage.

7.6.3.3 ISCO 1870, 2870 Flow Meter and Recorder(s) -- See specific quality control procedures for this equipment in Section 5, Flow Measurement.

7.6.3.4 USGS Staff Gage(s) -- USGS staff gages shall:

- Be checked on receipt from the vendor. Any staff gage not accurate to within 0.01 foot when compared with the Invar steel surveyor's chain shall be discarded. Gages will be appropriately marked upon calibration.

- Be checked for damage, warpage, legibility, etc., before use. Any damaged or illegible staff gages shall be discarded.

- Be cleaned after use before being stored.

7.6.3.5 Weighted Steel Measuring Tapes -- Weighted steel measuring tapes shall:

- Be calibrated against the Invar steel surveyor's chain. The calibration shall be within 0.01 foot per 10 feet of length.

- Be checked for damage before use; damaged tapes shall be recalibrated or discarded.

- Be cleaned after use before being stored.

7.7 GROUND WATER LEVEL MEASUREMENT

7.7.1 General

The measurement of ground water level in wells is frequently conducted in conjunction with ground water sampling. Data from such measurements are needed to determine the "free" water surface and can be used to establish ground water flow direction and gradients. Specific techniques used by Branch personnel are presented in Appendix E.

Total well depth measurements, along with ground water level measurements, are necessary to determine the volume of water in a well casing prior to purging the well during ground water sampling.

All ground water level measurements, as well as total depth measurements, shall be made in reference to an established reference point on the well casing. This reference point shall be documented in field records. To be useful for establishing ground water gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. An arbitrary datum common to all wells in a group may be used for an isolated group of wells, if necessary.

7.7.2 Specific Ground Water Level Measuring Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods (8). Method accuracies are noted below for each of the specific methods described.

7.7.2.1 Popper or Bell Sounder -- A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight barely strikes the water. Measurements shall be recorded to the nearest 0.1 foot.

7.7.2.2 Weighted Tape -- This method is similar to the "bell sounder" method, except that any suitable weight, not necessarily one designed to create an audible pop, can be used to suspend the tape. The weight should, ideally, be made of a relatively inert material and should be easily cleaned. Measurements shall be made and recorded to the nearest 0.1 foot.

7.7.2.3 Chalked Tape -- Chalk rubbed on a weighted steel tape will discolor or be removed when in contact with water. Distance to the water surface can be obtained by subtracting the wet chalked length from the total measured length. The tape should be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. Measurements shall be made and recorded to the nearest 0.01 foot. This method is not recommended if samples are to be collected for analyses of organic or inorganic contaminants.

7.7.2.4 Electric Water Level Indicators -- This instrument consists of a spool of dual conductor wire, a probe attached to the end, and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter

light and/or buzzer attached to the spool will signal the contact. Penlight or 9-volt batteries are normally used for a power source. Measurements shall be made and recorded to the nearest 0.01 foot.

7.7.2.5 Other Methods -- There are other types of water level indicators and recorders available on the market such as the sliding float method, air line pressure method, and electrical and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells. Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot shall not be used.

7.7.3. Total Well Depth Measurement Techniques

The bell sounder, weighted tape, or electric water level indicators described in Section 7.7.2 can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well. Care must be taken in these situations to ensure accurate measurements. All total well depth measurements must be made and recorded to the nearest 0.1 foot.

7.7.4 Equipment Available

The following Branch equipment is available for ground water level and total well depth measurements:

- weighted steel measuring tapes, and
- electric water level indicators.

7.7.5 Specific Quality Control Procedures

All devices used to measure ground water levels shall be calibrated against the Invar steel surveyor's chain. These devices shall be calibrated to 0.01 foot per 10 feet length. Before each use, these devices shall be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. These devices should be decontaminated according to the procedures specified in Appendix B.7.1 prior to use at the next well. All calibration and maintenance data shall be recorded in a log book.

7.8 TIME-OF-TRAVEL

7.8.1 General

Three principal methods are used to determine travel time in streams, i.e., surface floats, measurements of cross sectional velocity, and tracers such as dye.

A very rough method for preliminary estimates of time-of-water travel con

sists of dropping sticks or other buoyant objects from bridges in the stream reach under observation, and noting the time required for them to float an estimated 10 feet or some other convenient distance. The velocity estimates are too inaccurate for use in interpretation of data or final reporting, but can be useful in preliminary planning of studies and in subsequent more precise measurements of time-of-water-travel.

Stream velocities at gaging stations, measured by the U. S. Geological Survey in developing rating curves, may be applied to the entire reach under observation to estimate time-of-water travel. This is somewhat more refined than the floating objects estimates, but can still be far from accurate. There rarely are more than one or two gaging stations in most stream reaches being studied. Stream channels generally are restricted at gaging stations and velocities there are generally higher than average velocities throughout the reach. Cross sectional velocities can also be determined at locations designated for a particular study.

Tracer dyes provide a direct and highly accurate method of determining time-of-travel. This is the preferred method if resources are available.

7.8.2 Procedures

7.8.2.1 Floats -- Surface floats may be followed downstream and timed for known distances to determine time-of-water-travel. This requires the use of considerable judgment, for floats tend to travel into quiet or eddy areas, or to become stuck on tree limbs, the stream bank, or other obstacles. The floats must frequently be retrieved and returned to the stream current. The principal judgment factors are how long the floats should be left in quiet areas before retrieval and where they should be placed in the current.

Surface water velocity is greater than the average for the entire stream, and a correction factor must be applied to the surface velocity. An average velocity of about 85 percent of that of the surface velocity is a reasonable rule-of-thumb value.

7.8.2.2 Cross Section Measurements -- The measurement of cross sectional velocities at frequent longitudinal intervals and the calculation of average velocity in the stream constitutes a time consuming method of obtaining time-of-water-travel.

The longitudinal intervals at which cross sections should be measured vary with the characteristics of the stream channel. One cross section per mile may be adequate for streams with reasonably uniform channels. Cross sections at every tenth of a mile may be desirable for streams with irregular channels.

Cross section measurement methods are described in detail in Section 5.

7.8.2.3 Tracers -- The most accurate method of measuring time-of-travel involves following a tracer. Some conservative industrial waste constituents, salt, or radioisotopes may serve as tracers; however, dye is most common. The most frequently used dye is Rhodamine WT that can be detected in concentrations as low as 0.01 ppb by a fluorometer.

Prior to injection into the stream, the concentrated dye should be diluted with the stream water. This will help insure immediate maximum dispersion. Addition of concentrated dye without dilution may result in incomplete dispersion, particularly in shallow streams. Calibration curves should be developed for each study with particular emphasis on accounting for natural background fluorescence.

The dye should be distributed across the stream at the upstream point, as nearly instantaneously as possible. The ideal distribution produces a narrow band of tracer in a uniform concentration across the stream. The band of tracer mixes with water ahead of and behind it by diffusion, or longitudinal mixing, as it moves downstream to produce an increasingly wider band. The peak concentration remains near, but somewhat downstream of, the center line of the band and decreases as longitudinal mixing proceeds. The times-of-water-travel to downstream points are the differences between the time the dye was added to the stream and the times the centroid of the dye mass arrives at downstream points. The length of the dye cloud and the peak concentrations produces a measure of instream dispersion.

If Rhodamine WT dye is used as the tracer, peak concentrations from 1.0 to 50 ppb allow satisfactory definition of the dye concentration curve.

Most methods of calculating the dosage of dye needed at the upstream point involve estimates of one or more stream characteristics, such as flow, velocity, length of reach, volume in the reach, cross-sectional area, average depth, and the roughness coefficient, "n", of Manning's formula. The USGS has produced excellent publications regarding to time-of-travel techniques, i.e., "Measurement of Time-of-Travel and Dispersion by Dye Tracing" (9) and "Fluorometric Procedures for Dye Tracing" (10).

The stream should be sampled frequently as the dye arrives at the downstream point to define the tracer concentration versus time curve with special emphasis on the peak. The frequency may be varied from once each minute to once every 10 to 15 minutes, depending on how wide the band of dye has become at the sampling point. The dye may be missed altogether by overestimating the time required for it to travel downstream. Much time may be wasted, on the other hand, waiting for it to arrive if the time-of-travel is underestimated. All information that will contribute to the best possible preliminary estimate of the time required should be used.

There are two primary methods by which the stream water can be sampled and analyzed for dye. A submersible pump can be used to pump dye continuously through a fluorometer or the stream samples can be grabbed (either by hand or by automatic sampler) at specified frequencies and then placed into the fluorometer individually. With the "flow-through" version, a strip chart recorder connected to the fluorometer can be used to plot the tracer concentration versus time. Readings directly from the fluorometer scale or conversion to dye concentration can be manually plotted against time when the grab sampling technique is used.

A version of the grab sampling technique would be to use an automatic water sampler which discharges into separate bottles. The sampler is pre-set to collect samples at certain intervals; at the end of the sample collection time,

the discrete samples shall be analyzed and the concentration determined for each. The concentrations are then plotted against time.

For proper determination of travel time, samples should continue to be analyzed until the stream background concentration following the peak is measured. With a time versus concentration plot from background level to peak to background level, the centroid, and thus actual travel time, can be determined.

The Water Supply Branch of the Water Management Division should be contacted prior to conducting tracer studies in freshwater systems to insure that tracer concentrations do not impart color to downstream public or private water supplies.

7.8.3 Equipment Available

The following Branch equipment is available for time-of-travel studies:

- fluorometers,
- tracer standards,
- automatic samplers,
- pumps,
- recorders,
- flow meters, and
- floats.

7.8.4 Specific Equipment Quality Control Procedures

All of the quality control procedures for equipment utilized in time-of-travel studies has been discussed in Section 4 (Sampling Procedures), 5 (Flow Measurement), or 6 (Field Analyses).

7.9 DILUTION STUDIES

7.9.1 Procedures

A great deal of the previous section (time-of-travel studies) applies to this section and USGS publications provide references to techniques, in particular "Measurement of Discharge by Dye-Dilution Methods" (11).

Dilution studies using tracer dyes evolve from "mass conservation" principles. That is, a known mass of tracer is introduced at an upstream point, and after mixing with the water to be traced, this mass should be accountable at downstream locations. Rhodamine WT provides an adequate tracer for such investigations. This dye is slightly photoreactive and reaction rates are available in the literature (generally K rate is 0.034/day). Other tracers either introduced into an upstream point or in some instances occurring at the upstream point are often used. The high degree of accuracy and detection ability of fluorometers plus the solubility properties of tracer dyes make them the technique of choice.

In dilution studies, the tracer dye is precisely metered into the waters to be traced and then monitored after mixing via a fluorometer at downstream

stations. This series of events requires highly controlled metering rates and very accurate fluorometric analyses. State-of-the-art fluorometers make the dilution study program a valuable assessment tool.

7.9.2 Equipment Available

The following Branch field equipment is available for dilution studies:

- fluorometer,
- metering pump,
- tracer standards, and
- pumps.

7.9.3 Specific Equipment Quality Control Procedures

See previous section. The metering pump shall be calibrated before and during use. Field calibration data shall be recorded in the field records.

The principal of superposition as developed by Kilpatrick and Yotsukura of the USGS is a reliable method to determine dilution levels of wastewaters in the receiving estuary (12). A tracer dye is metered into the wastewater stream during a tidal cycle. Successive slack tide measurements of dye concentrations in the estuary at selective distances from the outfall produce a series of concentration curves. By superposition, the accumulative concentration at each station provides a determination of the ultimate concentrations or steady-state concentration of a continuous discharge. By simple proportioning, with due regard to tracer photo decay, the dilution levels of the discharge can be produced for selective points in the estuary.

Calculation Procedure:

$$C_w = (C_t)(e^{kt})\left(\frac{Vw}{Vt}\right)$$

Where:

C_w = Ultimate concentration of wastewater at point of interest

C_t = Ultimate concentration of tracer (by superposition) at point of interest

e^{kt} = Photo decay of tracer

k = 0.034 tidal day

t = tidal days to ultimate concentration

Vw = Wastewater discharge per tidal day

Vt = Volume dye released in tidal day

For example:

Assume: C_t = 100 ppb

e^{kt} = 1.2 (ultimate concentration obtained in 5 tidal days

V_w = 100,000 gal/tidal day

V_t = 10 gal/for one tidal day

Then: C_w = 1,000,000 ppb
= 0.10% wastewater

Investigations of industrial and municipal facilities for NPDES permit compliance require measurements of discharge rates. Often encountered during these investigations are flow measuring devices such as orifices and magnetic meters which are inaccessible for measurements of flow by standard equations relating to hydraulic head and structure size. The following provides a direct technique for measurement of flow through the above devices using dye tracers.

Discharge rate through any structure can be defined by the following mass balance equation:

MASS BALANCE EQUATION

Q_2

$C^2 \ @ \ (Q_2+q_1)$

$q_1, \ @ \ C_1$

$(C_1) \ (q_1) = (C_2) \ (Q_2 + q_1)$

$$Q_2 = \frac{(C_1) \ (q_1) - (C_2) \ (q_1)}{C_2}$$

Where:

Q_2 = pipe flow rate

The following is brief description of the methods available and their applications.

7.10.3.1 Metal Detection -- Metal detectors are used to detect changes in electrical conductivity caused by the presence of metallic materials, both ferrous and non-ferrous. Metal detectors: (1) are limited to shallow depths (0 to 8 feet), (2) can detect large metallic objectives such as buried drums and metallic laden wastes, (3) are light weight and economical, and (4) are insensitive to soil moisture and small metallic objects.

7.10.3.2 Magnetometry -- Magnetometers are designed to detect and accurately measure changes in the earth's magnetic field. The major feature of the magnetometer is ease of operation and reliability.

The magnetometer's primary design function is detection of magnetic objects such as buried drums or large bodies of ore which alter the earth's magnetic field. Magnetometers should not be calibrated or used in or around buildings, near powerlines, or directly on the ground.

7.10.3.3 Electromagnetic Induction (EM) -- A transmitter induced coil directs induced current loops into the ground, which produce secondary fields. These secondary fields are then sensed or detected by the receiver coil, and then amplified and stored on a strip chart recorder or magtape, if desired.

EM instruments measure true soil conductivity in uniform, homogeneous subsurface conditions. EM units also measure apparent soil conductivity in layered soils.

Measurements can be obtained from depths to 60 meters with these instruments. EM units are very effective for rapid site reconnaissance and detection of buried drums, pipes, and metallic type conductors. EM's are not limited by frozen ground, or wet or dry soils.

7.10.3.4 Ground Penetrating Radar (GPR)

Ground penetrating radar (GPR) units radiate short duration electromagnetic pulses directly into the ground from an antenna near the surface. The pulses are reflected back to the receiver from subsurface structures and are plotted on a strip chart recorder.

The depth of GPR penetration is site specific ranging from as little as 3 feet in clay to as much as 100 feet in dry quartz sand. Depths are further reduced if ground water electrical conductivity is high. GPR may be useful in defining boundaries of buried trenches and other subsurface disturbances, but is difficult to use in silty or clay soils.

7.10.3.5 Seismic Refraction Devices (SRD)

Field operation is accomplished by transmitting sound waves into the ground by means of a sound source (hammer, drop weight, explosives, etc.). Reflected sound waves are then detected by receivers or geophones which automatically

translate them into electrical signals, which are recorded and displayed in graph form on a seismograph. Stratigraphic profiles can then be determined based on travel time of the sound waves through the different earth strata.

7.10.3.6 Resistivity

Resistivity is used to measure the electrical resistance of the soil, rock, and ground water. The resistivity method requires that a electrical current be injected into the ground through a pair of surface electrodes. The resulting potential field (voltage) is measured at the surface by a second pair of electrodes. The electrical current flows from the electrodes into the ground through the moisture-filled pore spaces in the soils and rocks. Resistivity is controlled by the amount of pore water present in the soil and rock strata. The resistivity method can be used to locate and map contaminant plumes, locate and define trenches, and determine natural geohydrologic conditions such as depth to ground water, and depth to bedrock. The resistivity method is limited in areas where soils contain little or no moisture, since dry soils will not permit current to flow. Very hard or compacted soils or frozen ground impede the use of resistivity because the electrodes cannot be driven into the ground. Resistivity surveys are costly and time consuming which make the resistivity method unfavorable for a short reconnaissance trip or a quick screening investigation.

7.10.3.7 Very Low Frequency (VLF) Ground Conductivity

The VLF instrument uses the magnetic components of the electromagnetic field generated by already-existing radio transmitters that use the VLF band (Very Low Frequency, 15-30 kHz). Such transmitters are now operating in a number of countries, and are used primarily for long-distance submarine communication.

Electrically conductive structures on the surface or underground, even when covered with thick overburden, locally affect the direction and strength of the field generated by the transmitted radio signal. A weak secondary field is generated around the geological structure, which is most commonly a water-filled fracture or ore body. This field is measured by the instrument. Different VLF instruments available vary in the degree of useful output produced by each instrument. Some merely quantify the secondary field measurement, while others provide real-time current density profiles and structure interpretation of identified anomalies.

7.10.3 Equipment Available

The following Branch equipment is available for geophysical studies:

- EM-31D Non-Contacting Terrain Conductivity Meter,
- Unimag II Portable Proton Magnetometer Model G-846,
- Pipe Seeker 5 metal detector, and
- ABEM Wadi VLF Instrument

7.10.4 Specific Equipment Quality Control Procedures

All geophysical instruments used by Hazardous Waste Section personnel or EPA contractors shall be calibrated in accordance with the manufacturers' specified calibration procedures, and shall only be calibrated by personnel that have been trained to do so. The calibration shall be checked periodically to insure accurate readings, especially on re-entering the study area after having left for a period of time. All calibration procedures and pertinent information shall be documented in the field logbook as outlined in Section 3.5.

Personnel using the geophysical equipment shall be trained in the use and maintenance of such equipment, and shall be able to interpret and present the gathered data in an easily understood manner in charts, graphs, maps, and formal reports. It is the responsibility of each Hazardous Waste Section project leader to insure that the personnel designated to use the geophysical equipment are qualified in the calibration and use of the equipment, and able to gather and interpret the data.

Training on the calibration and use of geophysical equipment that is currently available will be conducted by qualified Hazardous Waste Section personnel and will be given to all Hazardous Waste Section personnel during in-house training sessions scheduled throughout the year.

7.10.4.1 EM-31 Non-Contacting Terrain Conductivity Meter

7.10.4.1.1 Assembly and Calibration Procedure

- Align and connect transmitter tube to control box.
- Check batteries by setting mode switch to operate position and range switch to +B position and then to -B position. The needle should read in the battery mark. If not, replace batteries.
- Align and connect receiver tube to control box.
- Set range switch to 30 millimhos/meter position.
- Set mode switch to comp. position.
- Adjust meter to zero using coarse and fine comp. controls.
- Check phasing, set mode switch to phase position.
- Note meter reading.
- Rotate coarse control to original position. No further adjustments are needed.
- If there is a difference in meter readings, an adjustment is needed.

- Put coarse control in original position.
- Rotate phase potentiometer 1/4 turn clockwise and note meter reading.
- Rotate coarse control one step clockwise and note meter reading.
- If meter reading does not change, no further adjustment is needed. Return coarse control to original position.
- If meter reading changes - repeat above adjustments until meter reading remains the same when coarse control is rotated one step clockwise.
- Meter should read between 75 - 85 percent of full scale (in Black Mark).
- Return coarse control to original position.
- EM-31 is ready for operation!

Note: When calibrating the EM-31 over ground with higher conductivity than 30 millimhos/meter, the range switch should be set at the appropriate range level.

7.10.4.1.2 EM-31 Operating Procedure - Measuring Soil Conductivity

- Adjust the shoulder strap so that the instrument rests comfortably on the hip.
- Switch the mode switch to OPER position and rotate range switch so that meter reads in upper 2/3 of the scale.
- EM-31 can be operated continuously while moving from one measuring station to the other or the EM-31 can be turned off while walking from station to station and then turned on when taking a reading. The latter saves battery life.
- Dismantle EM-31 and clean before storage.

7.10.4.1.3 EM-31 Operating Procedure - Buried Metal Detection

- Set the mode switch to the COMP position.
- Set the range switch to 30 millimhos/meter.
- Adjust the COARSE and FINE compensation controls so that a meter deflection of about 20 percent of full scale is obtained.

- Operate the EM-31 while continuously moving to determine the exact location of the buried objects.

- Dismantle EM-31 and clean before storage.

7.10.4.2 Unimag II Portable Proton Magnetometer Model G-846

7.10.4.2.1 Calibration and Operating Procedure

The Unimag II is completely self-contained and ready for field operation. A few simple procedures should be observed to obtain optimum results.

- Check the sensor for sensor fluid: Shake the instrument gently and listen for a "sloshing" sound. If the fluid is not present or cannot be heard, it will be necessary to fill the sensor with strained kerosene or unleaded gasoline. This procedure is outlined in the operator's manual furnished with the instrument.

- Check the battery: Simply depress the black push bottom and observe the readout. If the readout flashes on/off during the display period, the battery is not fully charged. Refer to the operators manual for battery recharging instructions.

- Lift the Unimag II out of the carrying case and adjust the shoulder strap for a comfortable fit.

- Adjust the "tuning-kilograms" knob to a position that correlates with the earth's magnetic field. The earth's field can be estimated by referring to the world intensity map located in front of the operators manual.

- Depress the black button on top of the instrument and release. The center digit on the readout will, briefly flash. This indicates that the cycle has started. It will take two seconds for the display to illuminate and give the earth's magnetic field in gammas.

- When operating, hold the Unimag II waist high. When depressing black button for reading, hold instrument as still as possible.

- The instrument should exhibit one count stability. If one count stability is not possible, a ferromagnetic object is present or a steep magnetic gradient is being encountered. Verify the one count stability by repeating the measurement with the instrument held in the same position.

  Note: If the earth's magnetic field is 40,000 gammas or less (low magnetic latitudes-equator area), the sensor should be rotated 90°. See operator's manual for the correct procedure. The sensor rotation

is not necessary in Region IV. If problems arise with the instrument, refer to the operator's manual.

- Do not operate the Unimag II in buildings, near high energy sources (powerlines, etc.), or directly on the ground. Hold instrument waist high. Do not wear magnetic objects such as jewelry, keys, watches, zippers, pocket knives, belt buckles, etc.

- Become familiar with the instrument and it's operation before attempting a field survey.

7.10.4.3 Metal Detector - The Tracer Metallic Pipe & Liner Locator

This instrument is a very sensitive piece of equipment and has to be fine tuned (nulled) in order to detect buried objects. The operators's manual should be read and understood before any field operation is attempted.

7.10.4.3.1 Operating Procedure

- Test the battery voltage on the transmitter and receiver (refer to the instructions in the operators manual). Make sure that batteries are fully charged.

- Assembly of the transmitter to the receiver should be accomplished according to the instructions in the operator's manual.

- Null the instrument prior to use. "Nulling" should take place in an area similar to the area of concern but where there are no buried metal objects. Refer to the instructions.

- Practical with the instrument over objects of known size and depth.

- For highest sensitivity, adjust the sensitivity control for an approximately half scale meter reading with the instruments nulled.

- Store instrument in a secure, dry place when not in use.

7.10.4.4 ABEM Wadi VLF Instrument

See owners manual for detailed instructions. The following is a summary of the basic steps for routine operation of the Wadi for site reconnaissance for location of water-filled fractured geologic terrain.

7.10.4.4.1 Operating Procedure

- Turn instrument on.

- Select suitable transmitter. Face the direction of anticipated profile and press STATION key. Wadi will display current radio frequency and signal strength indicator. Turn 360 degrees and observe the indicator. The length of the bar should be longest (or more nearly so) when facing the direction of the profile. If not, and if the numerical value displayed with the bar is less than 10 or greater than 50, a new transmitter must be selected. If a new transmitter is required, enter 0, 0, 0, and press the STATION key again. After about three minutes a frequency scan will appear. After the scan is completed, select strongest signal with large arrows on key pad and check for orientation of transmitter, as before.

- Select profile start point and specify grid. Press COORDINATE key and select starting coordinate, profile separation, and measurement separation distance.

- Conduct measurements along profile. Press MEASURE key. Wait for prompt to press MEASURE key again. Observe inclinometer in lower right portion of screen. A straight line is best, although measurements can be obtained with the open-carrot symbol. If inclination of antenna is too great, instrument will not measure and will indicate this condition. Re-orient antenna and try again. Remain steady while Wadi conducts measurement. Move to next measurement point and conduct next measurement.

- For any additions profiles in the same grid, using large arrows, make turn as required at end of each profile to continue measurements along successive profiles. Wadi automatically stores data for proper interpretation.

- To interpret any anomaly identified on profile, press MEASUREMENT key once and, using small arrows, move cursor to top of selected anomaly. Press INTERPRETATION key. After several seconds, interpretation will appear above anomaly. Identical vertical and horizontal scales allow for estimates to be made of depth of anomaly.

7.11 REFERENCES

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2. Breed, C. B., and G. L. Hosmer, The Principles and Practices of Surveying Volume II, Higher Surveying, Eighth Edition, John Wiley and Sons, Inc.: New York, New York.

3. Compton, R. R., Manual of Field Geology, John Wiley and Sons, Inc.: New York, New York.1.

4. 18 U.S.C. Section 1385 provides, in pertinent part, "whoever, except in

cases and under circumstances expressly authorized by the Constitution or Art of Congress, willfully uses any part of the Army or Air Force ... to execute the laws of the United States shall be fined not more than $10,000 or imprisoned not more than two (2) years, or both."

5. Little, J. A., "Coordination of Remote Sensing Activities". (a memorandum to all Division Directors in Region IV), April 2, 1980.

6. Vick H. C., "Detailed Instructions on Enviropod Preparation, Installation and Usage," 1978.

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9. Kilpatrick, F. A., L. A. Martens, and J. F. Wilson, "Measurement of Time of Travel and Dispersion by Dye Tracing," Chapter A9, Applications of Hydraulics, Book 3, United States Geological Survey, 1968.

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11. Cobb, E. D. and J. F. Bailey, "Measurement of Discharges by Dye-Dilution Methods," Chapter 14, Hydraulic Measurement and Computation Book 1, United States Geological Survey, 1965.

12. "Tracer Simulation of Soluble Waste Concentrations," Journal of the Environmental Engineering Division, Proceedings of the ASCE, Volume 99, No. EE4, August 1973.

REFERENCE 25

DRINKING WATER REGULATIONS

AND HEALTH ADVISORIES

by

Office of Drinking Water
U.S. Environmental Protection Agency
Washington, D.C.
202-382-7571

SAFE DRINKING WATER HOTLINE
1-800-426-4791 (Toll-Free)
202-382-5533 (Washington, D.C.)
Monday thru Friday, 8:30 AM to 4:30 PM EST

November 1990

LEGEND

Abbreviations column descriptions are:

MCLG - Maximum Contaminant Level Goal. A non-enforceable concentration of a drinking water contaminant that is protective of adverse human health effects and allows an adequate margin of safety.

MCL - Maximum Contaminant Level. Maximum permissible level of a contaminant in water which is delivered to any user of a public water system.

RfD - Reference Dose. An estimate of a daily exposure to the human population that is likely to be without appreciable risk of deleterious effects over a lifetime.

DWEL - Drinking Water Equivalent Level. A lifetime exposure concentration protective of adverse, non-cancer health effects, that assumes all of the exposure to a contaminant is from a drinking water source.

(*) The codes for the Status Reg and Status HA columns are as follows:

F - final
D - draft
L - listed for regulation
P - proposed (Phase II and V draft proposals)

Other codes found in the table include the following:

NA - not applicable
PS - performance standard 0.5 NTU - 1.0 NTU
TT - treatment technique

** - No more than 5% of the samples per month may be positive. For systems collecting fewer than 40 samples/month, no more than 1 sample per month may be positive.

*** - guidance

- Large discrepancies between Lifetime and Longer-term HA values may occur because of the Agency's conservative policies, especially with regard to carcinogenicity, relative source contribution, and less than lifetime exposures in chronic toxicity testing. These factors can result in a cumulative UF (uncertainty factor) of 10 to 1000 when calculating a Lifetime HA.

DRINKING WATER STANDARDS AND HEALTH ADVISORIES

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
ORGANICS													
Acenaphthylene	-	-	-	-	-	-	-	-	60	-	-	-	-
Acifluorfen	-	-	-	F	2000	2000	100	400	13	400	-	100	B2
Acrylamide	P	zero	TT	F	1500	300	20	70	0.2	7	-	1	B2
Acrylonitrile	L	-	-	D	20	20	1	4	0.1	4	-	7	B1
Adipates (diethylhexyl)	P	500	500	-	-	-	-	-	700	20000	500	-	C
Alachlor	P	zero	2	F	100	100	-	-	10	400	-	40	B2
Aldicarb	P	10	10*	F	-	-	-	-	1.3	40	10	-	D
Aldicarb sulfone	P	40	40*	F	-	-	-	-	6.0	200	40	-	D
Aldicarb sulfoxide	P	10	10*	F	-	-	-	-	1.3	40	10	-	D
Aldrin	-	-	-	D	0.3	0.3	0.3	0.3	0.03	1	-	0.2	B2
Ametryn	-	-	-	F	9000	9000	900	3000	9	300	60	-	D
Ammonium Sulfamate	-	-	-	F	20000	20000	20000	80000	250	8000	2000	-	D
Anthracene (PAH)	L	-	-	-	-	-	-	-	300	-	-	-	D
Atrazine	P	3	3	F	100	100	50	200	5	200	3	-	C
Baygon	-	-	-	F	40	40	40	100	4	100	3	-	C
Bentazon	-	-	-	F	300	300	300	900	2.5	90	20	-	D
Benz(a)anthracene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2
Benzene	F	zero	5	F	200	200	-	-	-	-	-	100	A
Benzo(a)pyrene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2*
Benzo(b)fluoranthene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2
Benzo(g,h,i)perylene (PAH)	P	-	-	-	-	-	-	-	-	-	-	-	D
Benzo(k)fluoranthene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2
bis-2-Chloroisopropyl ether	-	-	-	F	4000	4000	4000	13000	40	1000	300	-	-
Bromacil	-	-	-	F	5000	5000	3000	9000	130	5000	90	-	C
Bromobenzene	-	-	-	D	-	-	-	-	-	-	-	-	-

* Under review.

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Ca Gr
Bromochloroacetonitrile	L	-	-	D	-	-	-	-	-	-	-	-	
Bromochloromethane	-	-	-	D	50000	1000	1000	5000	13	500	90	-	
Bromodichloromethane (THM)	L	-	-	D	7000	7000	400	1300	20	600	-	30	B
Bromoform (THM)	L	-	-	D	5000	2000	2000	6000	20	600	-	-	B
Bromomethane	-	-	-	F	100	100	100	500	1	50	10	-	
Butyl benzyl phthalate (PAE)	P	zero	4	-	-	-	-	-	200	-	-	-	
Butylate	-	-	-	F	2000	2000	1000	4000	50	2000	350	-	
Butylbenzene n-	-	-	-	D	-	-	-	-	-	-	-	-	
Butylbenzene sec-	-	-	-	D	-	-	-	-	-	-	-	-	
Butylbenzene tert-	-	-	-	D	-	-	-	-	-	-	-	-	
Carbaryl	-	-	-	F	1000	1000	1000	1000	100	4000	700	-	
Carbofuran	P	40	40	F	50	50	50	200	5	200	40	-	
Carbon Tetrachloride	F	zero	5	F	4000	200	70	300	0.7	30	-	30	B
Carboxin	-	-	-	F	1000	1000	1000	4000	100	4000	700	-	
Chloral Hydrate	L		-	D	7000	1000	200	600	2	60	50	-	
Chloramben	-	-	-	F	3000	3000	200	500	15	500	100	-	
Chlordane	P	zero	2	F	60	60	-	-	0.06	2	-	3	B
Chlorodibromomethane (THM)	L	-	-	D	7000	7000	2000	8000	20	800	20	-	
Chloroethane	L	-	-	D	-	-	-	-	-	-	-	-	
Chloroform (THM)	L	-	-	D	4000	4000	100	500	10	500	-	600	
Chloromethane	L	-	-	D	9000	400	400	1000	4	100	3	-	
Chlorophenol (2-)	L	-	-	D	50	50	50	200	5	200	40	-	
p-Chlorophenyl methyl sulfide/sulfone/sulfoxide	D	-	-	-	-	-	-	-	-	-	-	-	
Chloropicrin	L	-	-	-	-	-	-	-	-	-	-	-	
Chlorothalonil	-	-	-	F	200	200	200	500	15	500	-	150	
Chlorotoluene o-	L	-	-	F	2000	2000	2000	7000	20	700	100	-	
Chlorotoluene p-	L	-	-	F	2000	2000	2000	7000	20	700	100	-	
Chlorpyrifos	-	-	-	D	30	30	30	100	3	100	20	-	
Chrysene (PAH)	-	zero	0.2	-	-	-	-	-	-	-	-	-	
Cyanazine	L	-	-	F	100	100	20	70	2	70	10	-	

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	10-kg Child: Ten-day µg/l	10-kg Child: Longer-term µg/l	70-kg Adult: Longer-term µg/l	70-kg Adult: RfD µg/kg/day	70-kg Adult: DWEL µg/l	70-kg Adult: Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Cyanogen Chloride	L	-	-	-	-	-	-	-	-	-	-	-	-
Cymene p-	-	-	-	D	-	-	-	-	-	-	-	-	-
2,4-D	P	70	70	F	1000	300	100	400	10	400	70	-	D
DCPA (Dacthal)	-	-	-	F	80000	80000	5000	20000	500	20000	4000	-	D
Dalapon	P	200	200	F	3000	3000	300	900	26	900	200	-	D
Dichloroethylene (cis-1,2-)	P	70	70	F	4000	1000	3500	11000	10	400	70	-	D
Dichloroethylene (trans-1,2-)	P	100	100	F	20000	2000	2000	6000	20	600	100	-	D
Dichlorophenol (2,4-)	L	-	-	D	30	30	30	100	3	100	20	-	D
Diazinon	-	-	-	F	20	20	5	20	0.09	3	0.6	-	E
Dibenz(a,h)anthracene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	B2
Dibromoacetonitrile	L	-	-	D	2000	2000	2000	8000	20	800	20	-	C
Dibromochloropropane (DBCP)	P	zero	0.2	F	200	50	-	-	-	-	-	3	B2
Dibromomethane	L	-	-	-	-	-	-	-	-	-	-	-	D
Dibutyl phthalate (PAE)	P	zero	4	-	-	-	-	-	100	-	-	-	D
Dicamba	L	-	-	F	300	300	300	1000	30	1000	200	-	D
Dichloroacetaldehyde	L	-	-	D	-	-	-	-	-	-	-	-	-
Dichloroacetic acid	L	-	-	D	50000	50000	500	2000	5	200	3	-	C
Dichloroacetonitrile	L	-	-	D	1000	1000	800	3000	8	300	6	-	C
Dichlorobenzene p-	F	75	75	F	10000	10000	10000	40000	100	4000	75	-	C
Dichlorobenzene o-,m-	P	600	600	F	9000	9000	9000	30000	89	3000	600	-	D
Dichlorodifluoromethane	-	-	-	F	40000	40000	9000	30000	200	5000	1000	-	D
Dichloroethane (1,1-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Dichloroethane (1,2-)	F	zero	5	F	700	700	700	2600	-	-	-	40	B2
Dichloroethylene (1,1-)	F	7	7	F	2000	1000	1000	4000	9	400	7	-	C
Dichloromethane	P	zero	5	F	10000	2000	-	-	60	2000	-	500	B2
Dichloropropane (1,1-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropane (1,2-)	P	zero	5	F	-	-	-	-	-	-	-	50	B2
Dichloropropane (1,3-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropane (2,2-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropene (1,1-)	L	-	-	D	-	-	-	-	-	-	-	-	-

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Dichloropropene (1,3-)	L	-	-	F	30	30	30	100	0.3	10	-	20	B2
Dieldrin	L	-	-	F	0.5	0.5	0.5	2	0.05	2	-	0.2	B2
Diethyl phthalate (PAE)	P	zero	4	D	-	-	-	-	800	-	-	-	D
Diethylhexyl phthalate (PAE	P	zero	4	D	-	-	-	-	20	-	-	300	B2*
Diisopropyl methylphosphonate	-	-	-	F	8000	8000	8000	30000	80	3000	600	-	D
Dimethrin	-	-	-	F	10000	10000	10000	40000	300	10000	2000	-	D
Dimethyl methylphosphonate	-	-	-	D	-	-	-	-	-	-	-	-	-
Dimethyl phthlate (PAE	P	zero	4	-	-	-	-	-	-	-	-	-	D
1,3-Dinitrobenzene	-	-	-	D	40	40	40	140	0.1	5	1	-	D
Dinitrotoluene (2,4-)	L	-	-	D	-	-	-	-	-	-	-	-	-
2,4-/2,6-Dinitrotoluene	-	-	-	D	-	-	-	-	-	-	-	-	-
Dinoseb	P	7	7	F	300	300	10	40	1	40	7	-	D
Dioxane p-	-	-	-	F	4000	400	-	-	-	-	-	700	B2
Diphenamid	-	-	-	F	300	300	300	1000	30	1000	200	-	D
Diquat	P	20	20	-	-	-	-	-	2.2	-	-	-	D
Disulfoton	-	-	-	F	10	10	3	9	0.04	1	0.3	-	E
1,4-Dithiane	-	-	-	D	-	-	-	-	-	-	-	-	-
Diuron	-	-	-	F	1000	1000	300	900	2	70	10	-	D
Endothall	P	100	100	F	800	800	200	200	20	700	100	-	D
Endrin	P	2	2	F	20	20	3	10	3	9	2	-	D
Epichlorohydrin	P	zero	TT	F	100	100	70	70	2	70	-	400	B2
Ethylbenzene	P	700	700	F	30000	3000	1000	3000	100	3000	700	-	D
Ethylene dibromide (EDB)	P	zero	0.05	F	8	8	-	-	-	-	-	0.04	B2
Ethylene glycol	-	-	-	F	20000	6000	6000	20000	2000	40000	7000	-	D
ETU	L	-	-	F	300	300	100	400	0.03	1	-	6	B2
Fenamiphos	-	-	-	F	9	9	5	20	0.25	9	2	-	D
Fluometuron	-	-	-	F	2000	2000	2000	5000	13	400	90	-	D
Fluorene (PAH)	P	zero	0.2	-	-	-	-	-	40	-	-	-	D
Fluorotrichloromethane	-	-	-	F	7000	7000	3000	10000	300	10000	2000	-	D
Fog Oil	-	-	-	D	-	-	-	-	-	-	-	-	-

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Fonofos	-	-	-	F	20	20	20	70	2	70	10	-	D
Formaldehyde	-	-	-	D	10000	5000	5000	20000	150	5000	1000	-	B1-Inhal
Gasoline	-	-	-	D	-	-	-	-	-	-	5(benzene)	-	-
Glyphosate	P	700	700	F	20000	20000	1000	1000	100	4000	700	-	D
Heptachlor	P	zero	0.4	F	10	10	5	5	0.5	20	-	0.8	B2
Heptachlor epoxide	P	zero	0.2	F	10	-	0.1	0.1	0.013	0.4	-	0.4	B2
Hexachlorobenzene	P	zero	1	F	50	50	50	200	0.8	30	-	2	B2
Hexachlorobutadiene	-	-	-	F	300	300	100	400	2	70	1	-	C
Hexachlorocyclopentadiene	P	50	50	-	-	-	-	-	7	200	-	-	D
Hexachloroethane	-	-	-	D	5000	5000	100	500	1	40	1	-	C
Hexane (n-)	-	-	-	F	10000	4000	4000	10000	-	-	-	-	D
Hexazinone	-	-	-	F	3000	3000	3000	9000	30	1000	200	-	D
HMX	-	-	-	F	5000	5000	5000	20000	50	2000	400	-	D
Hypochlorite	L	-	-	-	-	-	-	-	-	-	-	-	-
Hypochlorous acid	L	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3,-c,d)pyrene (PAH)	P	zero	0.2	D	-	-	-	-	-	-	-	-	B2
Isophorone	L	-	-	D	15000	15000	15000	15000	200	7000	100	-	C
Isopropyl methylphosphonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopropylbenzene	-	-	-	D	-	-	-	-	-	-	-	-	-
Lindane	P	0.2	0.2	F	1000	1000	30	100	0.3	10	0.2	-	C
Malathion	-	-	-	D	200	200	200	800	20	800	200	-	D
Maleic hydrazide	-	-	-	F	10000	10000	5000	20000	500	20000	4000	-	D
MCPA	-	-	-	F	100	100	100	400	1.5	53	11	-	E
Methomyl	-	-	-	F	300	300	300	300	25	900	200	-	D
Methoxychlor	P	400	400	F	6000	2000	500	2000	50	2000	400	-	D
Methyl ethyl ketone	-	-	-	F	80000	8000	3000	9000	25	900	200	-	D
Methyl parathion	-	-	-	F	300	300	30	100	0.25	9	2	-	D
Methyl tert butyl ether	L	-	-	D	3000	3000	500	2000	5	200	40	-	D
Metolachlor	L	-	-	F	2000	2000	2000	5000	150	5000	100	-	C
Metribuzin	L	-	-	F	5000	5000	300	900	25	900	200	-	D

	Standards				Health Advisories								
					10-kg Child			70-kg Adult					
Chemicals	Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Status HA*	One-day µg/l	Ten-day µg/l	Longer-term µg/l	Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Monochloroacetic acid	L	-	-	D	-	-	-	-	-	-	-	-	-
Monochlorobenzene	P	100	100	F	2000	2000	2000	7000	20	700	100	-	D
Naphthalene	-	-	-	D	500	500	400	1000	4	100	20	-	D
Nitrocellulose (non-toxic)	-	-	-	F	-	-	-	-	-	-	-	-	-
Nitroguanidine	-	-	-	F	10000	10000	10000	40000	100	4000	700	-	D
Nitrophenols p-	-	-	-	D	800	800	800	3000	8	300	60	-	D
Oxamyl (Vydate)	P	200	200	F	200	200	200	900	25	900	200	-	E
Ozone by-products	L	-	-	-	-	-	-	-	-	-	-	-	-
Paraquat	-	-	-	F	100	100	50	200	4.5	200	30	-	E
Pentachloroethane	-	-	-	D	-	-	-	-	-	-	-	-	-
Pentachlorophenol	P	200/zero	200/0.1*	F	1000	300	300	1000	30	1000	-	30	B2
Phenanthrene (PAH)	P	zero	0.2	-	-	-	-	-	-	-	-	-	-
Phenol	-	-	-	D	6000	6000	6000	20000	600	20000	4000	-	D
Picloram	P	500	500	F	20000	20000	700	2000	70	2000	500	-	D
Polychlorinated byphenyls (PCBs)	P	zero	0.5	P	-	-	-	-	-	-	-	0.5	B2
Prometon	-	-	-	F	200	200	200	500	15	500	100	-	D
Pronamide	-	-	-	F	800	800	800	3000	75	3000	50	-	C
Propachlor	-	-	-	F	500	500	100	500	13	500	90	-	D
Propazine	-	-	-	F	1000	1000	500	2000	20	700	10	-	C
Propham	-	-	-	F	5000	5000	5000	20000	20	600	100	-	D
Propylbenzene n-	-	-	-	D	-	-	-	-	-	-	-	-	-
Pyrene (PAH)	P	zero	0.2	-	-	-	-	-	30	-	-	-	D
RDX	-	-	-	F	100	100	100	400	3	100	2	30	C
Simazine	P	1	1	F	500	500	50	200	2	60	1	-	C
Styrene	P	zero/100	5/100*	F	20000	2000	2000	7000	200	7000	0/100	1	B2/C
2,4,5-T	L	-	-	F	800	800	800	1000	10	350	70	-	D
2,3,7,8-TCDD (Dioxin)	P	zero	$5x10^{-8}$mg/L	F	0.0011	E-04	1E-05	4E-05	1E-06	4E-05	-	2E-05	B2
Tebuthiuron	-	-	-	F	3000	3000	700	2000	70	2000	500	-	D
Terbacil	-	-	-	F	300	300	300	900	13	400	90	-	E
Terbufos	-	-	-	F	5	5	1	5	0.13	5	0.9	-	D

Under review.

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Tetrachloroethane (1,1,1,2-)	L	-	-	F	2000	2000	900	3000	30	1000	70	100	C
Tetrachloroethane (1,1,2,2-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Tetrachloroethylene	P	zero	5	F	2000	2000	1000	5000	10	500	-	70	B2
Toluene	P	2000	2000*	F	20000	3000	3000	10000	100	5	1000	-	D
Toxaphene	P	zero	5*	F	500	40	-	-	100	3.5	-	3	B2
2,4,5-TP	P	50	50	F	200	200	70	300	7.5	300	50	-	D
1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroacetic acid	L	-	-	D	30000	30000	30000	100000	300	10000	200	-	C
Trichloroactonitrile	L	-	-	D	50	50	-	-	-	-	-	-	-
Trichlorobenzene (1,2,4-)	P	9	9	F	100	100	100	500	1	50	9	-	D
Trichlorobenzene (1,3,5-)	-	-	-	F	600	600	600	2000	6	200	40	-	D
Trichloroethane (1,1,1-)	F	200	200	F	100000	40000	40000	100000	35	1000	200	-	D
Trichloroethane (1,1,2-)	P	3	5	F	600	400	400	1000	4	100	3	-	C
Trichloroethanol (2,2,2-)	L	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	F	zero	5	F	-	-	-	-	7	300	-	300	B2
Trichlorophenol (2,4,6-)	L	-	-	D	-	-	-	-	-	-	-	300	B2
Trichloropropane (1,1,1-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Trichloropropane (1,2,3-)	-	-	-	F	600	600	600	2000	6	200	40	-	-
Trifluralin	L	-	-	F	80	80	80	300	7.5	300	5	-	C
Trimethylbenzene (1,2,4-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Trimethylbenzene (1,3,5-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Trinitroglycerol	-	-	-	F	5	5	5	5	-	-	5	-	-
Trinitrotoluene	-	-	-	F	20	20	20	20	0.5	20	2	-	C
Vinyl chloride	F	zero	2	F	3000	3000	10	50	-	-	-	1.5	A
White phosphorus	-	-	-	D	-	-	-	-	0.02	0.5	0.1	-	-
Xylenes	P	10000	10000	F	40000	40000	40000	100000	2000	60000	10000	-	D
Zinc chloride	-	-	-	D	-	-	-	-	-	-	-	-	-

* Under review.

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Health Advisories: Status HA*	10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
INORGANICS													
Aluminum	L	-	-	D	-	-	-	-	-	-	-	-	-
Ammonia	L	-	-	D	-	-	-	-	-	-	30000	-	D
Antimony	P	3	10/5	D	15	15	15	15	0.4	15	3	-	D
Arsenic	P	zero	-	D	-	-	-	-	1	-	-	3	A
Asbestos (fibers/l > 10um)	P	7E+06	7E+06	-	-	-	-	-	-	-	-	-	-
Barium	P	5000	5000*	F	-	-	-	-	70	-	2000	-	D
Beryllium	P	zero	1	D	30000	30000	4000	20000	5	200	-	0.8	B2
Boron	L	-	-	D	4000	900	900	3000	90	3000	600	-	D
Cadmium	P	5	5	F	40	40	5	20	0.5	20	5	-	D
Chloramine	L	-	-	D	1000	1000	1000	4000	10	400	300	-	D
Chlorate	L	-	-	D	40	40	40	100	0.4	10	10	-	D
Chlorine	L	-	-	D	3000	3000	400	2000	40	2000	1000	-	D
Chlorine dioxide	L	-	-	D	300	300	300	1000	3	100	80	-	D
Chlorite	L	-	-	D	100	100	400	400	1	40	30	-	-
Chromium (total)	P	100	100	F	1000	1000	200	800	5	200	100	-	D
Copper	P	1300	1300	-	-	-	-	-	-	-	-	-	D
Cyanide	P	200	200	F	200	200	200	800	22	800	200	-	D
Fluoride	F	4000	4000	-	-	-	-	-	60	-	-	-	-
Lead (at source)	P	zero	5*	-	-	-	-	-	-	-	-	-	B2
Lead (at tap)	P	zero	TT*	-	-	-	-	-	-	-	-	-	B2
Manganese	-	-	-	D	-	-	-	-	140	-	-	-	-
Mercury	P	2	2	F	-	-	-	2	0.3	10	2	-	D
Molybdenum	L	-	-	D	80	80	10	50	1	50	50	-	D
Nickel	P	100	100	F	1000	1000	100	600	20	600	100	-	D
Nitrate (as N)	P	10000	10000	F	-	10000	-	-	1600	-	-	-	D

* Under review.

Chemicals	Standards: Status Reg.*	MCLG (µg/l)	MCL (µg/l)	Status HA*	Health Advisories: 10-kg Child: One-day µg/l	Ten-day µg/l	Longer-term µg/l	70-kg Adult: Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Nitrite (as N)	P	1000	1000	F	-	1000	-	-	1600	-	-	-	D
Nitrate + Nitrite	P	10000	10000	-	-	-	-	-	-	-	-	-	-
Selenium	P	50	*50	-	-	-	-	-	-	-	-	-	-
Silver	L	-	-	D	200	200	200	200	5	200	100	-	D
Sodium	L	-	-	D	-	-	-	-	-	20000***	-	-	-
Strontium	L	-	-	D	25000	25000	25000	90000	2500	90000	17000	-	D
Sulfate	P	400000/500000	400000/500000	-	-	-	-	-	-	-	-	-	-
Thallium	P	0.5	2/1	D	7	7	7	20	0.07	2	0.4	-	-
Vanadium	L	-	-	D	80	80	30	100	3	100	20	-	D
Zinc	L	-	-	D	4000	4000	4000	4000	100	4000	4000	-	D
ADIONUCLIDES													
Beta particle and photon activity (formerly man-made radionuclides)	F	zero	4 mrem	-	-	-	-	-	-	-	-	4 mrem/y	A
Gross alpha particle activity	F	zero	15 pCi/L	-	-	-	-	-	-	-	-	-	A
Radium 226/228	F	zero	5 pCi/L	-	-	-	-	-	-	-	-	21/28 pCi/l	A
Radon	T	zero	-	-	-	-	-	-	-	-	-	160 pCi/l	A
Uranium	T	zero	-	-	-	-	-	-	-	-	-	26 pCi/l	A

MICROBIOLOGY

	Status	MCLG	MCL
Cryptosporidium	L	-	-
Giardia lamblia	F	zero	TT
Legionella	F[a]	zero	TT
Standard Plate Count	F[a]	NA	TT
Total Coliforms (Current)	F	NA	varies
Total Coliforms (after 12/31/90)	F	zero	**
Turbidity (before 1/1/91)	F	NA	1 and 5 NTU
Turbidity (after 12/31/90)	F	NA	PS
Viruses	F[a]	zero	TT

Key: PS, TT, F, defined as previously stated.

[a]: Final for systems using surface water; also being considered for regulation under groundwater disinfection rule.

Varies: MCL varies based on analytical method used, sample volume, and number of samples collected per month. Also, two types of MCLs = the monthly average and the "single sample" MCL. Both are based on coliform density.

'1 and 5 NTU": These are two MCLs for turbidity. The monthly average MCL is 1 NTU; the two-day consecutive average MCL is 5 NTU.

SECONDARY MAXIMUM CONTAMINANT LEVELS

Chemicals	Status*	SMCLs (mg/l)
Aluminum	P	0.05 to 0.2
Chloride	F	250
Color	F	15 color units
Copper	F	1
Corrosivity	F	non-corrosive
Dichlorobenzene -o	P	0.01
Dichlorobenzene -p	P	0.005
Ethylbenzene	P	0.03
Fluoride	F	2
Foaming Agents	F	0.5
Hexachlorocyclopentadiene		0.008
Iron	F	0.3
Manganese	F	0.05
Odor	F	3 threshold odor numbers
Pentachlorophenol	P	0.03
pH	F	6.5 - 8.5
Silver	P	0.09
Sulfate	F	250
Toluene	P	0.04
Total Dissolved Solids (TD)	F	500
Xylene	P	0.02
Zinc	F	5

* Status Codes: P - proposed, F - final

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RECORD OF PHONE CONVERSATION

DATE: January 31, 1992 TIME: 10:45am

INCOMING/OUTGOING (circle one) PHONE NUMBER: (919) 733-3221

G&O REP: Christopher Huff, Environmental Engineer

TALKED WITH: North Carolina Environmental Management Division, Groundwater Section

G&O JOB REFERENCE: General Information Concerning Wellhead Protection Areas

Talked to a representative from the Groundwater Section about Wellhead Protection Areas in North Carolina. This person stated that North Carolina does not have a Wellhead Protection Plan as of yet, but are in the process of developing a program. The initial proposal for the program should be ready for submittal to EPA in the spring, but no indication were given on how long this process will take or when the program would be implemented.

G&O Representative Signature and Date: Christopher Huff 1-31-91