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SITE INSPECTION REPORT

Toddville Operations Center

NC D981478480
610 Toddville Road
Charlotte, NC

CERCLA

31 March 1987

Stan T. Atwood, Toxicologist

NC Division of Health Services
Solid and Hazardous Waste Management Branch
Environmental Health Section
CERCLA Unit

EXECUTIVE SUMMARY

Toddville Operations Center is owned by Duke Power Company and has been used to service and store transformers and capacitors since 1956. The site is located just inside the city limits in an industrial/residential area on the northwest side of Charlotte.

A CERCLA Site Investigation was initiated after receiving a citizen's complaint of possible PCB contamination at the site. A PCB audit conducted at this site in 1981 by EPA reportedly did not find any problems.

On 19 November 1986, NC CERCLA Unit personnel visited the site and found several shallow wells still in use adjacent to the site. Two off-site wells were sampled. There are two wells on site which have not been used since 1971. One of the on-site wells was sampled without purging because of its size (8 in. casing, depth greater than 250 ft.). PCB's were detected at about 1 ppb in this well. Surface soil samples collected in storage areas contained up to 11 ppm PCBs. Subsurface samples (15 to 25 in.) did not contain PCBs.

The underlying bedrock at the site is believed to belong to the diorite-granite complex. Saprolite is estimated to be 20 to 30 ft. thick, and the water table was measured to be 16 ft. below the surface.

BACKGROUND

Location

Toddville Operations Center is located in Mecklenburg County just northwest of Charlotte, NC at 610 Toddville Road. The coordinates are: latitude 35° 16' 32", longitude 80° 54' 58".

Site Layout

The site is located on a 115 acre tract of land. It is bordered by Toddville Road on the east, a railroad track on the south, undeveloped land on the west, and a residential area to the north. There are two on-site wells which have been capped since 1971. Capacitors and transformers are stored on pallets south and west of the main warehouse building (Figure 1). Surface drainage is southwest (Appendix A - topo map).

Ownership History

Duke Power Company has owned and operated the site since 1956 (1).

Site Use History

Duke Power has used the site to service and store capacitors and transformers for about 30 years (1). PCB containing oil may have been spilled or leaked onto the site during this time.

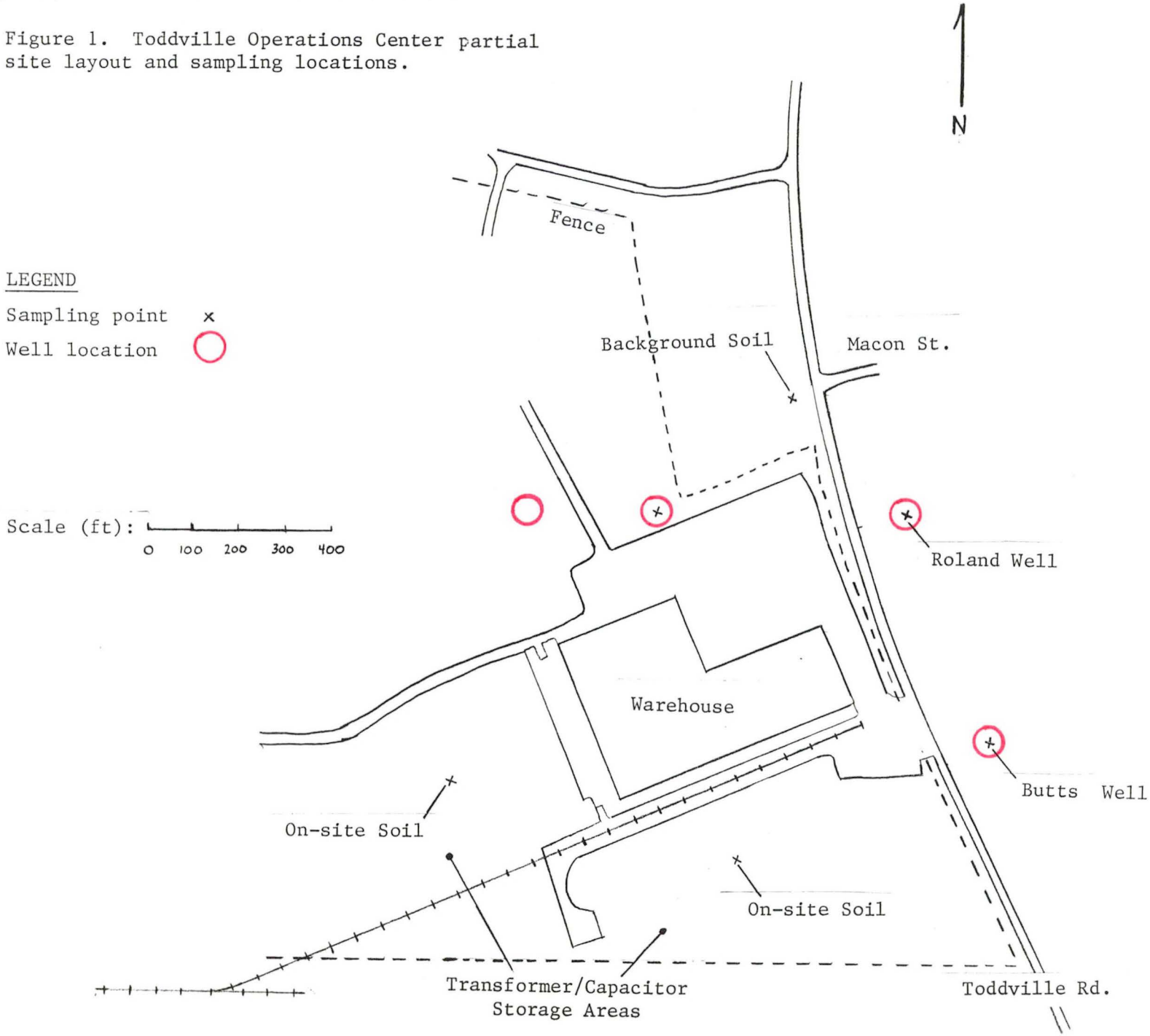
Permit and Regulatory History

None identified.

Remedial Actions to Date

None identified.

Figure 1. Toddville Operations Center partial site layout and sampling locations.



Summary Trip Report

On 19 November 1986, Stan Atwood, Jack Butler, and Cheryl McMorris, NC DHR/DHS CERCLA Unit, conducted an investigation of the Toddville site. We arrived at the site at 10:00 a.m. and located the nearest off-site wells. Alan Giles, Mecklenburg County Health Department, met us and accompanied us throughout the investigation. Two off-site wells, just across Toddville Road from the site, were sampled for organic and inorganic contaminants. The exact depth of the first well was unknown but was reported to be less than 100 ft. The second well was reported to be between 36 and 38 feet deep. Temperature and pH measurements for the first well were 15.6°C and 7.06; readings for the second well were 16°C and 6.33. Both wells were located within 110 feet of the highway (Figure 1).

At 11:00 a.m. we met with Michael Lascara, Dave Anderson, John Mease, Jay Perkins, and Warren Baker of Duke Power Company. They accompanied us throughout the remainder of the investigation. Duplicate samples were requested and supplied. A prearranged sampling plan was followed. A ten foot square was marked at each sampling area. Surface and subsurface samples were collected at the corners.

Background soil samples were collected first. The area sampled is in a field north of the site located 42 feet west of Toddville Road and 106 feet north of the fence that surrounds the site (Figure 1). Subsoil samples were taken at a depth of 20 inches in red clay with a hand auger.

An on-site well was uncapped by Duke Power Company personnel to allow access to ground water (Figure 1). A teflon bailer was used to collect grab samples. The water was silty. Measurements taken included water temperature (17.9°C), pH (7.5), well depth (greater than 250 ft.), water level (16 ft.), and casing width (8 in.).

The final soil sampling locations were near the centers of the storage areas on the west and south sides of the warehouse. Both surface and subsurface samples were collected. Subsurface samples were taken at depths ranging from 15 to 25 inches. Soil texture ranged from yellow loamy clay to red clay. Both storage areas were covered with several inches of gravel. Photographs were taken at each sampling point. The investigation was concluded at 2:00 p.m.

ENVIRONMENTAL SETTING

Topography

The site is located on about 150 acres of flat terrain. Drainage is to the south-southeast. On-site slopes are less than three percent. Surface runoff would be minimal, except during heavy storms. Any runoff would flow west along the railroad track bordering the site (USGS topo map, Appendix A).

Surface Waters

The site is drained by an unnamed tributary of Paw Creek. Paw Creek flows into Lake Wylie, an impoundment of the Catawba River. Paw Creek is a Class C stream; Lake Wylie is classified WS-III and B (2).

Geology and Soils

The rocks underlying the Piedmont can be divided into two groups: bedrock and saprolite. Saprolite underlies the land surface and varies in thickness from a few feet to more than 100 feet (3). Based on available well data, the saprolite is estimated to be at least 25 to 30 feet thick at the site, but it may be more than 50 feet thick (4,5).

With the exception of the rocks of the Carolina slate belt in the east, the rocks of Mecklenburg County belong to the diorite-granite complex or are believed to be associated with it. The diorite-granite complex proper covers a large area around Charlotte. Granite is probably predominant in the site vicinity (5).

The diorite in a semi-weathered state is a medium-textured rock composed predominantly of hornblende and feldspar. The rock granulates readily near the surface of the ground. The granite forming the complex with the diorite is composed almost entirely of feldspar and quartz. The granite also disintegrates readily near the surface (5).

Hydraulic conductivity of both saprolite and granite bedrock is 5 ft/day (3). This equals 1.76×10^{-3} cm/sec.

Soils on site, to a depth of 25 inches, ranged from a yellow clay loam to red clay (4). Adjacent soils are classified in the Cecil series. Typically the surface layer is a yellowish-red sandy clay loam about 6 inches thick. The red clay to red clay loam subsoil is 47 inches thick. The underlying material to a depth of 65 inches is red and yellow loam. Organic content is low in the surface layer and permeability is moderate (10^{-3} to 10^{-4} cm/sec). The subsoil is strongly acid to very strongly acid (pH 4.5 to 5.5) (6). It is likely that the original soil has been distributed due to excavation and building at the site; therefore, on site soils are classified as urban (6).

Groundwater

The ground water system in the Piedmont of North Carolina generally consists of a saprolite reservoir overlying a bedrock pipeline (3). As discussed above, granite and/or diorite bedrock underlies the site. Although well logs were not available for wells sampled at the site, data from wells in Mecklenburg County show an average yield of about 14 gpm. Granite aquifers yielded an average of 11.5 gpm while diorite aquifers yielded an average of 17.9 gpm (5).

The quality of ground water in Mecklenburg County is good. Wells penetrating diorite would be expected to contain more dissolved minerals than those in granite (5).

Ground water flow at the site is likely south to southwest toward Paw Creek and its tributaries (Topo map - Appendix A). Depth to the water table, as measured in an on-site well on 19 November 1986, was 16 feet. This probably represents a seasonally low water table. Water levels peak in the spring in the Charlotte area (5).

Climate and Meteorology (7,8)

	(°F)	January	July
Seasonal Temperatures:	Mean Max.	50 - 54	88 - 90
	Mean Min.	32 - 36	68 - 72
	Mean	42 - 44	80

Precipitation:	(inches)	
	Mean annual precipitation:	44 - 48
	Mean annual evaporation:	40 - 42
	Net annual precipitation:	4 - 6
	Mean annual snowfall:	4 - 6
	1 year 24-hour rainfall:	3
Storm Events:	Mean days/year with thunderstorms:	40 - 60
	Prevailing winds and wind speeds:	SW at 9 mph

Emissions Inventory Summary for Mecklenburg County (Tons/yr) (9)

Type	Area Sources	Point Sources
Particulates	20,657	3,335
Sulfur Dioxide	3,503	3,631
Nitrogen Oxides	24,745	813
Volatile Organics & Hydrocarbons	36,601	5,707
Carbon Monoxide	156,662	1,758

Land Use

The site is located in an industrial/residential area in northwest Charlotte. About 60-65% of the land area within three miles of the site is urban; the remaining area is suburban.

Population Distribution

The 1980 population density of Mecklenburg County was 766 people per square mile; the 1980 density of Charlotte was 2251 (9). The true population density of the area surrounding the site would be between these values. The following table presents maximum and minimum populations within one, two, and three miles of the site based on the above figures.

	Population	
Radius	Maximum	Minimum
1 mile	7,068	2,045
2 miles	28,295	9,629
3 miles	63,636	21,655

Water Supply

Charlotte's water supply is Mountain Island Lake; however, several community and private wells were identified in the site vicinity (Figure 1, topo map - Appendix A). Ground water use in this area was based on house counts outside the Charlotte water distribution system and data from community wells. The total house count (800) was multiplied by 3.8 to derive a population figure of 3040 (Topo map, Appendix A; 8). Two community well systems identified within the city limits (McClure Circle and Burke MHP) add an additional 308 people to the above total (4,10).

Critical Environments

None identified.

WASTE TYPES AND QUANTITIES

Waste Quantities

Unknown.

Waste Disposal Methods and Locations

Transformer and capacitor storage areas are marked on Figure 1 and have been in use since 1956. Soil contamination likely resulted from leaks or servicing equipment at the site.

Waste Types

Transformer oils containing PCBs (Appendix B).

LABORATORY DATA

Summary

PCBs were not detected in residential wells, background soil, or subsurface soil. Table 1 compares results from split samples for the on-site well and surface soils. Sample location 5 is west of the warehouse; location 6 is south of the warehouse (Figure 1).

Table 1. Comparison of PCB concentrations from split samples
Toddville Operations Center

Location	Concentrations (ppm) Duke Power	NC DHR
5A	1.10	0.49
5B	0.89	0.37
5C	0.28	0.38
5D	0.33	0.46
6A	2.5	3.58
6B	3.6	11.64
6C	2.8	4.90
6D	11.0 *	4.63
Well	0.00029	0.0012

* Assumed that samples 6B and 6D were switched by mistake.

Quality Assurance Review

The on-site well was not purged prior to sampling. A "grab" sample was collected with a one liter teflon bailer. The water was silty.

TOXICOLOGICAL/CHEMICAL CHARACTERISTICS

There are more than 200 possible isomers of PCBs; therefore, toxicity and chemical characteristics depend on the form. In addition, most commercial PCBs are a mixture of several isomers and may contain trace amounts of polychlorinated dibenzofurans (PCDFs) and other contaminants. All PCBs have low solubility (0.007 to 5.9 mg/1) and persist in the environment (11).

Oral LD_{50}s for some Aroclor mixtures range between 4 g/kg and 11.3 g/kg (slight to moderate acute toxicity). PCBs may affect the skin, GI tract, eyes, liver, blood, nervous system, and lymphatic system. They are classified as a Group 2B carcinogen (inadequate evidence in humans, sufficient evidence in laboratory animals) (11). Current estimates for a 10^{-6} increase in lifetime carcinogenic risk, based on drinking water concentrations, range from 0.0079 ug/1 to 0.16 ug/1 (12). These estimates are based on a 70 kg adult drinking 2 liters of water per day for life.

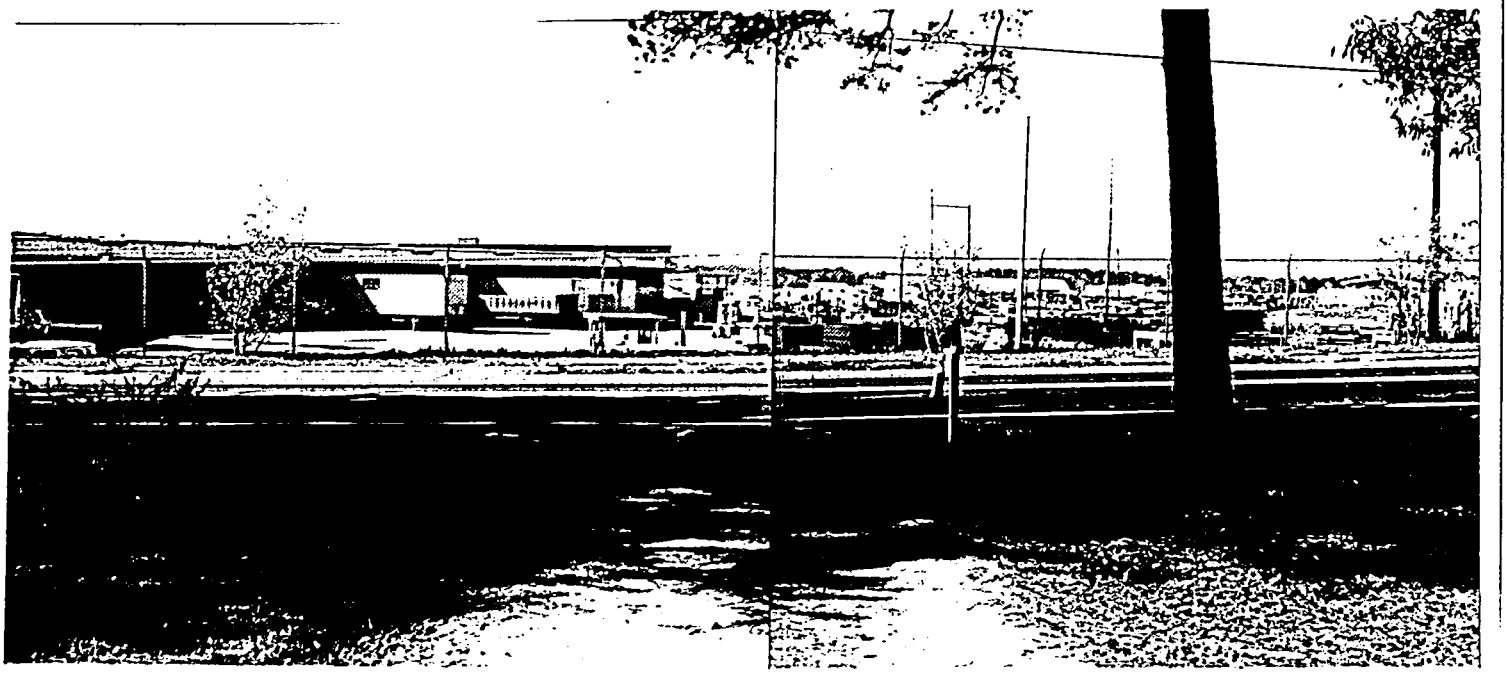
There have been two major population exposures to PCBs from contaminated rice oil. More than 1600 people were exposed between 1968 and 1975 in Japan, and more than 2000 people were exposed between 1978 and 1983 in Taiwan. However, there is increasing evidence that the symptoms of poisoning were due to PCDFs in the cooking oil rather than the PCBs (13,14).

Recently EPA developed some guidelines for PCBs in soil. Removal action levels were recommended for chronic and subchronic (10 day) exposures according to route of exposure (soil ingestion, inhalation, and dermal contact versus inhalation only). Two ppm was the recommended permissible level for chronic exposure via inhalation (15).

Appendix A

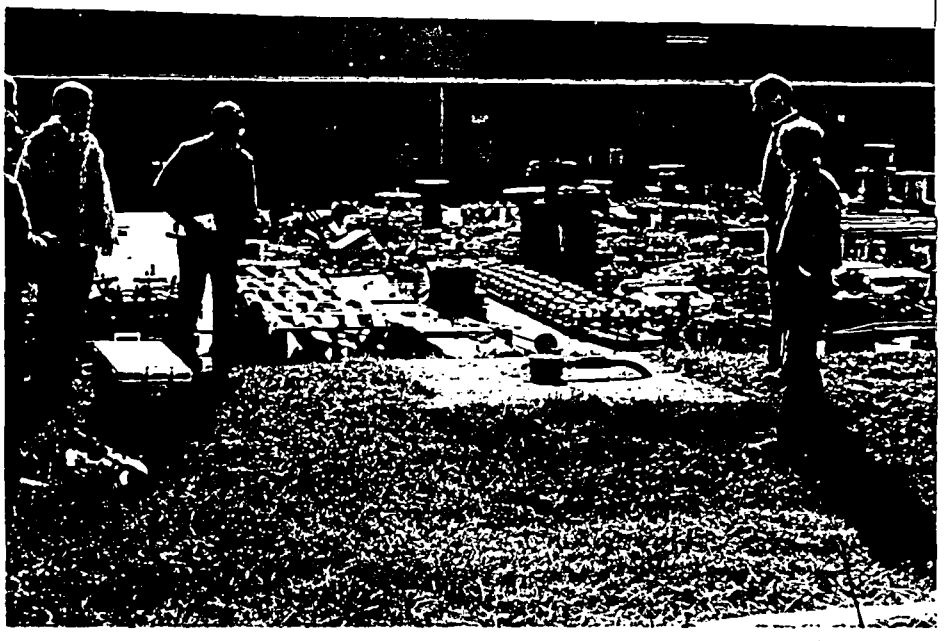
Maps and Photographs

USGS Topographic Map inside back cover

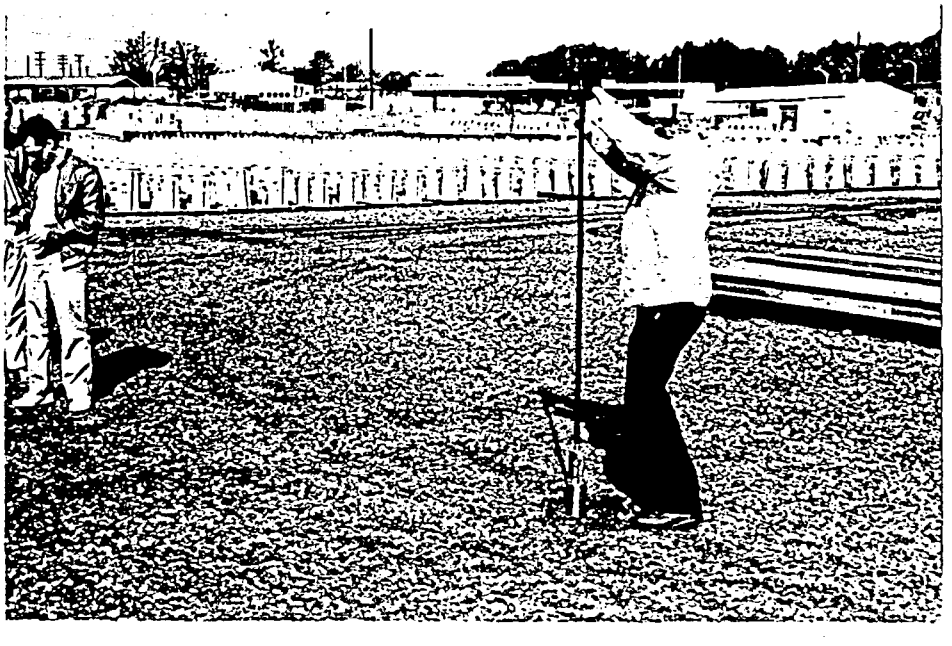


Toddville Operations Center from Roland front yard looking west.

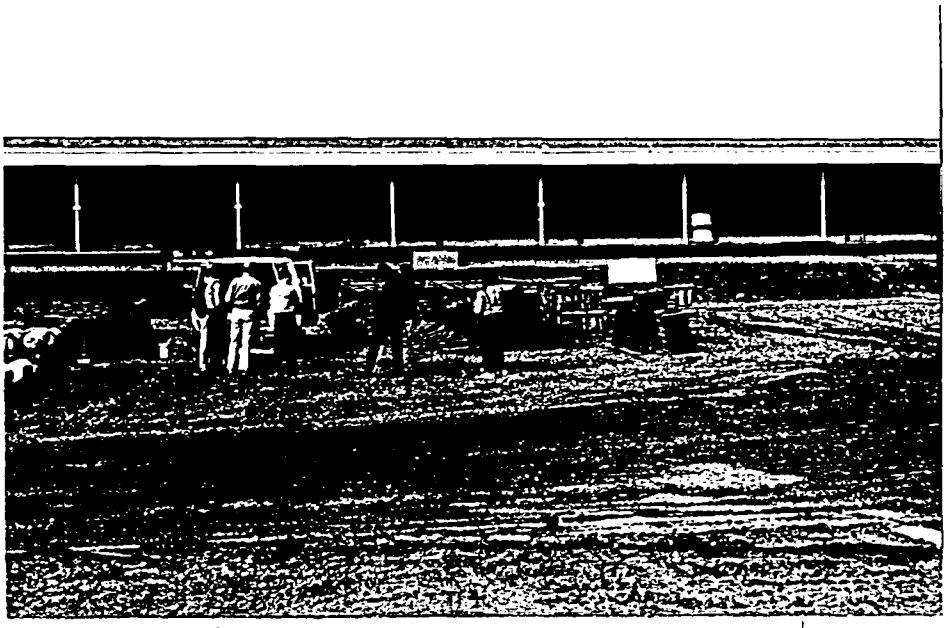
Background soil sampling location north of the site.



On-site well north of the warehouse.



Sampling location west of the warehouse
looking southeast.



Sampling location south of the warehouse looking north.

Sampling location south of the warehouse looking south.

Appendix B

Laboratory Data

P. O. BOX 33189

DUKE POWER COMPANY
GENERAL OFFICES
422 SOUTH CHURCH STREET
CHARLOTTE, N. C. 28242

TELEPHONE: AREA 704
373-4011

January 8, 1987

Mr. Jack Butler, Environmental Engineer
CERCLA Unit
Solid and Hazardous Waste Management Branch
Environmental Health Section
N.C. Departmentment of Human Resources
P. O. Box 2091
Raleigh, North Carolina 27602-2091

Re: PCB Sampling at Toddville
File Nos: ENV-0106, GAH-0207

Dear Mr. Butler:

Attached are the detailed results of our analyses performed on soil and water samples obtained from the Toddville Warehouse Facility. In summary, no PCB concentrations were detected in the subsurface soil and wellwater samples. The surface soil samples indicated PCB concentrations that were just slightly above detection limits.

Based on these results, additional samples should not be required.

We look forward to receiving the results of your analyses when they become available. If you have any questions or comments about these results, please contact me at 704/373-8494.

Yours truly,

S. B. Hager, Chief Engineer
Civil/Environmental Division

J. E. Harwood/DWA

By: J. E. Harwood
Environmental Affairs Specialist

MAL/mdc

Attachment

cc w/att: Central Records
D. W. Anderson
M. A. Lascara

December 10, 1986

Memo To: D.W. Anderson

Subject: Analyses of Samples Taken at Toddville Warehouse on November 19, 1986

PARTICIPANTS

Soil and water samples were taken at the Toddville warehouse facility on November 19, 1986. The following people were present.

Mecklenburg Department Of Environmental Health
Allan Giles

N. C. Department of Human Resources/DHS/EHS
Jack Butler
Stan Atwood
Sheryl McMorris

Duke Power Company
Warren Baker
David Anderson
Michael Lascara
John Mease
Jay Perkins

SAMPLING

Soil samples were taken at three locations: a reference area, designated as Location 3, and at two locations (5 and 6) on the Toddville grounds. Each location was characterized by taken 4 surface samples and 4 samples at approximately 20 inches down. All vegetation was removed prior to taking a surface sample. A stainless steel corer was used to obtain the 'bottom' samples. Water samples were taken from a residential well and from a capped well on-site. The on-site well water sample was collected by taking a grab sample at the surface of the water. The depth of the well was over 250 feet. Except for the water sample taken at the residential well, all samples were taken in duplicate and split between Duke Power and the State. The State laboratory analyzed the residential well water for pH, metals, volatile organics and PCB's.

ANALYSES

The following variables were analyzed:

<u>Soil Samples</u>: PCB's

<u>Water Samples</u>: PCB's, Metals, Volatile Organics, pH

<u>On-site Analyses</u>: pH

Laboratory Analyses: PCB analyses performed on the soil samples were conducted in accordance with EPA Method 8080, Organochlorine Pesticides and PCB's, 1984. A GC, equipped with an electron capture detector was used to quantitate PCB's. PCB analysis of the water sample was conducted in accordance with EPA Method 608, Organochlorine Pesticides and PCB's, 1982. Volatile organics were sent to Clayton Environmental Consultants Inc. The analyses were performed by GC/MS following protocol for EPA volatile fractions, Method 624. Metal analyses were determined using either inductively coupled plasma or graphic furnace atomic absorption spectroscopy. Metal analyses were conducted in accordance with EPA Methods for Chemical Analysis of Water and Wastes, 1979.

Samples 6b' and 6d' exhibited an interference peak which made PCB identification uncertain. To verify the presence or absence of PCB's in the sample GC/MS analyses would be needed.

DATA SUMMARY-PCB

Data, prior to being subjected to analysis of variance, (ANOVA) were tested for outliers. The criteria for determining outlier values was based on information received from Jack Butler. As a result of subjecting the data to the outlier test, the 11 mg/L result obtained at the surface of Location 6 was rejected. Consequently, this value was not used in the ANOVA. The ANOVA indicated statistical significance between location, depth, and the interaction between location and depth. Specifically, the surface values were statistically different at the locations. No statistical difference was indicated at the bottom depth among locations.

The mean concentration was determined to get an idea of the 'true' concentration at each location. Results are listed below:

STATION	PCB's(ppm)
3, surface	<0.045
3, at 20 inches	<0.045
5, surface	0.65
5, at 20 inches	<0.041
6, surface	3.0 (5.0 using 11ppm)
6, at 20 inches	<0.041

Attached are data analyzed by Duke Power and Clayton Environmental Consultants Inc.

Jay Perkins
Chemist

xc: W. D. Adair
P. S. Wingo
J. E. Harwood
W. D. Baker
N. J. Melton
R. E. Holmes Jr.
M. A. Lascara
Mat Butcher
INH Staff

Attachments

ATTACHMENT 1
Total PCB Concnetrations of Soil and Water Samples

Location	Concentration(ppm)
Surface	
3a	< 0.048
3b	< 0.045
3c	< 0.045
3d	< 0.043
5a	1.1
5b	0.89
5c	0.28
5d	0.33
6a	2.5
6b	3.6
6c	2.8
6d	11
Bottom(20inches)	
3a[1]	< 0.043
3b[1]	< 0.042
3c[1]	< 0.042
3d[1]	< 0.042
5a[1]	< 0.041
5b[1]	< 0.038
5c[1]	< 0.044
5d[1]	< 0.041
6a[1]	< 0.042
6b[1]	< 0.038
6c[1]	< 0.043
6d[1]	< 0.039

Location	Concentration
Well sample	< 0.00029

ATTACHMENT 2

Metal and pH Concentrations

VARIABLE	CONCENTRATIONS(ppm)
Arsenic	< 0.005
Selenium	< 0.002
Silver	< 0.0001
Barium	0.13
Padmium	0.00054
Chromium	0.0037
Copper	0.016
Iron	4.3
Manganese	0.040
Lead	0.18
Zinc	2.9
Mercury	< 0.0001
pH	7.7

CLAYTON ENVIRONMENTAL CONSULTANTS INC.

Results of Analysis For: DUKE POWER COMPANY

Project No.: 37551-17
Lab No.: 508456
File No.: 85934
Sample Id.: TDV-111986-5-4V02

Volatile Compounds - Priority Pollutants

COMPOUND NAME	CONCENTRATION (ug/L)	LOD (ug/L)
Benzene	ND	5
Bromodichloromethane	ND	5
Bromoform	ND	5
Bromomethane	ND	10
Carbon tetrachloride	ND	5
Chlorobenzene	ND	5
Chloroethane	ND	10
2-Chloroethylvinyl ether	ND	10
Chloroform	ND	5
Chloromethane	ND	10
Dibromochloromethane	ND	5
1,2-Dichlorobenzene	ND	5
1,3-Dichlorobenzene	ND	5
1,4-Dichlorobenzene	ND	5
1,1-Dichloroethane	ND	5
1,2-Dichloroethane	ND	5
1,1-Dichloroethene	ND	5
trans-1,2-Dichloroethene	ND	5
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	5
trans-1,3-Dichloropropene	ND	5
Ethyl benzene	ND	5
Methylene chloride	ND	10
1,1,2,2-Tetrachloroethane	ND	5
Tetrachloroethene	ND	5
Toluene	ND	5
1,1,1-Trichloroethane	ND	5
1,1,2-Trichloroethane	ND	5
Trichloroethene	ND	10
Trichlorofluoromethane	ND	5
Vinyl chloride	ND	10

LOD = Limit of Detection ND = Not Detected at or above LOD

Analysis performed by gas chromatography/mass spectrometry (GC/MS)

CLAYTON ENVIRONMENTAL CONSULTANTS INC.

Results of Analysis For: DUKE POWER COMPANY

Project No.: 37551-17
Lab No.: 508455
File No.: B5933
Sample Id.: TDV-111986-5-4V01

Volatile Compounds - Priority Pollutants

COMPOUND NAME	CONCENTRATION (ug/L)	LOD (ug/L)
Benzene	ND	5
Bromodichloromethane	ND	5
Bromoform	ND	5
Bromomethane	ND	10
Carbon tetrachloride	ND	5
Chlorobenzene	ND	5
Chloroethane	ND	10
2-Chloroethylvinyl ether	ND	10
Chloroform	ND	5
Chloromethane	ND	10
Dibromochloromethane	ND	5
1,2-Dichlorobenzene	ND	5
1,3-Dichlorobenzene	ND	5
1,4-Dichlorobenzene	ND	5
1,1-Dichloroethane	ND	5
1,2-Dichloroethane	ND	5
1,1-Dichloroethene	ND	5
trans-1,2-Dichloroethene	ND	5
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	5
trans-1,3-Dichloropropene	ND	5
Ethyl benzene	ND	5
Methylene chloride	ND	10
1,1,2,2-Tetrachloroethane	ND	5
Tetrachloroethene	ND	5
Toluene	ND	5
1,1,1-Trichloroethane	ND	5
1,1,2-Trichloroethane	ND	5
Trichloroethene	ND	10
Trichlorofluoromethane	ND	5
Vinyl chloride	ND	10

LOD = Limit of Detection ND = Not Detected at or above LOD

Analysis performed by gas chromatography/mass spectrometry (GC/MS)

CLAYTON ENVIRONMENTAL CONSULTANTS INC.

Results of Analysis For: DUKE POWER COMPANY

Project No.: 37551-17
Lab No.: ------
File No.: B5930
Sample Id.: LAB BLANK L/W

Volatile Compounds - Priority Pollutants

COMPOUND NAME	CONCENTRATION (ug/L)	LOD (ug/L)
Benzene	ND	5
Bromodichloromethane	ND	5
Bromoform	ND	5
Bromomethane	ND	10
Carbon tetrachloride	ND	5
Chlorobenzene	ND	5
Chloroethane	ND	10
2-Chloroethylvinyl ether	ND	10
Chloroform	ND	5
Chloromethane	ND	10
Dibromochloromethane	ND	5
1,2-Dichlorobenzene	ND	5
1,3-Dichlorobenzene	ND	5
1,4-Dichlorobenzene	ND	5
1,1-Dichloroethane	ND	5
1,2-Dichloroethane	ND	5
1,1-Dichloroethene	ND	5
trans-1,2-Dichloroethene	ND	5
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	5
trans-1,3-Dichloropropene	ND	5
Ethyl benzene	ND	5
Methylene chloride	ND	10
1,1,2,2-Tetrachloroethane	ND	5
Tetrachloroethene	ND	5
Toluene	ND	5
1,1,1-Trichloroethane	ND	5
1,1,2-Trichloroethane	ND	5
Trichloroethene	ND	10
Trichlorofluoromethane	ND	5
Vinyl chloride	ND	10

LOD = Limit of Detection ND = Not Detected at or above LOD

Analysis performed by gas chromatography/mass spectrometry (GC/MS)

ATTACHMENT 1
Total PCB Concnetrations of Soil and Water Samples

Location	Concentration(ppm)
Surface	
3a	< 0.048
3b	< 0.045
3c	< 0.045
3d	< 0.043
5a	1.1
5b	0.89
5c	0.28
5d	0.33
6a	2.5
6b	3.6
6c	2.8
6d	11
Bottom(20inches)	
3a[1]	< 0.043
3b[1]	< 0.042
3c[1]	< 0.042
3d[1]	< 0.042
5a[1]	< 0.041
5b[1]	< 0.038
5c[1]	< 0.044
5d[1]	< 0.041
6a[1]	< 0.042
6b[1]	< 0.038
6c[1]	< 0.043
6d[1]	< 0.039

Location	Concentration
Well sample	< 0.00029

ATTACHMENT 2

Metal and pH Concentrations

VARIABLE	CONCENTRATIONS(ppm)
Arsenic	< 0.005
Selenium	< 0.002
Silver	< 0.0001
Barium	0.13
Padmium	0.00054
Chromium	0.0037
Copper	0.016
Iron	4.3
Manganese	0.040
Lead	0.18
Zinc	2.9
Mercury	< 0.0001
pH	7.7

CLAYTON ENVIRONMENTAL CONSULTANTS INC.

Results of Analysis For: DUKE POWER COMPANY

Project No.: 37551-17
Lab No.: 508456
File No.: B5934
Sample Id.: TDV-111986-5-4V02

Volatile Compounds - Priority Pollutants

COMPOUND NAME	CONCENTRATION (ug/L)	LOD (ug/L)
Benzene	ND	5
Bromodichloromethane	ND	5
Bromoform	ND	5
Bromomethane	ND	10
Carbon tetrachloride	ND	5
Chlorobenzene	ND	5
Chloroethane	ND	10
2-Chloroethylvinyl ether	ND	10
Chloroform	ND	5
Chloromethane	ND	10
Dibromochloromethane	ND	5
1,2-Dichlorobenzene	ND	5
1,3-Dichlorobenzene	ND	5
1,4-Dichlorobenzene	ND	5
1,1-Dichloroethane	ND	5
1,2-Dichloroethane	ND	5
1,1-Dichloroethene	ND	5
trans-1,2-Dichloroethene	ND	5
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	5
trans-1,3-Dichloropropene	ND	5
Ethyl benzene	ND	5
Methylene chloride	ND	10
1,1,2,2-Tetrachloroethane	ND	5
Tetrachloroethene	ND	5
Toluene	ND	5
1,1,1-Trichloroethane	ND	5
1,1,2-Trichloroethane	ND	5
Trichloroethene	ND	10
Trichlorofluoromethane	ND	5
Vinyl chloride	ND	10

LOD = Limit of Detection ND = Not Detected at or above LOD

Analysis performed by gas chromatography/mass spectrometry (GC/MS)

CLAYTON ENVIRONMENTAL CONSULTANTS INC.

Results of Analysis For: DUKE POWER COMPANY

Project No.: 37551-17
Lab No.: 508455
File No.: 85933
Sample Id.: TDV-111986-5-4V01

Volatile Compounds - Priority Pollutants

COMPOUND NAME	CONCENTRATION (ug/L)	LOD (ug/L)
Benzene	ND	5
Bromodichloromethane	ND	5
Bromoform	ND	5
Bromomethane	ND	10
Carbon tetrachloride	ND	5
Chlorobenzene	ND	5
Chloroethane	ND	10
2-Chloroethylvinyl ether	ND	10
Chloroform	ND	5
Chloromethane	ND	10
Dibromochloromethane	ND	5
1,2-Dichlorobenzene	ND	5
1,3-Dichlorobenzene	ND	5
1,4-Dichlorobenzene	ND	5
1,1-Dichloroethane	ND	5
1,2-Dichloroethane	ND	5
1,1-Dichloroethene	ND	5
trans-1,2-Dichloroethene	ND	5
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	5
trans-1,3-Dichloropropene	ND	5
Ethyl benzene	ND	5
Methylene chloride	ND	10
1,1,2,2-Tetrachloroethane	ND	5
Tetrachloroethene	ND	5
Toluene	ND	5
1,1,1-Trichloroethane	ND	5
1,1,2-Trichloroethane	ND	5
Trichloroethene	ND	10
Trichlorofluoromethane	ND	5
Vinyl chloride	ND	10

LOD = Limit of Detection ND = Not Detected at or above LOD

Analysis performed by gas chromatography/mass spectrometry (GC/MS)

CLAYTON ENVIRONMENTAL CONSULTANTS INC.

Results of Analysis For: DUKE POWER COMPANY

Project No.: 37551-17
Lab No.: ------
File No.: B5930
Sample Id.: LAB BLANK L/W

Volatile Compounds - Priority Pollutants

COMPOUND NAME	CONCENTRATION (ug/L)	LOD (ug/L)
Benzene	ND	5
Bromodichloromethane	ND	5
Bromoform	ND	5
Bromomethane	ND	10
Carbon tetrachloride	ND	5
Chlorobenzene	ND	5
Chloroethane	ND	10
2-Chloroethylvinyl ether	ND	10
Chloroform	ND	5
Chloromethane	ND	10
Dibromochloromethane	ND	5
1,2-Dichlorobenzene	ND	5
1,3-Dichlorobenzene	ND	5
1,4-Dichlorobenzene	ND	5
1,1-Dichloroethane	ND	5
1,2-Dichloroethane	ND	5
1,1-Dichloroethene	ND	5
trans-1,2-Dichloroethene	ND	5
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	5
trans-1,3-Dichloropropene	ND	5
Ethyl benzene	ND	5
Methylene chloride	ND	10
1,1,2,2-Tetrachloroethane	ND	5
Tetrachloroethene	ND	5
Toluene	ND	5
1,1,1-Trichloroethane	ND	5
1,1,2-Trichloroethane	ND	5
Trichloroethene	ND	10
Trichlorofluoromethane	ND	5
Vinyl chloride	ND	10

LOD = Limit of Detection ND = Not Detected at or above LOD

Analysis performed by gas chromatography/mass spectrometry (GC/MS)

HAZARDOUS WASTE MANAGEMENT BRANCH

Chain of Custody Record

Hazardous Waste Materials

Location of Sampling: ____ Generator ____ Transporter ____ Treatment Facilit
____ Storage Facility ____ Disposal Facility ____ Landfill
X Other: _____

Company's Name Duke Power Co Telephone (704-) 373-8494

Address 610 Toddville Rd Charlotte, NC 28242

Collector's Name Stan Atwood Telephone (919) 733-2801
signature

Date Sampled 11-19-86 Time Sampled 10:00 AM - 2:00 PM

Type of Process Generating Waste Storage of transformers and capacitors with PCB containing oils

Field Information

Field Sample No. 3471 — 3500

Chain of Possession:

	signature	title	inclusive dates
1.	J. C. Perkins	Chemist	11-19-86
2.	Stan Atwood	Toxicologist	
3.	Norma Deese	Chemical Analyst I	11-21-86

Results reported

signature	title	date

Instructions: Complete all applicable information including signatures, and submit with analysis request forms.

Receipt for Samples

The samples described below were collected in connection with the administration, enforcement, and documentation of the:

( ) North Carolina Hazardous Waste Management Rules, 10 NCAC 10F

( ) North Carolina Solid Waste Management Rules, 10 NCAC 10G

( ) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

( ) Toxic Substances Control Act (TSCA) 15 U.S.C. §2601, et seq., specifically Section 11 of TSCA, 15 U.S.C. § 2610.

Stan Atwood — P.O. Box 2091 Raleigh, NC 27602-2091

Inspector's Name — Inspector's Address

Duke Power Co. — P.O. Box 33189 Charlotte, NC 28242

Name of Firm — Firm Address

Firm Owner, Operator, or Agent — Title

SAMPLE NUMBER	COLLECTED		SAMPLE TYPE			DUPLICATE SAMPLES			SAMPLE LOCATION	
	DATE	TIME	WATER	SOIL	OTHER	OFFERED	ACCEPTED	REJECTED	ON-SITE	OFF-SITE

Receipt for the sample(s) described above is hereby acknowledged:

Stan Atwood
Signature of Inspector

Toxicologist
Title

Receipt/rejection of duplicate or split samples is hereby acknowledged:

Jay C. Pope
Signature of Firm Owner, Operator, or Agent

Chemist
Title

COMMENTS

N. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

received 12-31-86

Site Number 6009814784 80 Field Sample Number 3471

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1015

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Butts Well #1
___ Surface Water (2)	___ Liquid (6)	
___ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ Arsenic		___ Arsenic		___ Silver	
___ Barium		___ Barium		___ Sulfates	
___ Cadmium		___ Cadmium		___ Zinc	
___ Chromium		___ Chloride		___ Ph	
___ Lead		___ Chromium		___ Conductivity	
___ Mercury		___ Copper		___ TDS	
___ Selenium		___ Fluoride		___ TOC	
___ Silver		___ Iron			
		___ Lead			
		___ Manganese			
		___ Mercury			
		___ Nitrate			
		___ Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
✓ P&T:GC/MS	✓	___ EDB		___ Methoxychlor	
___ Acid:B/N Ext.		___ PCB's		___ Toxaphene	
___ TOX		___ Petroleum		___ 2,4-D	
		___ Endrin		___ 2,4,5-TP (silvex)	
		___ Lindane			

MICROBIOLOGY

Parameter
___ (MF) Coliform Colonies/100mls
___ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
___ Gross Alpha	
___ Gross Beta	

RECEIVED DEC 31 1986 SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH

Date Received 11-21-86 2.10. Date Reported

Date Extracted Date Analyzed PT 12-16-86 mw

Reported By Lab Number 603111

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.-C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60098147848 0 Field Sample Number 3472

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1015

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Butts Well #1
___ Surface Water (2)	___ Liquid (6)	
___ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ Arsenic		___ Arsenic		___ Silver	
___ Barium		___ Barium		___ Sulfates	
___ Cadmium		___ Cadmium		___ Zinc	
___ Chromium		___ Chloride		___ Ph	
___ Lead		___ Chromium		___ Conductivity	
___ Mercury		___ Copper		___ TDS	
___ Selenium		___ Fluoride		___ TOC	
___ Silver		___ Iron			
		___ Lead			
		___ Manganese			
		___ Mercury			
		___ Nitrate			
		___ Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
___ P&T:GC/MS		___ EDB		___ Methoxychlor	
✓ Acid:B/N Ext.	✓	✓ PCB's	<0.0001 ppm	___ Toxaphene	
___ TOX		___ Petroleum		___ 2,4-D	
		___ Endrin		___ 2,4,5-TP (silvex)	
		___ Lindane			

MICROBIOLOGY

Parameter
___ (MF) Coliform Colonies/100mls
___ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
___ Gross Alpha	
___ Gross Beta	

Date Received 11-21-86 LD Date Reported

BNA LD Pest.

Date Extracted 12-1-86 FBA 12-3-86 FA Date Analyzed PCB's 12-15-86

Reported By Lab Number 6 3112

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 600981478480 Field Sample Number 3473

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1040

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Roland well #2
___ Surface Water (2)	___ Liquid (6)	
___ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ Arsenic		___ Arsenic		___ Silver	
___ Barium		___ Barium		___ Sulfates	
___ Cadmium		___ Cadmium		___ Zinc	
___ Chromium		___ Chloride		___ Ph	
___ Lead		___ Chromium		___ Conductivity	
___ Mercury		___ Copper		___ TDS	
___ Selenium		___ Fluoride		___ TOC	
___ Silver		___ Iron			
		___ Lead			
		___ Manganese			
		___ Mercury			
		___ Nitrate			
		___ Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
✓ P&T:GC/MS	✓	___ EDB		___ Methoxychlor	
___ Acid:B/N Ext.		___ PCB's		___ Toxaphene	
___ TOX		___ Petroleum		___ 2,4-D	
		___ Endrin		___ 2,4,5-TP (silvex)	
		___ Lindane			

MICROBIOLOGY

Parameter
___ (MF) Coliform Colonies/100mls
___ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
___ Gross Alpha	
___ Gross Beta	

Date Received 11-21-86 AP Date Reported

Date Extracted Date Analyzed PT 12-16-86 mw

Reported By Lab Number 6 3113

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60098147848 0 Field Sample Number 3474

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1040

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Roland Well #2
___ Surface Water (2)	___ Liquid (6)	
___ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ Arsenic		___ Arsenic		___ Silver	
___ Barium		___ Barium		___ Sulfates	
___ Cadmium		___ Cadmium		___ Zinc	
___ Chromium		___ Chloride		___ Ph	
___ Lead		___ Chromium		___ Conductivity	
___ Mercury		___ Copper		___ TDS	
___ Selenium		___ Fluoride		___ TOC	
___ Silver		___ Iron			
		___ Lead			
		___ Manganese			
		___ Mercury			
		___ Nitrate			
		___ Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ P&T:GC/MS		___ EDB		___ Methoxychlor	
✓ Acid:B/N Ext.	✓	✓ PCB's	<0.0001 ppm	___ Toxaphene	
___ TOX		___ Petroleum		___ 2,4-D	
		___ Endrin		___ 2,4,5-TP (silvex)	
		___ Lindane			

MICROBIOLOGY

Parameter
___ (MF) Coliform Colonies/100mls
___ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
___ Gross Alpha	
___ Gross Beta	

Date Received 11-21-86 LP Date Reported

Date Extracted PCB 12-2-86 PA BNA 12-4-86 SD AA VP Date Analyzed PCBs 12-15-86 V.P.

Reported By Lab Number 63114

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60098147848 0 Field Sample Number 3475

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1100

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	Bkgr. Soil 3A (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 AQ Date Reported

Date Extracted 11-25-86 F.B. V.P. Date Analyzed 12-15-86 V.P.

Reported By Lab Number 6-3115

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number: 6009814784 80 Field Sample Number: 3476

Name of Site: Toddville Operations Center Site Location: Charlotte, N.C.

Collected By: Stan Atwood ID#: 45 Date Collected: Nov. 19, 1986 Time: 1110

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	Bkgr. Soil 3A' (20")
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received: 11-21-86 RP Date Reported:

Date Extracted: 11-25-86 F.B. V.P. Date Analyzed: 12-15-86 V.P.

Reported By: Lab Number: 603116

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 6OD981478480 Field Sample Number 3477

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1125

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	Bkgr. Soil 3B (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 F.B. Date Reported

Date Extracted 11-25-86 V.P. Date Analyzed 12-15-86 V.P.

Reported By Lab Number 6 3117

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 600981478480 Field Sample Number 3478

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1137

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	Bkgr. Soil 3B' (20")
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 VP Date Reported

Date Extracted 11-25-86 F.B. V.P. Date Analyzed 12-16-86 V.P.

Reported By Lab Number 603118

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60D981478480 Field Sample Number 3479

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1135

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	Bkgr. Soil JC (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 F.B. Date Reported

Date Extracted 11-25-86 V.P. Date Analyzed 12-16-86 V.P.

Reported By Lab Number 63119

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60098147848 0 Field Sample Number 3480

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1142

Type of Sample:

Environmental	Concentrate	Comments
____ Groundwater (1)	____ Solid (5)	Bkgr. Soil 3C' (20")
____ Surface Water (2)	____ Liquid (6)	
✓ Soil (3)	____ Sludge (7)	
____ Other (4)	____ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LP Date Reported

Date Extracted 11-25-86 F.B. V.P. Date Analyzed 12-16-86 V.P.

Reported By Lab Number 63120

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number: 60098147848 0 Field Sample Number: 3481

Name of Site: Toddville Operations Center Site Location: Charlotte, N.C.

Collected By: Stan Atwood ID#: 45 Date Collected: Nov. 19, 1986 Time: 1140

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	Bkgr. Soil 30 (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received: 11-21-86 V.P. Date Reported:

Date Extracted: 11-25-86 F.B. V.P. Date Analyzed: 12-16-86 V.P.

Reported By: Lab Number: 6 8121

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60098147848 0 Field Sample Number 3482

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1145

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	Bkgr. Soil 30' (20")
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LP Date Reported

Date Extracted 11-25-86 F.B. V.P. Date Analyzed 12-16-86 V.P.

Reported By Lab Number 63122

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60098147848 0 Field Sample Number 3483

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1200

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	On Site Well #4
___ Surface Water (2)	___ Liquid (6)	
___ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ Arsenic		___ Arsenic		___ Silver	
___ Barium		___ Barium		___ Sulfates	
___ Cadmium		___ Cadmium		___ Zinc	
___ Chromium		___ Chloride		___ Ph	
___ Lead		___ Chromium		___ Conductivity	
___ Mercury		___ Copper		___ TDS	
___ Selenium		___ Fluoride		___ TOC	
___ Silver		___ Iron			
		___ Lead			
		___ Manganese			
		___ Mercury			
		___ Nitrate			
		___ Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
✓ P&T:GC/MS	✓	___ EDB		___ Methoxychlor	
___ Acid:B/N Ext.		___ PCB's		___ Toxaphene	
___ TOX		___ Petroleum		___ 2,4-D	
		___ Endrin		___ 2,4,5-TP (silvex)	
		___ Lindane			

MICROBIOLOGY

Parameter
___ (MF) Coliform Colonies/100mls
___ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
___ Gross Alpha	
___ Gross Beta	

Date Received 11-21-86 LP Date Reported

Date Extracted Date Analyzed PT 12-16-86 MW

Reported By Lab Number 6 3123

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 6009814784 80 Field Sample Number 3484

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1200

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	On Site Well #4
___ Surface Water (2)	___ Liquid (6)	
___ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
✓ Acid:B/N Ext.	✓	✓ PCB's	0.0012 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LD

Date Reported

Date Extracted 3x/A 12-01-86 LDFB, AD Post AA,FB,UP 12-16-86

Date Analyzed 12-18-86 V.P.

Reported By

Lab Number 6 3124

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

.C. Department of Human Resources
ivision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box
306 N. Wilmington
Raleigh,

ite Number 60D981478480 Field Sample Number 3485

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 12:30

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	West Soil 5A (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	0.49 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LD Date Reported

Date Extracted 12-1-86 V.P. Date Analyzed 12-22-86 V.P.

Reported By Lab Number 63125

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

..C. Department of Human Resources
ivision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box 7
306 N. Wilmington
Raleigh,

ite Number 600981478480 Field Sample Number 3486

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 12:35

Type of Sample:

Environmental	Concentrate	Comments
____ Groundwater (1)	____ Solid (5)	West Soil 5A' (24")
____ Surface Water (2)	____ Liquid (6)	
✓ Soil (3)	____ Sludge (7)	
____ Other (4)	____ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LP Date Reported

Date Extracted 12-1-86 V.P. Date Analyzed 12-18-86 V.P.

Reported By Lab Number 613126

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 600981478480 Field Sample Number 3487

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1245

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	West Soil 5B (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ Arsenic		___ Arsenic		___ Silver	
___ Barium		___ Barium		___ Sulfates	
___ Cadmium		___ Cadmium		___ Zinc	
___ Chromium		___ Chloride		___ Ph	
___ Lead		___ Chromium		___ Conductivity	
___ Mercury		___ Copper		___ TDS	
___ Selenium		___ Fluoride		___ TOC	
___ Silver		___ Iron			
		___ Lead			
		___ Manganese			
		___ Mercury			
		___ Nitrate			
		___ Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ P&T:GC/MS		___ EDB		___ Methoxychlor	
___ Acid:B/N Ext.		✓ PCB's	0.37 ppm	___ Toxaphene	
___ TOX		___ Petroleum		___ 2,4-D	
		___ Endrin		___ 2,4,5-TP (silvex)	
		___ Lindane			

MICROBIOLOGY

Parameter
___ (MF) Coliform Colonies/100mls
___ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
___ Gross Alpha	
___ Gross Beta	

Date Received 11-21-86 VP Date Reported

Date Extracted 12-1-86 V.P. Date Analyzed 12-22-86 V.P.

Reported By Lab Number 63127

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60D981478480 Field Sample Number 3488

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1250

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	West Soil 5B' (25")
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LP Date Reported

Date Extracted 12-1-86 V.P. Date Analyzed 12-18-86 V.P.

Reported By Lab Number 63128

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

.C. Department of Human Resources
ivision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

te Number 60098147848 0 Field Sample Number 3489

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1255

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	West Soil 5C (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	0.38 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 VP Date Reported

Date Extracted 12-1-86 V.P. Date Analyzed 12-22-86 V.P.

eported By Lab Number 613129

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

C. Department of Human Resources
vision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box 2
306 N. Wilmington
Raleigh, 2

te Number 6009814784 80 Field Sample Number 34490

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1300

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	West Soil 50' (25")
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LP Date Reported

Date Extracted 12-1-86 V.P. Date Analyzed 12-18-86 V.P.

eported By Lab Number 6 3130

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

. C. Department of Human Resources
ivision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box 2
306 N. Wilmington
Raleigh, 2

ite Number 6009814784 80 Field Sample Number 3491

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1310

Type of Sample:

Environmental	Concentrate	Comments
____ Groundwater (1)	____ Solid (5)	West Soil 50 (surface)
____ Surface Water (2)	____ Liquid (6)	
✓ Soil (3)	____ Sludge (7)	
____ Other (4)	____ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	0.46 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LD Date Reported

Date Extracted 12-1-86 V.P. Date Analyzed 12-22-86 V.P.

Reported By Lab Number 613131

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

.C. Department of Human Resources
ivision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public I
P. O. Box
306 N. Wilmington
Raleigh,

ite Number 60098147848 0 Field Sample Number 3492

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1315

Type of Sample:

Environmental	Concentrate	Comments
____ Groundwater (1)	____ Solid (5)	West Soil 50" (18")
____ Surface Water (2)	____ Liquid (6)	
✓ Soil (3)	____ Sludge (7)	
____ Other (4)	____ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
____ Arsenic		____ Arsenic		____ Silver	
____ Barium		____ Barium		____ Sulfates	
____ Cadmium		____ Cadmium		____ Zinc	
____ Chromium		____ Chloride		____ Ph	
____ Lead		____ Chromium		____ Conductivity	
____ Mercury		____ Copper		____ TDS	
____ Selenium		____ Fluoride		____ TOC	
____ Silver		____ Iron			
		____ Lead			
		____ Manganese			
		____ Mercury			
		____ Nitrate			
		____ Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
____ P&T:GC/MS		____ EDB		____ Methoxychlor	
____ Acid:B/N Ext.		✓ PCB's	<0.1 ppm	____ Toxaphene	
____ TOX		____ Petroleum		____ 2,4-D	
		____ Endrin		____ 2,4,5-TP (silvex)	
		____ Lindane			

MICROBIOLOGY

Parameter
____ (MF) Coliform Colonies/100mls
____ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
____ Gross Alpha	
____ Gross Beta	

Date Received 11-21-86 LD Date Reported

Date Extracted 12-1-86 V.P. Date Analyzed 12-18-86 V.P.

Reported By: Lab Number 6 3132

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

C. Department of Human Resources
vision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box 2
306 N. Wilmington
Raleigh, 2

te Number 60098147848 0 Field Sample Number 3493

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1325

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	South Soil 6A (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	3.58 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

ate Received 11-21-86 Date Reported

Date Extracted 12-02-86 Date Analyzed 12-18-86 V.P.

eported By Lab Number 63133

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 6009814784 80 Field Sample Number 3494

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1330

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	South Soil 6A' (15")
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LP Date Reported

Date Extracted 12-02-86 LP Date Analyzed 12-18-86 V.P.

Reported By Lab Number 63134

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

C. Department of Human Resources
vision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public I
P. O. Box 2
306 N. Wilmington
Raleigh, 2

te Number 60098147848 0 Field Sample Number 3495

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1335

Type of Sample:

Environmental	Concentrate	Comments
____ Groundwater (1)	____ Solid (5)	South Soil 6B (surface)
____ Surface Water (2)	____ Liquid (6)	
✓ Soil (3)	____ Sludge (7)	
____ Other (4)	____ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	11.64 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LP Date Reported

Date Extracted 12-02-86 LP Date Analyzed 12-22-86 V.P.

eported By Lab Number 63135

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

C. Department of Human Resources
ivision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box 2
306 N. Wilmington
Raleigh, 2

te Number 600981478480 Field Sample Number 3496

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1340

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	South Soil 6B' (18")
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

ate Received 11-21-86 LD Date Reported

Date Extracted 12-02-86 LD Date Analyzed 12-18-86 V.P.

eported By Lab Number 6 3136

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

C. Department of Human Resources
vision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box 2
306 N. Wilmington
Raleigh, 2

te Number 60098147848 0 Field Sample Number 3497

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1345

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	South Soil 6C (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	4.90 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

ate Received 11-21-86 LD Date Reported

Date Extracted 12-02-86 LD Date Analyzed 12-19-86 V.P.

eported By Lab Number 6 3137

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N.C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box 2
306 N. Wilmington
Raleigh, 2

Site Number 60098147848 0 Field Sample Number 3498

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1350

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	South Soil 6C' (24")
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 Date Reported

Date Extracted Date Analyzed 12-19-86 V.P.

Reported By Lab Number 6 3138

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

C. Department of Human Resources
vision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box 2
306 N. Wilmington
Raleigh, 2

te Number 60098147848 0 Field Sample Number 3499

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1355

Type of Sample:

Environmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	South Soil 60 (surface)
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	4.63 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 Date Reported

Date Extracted 12-02-86 Date Analyzed 12-19-86 V.P.

Reported By Lab Number 6 3139

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

C. Department of Human Resources
vision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public H
P. O. Box 2
306 N. Wilmington
Raleigh, 2

te Number 6009814784 80 Field Sample Number 3500

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

ollected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1400

Type of Sample:

Environmental	Concentrate	Comments
____ Groundwater (1)	____ Solid (5)	South Soil 60' (19")
____ Surface Water (2)	____ Liquid (6)	
✓ Soil (3)	____ Sludge (7)	
____ Other (4)	____ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/
Arsenic		Arsenic		Silver	
Barium		Barium		Sulfates	
Cadmium		Cadmium		Zinc	
Chromium		Chloride		Ph	
Lead		Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		Lead			
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
P&T:GC/MS		EDB		Methoxychlor	
Acid:B/N Ext.		✓ PCB's	<0.1 ppm	Toxaphene	
TOX		Petroleum		2,4-D	
		Endrin		2,4,5-TP (silvex)	
		Lindane			

MICROBIOLOGY

Parameter
(MF) Coliform Colonies/100mls
(MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
Gross Alpha	
Gross Beta	

Date Received 11-21-86 LD Date Reported

Date Extracted 12-02-86 LD Date Analyzed 12-19-86 V.P.

Reported By Lab Number 6 3140

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES, N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 - 306 N. WILMINGTON, ST., RALEIGH, N.C. 27611

ORGANIC CHEMICAL ANALYSIS

BASE/NEUTRAL AND ACID EXTRACTABLES	LAB NO	603112	603114	603124			
	FIELD #	3472	3474	3484			
COMPOUND	TYPE	(1/)	(1)	(1)	( )	( )	( )
	UNITS	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg
-nitrosodimethylamine	10	4	4	4			
bis(2-chloroethyl)ether							
-chlorophenol							
henol							
1,3-dichlorobenzene							
1,4-dichlorobenzene							
,2-dichlorobenzene							
is(2-chloroisopropyl)ether							
hexachloroethane							
-nitroso-di-n-propylamine							
itrobenzene							
isophorone							
-nitrophenol							
,4-dimethylphenol							
bis(2-chloroethoxy)methane							
2,4-dichlorophenol							
,2,4-trichlorobenzene							
aphthalene							
hexachlorobutadiene							
-chloro-m-cresol							
exachlorocyclopentadiene							
2,4,6-trichlorophenol							
-chloronaphthalene							
cenaphthylene							
dimethyl phthalate							
2,6-dinitrotoluene							
acenaphthene	↓						
,4-dinitrophenol	50						
2,4-dinitrotoluene	10						
4-nitrophenol	50						
fluorene	10						
4-chlorophenylphenylether	10						
diethyl phthalate	10						
4,6-dinitro-o-cresol	50						
diphenylamine	50						
azobenzene	50						
4-bromophenylphenylether	10						
hexachlorobenzene	10						
pentachlorophenol	50						
phenanthrene	10						
anthracene	10						
dibutyl phthalate	10						
fluoranthene	10	↓	↓	↓			

J - Estimated value.
K - Actual value is known to be less than value given.
L - Actual value is known to be greater than value given.
U - Material was analyzed for but not detected. The number is the Minimum Detection Limit.
NA - Not analyzed.
1/ - Tentative identification.
2/ - On NRDC List of Priority Pollutants.

N.C. Division of Health Services
DHS 3068-0 (4/86 Laboratory)

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES, N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 - 306 N. WILMINGTON, ST., RALEIGH, N.C. 27611

ORGANIC CHEMICAL ANALYSIS

BASE/NEUTRAL AND ACID EXTRACTABLES	LAB NO	603112	603114	603124			
	FIELD #	3472	3474	3484			
COMPOUND	TYPE	(/)	(/)	(/)	( )	( )	( )
	UNITS	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg
pyrene	10	U	U	U			
benzidine	50						
butyl benzyl phthalate	10						
benz(a)anthracene	10						
chrysene	10						
3,3-dichlorobenzidine	50						
bis(2-ethylhexyl)phthalate	10						
di-n-octyl phthalate	10						
benzo(b)fluoranthene	50						
benzo(k)fluoranthene							
benzo(a)pyrene							
indeno(1,2,3-cd)pyrene							
dibenzo(a,h)anthracene							
benzo(g,h,i)perylene							
aniline	50	U	U	U			
benzoic acid	50						
benzyl alcohol	10						
4-chloroaniline	10						
dibenzofuran	10						
2-methylnaphthalene	10						
2-methylphenol	10						
4-methylphenol	10						
2-nitroaniline	50						
3-nitroaniline	50						
4-nitroaniline	50						
2,4,5-trichlorophenol	50						

J - Estimated value.
K - Actual value is known to be less than value given.
L - Actual value is known to be greater than value given.
U - Material was analyzed for but not detected. The number is the Minimum Detection Limit.
NA - Not analyzed.
1/ - Tentative identification.
2/ - On NRDC List of Priority Pollutants.

N.C. Division of Health Services
DHS 3068-0 (4/86 Laboratory)

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES, N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 - 306 N. WILMINGTON, ST., RALEIGH, N.C. 27611

ORGANIC CHEMICAL ANALYSIS

PURGEABLE COMPOUNDS	LAB NO	603111	603113	603123			
	FIELD #	3471	3473	3483			
COMPOUND	TYPE	(1)	(1)	(1)	( )	( )	( )
	UNITS	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg	µg/l µg/kg
chloromethane	10	u	u	u			
bromomethane	10						
dichlorodifluoromethane	20						
vinyl chloride	10						
chloroethane	10						
methylene chloride	5						
trichlorofluoromethane	20						
ethene, 1,1-dichloro	5						
ethane, 1,1-dichloro-							
1,2-trans-dichloroethene							
chloroform							
ethane, 1,2-dichloro-							
ethane, 1,1,1-trichloro-							
carbontetrachloride							
bromodichloromethane							
propane, 1,2-dichloro-							
1,3-trans-dichloropropene							
trichloroethylene							
chlorodibromomethane							
benzene							
ethane, 1,1,2-trichloro-							
1,3-cis-dichloropropene							
2-chloroethyl vinyl ether	10						
bromoform	5						
ethane, 1,1,2,2-tetrachloro-							
ethene, tetrachloro-							
toluene							
chlorobenzene							
ethylbenzene							
acetone	10	u	u	u			
2-butanone	10						
carbondisulfide	5						
2-hexanone	10						
4-methyl-2-pentanone	10						
styrene	5						
vinyl acetate	10						
xylenes (total)	5						

J - Estimated value.
K - Actual value is known to be less than value given.
L - Actual value is known to be greater than value given.
U - Material was analyzed for but not detected. The number is the Minimum Detection Limit.
NA - Not analyzed.
1/ - Tentative identification.
2/ - On NRDC List of Priority Pollutants.

N.C. Division of Health Services

DHS 3068-O (4/86 Laboratory)

N.C. Department of Human Resources
Division of Health Services

CERCLA

SAMPLE ANALYSES REQUEST

Received 12-4-86

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 6009814784 80 Field Sample Number 3778

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1015

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Butts Well #1
___ Surface Water (2)	___ Liquid (6)	
___ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	Preserved with 3ml HNO_3

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ Arsenic		✓ Arsenic	<0.01	✓ Silver	<0.05
___ Barium		✓ Barium	<0.1	___ Sulfates	
___ Cadmium		✓ Cadmium	<0.005	___ Zinc	
___ Chromium		___ Chloride		___ Ph	
___ Lead		✓ Chromium	<0.01	___ Conductivity	
___ Mercury		___ Copper		___ TDS	
___ Selenium		___ Fluoride		___ TOC	
___ Silver		___ Iron			
		✓ Lead	0.04		
		___ Manganese			
		✓ Mercury	<0.0002		
		___ Nitrate			
		✓ Selenium	<0.005		

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results m
___ P&T:GC/MS		___ EDB		___ Methoxychlor	
___ Acid:B/N Ext.		___ PCB's		___ Toxaphene	
___ TOX		___ Petroleum		___ 2,4-D	
		___ Endrin		___ 2,4,5-TP (silvex)	
		___ Lindane			

MICROBIOLOGY

Parameter
___ (MF) Coliform Colonies/100mls
___ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
___ Gross Alpha	
___ Gross Beta	

Date Received ___ Date Reported 12-3-86

Date Extracted ___ Date Analyzed ___

Reported By ___ Lab Number 023713 NOV 21 86

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60098147848 0 Field Sample Number 3779

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1040

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Roland Well #2
___ Surface Water (2)	___ Liquid (6)	
___ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	Preserved with 3ml HNO3

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ Arsenic		✓ Arsenic	<0.01	✓ Silver	<0.05
___ Barium		✓ Barium	<0.1	___ Sulfates	
___ Cadmium		✓ Cadmium	<0.005	___ Zinc	
___ Chromium		___ Chloride		___ Ph	
___ Lead		✓ Chromium	<0.01	___ Conductivity	
___ Mercury		___ Copper		___ TDS	
___ Selenium		___ Fluoride		___ TOC	
___ Silver		___ Iron			
		✓ Lead	<0.03		
		___ Manganese			
		✓ Mercury	<0.0002		
		___ Nitrate			
		✓ Selenium	<0.005		

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ P&T:GC/MS		___ EDB		___ Methoxychlor	
___ Acid:B/N Ext.		___ PCB's		___ Toxaphene	
___ TOX		___ Petroleum		___ 2,4-D	
		___ Endrin		___ 2,4,5-TP (silvex)	
		___ Lindane			

MICROBIOLOGY

Parameter
___ (MF) Coliform Colonies/100mls
___ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
___ Gross Alpha	
___ Gross Beta	

Date Received ___ Date Reported 12-3-86

Date Extracted ___ Date Analyzed ___

Reported By ___ Lab Number 023714 NOV 21 86

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

N. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public
P. O. Box
306 N. Wilmington
Raleigh,

Site Number 60098147848 0 Field Sample Number 3780

Name of Site Toddville Operations Center Site Location Charlotte, N.C.

Collected By Stan Atwood ID# 45 Date Collected Nov. 19, 1986 Time 1200

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	On Site Well #4
___ Surface Water (2)	___ Liquid (6)	
___ Soil (3)	___ Sludge (7)	Unpreserved
___ Other (4)	___ Other (8)	~~[illegible]~~

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg.
___ Arsenic		✓ Arsenic	<0.01	✓ Silver	<0.05
___ Barium		✓ Barium	0.2	___ Sulfates	
___ Cadmium		✓ Cadmium	<0.005	___ Zinc	
___ Chromium		___ Chloride		___ Ph	
___ Lead		✓ Chromium	<0.01	___ Conductivity	
___ Mercury		___ Copper		___ TDS	
___ Selenium		___ Fluoride		___ TOC	
___ Silver		___ Iron			
		✓ Lead	0.32		
		___ Manganese			
		✓ Mercury	<0.0002		
		___ Nitrate			
		✓ Selenium	<0.005		

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg
___ P&T:GC/MS		___ EDB		___ Methoxychlor	
___ Acid:B/N Ext.		___ PCB's		___ Toxaphene	
___ TOX		___ Petroleum		___ 2,4-D	
		___ Endrin		___ 2,4,5-TP (silvex)	
		___ Lindane			

MICROBIOLOGY

Parameter
___ (MF) Coliform Colonies/100mls
___ (MPN) Coliform Colonies/100mls

RADIOCHEMISTRY

Parameter	Results PCi/1
___ Gross Alpha	
___ Gross Beta	

Date Received ___ Date Reported 12-3-86

Date Extracted ___ Date Analyzed ___

Reported By ___ Lab Number 023715 NOV 21 86

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

Appendix C

References

REFERENCES

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3. U.S.G.S. Water Resources Investigations, Open File Report 80-44. Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina. U.S Department of the Interior and NC Natural Resources and Community Development, 1980.

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11. IARC, IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans; Polychlorinated biphenyls and Polybrominated biphenyls. Lyon, 1978, pp. 43-103.

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Ref 2

STATE OF NORTH CAROLINA

DEPARTMENT OF NATURAL RESOURCES AND COMMUNITY DEVELOPMENT

CLASSIFICATIONS AND WATER QUALITY STANDARDS ASSIGNED TO THE WATERS OF THE CATAWBA RIVER BASIN

DIVISION OF ENVIRONMENTAL MANAGEMENT

RALEIGH, NORTH CAROLINA

Reprint from North Carolina Administrative Code: 15 NCAC 2B .0308
Current through: September 1, 1981

examiner or examiners, will adopt its final action with respect to the assignment of classifications applicable to the waters under consideration. The commission will publish such action, together with the effective date for the application of the provisions of General Statute 143-215.1 and 143-215.2, as amended, as a part of the commission's official regulations.

(8) The final action of the commission with respect to the assignment of classification with its accompanying standards shall contain the commission's conclusions relative to the various factors given in General Statute 143-214.1(d), and shall specifically include the class or classes to which such specifically designated waters in the watershed or watersheds shall be assigned on the basis of best usage in the interest of the public.

(A) Freshwater Classifications.

(i) Class WS-I; waters protected as water supplies which are in natural and uninhabited or predominantly undeveloped (not urbanized) watersheds; no point source discharges are permitted and local land management programs to control nonpoint source pollution are required; suitable for all Class C uses;

(ii) Class WS-II; water protected as water supplies which are in low to moderately developed (urbanized) watersheds; discharges are restricted to primarily domestic wastewater or industrial non-process waters specifically approved by the commission; local land management programs to control nonpoint source pollution are required; suitable for all Class C uses;

(iii) Class WS-III; water supply segment with no categorical restrictions on watershed development or discharges; suitable for all Class C uses;

(iv) Class B; suitable for swimming, primary recreation and all Class C uses;

(v) Class C; suitable for secondary recreation and fish propagation;

(B) Tidal Salt Water Classifications.

(i) Class SA; suitable for commercial shellfishing and all other tidal salt water uses;

(ii) Class SB; suitable for swimming and primary recreation and all Class SC uses;

Name of Stream	Description	Classification Class	Classification Date	Index No.
Ore Bank Branch	From source to Leepers Creek	C	3/1/62	11-119-1-5
Lick Run	From source to Leepers Creek	C	3/1/62	11-119-1-6
Reed Creek	From source to Leepers Creek	C	3/1/62	11-119-1-7
Bradshaw Branch	From source to Leepers Creek	C	3/1/62	11-119-1-8
Dellinger Branch	From source to Leepers Creek	C	3/1/62	11-119-1-9
Armstrong Branch	From source to Dellinger Branch	C	3/1/62	11-119-1-9-1
Crooked Creek	From source to Leepers Creek	C	3/1/62	11-119-1-10
McClure Branch	From source to Leepers Creek	C	3/1/62	11-119-1-11
Killian Creek	From source to Dutchmans Creek	C	3/1/62	11-119-2
Snyder Creek	From source to Killian Creek	C	3/1/62	11-119-2-1
Anderson Creek	From source to Killian Creek	C	3/1/62	11-119-2-2
Wingate Creek	From source to Anderson Creek	C	3/1/62	11-119-2-2-1
Wilkinson Creek	From source to Wingate Creek	C	3/1/62	11-119-2-2-1-1
Ballard Creek	From source to Wingate Creek	C	3/1/62	11-119-2-2-1-2
Hooper Branch	From source to Anderson Creek	C	3/1/62	11-119-2-2-2
Forney Creek	From source to Killian Creek	C	3/1/62	11-119-2-3
Stanley Creek	From source to Dutchmans Creek	C	3/1/62	11-119-3
South Stanley Creek	From source to Dutchmans Creek	C	3/1/62	11-119-4
Taylors Creek	From source to Dutchmans Creek	C	3/1/62	11-119-5
Long Creek	From source to Lake Wylie, Catawba River	C	9/1/74	11-120
Dixon Branch	From source to Long Creek	C	9/1/74	11-120-1
Vances Twin Lakes	Entire lakes and connecting stream to Dixon Branch	C	9/1/74	11-120-1-1
Swaringer Lake	Entire lake and connecting stream to Long Creek	C	9/1/74	11-120-2
McIntyre Creek	From source to Long Creek	C	9/1/74	11-120-3
Gutter Branch	From source to Long Creek	C	9/1/74	11-120-4
Gum Branch	From source to Long Creek	C	9/1/74	11-120-5
Thomas Pond	Entire pond and connecting stream to Long Creek	C	9/1/74	11-120-6
Fites Creek	From source to Lake Wylie, Catawba River	C	9/1/74	11-121
CATAWBA RIVER (Lake Wylie below elevation 570) North Carolina portion	From Interstate Highway 85 Bridge at Belmont to North Carolina-South Carolina State Line	A-II&B	3/1/62	11-(122)
Unnamed Tributary at Belmont Abbey College	From source to Lake Wylie, Catawba River	C	9/1/74	11-123
Paw Creek	From source to Lake Wylie, Catawba River	C	9/1/74	11-124
Ticer Branch (Tiser Branch)	From source to Paw Creek	C	9/1/74	11-124-1
Little Paw Creek (Danga Lake)	From source to Lake Wylie, Catawba River	C	9/1/74	11-125
Beaverdam Creek	From source to Lake Wylie, Catawba River	C	9/1/74	11-126
Legion Lake and Shoaf Lake	Entire lake and connecting stream to Beaverdam Creek	C	9/1/74	11-126-1
Stowe Branch	From source to Lake Wylie, Catawba River	C	9/1/74	11-127
Neal Branch (Armour Creek)	From source to Lake Wylie, Catawba River	C	9/1/74	11-128
South Fork Catawba River	From source to Cramerton Dam and Lake Wylie at Upper Armstrong Bridge	A-II	3/1/62	11-129
Henry Fork	From source to Morganton Water Intake	A-I	3/1/62	11-129-1-(1)
Henry Fork	From Morganton Water Intake to South Fork Catawba River	C	3/1/62	11-129-1-(2)
Jerry Branch	From source to Morganton Water Intake	A-I	3/1/62	11-129-1-3-(1)
Jerry Branch	From Morganton Water Intake to Henry Fork	C	3/1/62	11-129-1-3-(2)

Ref 2

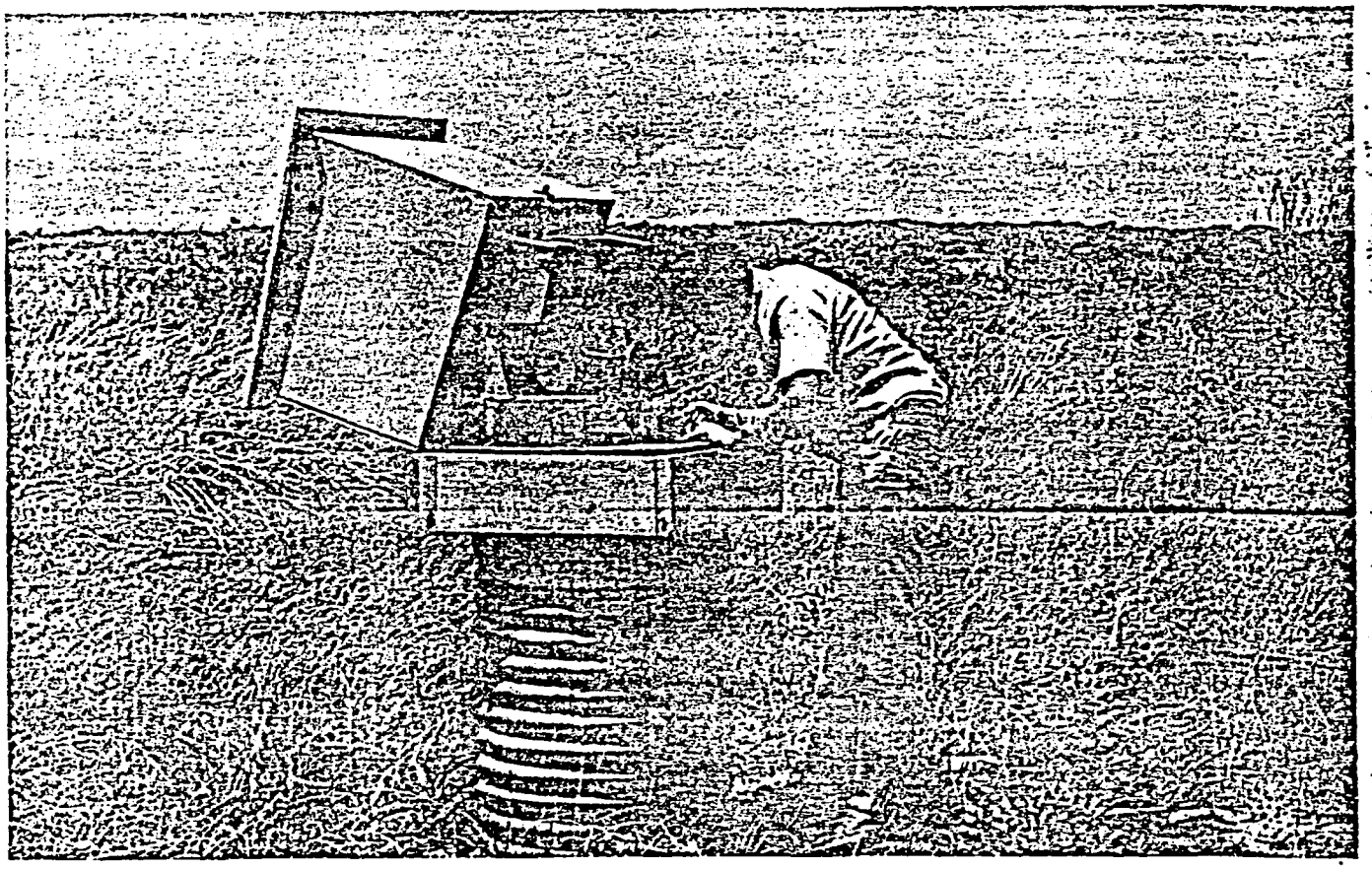
Reference Material to Regulation 15 NCAC 2B .0308 Catawba River Basin, entitled CLASSIFICATION AND WATER QUALITY STANDARDS ASSIGNED TO THE WATERS OF THE CATAWBA RIVER BASIN, has been amended 2-1-86 as follows:

Name of Stream	Description	Class	Index No.
CATAWBA RIVER	From source to Old Fort Finishing Plant Water Supply Intake	WS-III Tr	11-(1)
Chestnut Branch (Fork)	From source to Catawba River	WS-III Tr	11-2
Clover Patch Branch	From source to Catawba River	WS-III Tr	11-3
Youngs Fork Creek	From source to Catawba River	WS-III Tr	11-4
Spring Branch	From source to Catawba River	WS-III Tr	11-5
Left Prong Catawba River	From source to Catawba River	WS-III Tr	11-6
Jarrett Creek	From source to Old Fort Water Supply Intake	WS-I	11-7-10-(1)
Lost Cove Creek	From source to Jarrett Creek	WS-I	11-7-10-2
Curtis Creek	From source to Long Branch	WS-I Tr	11-10-(1)
Bear Drive Branch	From source to Curtis Creek	WS-I Tr	11-10-2
Licklog Branch	From source to Curtis Creek	WS-I Tr	11-10-3
Big Camp Rock Branch	From source to Curtis Creek	WS-I Tr	11-10-4
Rest Branch	From source to Curtis Creek	WS-I Tr	11-10-5
Curtis Creek (including proposed Dam and Reservoir)	From Long Branch to a point located 250 feet upstream from U.S. Hwy. 70 Bridge	WS-III Tr	11-10-(6)
Long Branch	From source to Curtis Creek	WS-I Tr	11-10-7
Hickory Branch	From source to Long Branch	WS-I Tr	11-10-7-1
Slick Falls Branch	From source to Curtis Creek	WS-I Tr	11-10-8
Newberry Creek	From source to Newberry Road Bridge, located 1.5 miles more or less upstream from Curtis Creek	WS-I Tr	11-10-9-(1)
Chute Branch	From source to Newberry Creek	WS-I Tr	11-10-9-2
Laurel Jog Creek	From source to Newberry Creek	WS-I Tr	11-10-9-3
Left Prong Laurel Jog Creek	From source to Laurel Jog Creek	WS-I Tr	11-10-9-3-1

Name of Stream	Description	Class	Index No.
Lucky Creek	From source to Lake Norman, Catawba River	WS-III&B	11-110
CATAWBA RIVER (Mountain Island Lake below elevation 648)	From Cowan's Ford Dam to Water Intake at River Bend Steam Station	WS-III	11-(112)
Johnson Creek	From source to Mountain Island Lake, Catawba River	WS-III	11-113
CATAWBA RIVER (Mountain Island Lake below elevation 648)	From Water Intake at River Bend Steam Station to Mountain Island Dam	WS-III&B	11-(114)
McDowell Creek	From mouth of Torrence Creek to Mountain Island Lake, Catawba River	WS-III	11-115-(3)
Gar Creek	From source to Mountain Island Lake, Catawba River	WS-III	11-116
CATAWBA RIVER (Lake Wylie below elevation 570)	From Mountain Island Dam to Interstate Highway 85 Bridge at Belmont	WS-III	11-(117)
Harwood Lakes and Brinkley Twin Lakes	Entire lakes and connecting streams to Lake Wylie, Catawba River	WS-III	11-118
Leepers Creek	From source to a point approximately 2400 feet upstream from Lincoln County SR 1354 at Old Grier Iron Furnace	WS-III	11-119-1-(1)
Sawmill Branch	From source to Leepers Creek	WS-III	11-119-1-2
Lippard Creek	From soruce to Leepers Creek	WS-III	11-119-1-3
Link Creek	From source to Lippard Creek	WS-III	11-119-1-3-1
CATAWBA RIVER (Lake Wylie below elevation 570) North Carolina portion	From Interstate Highway 85 Bridge at Belmont to North Carolina-South Carolina State Line	WS-III&B	11-(122)
South Fork Catawba River	From source to Cramerton Dam and Lake Wylie at Upper Armstrong Bridge	WS-III	11-129
Henry Fork	From source to Morganton Water Intake	WS-I	11-129-1-(1)
Jerry Branch	From source to Morganton Water Intake	WS-I	11-129-1-3-(1)
He Creek	From source to Morganton Water Intake	WS-I	11-129-1-4-(1)
Long Branch	From source to Broughton Hospital Water Intake	WS-I	11-129-1-8-(1)

Ref 3

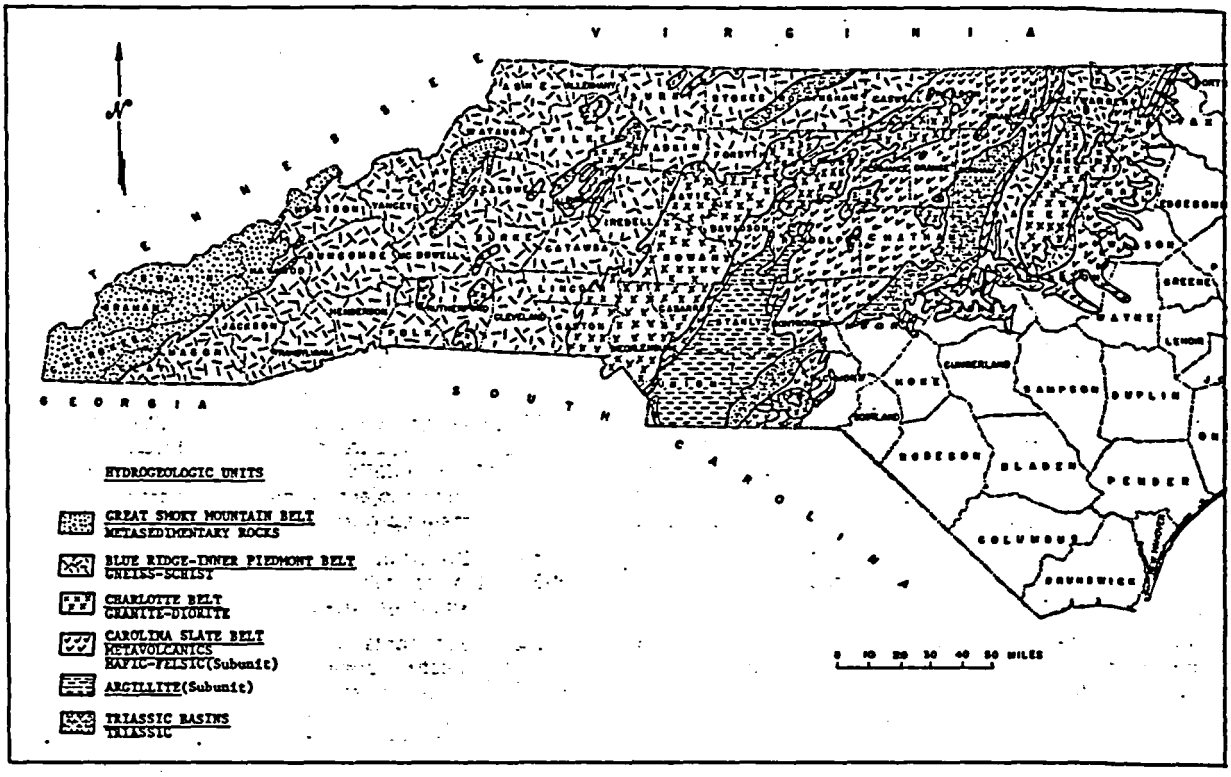
Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina



U.S. GEOLOGICAL SURVEY
WATER RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 80-44

Prepared in cooperation with the
North Carolina Department of Natural
Resources and Community Development

Rock Units and Aquifers in the Piedmont and Mountains



The rocks underlying the Piedmont and mountains can be divided into two groups: (1) bedrock, and (2) saprolite (or residuum). The saprolite underlies the land surface and ranges in thickness from a foot or two near bedrock outcrops to more than 100 ft. Bedrock underlies the saprolite and is the parent rock from which the saprolite was derived in the process referred to as weathering.

Many stream valleys, especially those of larger streams, are underlain by a layer of material similar in composition to saprolite. This material, which has been deposited by the streams during floods, is correctly referred to as *alluvium*. However, to avoid unnecessary complications, we will lump the alluvium in with the saprolite for the purpose of this discussion.

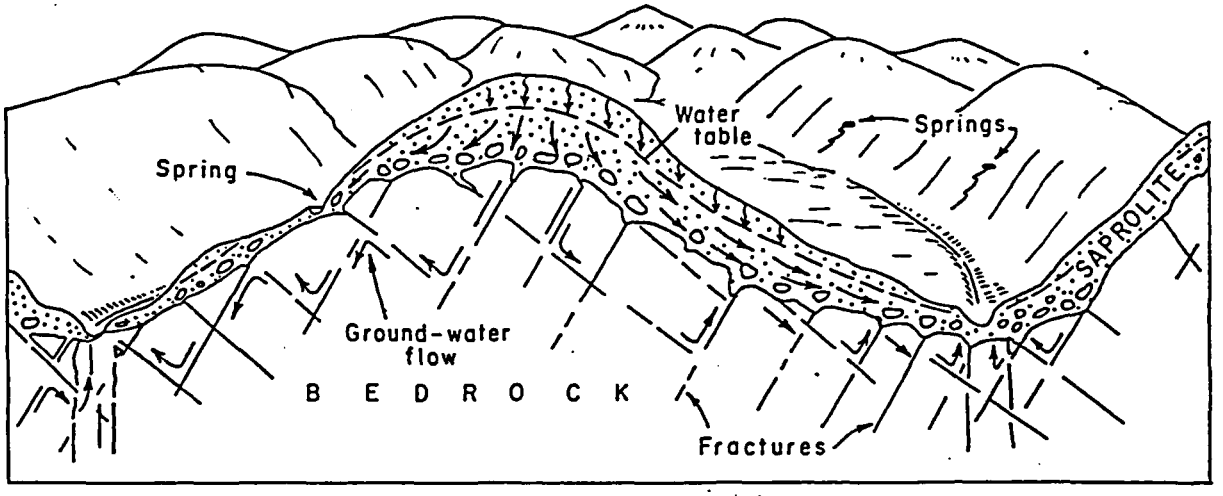
The bedrock underlying the Piedmont and mountains consists of many different types of igneous and metamorphosed igneous and sedimentary rocks. The Generalized Geological Map of North Carolina accompanying the discussion of WATER-BEARING ROCKS divides the bedrock in the Piedmont and mountains into six units. The 1:500,000 scale Geologic Map of North Carolina, published in 1958, divides the bedrock in the same area into 48 different units. But, a much larger number of units have been identified and are shown on large scale geologic maps.

The bedrock units differ from each other in mineral composition and other geologic characteristics. Fortunately, these differences do not result in large differences in hydraulic characteristics so that it is possible to combine the bedrock units into a relatively small number of hydrogeologic units.

The accompanying map shows the hydrogeologic units into which the bedrock in the Piedmont and mountains has been divided by the U.S. Geological Survey and the North Carolina Groundwater Section.

The most productive hydrogeologic units are the Great Smoky Mountain belt and the Blue Ridge-Inner Piedmont belt. The least productive units are the Carolina Slate Belt and the Triassic Basins. The Charlotte Belt is intermediate in productivity.

Ground-Water Situation in the Piedmont and Mountains



The *saprolite* (weathered rock) that forms the land surface in the Piedmont and mountains consists of unconsolidated granular material. It thus contains water in the pore spaces between rock particles.

The *bedrock*, on the other hand, does not have any significant intergranular (primary) porosity. It contains water, instead, in sheet-like openings formed along fractures (that is, breaks in the otherwise "solid" rock). Fractures in bedrock are of two types: (1) *joints*, which are breaks along which there has been no differential movement; and (2) *faults*, which are breaks along which the adjacent rocks have undergone differential movement.

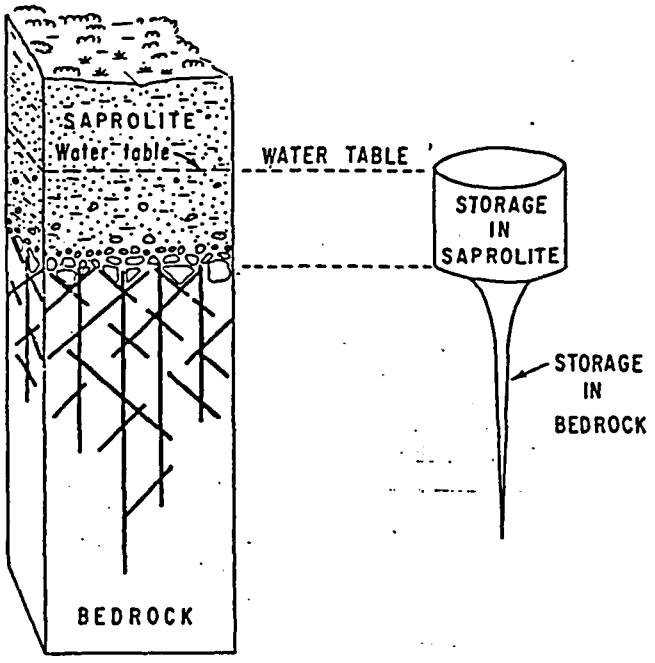
Faults are formed during earthquakes and generally contain larger and more extensive openings than those developed along joints. Joints, however, are far more numerous than faults.

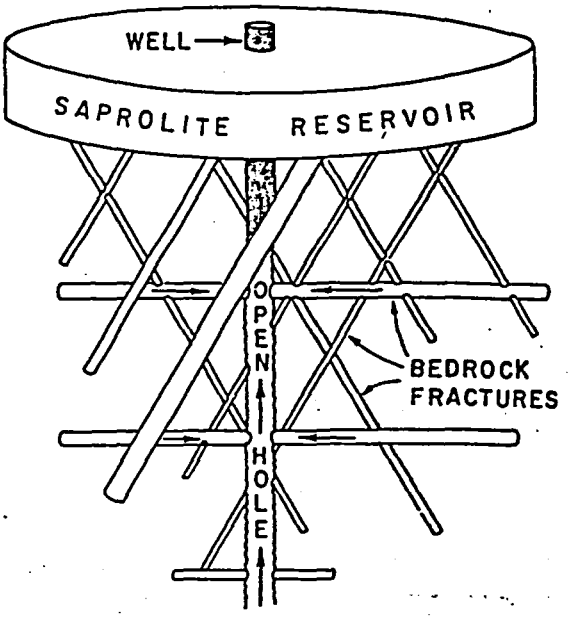
Fractures (joints and faults) are more abundant under valleys, draws, and other surface depressions than under hills. In fact, geologists assume that it is the presence of fractures that determined the position of valleys in the first place. Fractures tend to be more closely-spaced and the openings developed along them tend to be larger near the surface of the bedrock. Most fractures appear to be non water-bearing below a depth of 300 to 400 ft. Large water-bearing openings, penetrated below this depth are probably associated with faults.

The ground-water system in the Piedmont and mountains is recharged by precipitation on the interstream areas. A part of the precipitation infiltrates through the unsaturated zone to the water table, which normally occurs in the saprolite.

Ground water moves laterally and downward through the saprolite to points of ground-water seepage (springs) on the hillsides and to the streams in the adjacent valleys. Some of the water in the saprolite also moves downward into the bedrock and, thereafter, through the fractures to the adjacent valleys.

Hydraulic Characteristics of the Piedmont and Mountain Ground-Water System





One of the most basic concepts of ground-water hydrology is that aquifers function both as reservoirs, in which water is in storage, and as pipelines, which transmit water from one point to another. This is referred to as the *reservoir-pipeline concept.* This concept forms a useful basis on which to discuss the hydraulic characteristics of the Piedmont and mountain ground-water system.

The reservoir (storage) function of aquifers depends on the porosity. The pipeline function depends on the hydraulic conductivity and the thickness of the aquifer. The approximate range in porosity and hydraulic conductivity for the saprolite and bedrock is shown in the following table.

Rock type	Porosity in percent	Hydraulic conductivity in feet per day
Saprolite	20-30	1-20
Bedrock	0.1-1	1-20

The above values suggest that the principal difference between saprolite and bedrock is in water-storage capacity. In other words, the saprolite has the capacity to store a much larger quantity of water than does the bedrock. This is not the entire story, however.

As we noted above, the capacity of an aquifer to transmit water depends both on hydraulic conductivity and on aquifer thickness. The part of the bedrock containing water-bearing fractures is several times thicker than the saprolite.

We can then, without great error, view the ground-water system in the Piedmont and mountains as consisting of a saprolite reservoir overlying a bedrock pipeline consisting of numerous small, interconnected pipes. In the vicinity of a pumping well the bedrock fractures ("pipes") convey water from the saprolite reservoir to the well.

The yield of a well drawing from fractured bedrock depends on several factors. The most important of these are believed to be:

1. The number, size, areal extent, and degree of interconnection of the fractures penetrated by the well,
2. The thickness of saturated saprolite in the vicinity of the well and the specific yield of the saprolite, and
3. The hydraulic conductivity of the saprolite and the nature of the hydraulic connection between the saprolite and the bedrock.

The number and the size of the fractures control the rate at which water can enter the well. The areal extent and degree of interconnection of the fractures control the size of the area that supplies water to the well.

The thickness and the specific yield of the saprolite determines the volume of water available from storage in the saprolite. The hydraulic conductivity of the saprolite and the nature of the hydraulic connection between the saprolite and the bedrock determines the rate at which water can drain from the saprolite into the bedrock fractures.

Hydraulic Conductivity of Selected Rocks

Material	Hydraulic conductivity (rounded values) (ft/day)	[(gal/day)/ft²]	(meters/day)
Coarse sand	200	1500	60
Medium sand	130	1000	40
Silt	1	5	0.2
Clay	0.001	0.01	0.0004
Limestone (Castle Hayne)	300	2000	80
Saprolite	5	50	2
Granite and gneiss	5	50	2
Slate	3	25	1

Hydraulic conductivity replaces the term "field coefficient of permeability" and should be used when referring to the water-transmitting characteristic of material in quantitative terms. It is still permissible to refer in qualitative terms to "permeable" and "impermeable" material.

PROBLEM - Determine the hydraulic conductivity of the confined aquifer shown in the preceding drawing in both feet per day and gallons per day per square foot.

(1) Solution in feet per day

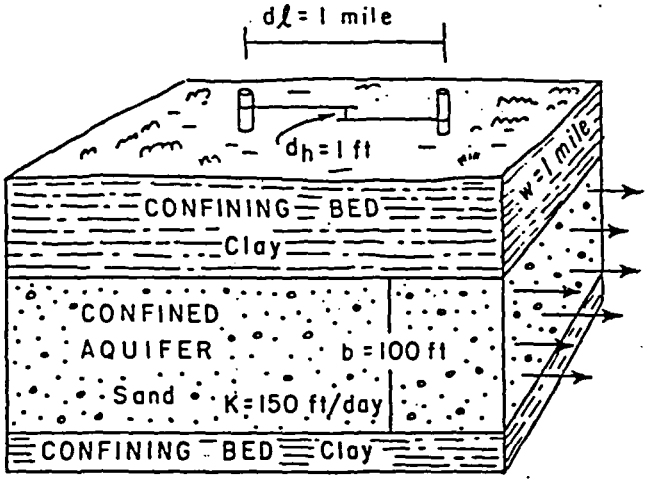
(Equation) (Q) (A) (dl/dh)

$$K = \frac{Qdl}{Adh} = \frac{150\ ft^3}{day} \times \frac{1}{ft^2} \times \frac{1\ ft}{1\ ft} = \frac{150\ ft^3}{day\ ft^2} = 150\ ft/day$$

(2) Conversion of feet per day to gallons per day per square foot

$$\frac{150\ ft^3}{day\ ft^2} \times \frac{7.5\ gal}{ft^3} = 1125\ (gal/d)/ft^2$$

Transmissivity



The capacity of an aquifer to transmit water is referred to as its transmissivity. The *transmissivity* (T) of an aquifer is equal to the hydraulic conductivity of the material comprising the aquifer multiplied by the thickness of the aquifer. Thus

$$T = Kb \qquad (1)$$

where T is transmissivity,
K is hydraulic conductivity, and
b is aquifer thickness.

As was the case with hydraulic conductivity, transmissivity is also defined in terms of a unit hydraulic gradient.

If we combine equation 1 with Darcy's law (see HYDRAULIC CONDUCTIVITY), the result is an equation that can be used to calculate the quantity of water moving through a width, w, of an aquifer. Thus,

$$Q = KA\frac{dh}{dl} = K(bw)\frac{dh}{dl} = (Kb)w\frac{dh}{dl}$$

$$Q = Tw\frac{dh}{dl} \qquad (2)$$

Equation 2 is also used to calculate transmissivity, where the quantity of water (Q) discharging from a known width of aquifer can be determined as, for example, with streamflow measurements. Rearranging terms, we obtain

$$T = \frac{Q\,dl}{w\,dh} \qquad (3)$$

The units of transmissivity, as can be demonstrated with the preceding equation, are

$$T = \frac{(ft^3\ day^{-1})\ (ft)}{(ft)\ \ (ft)} = \frac{ft^2}{day}$$

Because transmissivity depends both on K and b, its value is different in different aquifers and from place to place in the same aquifer.

Average Values of Hydraulic Conductivity, Thickness, and Transmissivity for Selected Aquifers in North Carolina

Aquifer	Hydraulic Conductivity (ft./day)	Thickness (ft.)	Transmissivity (ft^2./day)
Post-Yorktown deposits	50	20	1000
Yorktown Formation	50	40	2000
Castle Hayne Limestone	300	100	30000
Cretaceous deposits	20	200	4000
Saprolite	5	50	250
Granite and gneiss	5	200	1000

Transmissivity replaces the term "coefficient of transmissibility" because, by convention, an aquifer is transmissive and the water in it is transmissible.

PROBLEM - Determine the quantity of water (Q) moving through the segment of the confined aquifer shown in the preceding drawing in both $ft.^3$/day and gal./day.

(1) Calculation of transmissivity

$$T = Kb = \frac{150\ ft}{day} \times \frac{100\ ft}{1} = \frac{15{,}000\ ft^2}{day}$$

(2) Solution in $ft.^3$/day

$$Q = Tw\frac{dh}{dl} = \frac{15{,}000\ ft^2}{day} \times \frac{5280\ ft}{1} \times \frac{1\ ft}{5280\ ft} = \frac{15{,}000\ ft^3}{day}$$

(3) Conversion of ft^3./day to gal./day

$$\frac{15{,}000\ ft^3}{day} \times \frac{7.5\ gal}{ft^3} = 112{,}500\ gal/day$$

Ref 4

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 November 1986

Ms. Denise Smith
EPA NC CERCLA Project Officer
EPA Region IV Waste Division
345 Courtland Street, N.E.
Atlanta, GA 30365

Dear Ms. Smith:

SUBJECT: Summary Trip Report
Toddville Operations Center NC D981478480
610 Toddville Road
Charlotte, NC 28242

The Duke Power Toddville Operations Center is located just northwest of Charlotte on about 115 acres of land. The site has been used for about 30 years to service and store electrical equipment. The oil used in some of the transformers and capacitors serviced on site contained PCB's. There are two wells on site which have been capped since 1971.

On 19 November 1986, Stan Atwood, Jack Butler, and Cheryl McMorris, NC DHR/DHS CERCLA Unit, conducted an investigation of the Toddville site. We arrived at the site at 10:00 a.m. and located the nearest off-site wells. Alan Giles, Mecklenburg County Health Department, met us and accompanied us throughout the investigation. Two off-site wells, just across Toddville road from the site, were sampled for organic and inorganic contaminants. The exact depth of the first well was unknown but was reported to be less than 100 ft. The second well was reported to be between 36 and 38 feet deep. Temperature and pH measurements for the first well were 15.6°C and 7.06; readings for the second well were 16°C and 6.33. Both wells were located within 110 feet of the highway (Figure 1).

At 11:00 a.m. we met with Michael Lascara, Dave Anderson, John Meau, Jay Perkins, and Warren Baker of Duke Power Company. They accompanied us throughout the remainder of the investigation. Duplicate samples were requested and supplied. A prearranged sampling plan was followed. A ten foot square was marked at each sampling area. Surface and subsurface samples were collected at the corners.

Background soil samples were collected first. The area sampled is in a field north of the site located 42 feet west of Toddville road and 106 feet north of the fence that surrounds the site (Figure 1). Subsoil samples were taken at a depth of 20 inches in red clay with a hand auger.

An on-site well was uncapped by Duke Power Company personnel to allow access to ground water (Figure 1). A teflon bailer was used to collect grab samples. The water was silty. Measurements taken included water temperature (17.9°C), pH (7.5), well depth (greater than 250 ft.), water level (16 ft.), and casing width (8 in.).

The final soil sampling locations were located near the centers of storage areas on the west and south sides of the warehouse. Both surface and subsurface samples were collected. Subsurface samples were taken at depths ranging from 15 to 25 inches. Soil texture ranged from yellow loamy clay to red clay. Both storage areas were covered with several inches of gravel. The investigation was concluded at 2:00 p.m.

A visit was also made to Carolina Water Services at 5701 Westpark Drive, Suite 101, Charlotte, NC. They operate more than 30 community well systems in Mecklenburg County. We met with Jerry Oliver who supplied us with a list of their systems, locations, and the number of meters. He said he would mail information on well depths and yields at a later date. Three of their systems are located within three miles of the Toddville site. These are McClure Circle, Trexler Park, and Oakdale which serve 80, 167, and 430 people, respectively.

If you have any questions, please contact me at (919) 733-2801.

Sincerely,

Stan Atwood, Toxicologist
CERCLA Unit
Solid and Hazardous Waste Management Branch
Environmental Health Section

SA/tb/0342b

Ref 5

NORTH CAROLINA
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
GEORGE R. ROSS, *Director*

DIVISION OF MINERAL RESOURCES
JASPER L. STUCKEY, *State Geologist*

BULLETIN NUMBER 63

GEOLOGY AND GROUND WATER
IN THE
Charlotte Area, North Carolina

By

H. E. LEGRAND and M. J. MUNDORFF
Geologists, U. S. Geological Survey

PREPARED COOPERATIVELY BY THE GEOLOGICAL SURVEY,
UNITED STATES DEPARTMENT OF THE INTERIOR

1952

Ref 5

most places. The limestone proper is generally less than 100 feet thick, as a result of which its areal extent is small. In contrast to the quartzite it weathers readily, forming longitudinal valleys along its strike.

Keith[7] has named this rock the Gaffney marble because of its prominence near Gaffney, S. C. It is mostly gray in color and contains, in addition to calcite and dolomite, such impurities as quartz, mica, graphite, and hornblende.

Diorite and granite complex.—Rocks of the diorite and granite group cover a large area in Cabarrus and Mecklenburg Counties, and they also occur in eastern Gaston and Lincoln Counties. They are believed to have a wide distribution outside the Charlotte area, although very little geological study has been made of rocks of this complex.

A mafic component, chiefly diorite, and a felsic component, chiefly granite, form this complex, (fig. 3), The mafic component varies in composition, being a gabbro in some places and a diorite in others, but, for convenience, it is called diorite in this report. The felsic component is granite in all places.

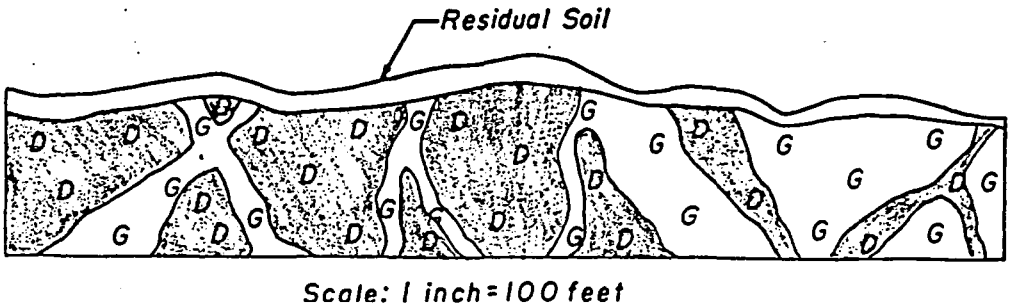


FIGURE 3.—*Diagrammatic sketch showing the relation of granite (G) and diorite (D) in Cabarrus and Mecklenburg Counties.*

So closely spaced are individual rocks within the complex that not even the larger bodies can be shown on the accompanying maps. It was decided to split the complex proper into two units, one in which the diorite predominates and the other in which the granite predominates. In using this subdivision the boundaries between these units are necessarily arbitrary and somewhat indefinite.

The most conspicuous occurrence of the granite is as discrete bodies veining and penetrating the diorite in random fashion. Thus, in most places, it is evident that granite was intruded into the diorite, although each type of rock is clearly separated from the other, without any appreciable modification of either.

The diorite in a semiweathered state, commonly seen, is a dark-blue or gray medium-textured rock composed predominantly of hornblende and feldspar and containing varying amounts of quartz, biotite, pyroxene, and other accessory minerals. The rock granulates readily near the surface of the ground, and the soil may be composed in part of individual hornblende and feldspar crystals typical of the Mecklenburg soil types.

The granite forming the complex with the diorite is light in color, being composed almost entirely of feldspar and quartz. Biotite, muscovite, and the accessory minerals common to most granites are not conspicuous. Like the diorite with which it is associated, the granite disintegrates readily near the surface, breaking down into pea-size aggregates of quartz and feldspar.

Some of the diorite is strongly schistose and much of the granite is sheared. The wide range in degree of metamorphism of the diorite suggests that basic rocks of different ages are included in this complex. Laney[8] describes a group of diorite dikes younger than the granite and diorite and cutting both.

The source of the granite forming the complex with the diorite is not known. It is in contact with a large granite mass near Kannapolis in Cabarrus County and with the syenite ring dike south of Concord. Although differing in general appearance from the other granites of the Charlotte area, general field relations suggest that the various granites may be of the same age. Where granite occurs in lesser

[7]Op cit., p. 6.

[8]Laney, F. B., Gold Hill mining district of North Carolina: North Carolina Geol. and Econ. Survey Bull. 21, p. 56, 1910.

Ref 5

amounts than diorite it appears that the granite was emplaced after the diorite, and this relation may exist also in areas where the granite is dominant over the diorite. It is possible that the granite and diorite are genetically related and that the emplacement of the granite followed quickly that of the diorite. Although some outcrops show that granite has assimilated the diorite locally, these two rocks normally occur as distinct bodies. In places where the granite is subordinate the basic component may be a gabbro, suggesting that the diorite of the complex is related to the gabbro-diorite rocks not included in the complex.

Syenite.—A more or less circular belt or ring dike of augite-syenite occurs about 4 miles southwest of Concord in Cabarrus County (fig. 9). Inside the ring is massive gabbro-diorite. The area is about 6 miles wide although the width of the ring averages less than 1 mile.

The rock is described[9] as "of uniformly coarse texture over the entire area, of massive structure and composed of large bluish gray feldspar individuals, without pronounced crystal outline (allotriomorphic). It contains little of the other minerals, as a rule, but is largely made up of the coarse crystallization of feldspar . . .

". . . The small amount of groundmass present in the rock is coarse-textured and dark gray from the proportion of the dark bisilicates present."

Large boulders, characteristic of the syenite, indicate that vertical joints are widely spaced. Its massiveness appears to be a factor in its resistance to erosion because it stands slightly higher than the mafic and felsic rocks along both the inner and outer edges. The syenite disintegrates readily but decomposes slowly, resulting in a granulated and crumbly weathered rock and soil composed almost entirely of feldspar crystals or aggregates.

In 1944 Dr. William A. White of the University of North Carolina and M. J. Mundorff mapped the syenite outcrop in some detail and studied its relation to adjacent rocks. At that time its concentric-ring outline was ascertained—an almost circular ring which is broken on the southeast side by gaps that total less than 2 miles. The rock within the ring is, for the most part, gabbro-diorite and that on the outside is chiefly the diorite injection complex, there being some granite in the town of Concord.

The origin and underground shape of the syenite ring dike are not known. The circular shape of the dike at the surface suggests that the syenite filled a peripheral fault after the central core had subsided, perhaps during late Palezoic time. The syenite is not interpenetrated by other rocks and is not metamorphosed. It may be younger than the granites.

Slates and related volcanic rocks.—In the eastern part of Cabarrus and Mecklenburg Counties a series of sedimentary slates is interbedded with volcanic rocks. These rocks form the western edge of a northeastward-trending belt that extends across the State and is generally known as the Carolina Slate Belt. The contained ore deposits, chiefly gold, have led to detailed study of parts of the belt. A part of the belt lying in the northeast corner of Cabarrus County and extending into Rowan and Stanly Counties has been described by Laney.[10].

The most common rock of the Slate Belt is a slate that appears to represent sedimentary beds of shale. The slate, blue and dense where fresh, shows distinct bedding planes especially near the Cabarrus-Stanly County line. The slates and the volcanic rocks that they enclose strike northeastward.

The volcanic rocks, chiefly tuffs of rhyolite and andesite, are interbedded with the slates and grade into them. The fine-grained tuff is dense and resembles chert; it grades into the slate and also into coarser tuffs which show fragments of coarse feldspar and quartz.

The rocks of the slate belt represent a period of intermittent volcanic activity. During the active intervals lavas of rhyolite and andesite were thrown out. The commingling of volcanic ash and other ejecta with some land waste led to the formation of tuffs. During the more quiet intervals beds of finer materials were deposited. Some of the beds, especially the finer tuffs and slates, are believed to have been deposited in water.

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[9]Watson, T. L., and Laney, F. B., The building and ornamental stones of North Carolina: North Carolina Geol. Survey Bull. 2, p. 94, 1906.

[10]Laney, F. B., Op. cit., pp. 25-42.

The slates are generally regarded as being of pre-Cambrian age. Detailed studies of local areas in the slate belt by Laney,[11] Pogue,[12] and Stuckey,[13] and regional investigations by King[14] indicate that the age is conjectural.

Greenstone schist.—The greenstone schist crops out in a thin belt extending northeastward through the eastern parts of Mecklenburg and Cabarrus Counties. The greenstone includes an assemblage of rocks that were mapped together because it is difficult to separate them in the field. All are green in color, are slightly to highly schistose, and are mafic rocks of igneous origin. The typical greenstone is fine-grained and in the more massive facies[15] phenocrysts of dark-green hornblende and greenish-yellow epidotized feldspars are distinguishable. The rock probably represents a basic lava flow. Along its western border the greenstone is coarser and is similar to the schistose diorite with which it is in contact on the west side. The contact was not observed, chiefly because of the thick cover of decomposed rock.

Insofar as the capacity to yield ground water is concerned, the greenstone is similar to the rocks of the slate belt in structure, showing strong schistosity and prominent joints transverse to the schistosity. It is similar to the diorite in general chemical composition and in the quality of ground water that it yields. Both the greenstone and diorite are intruded by granite, whereas the slate is not.

GROUND WATER

Ground water in the Charlotte area is derived from precipitation as rain or snow. The average annual precipitation of the area is about 47 inches.

The surficial materials at many places are relatively impermeable clays, and the fraction of precipitation that reaches the water table may be somewhat less than one-third. Thus, recharge to the ground-water reservoir probably is between 10 and 15 inches per year. Seasonal fluctuations of the water table are considerable, and there may be considerable change in water level between dry and wet years. However, over a period of many years the net change in water level is small, indicating that the average annual discharge of ground water is about equal to the average annual recharge.

Ground water is discharged by springs and seeps, by evaporation and transpiration, and by wells. Most of the water discharged by springs and seeps enters the streams and maintains their flow during periods of fair weather.

OCCURRENCE AND MOVEMENT

Large quantities of water are contained below the land surface in the openings or interstices in the rocks. These range in size from the minute pores in clays to large tunnels and caverns in lavas and limestones. The interstices in unconsolidated sedimentary rocks, such as gravel, sand, and clay, are primary interstices consisting of pores or openings between the sand or clay particles. Crystalline rocks, such as granite, diorite, gneiss, and schist, have little primary pore space between the component grains. The important interstices in these rocks are the joints, fractures, cleavage planes, planes of schistosity, bedding planes, and solution channels. Consolidated sedimentary rocks have had their primary openings reduced by compaction and cementation. However, in these rocks jointing and fracturing have produced secondary interstices in which water may accumulate.

The porosity of a rock is the percentage of the total volume that is occupied by the interstices. The porosity of the different rock materials covers a wide range, that of some clays, for example, may be more than 50 percent, whereas that of some crystalline rocks may be less than 1 percent. The porosity of clean sands and gravels generally is between 20 and 40 percent. Sands and clays that are cemented and compacted to form sandstones and shales have a much lower porosity.

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[11] Laney, F. B., Op. cit., p. 74.
[12] Pogue, J. E., Jr., Cid mining district of Davidson County: North Carolina Geol. and Econ. Survey Bull. 22, p. 95, 1910.
[13] Stuckey, J. L., The pyrophyllite deposits of North Carolina: North Carolina Dept. Cons. and Dev. Bull. 37, p. 25, 1928.
[14] King, P. B., Tectonic framework of the Southeastern States: Proc. Symposium on the mineral resources of the Southeastern United States, University of Tennessee Press, Knoxville, p. 18, 1949.
[15] Laney, F. B., Op. cit., p. 43.

Ref 5

Many of the secondary interstices in the igneous and metamorphic rocks are formed or enlarged by weathering processes near the earth's surface; therefore they decrease in number and size with depth. Solution of mineral constituents of the soil and decay of vegetal matter in it may result in a porosity of 50 percent or more, but the porosity decreases downward in the subsoil and the partially decomposed and disintegrated bedrock. The solid bedrock may have a very low porosity.

A material may have a high porosity and yet yield little water, even though saturated and allowed to drain for a long time. For example, a clay having a porosity of 50 percent might not yield any water because of the smallness of the pores, the water being retained because of molecular attraction. Some water may be retained in a rock also because the pores are isolated or poorly interconnected. The ratio of the volume of water that saturated material will yield to the total volume is known as the specific yield and is stated as a percentage.

One of the most important characteristics of an aquifer is its permeability, that is, its relative ability to transmit water. Permeability and porosity are not necessarily related; a clay having a porosity of 50 percent may transmit water very slowly or not at all, whereas a sand or gravel having half the porosity may transmit water with relative rapidity.

The movement of ground water generally is due to the force of gravity and the velocity of flow varies directly with the hydraulic gradient. Normally the places at which ground water discharges are at lower altitudes than the areas of recharge. In a humid region such as the Charlotte area, recharge occurs in the interstream areas and the discharge is into streams, lakes, and swamps. Rain falling on the land surface percolates downward to the water table and then moves laterally toward the points of discharge. During the winter and spring, when the water table is higher, the head is greater; therefore the velocity is higher and the volume of ground water discharged is greater than in summer and autumn when the water table is lower.

THE WATER TABLE

A part of the rain falling on an area percolates downward through the soil until it reaches the zone of saturation. In this zone all the pores and interstices are completely filled with water. The top of the zone of saturation is known as the water table, which is not a stationary surface, but one which is continually fluctuating, rising during and immediately after periods of rainfall and declining during periods of fair weather. In humid regions such as the Charlotte area, the water table is an undulating surface reflecting in a subdued way the irregularities of the topography. The relief, that is the difference in altitude between high and low points of the water table, generally is much less than the relief of the topography.

The depth to the water table depends chiefly upon the climate, the topography, and the character of the rocks. In the Charlotte area the climate is fairly uniform and the various rocks are similar in regard to porosity and permeability, so that differences in depth to the water table depend largely upon topography. In valleys the water table generally is at or near the surface; on wide flat uplands the water table generally is not more than a few tens of feet below the surface; and on sharp hills the water table may be more than 100 feet below the surface. The relation of the water table to the topography, in homogeneous materials, is shown in figure 4.

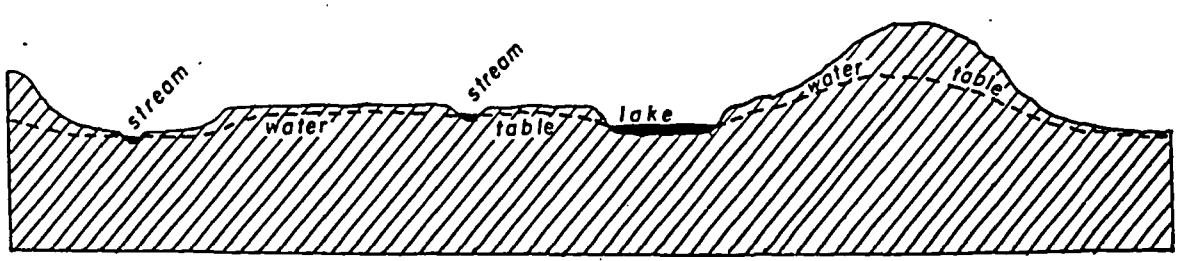


FIGURE 4.—*Diagrammatic section illustrating the relation of the water table to the topography.*

FLUCTUATIONS OF THE WATER TABLE

As the source of ground water is precipitation, the water table fluctuates in response to rainfall. However, correlation of the fluctuations with the rainfall is complicated by a number of factors.

The intensity and duration of the rainfall have a considerable effect on the proportion of water that reaches the water table. A heavy rainfall of short duration may result in a large percentage of surface runoff because of the inability of the soil to transmit the water rapidly to the water table. The same amount of rain, falling during a longer period, may result in a much larger proportion of water reaching the water table. However, during the longer period of rainfall there may be an increase in the total amount of water evaporated, reducing to that extent the amount of water reaching the water table.

The evaporation capacity of the air which is dependent upon temperature, humidity, and rate of air movement, determines the rate of evaporation and thus has considerable bearing on the proportion of rainfall that may reach the water table. Evaporation records are available for a floating pan on Lake Michie, near Durham.[16] Average monthly evaporation ranges from 1.44 inches in January to 6.39 inches in July.

Transpiration is an important factor with respect to recharge and discharge of ground-water. During spring and summer months large quantities of water are used by plants and a considerable part of the rainfall is taken from the soil before it can reach the water table. Also, large quantities of ground water are withdrawn by plants growing in lowlands and swamps. During fall and winter months vegetation requires much less water. Transpiration probably has greater effect on the proportion of rainfall that reaches the water table at various seasons than any other factor in this area.

The porosity and permeability of the soil differs from place to place and thus variously affects the proportion of rainfall that recharges the ground-water reservoir. The porosity and permeability may be changed by rainfall, heavy rains beating down and compacting the soils. Type of vegetation and land usage also have considerable effect on the porosity and permeability; intensive cultivation usually reduces both.

In the Charlotte area water levels begin to decline in April or May, owing to the increasing amount of evaporation and transpiration by plants. Generally this decline continues, interrupted only by minor rises due to heavy rainfall, through summer and early autumn, in spite of the fact that the greatest average monthly rainfall occurs in July and August. In late autumn, generally in November or December, when most of the vegetation is dormant and the evaporative capacity of the air is low, the water levels begin to rise. The winter rains generally are slow and steady in comparison with the summer rains and are more favorable for infiltration than the summer rainstorms. The first rains in winter often do not have as much effect on the water table as the later winter and spring rains because of the general deficiency in soil moisture prevailing by late autumn. Soil, which consists of varying proportions of fine sand, silt, and clay, holds considerable amounts of water in its pore space by molecular attraction of the particles, and this water does not percolate downward to the water table. After a long dry period this moisture is depleted, perhaps for many feet below the surface, by evaporation and transpiration. Before any water can reach the water table, this soil-moisture deficiency must be made up, and sometimes several weeks of winter rains are needed.

UTILIZATION OF GROUND WATER

In the Charlotte area water is obtained through dug, bored, or drilled wells or springs.

Dug wells.—Dug wells listed in this report range in depth from 17 to 100 feet, although the majority are from 25 to 60 feet. The diameter of the curbed wells ranges from 18 to 36 inches, and the diameter of uncurbed wells is somewhat larger. The well with the largest diameter, 120 inches, was dug as a shaft for a mine.

Many dug wells are curbed with stone, brick, clay, or concrete tile, and occasionally wood. Many are not curbed or lined in any way, and others have only a few joints of tile placed in the bottom, generally extending a short distance above the water table.

The chief advantage of a dug well is its large storage capacity, which helps to afford an adequate supply for domestic use if the yield is low.

[16] Hydrologic data on the Neuse River basin, 1866-1945, North Carolina Dept. Cons. and Devel., 1947.

Ref 5

MECKLENBURG COUNTY

(Area 542 square miles; population in 1950, 197,052)

Geography and physiography.—Mecklenburg County, in the southeast part of the Charlotte area, is the most densely populated county in the area. Charlotte, the only city, is the county seat; it is the largest city in the State and had a population of 133,219 according to the 1950 U. S. census. The county is the center of the textile industry of the State, many of the mills lying in the close environs of Charlotte.

That part of the Piedmont Province that includes Mecklenburg County consists of a series of moderately level interstream areas which are appreciably hilly near the larger streams. No hills stand out prominently above the general level of the upland. The highest land in the county is near Davidson, in the extreme northern part of the county, where the altitude is slightly more than 850 feet above sea level, and the lowest land is on the Catawba River at the South Carolina line, where the altitude is about 520 feet.

The western part of Mecklenburg County is drained by the Catawba River, whereas the eastern part is drained by small streams tributary to Rocky River, which itself is in the drainage basin of the Pee Dee River. The major divide formed by these drainage systems extends from Davidson in the north through Derita to the vicinity of Matthews. The Catawba River flows southward along the western border of the county, whereas the Rocky River flows along the northeast part. These rivers are only 10 miles apart in the northern part of the county, and as a consequence the interstream area is narrow and much dissected. On the other hand, Catawba and Rocky Rivers in the southern part of the county are more widely spaced which results in longer tributaries of lower gradients extending to the major divide. Thus, the topography in the southern part is rather gentle.

Geology.—The most striking feature of the geology of Mecklenburg County is the near absence of schistose rocks (fig. 17). With the exception of a thin belt of slaty rocks in the extreme east, the rocks of the county are, for the most part, massive and are generally lacking in regional structural trends.

Rocks of the Carolina slate belt occur in the southeastern part of the county where they extend southward from Cabarrus County. Although several types of rock occur within the belt only two are shown on the accompanying geologic map; they are the greenstone and undifferentiated rocks, including slates and associated volcanic rocks. The slates are generally composed of dense, fine-grained siliceous material. At least a part of the slate is well bedded and resembles the slate at Monroe,[28] which is a distinctive part of the Carolina slate belt. The slates, as a rule, are well jointed and possess a gentler dip than other rocks in the Charlotte area.

With the exception of the rocks of the Carolina slate belt in the east, the rocks of Mecklenburg County belong to the diorite-granite complex or are believed to be associated with it. Gabbro-diorite is widely exposed along N. C. Route 49 south of Shopton in the southwest part of the county. It is a massive medium- to coarse-grained dark colored igneous rock composed mostly of pyroxene or hornblende and plagioclase feldspars. It is exposed in a few road cuts and as isolated boulders above the generally flat land surface. It is locally referred to as "blackjack" and is the source of the Mecklenburg soil type.[29] The extent of the gabbro-diorite to the south in South Carolina is not known, but it is bounded in Mecklenburg County by rocks of the diorite-granite complex.

The diorite-granite complex proper covers a large area around Charlotte. Bodies of diorite are locally separate from bodies of granite, but as a whole the two rocks are too closely intermixed to map separately. Outcrops are not common enough to ascertain the predominance of one type over the other except in a general way. However, the granite component is everywhere conspicuous and appears to make up the greater part of the complex. It appears to be subordinate to the diorite in a band bordering the gabbro-diorite in the south and along the Cabarrus County line in the northeast.

Rocks in the northern part of the county do not fall easily into the classification of rocks designed for the Charlotte area. They are granitic but contain considerable hornblende and biotite in places. They

[28] Stuckey, J. L., Personal communication.
[29] Report on Mecklenburg County Soils, Agriculture, and Industry: North Carolina Dept. Agriculture County Soil Report No. 1, vol. 38, no. 4, p. 32, 1917.

Ref 5

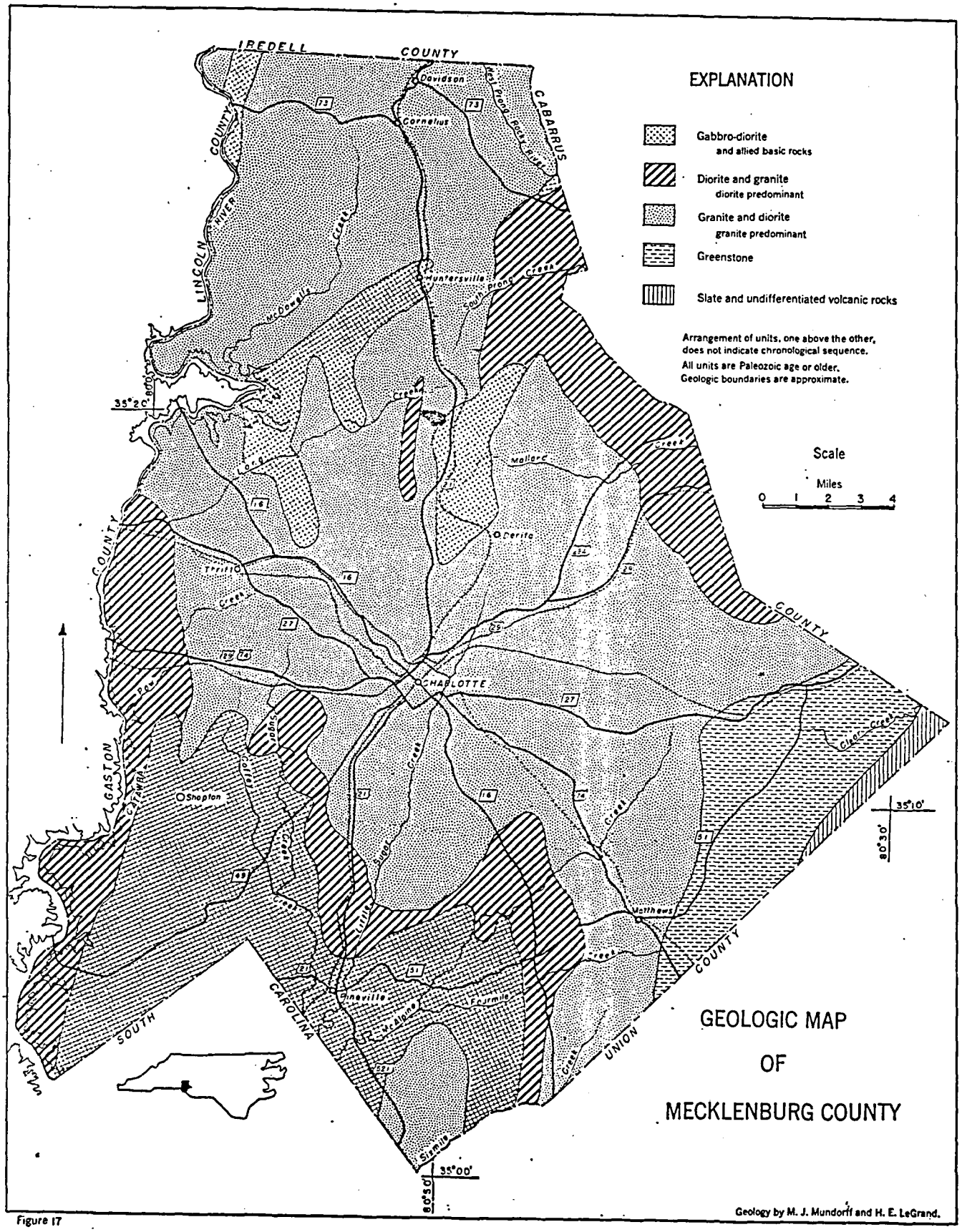


Figure 17

FIGURE 17.—GEOLOGIC MAP OF MECKLENBURG COUNTY.

Ref 5

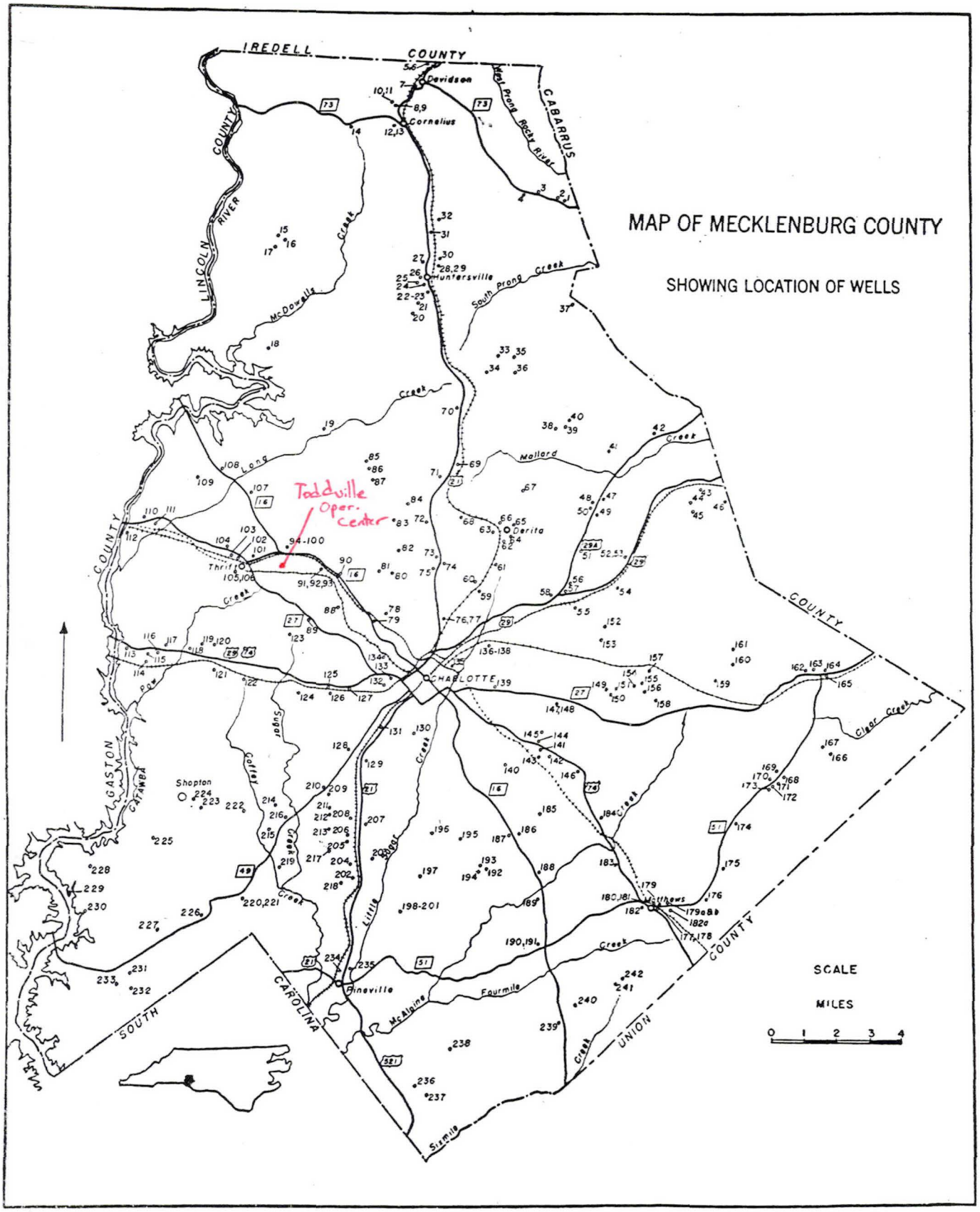


FIGURE 18.—MAP OF MECKLENBURG COUNTY SHOWING LOCATION OF WELLS.

Ref 5

are shown on the geologic map of Mecklenburg County as predominantly granite although they contain a greater quantity of black minerals than other granites in the Charlotte area. These rocks appear to have the same composition as those of the diorite-granite complex if a complete mixing of diorite and granite had occurred. Thus this approximate equivalence and the juxtaposition of these rocks suggest that they may be genetically related and that the hornblende-biotite granite in the northern part of the county may represent a nearly complete mixing of the diorite and granite components.

The soil derived from the hornblende-biotite granite has a deeper color than soils from other granites of the Charlotte area and contains many yellow flakes of vermiculite.

The rock weathers deeply, owing to the sharp relief in its area of outcrop, thus allowing a thick zone of weathering above the general water table.

Ground water.—Nearly all domestic water supplies and three municipal water supplies are obtained from wells (fig. 18).

Dug wells are extensively used for domestic supplies in rural districts. Normally they are from about 15 to 50 feet deep and 2½ to 4 feet in diameter. As these wells cannot easily penetrate hard rock, they generally yield adequate water as long as the water table does not fall below the surface of the hard rock, or more specifically as long as the water table does not fall below the bottom of the well. Where the bedrock lies at or near the surface, as in much of the area underlain by diorite and gabbro in the southwestern part of the county, wells may not be dug deep enough to prevent them from going dry during long periods of dry weather.

Records of more than 245 drilled wells are given in the tables of well data for Mecklenburg County. Many of these, especially in the rural areas, were core-drilled with chilled shot and are 2 or 3 inches in diameter. Their cheapness makes them suitable for domestic use, but inasmuch as 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 they are not generally used where large supplies of water are desired. Most industrial and public-supply wells are drilled with a percussion drill and are from 4 to 8 inches in diameter. The large-diameter wells might encounter fractures and cracks than missed by small-diameter wells. Also, more water can be pumped from a large-diameter well. Also, pumps with greater capacities can be installed in the larger wells.

The rocks penetrated by wells in Mecklenburg County are chiefly granite and diorite. The gabbroid rocks, occurring mostly in the southwestern part of the county, are included, for the purposes of ground-water description, with the diorite. A few wells in the eastern part of the county are drilled in slate but complete data on these wells are lacking. As the diorite and granite are rather closely intermingled, some wells doubtless penetrate both rocks. Table 13 presents characteristics of the wells as related to rock types and topographic locations.

TABLE 13.—SUMMARY OF DATA ON WELLS IN MECKLENBURG COUNTY

ACCORDING TO ROCK TYPE

Type of Rock	Number of wells	Average depth (feet)	Yield (gallons a minute)			Percent of wells yielding 1 gallon a minute or less.
			Range	Average	Per foot of well	
Diorite	41	117	1—75	17.9	0.153	2
Granite	54	124	2—65	11.5	.092	0
All wells	95	132	1—75	14.3	.109	1

[1] Drilled wells 2 inches or more in diameter.

Ref 5

SUMMARY OF DATA ON WELLS IN MECKLENBURG 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 1 gallon a minute or less.
			Range	Average	Per foot of well	
Diorite	30	155	3—75	22.6	.147	0
Granite	36	136	3—100	14.8	.109	0
All wells	66	144	3—100	18.4	.128	0

ACCORDING TO TOPOGRAPHIC LOCATION

Topographic location	Number of wells	Average depth (feet)	Yield (gallons a minute)			Percent of wells yielding 1 gallon a minute or less.
			Range	Average	Per foot of well	
Hill	41	125	1-65	8.5	0.068	2
Flat	13	119	2—40	13.1	.110	0
Slope	19	144	2—75	15.9	.110	0
Draw	21	144	5—75	24.9	.173	0
Valley	1	97	----------	8	.082	0

According to table 13 wells in diorite have greater yield and average yield per foot of well than wells in granite. The average yield of all diameters for which information is available in diorite is 17.9 gallons a minute as compared with an average of 11.5 gallons a minute for wells in granite. If only 3-inch and larger wells are considered, those in diorite yield 22.6 gallons a minute and those in granite 14.8 gallons a minute.

Although granite occurs extensively throughout the county, the data on wells do not indicate that it yields more water at one place than another, if topography is disregarded. The same condition holds true for the diorite. According to topographic location, wells on hills yield less water than wells on any other topographic site, yielding only .068 gallons a minute per foot of well. This is slightly more than one-third of the yield of wells in the most favorable locations, draws, that yield .173 gallon a minute per foot of well. Thus wells in draws have an average depth of 144 feet and an average yield of 24.9 gallons a minute. The average yield might be appreciably higher if only 3-inch and larger wells were considered.

As no particular part of the county can be designated as unusually poor and no part as exceptionally good, it appears advisable to give considerable attention to local conditions in locating a well. West of the slate belt, diorite, the best aquifer, occurs sporadically in almost every square mile. Thus in many cases it is possible to locate a well in the dark-colored diorite or gabbro without sacrificing convenience of location. As topography is an important consideration, the location of wells in lowlands or especially in draws should be attempted if relatively large yields are desired.

The quality of ground water in Mecklenburg County is good almost everywhere. (See table of analysis.) Analyses of water from wells penetrating granite in Mecklenburg County vary considerably in the concentration of dissolved mineral solids. This is doubtless due to the penetration of one or more small bodies of dioritic material in the granite. By virtue of their relatively insoluble mineral constituents the granites should contain water lower in mineral matter. Analyses of water from wells 27, 133, and 180 suggest that, although the predominant rock is granite, a large part of the mineral matter in solution comes from dioritic or mafic bodies penetrated by the wells.

Ref 5

Well 235, at Pineville, drilled in a large area of dark-colored gabbroid rocks, yields water containing 395 parts per million dissolved solids. Although this water is considered more or less typical of that in gabbro-diorite, it is doubtful if any of the ground waters in the county greatly exceed this in mineral matter; most of the ground waters should contain much less.

Temperatures range from 59° to 63° F and average 61° F.

Municipal supplies.—Huntersville, population 763 (1940 census), obtains its supply from deep wells. Four deep wells have been drilled for the municipal supply and yields of 5, 9, 22, and 35 gallons a minute are reported for individual wells. The well yielding 5 gallons a minute originally yielded 20, and the well yielding 9 gallons a minute originally yielded 40. The decline in yields in these two wells may be due to interference of wells. In 1945 the average daily use was 30,000 gallons. The water is not treated. The chemical quality of the water, as shown by the analysis of well 27, is good.

Matthews, population 486 (1940 census), obtains its water from a deep well drilled in greenstone, which yields 20 gallons a minute. The water is not treated.

RECORDS OF WELLS IN MECKLENBURG COUNTY

Well no.	Location	Owner	Driller	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Water level (feet below surface)	Yield (g.p.m.)	Total hardness (field tests) (p.p.m.)	Remarks
1	4¾ miles NE. of Huntersville	H. G. Bradford	Sherril	Cr-Dr	160	2					Granite. Adequate yield, slightly hard water. Flat.
2	do	R. G. Summers	Earl Torrence	Cr-Dr	83	2	60		7		Granite. Water slightly hard. Hill.
3	4 miles NE of Huntersville	John G. Caldwell J. H. Stillwell		Cr-Dr	70	2			2-3		Granite. Moderately soft water. Hill.
4	do	R. C. Bradford		Cr-Dr	85	3			6+		Granite; 61°F. Hard water. Hill.
5	Davidson	Davidson Cotton Mills Inc.		Cr-Dr	80±	2		22	4	65	62½° F. Well at machine shop. Draw.
6	do	do		Cr-Dr	60-80				14		7 wells in group. Aggregate yield 14 g.p.m. to suction pump. When drilled 6 of the 7 wells flowed. Draw.
7	do	Davidson Ice & Fuel Co.	Jim Robbins	Cr-Dr	100	4	35		11	80	Rock at 30 feet. Slope.
8	Cornelius	Cornelius Mills, Inc.		Cr-Dr	115	3	90±		15	60	Rock reported at 90 feet. Schist. Flat.
9	do	do		Cr-Dr	127	2			8		Schist. Flat.
10	do	do	W. A. Kirkley	Cr-Dr	106	4			70		Schist. Water level 60 feet below surface when pumped at 20 g.p.m. Flat.
11	do	do	do	Cr-Dr	55	4			50		Schist. Flat.
12	do	Gem Yarn Mills		Cr-Dr	90±	2			5		Schist. Draw.
13	do	do		Cr-Dr	160	2			3¾		Do.
14	1¾ miles W. of Cornelius	Mrs. Mary C. Hager		Cr-Dr	45	2			3	40	Schist. Hill.
15	4½ miles W. of Huntersville	Mrs. J. C. Blythe		Dug	30	24	30	23.24			Schistose diorite. Hill.
16	do	Joe L. Blythe		Cr-Dr	175	3	100		5+	40	Do.
17	do	J. L. Norket		Cr-Dr	125	2			6	35	Schistose diorite. Slope.
18	5 miles SW. of Huntersville	W. O. Hollingsworth		Cr-Dr						60	Schistose diorite.
19	do	Long Creek High School	Hickory Drilling Co.	Dr	101	6			65	25	Granite. 62½° F. Hill.
20	2 miles S. of Huntersville	Prison Camp		Cr-Dr	225	3			2½	100	Granite. 60½° F. Rock at 20 feet. Hill.
21	1¾ miles S. of Huntersville	do		Cr-Dr	97	3			7½	65	Granite. 59¾° F. Valley.
22	1¼ miles S. of Huntersville	County Sanatorium		Dr	120+	8		16	15	35	62° F.
23	do	do		Dr	140+	8			11	50	63° F. Draw.
24	Huntersville	Town well 1		Dr	70	5		40	9	55	62° F. Originally 110 ft. deep, 8 in. in diameter. Yielded 40 g.p.m. Filled with sand and was redrilled. Draw.
25	Huntersville	Town well 2	Abernathy	Dr	210	8	100	30	22	65	62½° F. Draw.
26	do	Town well 3	Ralph Robbins	Dr	97	5	97		5	50	Granite. Originally yielded 20 g.p.m. Draw.

Ref 5

RECORDS OF WELLS IN MECKLENBURG COUNTY—*Continued*

Well no.	Location	Owner	Driller	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Water level (feet below surface)	Yield (g.p.m.)	Total hardness (field tests) (p.p.m.)	Remarks
27	Huntersville	Town well 4	R. E. Faw	Dr	190	8	100±	20	35	64	Analysis. Granite. Draw.
28	do	Anchor Mills Co.		Cr-Dr	38-81	2	38 to 81	5 to 30	27½	105	62° F. Combined yield of 10 wells. 27½ g.p.m. Draw.
29	do	do	Robbins	Dr	185	5			10-12		Hard water reported. Draw.
30	do	do		Cr-Dr	300 or 400	3			12	70	63° F. Hill.
31	1¼ miles N. of Huntersville	G. R. Fleenor	Sherril	Cr-Dr	72	2			10	35	Flat.
32	1½ miles N. of Huntersville	Ralph Johnson		Cr-Dr	140	2	100		3		Flat.
33	2½ miles SE. of Huntersville	D. B. Jordan J. R. Westbrook, tenant		Dug	62	40	62	58			Granite. Hill.
34	3 miles SE. of Huntersville	Plantation Pipeline Co.		Dr	260	8				15	Granite. Draw.
35	2¾ miles SE. of Huntersville	F. M. Fite	Robbins	Cr-Dr	116½	3	20	45	3	70	61° F. Granite. Hill.
36	3½ miles SE of Huntersville	B. C. Zeigler		Cr-Dr	50+	2				55	Diorite. Water contains iron. Hill.
37	4½ miles E. of Huntersville	M. B. Wallace		Cr-Dr	69	2	45±	15	5	580	Diorite. Laboratory test. "Black jack" soil. Draw.
[illegible]	3½ miles NE. of Derita	B. W. Alexander		Cr-Dr	118	2	18		2	110	Diorite. Slope.
[illegible]	do	James I. Crenshaw	Va. Mach. Co.	Dr	85	6			12	95	Diorite. Water contains iron. Hill.
[illegible]	4 miles NE. of Derita	O. B. Cochran	do	Dr	38	6			4-5	50	Granite. Water contains iron. Hill.
[illegible]	do	Clarence Pender	Will Fortner	Cr-Dr	96	2				65	Diorite. 61¾° F. Adequate yield. Hill.
[illegible]	5½ miles NE of Derita	Henry Doster		Cr-Dr		2				237	Diorite. (Laboratory test). Adequate yield. Draw.
[illegible]	3½ miles NE. of Newell	Frank Cochran	Bowers	Cr-Dr	132	3			8	85	Diorite. Slope.
[illegible]	[illegible] miles NE. of Newell	L. W. Austin		Dug	32½	30		31.58			Diorite. Hill.
[illegible]	2¼ miles NE. of Newell	J. R. Austin		Cr-Dr	137	2			7½		Diorite. Slope.
[illegible]	3½ miles NE. of Newell	James Caldwell	Bostin	Cr-Dr	79	4	58	20	20		Diorite. Slightly hard water. Hill.
[illegible]	2 miles N. of Newell	County Home	Hinson	Dr	162	10			60	140	Diorite. 64° F. Use, about 35,000 to 40,000 gallons a day. Draw.
[illegible]	do	Victor Penninger	Bowers	Cr-Dr	92	2	86	23	5	45	Pump in basement, 8 feet below surface. Granite. Slope.
[illegible]	2 miles N. of Newell	N. M. Christenbury	J. Torrence	Cr-Dr	133	2	35±		5	75	Granite. Hill.
[illegible]	do	J. W. Dierstein		Cr-Dr	80	2		14.5	2½	50	Granite. 61¾° F. Slope.
51	1½ miles NW. of Newell	S. P. Moyer		Cr-Dr	90	2			½	65	Diorite. Hill.
52	Newell	High School		Cr-Dr	335	3			8	30	Granite. 62½° F. Slope.
[illegible]	do	do		Cr-Dr	80	3			8		Granite. Slope.
[illegible]	¾ mile S. of Newell	Mrs. Annie Babb	W. A. Kirkley	Cr-Dr	96½	3	35	16	8	30	Granite. Hill.
[illegible]	5 miles E. of Charlotte	Galloway Estate		Cr-Dr	113	2			7		Do.
56	5¼ miles NE. of Charlotte	F. S. Neal Estate		Cr-Dr	196	2½		22	5-10	45	Flat.
57	4¾ miles NE. of Charlotte	Mecklenburg Furniture Shop	E. Mullis	Cr-Dr	134	3	94		9	60	Flat.
58	4½ miles NE. of Charlotte	W. S. Abernathy	Montgomery	Cr-Dr	165	2			12	35	Draw.
59	1¾ miles SW. of Derita	J. E. Heafner	do	Cr-Dr	130	2	130	9	7	50	Draw.
60	1½ miles SW. of Derita	E. T. Robinson	Everett Mullis	Cr-Dr	116	3	100		7	55	Granite. Flat.
61	1 mile SW. of Derita	B. J. Hunter	Allen (?)	Cr-Dr	380	2			3	60	61¾° F. Rock at 80 feet. Hill.
62	Derita	Louis G. Ratcliffe, Inc.	Bill Brathn	Cr-Dr	92 to 135	2	92-135		11 to 35 each	55	Group of 4 wells used at greenhouses. Draw.
[illegible]	do	Bob Farington		Cr-Dr	65	3		21	12		Draw.
[illegible]	¾ mile E. of Derita	H. L. Young		Dug	38	36	36	31.5		15	60° F. Adequate supply. Hill.
65	Derita	School		Dr	90	6			20		Hill.
66	do	B. J. Hunter	Ed. Hunter	Cr-Dr	92	2	61	21	12	30	Supplies 27 houses. Hill.
67	1½ miles NE. of Derita	C. A. Seegar		Cr-Dr	99	2				20	Draw.
68	1 mile NW. of Derita	J. H. Stevens		Dug	40	36	40	23.5			
69	2½ miles NW. of Derita	P. J. Penninger		Dug	21	36	21	13	1½	55	Granite. Flat.
70	4 miles NW. of Derita	J. E. Penninger	Homer Sherril	Cr-Dr	125½	2	80	12	5	30	Granite. 62° F. Supplies 3 buildings. Flat.
71	2½ miles NW. of Derita	Clyde Hunter	Martin	Cr-Dr	146	3		20-25	7		Soft water. Flat.
72	4½ miles N. of Charlotte	C. E. Collins	Robbins	Cr-Dr	113	2	40	21	3	65	Gneiss. Flat.

Ref 5

RECORDS OF WELLS IN MECKLENBURG COUNTY—*Continued*

Well no.	Location	Owner	Driller	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth casing (feet)	Water level (feet below surface)	Yield (g.p.m.)	Total hardness (field tests) (p.p.m.)	Remarks
73	3¾ miles N. of Charlotte	G. V. Burris	W. A. Ivester	Cr-Dr	48	2			15		Moderately soft water. Draw.
74	do	C. T. Stallings	Robbins	Cr-Dr	71½	2	31		6		Slightly hard water. Draw.
75	3¼ miles N. of Charlotte	Mrs. Eva Mae Ellis		Cr-Dr	96	2			2½		Gneiss. Hard water. Hill.
76	2½ miles NE. of Charlotte	Interstate Granite Corporation	W. A. Kirkley	Cr-Dr	165	4			35		Granite. Slope.
77	do	do	do	Cr-Dr	200	4			35		Granite. Draw.
78	2½ miles NW. of Charlotte	G. V. Keller	Hinson	Dr	190	6	190	26	10–15	65	Diorite. Hill.
79	do	Planters Fertilizers & Phosph. Co.		Dug	31	30		25	5		
80	3 miles N. of Charlotte	I. T. Hutchison		Cr-Dr	110	2		22	5	25	Hill.
81	3½ miles NW. of Charlotte	T. P. Caldwell	Montgomery	Cr-Dr	158	2	83	30	3½		Diabase dike. 63° F. Soft water. Well was dynamited to increase yield. Hill.
82	4 miles N. of Charlotte	E. C. Glenn		Cr-Dr	150	2			5±	25	Hill.
83	4¾ miles N. of Charlotte	J. W. Buchanan		Cr-Dr	85	2			7½	50	Hill.
84	5½ miles N. of Charlotte	F. W. Dotzer		Cr-Dr	82	2	78		7	35	Diorite. Hill.
85	7 miles N. of Charlotte	P. V. Humphrey	Geo. Stephenson	Cr-Dr	100	2	99		5	35	
86	do	R. W. Parker	do	Cr-Dr	140	2	85	25	6		No water until well was dynamited.
87	do	H. T. Reavis	do	Cr-Dr	130	2	100	25	5		Do. Slope.
88	3½ miles NW. of Charlotte	Chadwick-Hoskins Co.	Sydnor	Dr	549	10			100	80	63° F. Well at plant 2 supplies both plants and school. Draw.
89	4 miles NW. of Charlotte	Mecklenburg Nurseries		Cr-Dr	135	2	90		4–5	60	Dug well, nearly went dry in 1941–1942. Hill.
90	do	Godley Bros.		Cr-Dr	80	3			6		Soft water. Hill.
91	4¼ miles NW. of Charlotte	National Carbon Co.	W. A. Kirkley	Cr-Dr	150	4	100		18	35	63° F. Company well 1. Draw
92	do	do	do	Cr-Dr	135	4	102		8		62° F. Company well 2. Draw
93	do	do	do	Cr-Dr	108	4	84		7		Company well 3. Slope.
94	1¼ miles NE. of Paw Creek	Leaksville Woolen Mill Co.	Sydnor	Dr	350	10			36	55	62½° F. Company well 4. Draw.
95	do	do		Dr	300	10			60	75	59° F. Company well 5. Temperature taken after pumping 35 minutes—7/17/45. Draw.
96	do	do	do	Dr	1,166½	10			68	170	63° F. Company well 6. Pumping level 173 feet below surface in 1942. Draw.
97	1¼ miles NE. of Paw Creek	Leaksville Woolen Mills Co.	Sydnor	Dr	1,074	10			67¼	72	61½° F. Company well 7. Temperature after pumping 20 minutes. Draw.
98	do	do	do	Dr	250	8			30		Company well 1. Not in use. Draw.
99	do	do		Dr	250	10–8			50		Company well 2. Never used Water too hard.
100	do	do		Dr	250	10			25		Company well 3. Not used. Originally yielded 100 g.p.m.
101	Paw Creek	High School	Carolina Drill. Co.	Dr	140	6			30		Slope.
102	do	Standard Oil Plant	J. S. Hinson	Dr	306	6			55	40	Draw.
103	do	Shell Oil Plant	Heater Well Co.	Dr	148	6	80½	21	36	40	61½° F. Draw.
104	do	American Oil Co. Plant		Cr-Dr	85	3				80	62° F. Draw.
105	do	Kendall Mills Thrift Plant		Dr	600	10–8	60	32	55	150	63° F. Slope.
106	do	do		Cr-Dr	33 to 65	2½	33 to 65	½ to 2	14	60	59½° F. Group of 6 wells. Valley.
107	2 miles N. of Paw Creek	McClure Lumber Co.		Cr-Dr	115	3	76		4		Granite. Hill.
108	3 miles NW. of Paw Creek	M. L. Dunn	Robbins	Cr-Dr	54	2			3	50	Granite. Flat.
109	3¼ miles NW. of Paw Creek	James Costevens		Dug	30	12	30	23.0			Adequate water supply. Soft water. Flat.
110	3¼ miles NW. of Paw Creek	R. C. Beatty	Geo. Stevenson	Cr-Dr	90	3			10	80	61½° F. Granite "sand". Draw.
111	do	C. O. Hager		Dug	80	36		65			Supplies 12 houses. Soft water. Hill.
112	4 miles NW. of Paw Creek	Southern Dyestuff Corp.	Sydnor	Dr	221	6	60		38	450	61¾° F. Laboratory test.

Ref 5.

RECORD OF WELLS IN MECKLENBURG COUNTY—*Continued*

Well No.	Location	Owner	Driller	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth casing (feet)	Water level (feet below surface)	Yield (g.p.m.)	Total hardness (field tests) (p.p.m.)	Remarks
113	8¾ miles W. of Charlotte	K. M. Beaty		Dug	39½	18	39½	34.7			
114	8¼ miles W. of Charlotte	Paul Thompson	Helms	Cr-Dr	115	2			4-5		Granite. Soft water. Flat.
115	do	C. E. Berryhill		Cr-Dr	126	2			5-6	40	Granite. Slope.
116	8 miles W. of Charlotte	Cathey Brothers		Dr	80	6			18	40	Granite.? Supplies house and dairy. Hill.
117	7½ miles W. of Charlotte	Otis Keeter	W. A Kirkley	Cr-Dr	136	3			25	45	Recreational Park. Hill.
118	7¼ miles W. of Charlotte	(Willamette Park) R. A. Suttle	Ralph Robbins	Dr	95	6	30	10 to 12	17		Recreational park. Draw.
	6¾ miles W. of Charlotte	E. E. Williams		Cr-Dr	120					95	Hill.
	6 miles W. of Charlotte	E. L. Black	Everett Mullis	Cr-Dr	77	2	25		5		Granite. Hill.
121	6¼ miles W. of Charlotte	Berryhill High School	Abernathy	Dr	110	6			12	25	Always has furnished adequate supply. Flat.
	5 miles W. of Charlotte	Douglas Airport		Dr	300	6					Not used. Slope.
	4¼ miles W. of Charlotte	J. L. Todd		Cr-Dr	181	2					Slope.
	4 miles W. of Charlotte	Plato-Price High School		Dr	90	6			20		Slope.
	2¾ miles W. of Charlotte	American Cyanimide Co.	Robbins	Dr	149	6			28	42	Diorite.
	2 miles W. of Charlotte	Carolina Golf Course		Dr	70	6		1.8			Draw.
	2½ miles W. of Charlotte	Southern Engineering Co.	Robbins	Dr	42½	5 5/8	40	4	25	55	Used for cooling. Draw.
	2½ miles SW. of Charlotte	W. W. Davis		Dug	21	36	21	15.9			Adequate supply; soft water. Slope.
	do	Diamond Point Grocery	W. A. Kirkley	Cr-Dr	80	3			30	40	
	Charlotte	Scholtz Greenhouses	do	Cr-Dr	225	4	60	20	22	60	64° F. Slope.
	do	Shoenith Candy Co.		Dug	110	72			10	40	62° F. Well is abandoned mine shaft. Slope.
	do	Charlotte Pipe and Foundry Co.	J. S. Hinson	Dr	196	6		20	10-15	105	62½° F. Slope.
	do	Air Reduction Sales Co.	Sydnor	Dr	200	6	85		50	113	62° F. Analysis in table. Water used for cooling. Draw.
	do	National Welding Supply Co.	W. A. Kirkley	Cr-Dr	150	3			18	55	61° F. Granite. Used for cooling. Draw.
	do	Highland Park Mfg. Co., Plant 1		Cr-Dr	30 to 80	2			15		Group of 13 wells yield 15 g.p.m. Draw.
	do	Highland Park Mfg. Co.	Ralph Robbins	Dr	75	6			14		Slope.
	do	do	do	Dr	87	6			9		Slope.
	do	do	do	Cr-Dr	30 to 60	2			40		Three groups of six wells each; combined yield 40 g.p.m. Draw.
	2½ miles E. of Charlotte	Z. E. Hargett		Dr	150	6		26	25	60	61°½ F. Granite. Slope.
	4¼ miles SE. of Charlotte	A. C. Roundton	W. A. Kirkley	Cr-Dr	76	4		18	20		Granite. Slope.
	4¾ miles SE. of Charlotte	Pure Oil Co.	Ralph Robbins	Dr	62	6			30	35	63° F. Draw.
	do	Sharon Memorial Park		Dr	150	6					Slope.
	do	W. W. Covington	E. Mullis	Cr-Dr	83	2			6	40	Granite. Slope.
	4½ miles SE. of Charlotte	F. C. Thompson	W. A. Kirkley	Cr-Dr	95	2	85	15	9	50	Slope.
	4½ miles SE. of Charlotte	Hudson Hosiery Co.	W. A. Kirkley	Cr-Dr	95	4	85	18	15	30	62¾° F. Granite. Draw.
	5½ miles SE. of Charlotte	I. G. Wallace	Clayton Cooke	Cr-Dr	60	2	55	7	4-5	50	
	4¾ miles E. of Charlotte	Joe W. Yandle		Dug	30	24	30	19.3			Well not used. Flat.
	do	do		Cr-Dr	180	2			7-8	45	Draw.
	7 miles E. of Charlotte	Sam Wallace		Cr-Dr	200	2			1½		Hill.
	do	W. T. Harris		Cr-Dr	85	2			5½		Draw.
	do	D. B. Wilson	Glosson	Cr-Dr	85	2	68	8	8		Soft water. Draw.
	miles E. of Charlotte	H. G. Russell	do	Cr-Dr	60	2			4½	30	Granite. Slope.
	do	C. E. Morris		Cr-Dr	190	4		19	12	35	Hill.
	miles E. of Charlotte	S. M. Craig	Donaldson	Cr-Dr	95	2	90	20	4-5		Soft water. Slope.
	½ miles E. of Charlotte	Harvey Morris	Ralph Robbins	Dr	184½	5 5/8	128	23	20	35	
	do	J. A. Smith	Sam Allen	Cr-Dr	195	3	100	23.6	8		Hill.
	7 miles E. of Charlotte	Hickory Grove School	W. A. Mullis	Cr-Dr	135	2			5		Flat.
	do	United Arco Service		Cr-Dr	149	3		18	30		Granite. Draw.

Pf 5

RECORDS OF WELLS IN MECKLENBURG COUNTY—*Continued*

Well no.	Location	Owner	Driller	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth casing (feet)	Water level (feet below surface)	Yield (g.p.m.)	Total hardness (field tests) (p.p.m.)	Remarks
159	3½ miles NW. of Mint Hill	Clear Creek Negro School		Dr	91	6			60		Draw.
160	3¾ miles NW. of Mint Hill	Mrs. Montie Lucas		Cr-Dr	235	2			3		Soft water. Hill.
161	4 miles NW. of Mint Hill	Mason Wallace	Mullis	Cr-Dr	170	2			2-3		Granite. Soft water. Hill.
162	3¼ miles NE. of Mint Hill	Clear Creek High School	A. E. Beaver	Cr-Dr	110	3			12-15		Hill.
163	3½ miles NE. of Mint Hill	Allen and Brooks Ginning Co.		Cr-Dr	178	4			12		Slate. Not in use. Slope.
164	3¾ miles NE. of Mint Hill	do		Cr-Dr	134	2			5	50	Flat.
165	do	C. G. Allen		Cr-Dr	100	2			4		Slate. Soft water. Flat.
166	1¼ mile E. of Mint Hill	T. S. Houston	Glosson	Cr-Dr	100½	2			7		Hill.
167	do	R. C. Beaver		Dug	43	30		39.07			Hill.
168	Mint Hill	Kingcraft Hosiery Mill	Everett Mullis	Cr-Dr	110	2			8		
169	do	C. J. McEwen	Duncan	Cr-Dr	180	2			7		Slope.
170	do	R. J. McEwen & Son	W. C. Mullis	Cr-Dr	80	2			7	35	Draw.
171	do	C. J. McEwen		Dug	33	30	33				Hill.
172	do	W. F. Haigler	E. Mullis	Cr-Dr	155	2	100	12	5		Soft water. Slope.
173	do	Mrs. J. W. McEwen	Beaver	Cr-Dr	210	3			5-6		Dynamited well to increase yield. Slope.
174	2¼ miles SW. of Mint Hill	E. M. Gray	Mullis	Cr-Dr	105	2			5		Slope.
175	2½ miles NE. of Matthews	L. H. Yandle	E. Mullis	Cr-Dr	92	2			5	55	Hill.
176	1¼ miles E. of Matthews	D. B. Query	Sam Allen	Cr-Dr	100	2	70	25	6	50	Slope.
177	Matthews	E. M. Renfron	W. Donaldson	Cr-Dr	125	2			2½		Soft water. Slope.
178	do	L. H. Yandle	Abernathy	Cr-Dr	74	3	50	18	10-12		Do.
179	do	do	Will Mullis	Cr-Dr	75	3	40		20	35	Well at barn.
180	do	do	Walter Abernathy	Dr	187	6		11.3	55		Used for domestic uses and swimming pool. Greenstone. Draw.
181	do	C. L. Neal	Ben Aycock	Dr	87	4			45		Greenstone. Used for domestic uses and swimming pool. Draw.
182	do	B. D. Funderburk	W. Abernathy	Dr	200	3		18	18	61	Analysis in table. Supplies six businesses and four families. Granite. Draw.
183	do	do	do	Dr	125	3			7		Well at stable. Granite. Draw.
184	do	Matthews School	do	Dr	160	3			7	55	Well dynamited to increase yield.
185	do	Town	Ben Aycock	Dr	275	6	110		20		Greenstone. Distribution not yet installed. Slope.
186	1¾ miles NW. of Matthews	Carlyle Thompson	Sam Allen	Dr	50	2			5		Granite. Hill.
187	3 miles NW. of Matthews	J. B. Fowler		Dr	95	3			7	60	Hill.
188	5½ miles SE. of Charlotte	J. J. Akers	Ralph Robbins	Dr	165	5 5/8	110		35	55	Diorite. Slope.
189	do	John L. Hunter	W. A. Kirkley	Dr	96	3		36.78		45	Diorite. Flat.
190	do	T. W. Pritchard	Ralph Robbins	Dr	147	5 5/8			15		Granite. Slope.
191	7 miles SE. of Charlotte	F. W. Alexander		Cr-Dr	165	2			5	95	Slope.
192	4 miles W. of Matthews	Providence School		Cr-Dr	100	3			5		
193	3¾ miles W. of Matthews	Eli B. Springs	Ben Aycock	Dr	190	6	30	17 to 20	60	150	Draw.
194	do	do	W. A. Kirkley	Cr-Dr	150	3			15		Greenstone. Flat.
195	6 miles S. of Charlotte	C. R. Collins	Montgomery	Cr-Dr	180	3			5	60	Diorite. Hill.
196	6 miles S. of Charlotte	C. R. Collins	Ralph Robbins	Dr	60	55	20	15.00	5		Slope.
197	do	do	Ben Aycock	Dr	100	6		3	18		Gabbro. Draw.
198	5¼ miles S. of Charlotte	Sharon School		Dr	65	6			15		Flat.
199	5 miles S. of Charlotte	Springside Dairy	Robbins	Cr-Dr	137	3	32		6		Soft water. Slope.
200	4¼ miles NE. of Pineville	Harkey Bros. Nursery, Inc.		Dug	25	30	25	15.02		45	Greenstone? Flat.
201	5 miles NE. of Pineville	Dr. A. M. Whisnant		Cr-Dr	139	2			4		Diorite. Abandoned; not sufficient water. Hill.
202	do	do		Cr-Dr	209	3			8-10		Diorite. Abandoned; pumped sand. Hill.
203	do	do	Ralph Robbins	Dr	102	5 5/8		45	20	45	Diorite. Draw.
204	do	do	W. A. Kirkley	Cr-Dr	262	4-3			12		Diorite. Slope.
205	3½ miles N. of Pineville	Mrs. Eunice E. Smith		Dug	65	48	65	47.0			Soft water. Hill.
206	4½ miles N. of Pineville	Dr. T. N. Reed		Cr-Dr	200	3			5	85	Granite. Hill.
207	4 miles N. of Pineville	H. B. Smith	W. A. Kirkley	Cr-Dr	140					35	Hill.

Ref 5

RECORD OF WELLS IN MECKLENBURG COUNTY—*Continued*

Well no.	Location	Owner	Driller	Type of well	Depth of well (feet)	Diameter of well (inches)	Dept casing (feet)	Water level (feet below surface)	Yield (g.p.m.)	Total hardness (field tests) (p.p.m.)	Remarks
205	5¼ miles SW. of Charlotte	Ebenezer Presbyterian Church	W. A. Kirkley	Cr-Dr	156	3	60±		6	35	62° F. Slope.
206	do	H. R. Mauney		Cr-Dr	125	2					Moderately soft water. Slope.
207	4¾ miles SW. of Charlotte	C. N. Baker	W. A. Kirkley	Cr-Dr	93	4			8	35	Tested at 10 g.p.m. Hill.
208	4½ miles SW. of Charlotte	J. H. Huntley		Dug	26	36		20	2-3	30	Hill.
209	4¾ miles SW. of Charlotte	Mrs. L. J. Eller	W. A. Kirkley	Cr-Dr	145	4		14	18	30	Slope.
210	do	F. D. Hemphill	Hurley Helms	Cr-Dr	90	2			5	25	Slope.
211	5¼ miles SW. of Charlotte	E. L. Jenkins	W. A. Kirkley	Cr-Dr	92	3			10	45	Draw.
212	do	A. Y. Deal		Cr-Dr	88	2			5		Diorite. Flat.
213	5¾ miles SW. of Charlotte	Edwin Bruton	E. Mullis	Cr-Dr	108	2			7-8	45	Diorite. Draw.
214	6 miles SW. of Charlotte	R. S. Smith	W. A. Kirkley	Cr-Dr	108	4			3	50	Diorite. Hill.
215	6½ miles SW. of Charlotte	H. B. Hunter	Montgomery	Cr-Dr	204	3	60		8	60	62° F. Diorite. Hill.
216	5¾ miles SW. of Charlotte	J. N. Herron	W. A. Kirkley	Cr-Dr	127½	3	50		6-8	50	Hill.
217	6½ miles SW. of Charlotte	J. T. Greenwood		Dug	48	36		42.71			Diorite. Hill.
218	3¼ miles N. of Pineville	W.B.T. Radio Station	Montgomery	Cr-Dr	225	3			7-8		Slope.
219	4 miles NW. of Pineville	Arrowood	Abernathy	Dr	286	6	20		16	261	62¼° F. Laboratory test. Draw.
220	3¾ miles NW. of Pineville	U. S. Rubber Co. Shell Loading Plant	W. A. Kirkley	Cr-Dr	196	3		12	40		Gabbro. Well capped; not used. Flat.
221	do	do	do	Cr-Dr	145	3		12	30		Gabbro. Flat.
222	7 miles SW. of Charlotte	Miss Amanda Coffey	Tom Allen	Cr-Dr	112	2	80		5	60	61° F.
223	7¾ miles SW. of Charlotte	R. A. Grier		Cr-Dr						25	
224	do	Mrs. F. K. Byrum		Cr-Dr	100	2			6		Diorite. Flat.
225	9¼ miles SW. of Charlotte	Samuel Knox		Dug	20	24		14.51			Gabbro. Hill.
226	4½ miles NW. of Pineville	N. M. Boyd		Dug	21	30		10.55		125	Gabbro.
227	5¾ miles NW. of Pineville			Dug	17.5			11.79		185	Gabbro. Has always furnished adequate supply.
228	8 miles NW. of Pineville	O. B. Knox	Charles Montgomery	Cr-Dr	110	2			3	20	Diorite. Hill.
229	8½ miles NW. of Pineville	Island Point Club	do	Cr-Dr	100	2			2	105	Do.
230	8 miles NW. of Pineville	R. S. Smith	Ralph Robbins	Dr	181	5 5/8	83		25		Do.
231	6 miles W. of Pineville	J. R. Smith		Bored	52	12	52	43.08			Granite.
232	5¾ miles W. of Pineville	W. C. Stroup	Montgomery	Cr-Dr	128	3	80	20	15	25	62½° F. Granite. Hill.
233	6 miles W. of Pineville	H. M. Blackwelder	do	Cr-Dr	175	2			3-4	20	Granite. Hill.
234	Pineville	J. E. M. Davenport		Dr	132	6		12	75		Schistose diorite Slope.
235	do	Town		Dr	134	8		12	75	234	62½° F. Schistose diorite. Analysis. Draw.
236	4 miles SE. of Pineville	James K. Hall		Dr	90	2			5		Granite. Hill.
237	4¼ miles SE. of Pineville	R. G. Bryant	Robbins & Wilson	Cr-Dr	132	2	90	42	5	35	Do.
238	3¾ miles SE. of Pineville	Mrs. E. E. Niven		Dug	38	36	38	31.95			Adequate yield. Draw.
239	4½ miles SW. of Matthews	J. J. Grier		Bored	32	12	32	23.74		20	Hill.
240	3¾ miles SW. of Matthews	J. M. Knox		Dug	39	36		29.80		25	Well more than 50 years old; has never gone dry. Flat.
241	2½ miles SW. of Matthews	W. N. McKee	Abernathy	Cr-Dr	235	3-2	135		5	45	Granite. Hill.
242	2½ miles SW. of Matthews	Presley Smith	C. C. Montgomery	Cr-Dr	85	2	75		8-10		Granite.

Ref 5

ANALYSES OF GROUND WATER FROM MECKLENBURG COUNTY,[1] N. C.
(Numbers at heads of columns correspond to numbers in table of well data)
(parts per million)

	27	133	180	235
Silica (SiO_2)	35	37	39	60
Iron (Fe)	.12	.15	.06	.09
Calcium (Ca)	16	29	15	55
Magnesium (Mg)	5.8	9.8	5.8	26
Sodium and potassium (NA+K)	5.7	11	8.2	20
Carbonate (CO_3)	0	0	0	0
Bicarbonate (HCO_3)	70	108	62	185
Sulfate (SO_4)	3.9	29	2.8	94
Chloride (Cl)	4.5	10	12	22
Fluoride (F)	.1	.1	.2	.5
Nitrate (NO_3)	10	3.5	10	6.0
Dissolved solids	120	159	139	395
Total hardness as $CaCO_3$	64	113	61	244
Date of collection	6/12/45	7/21/45	6/25/45	6/25/47

[1] Analyzed by the U. S. Geological Survey.

POLK COUNTY

(Area 234 square miles; population in 1950, 11,627)

Geography and physiography.—Polk County forms the southwestern corner of the area included in this report (figs. 1 and 20). Agriculture, which is favored by the relatively high annual rainfall distributed throughout the year, is the principal industry in the county. Severe droughts are extremely rare. The water power afforded by the swift-flowing streams is an asset of the county.

The southern and eastern parts, including about three-fourths of the county, lie in the Piedmont Plateau. This section is an undulating upland which is more hilly toward the west than toward the east. The general altitude of the Plateau is about 1,000 feet above sea level.

Joining the Piedmont Plateau on the west and north and rising rather abruptly above it is a part of the Blue Ridge province. The topography of the latter area is decidedly hilly and is generally unsuited for farming. At least two of the peaks in the county are more than 3,200 feet above sea level.

As the Blue Ridge province forms a major drainage divide in the northwestern section the streams follow devious but prevailingly southeastern courses toward the Broad River. The heavy rainfall produces considerable water for the numerous streams that arise within the county. The streams have cut rather deep valleys below the general upland level and their steep gradients allow them to erode the land readily.

Geology.—A striking feature of the geology of Polk County is the absence of homogeneous rocks (fig. 19). Despite the great depth of weathering outcrops of rocks are more common than in other counties of the Charlotte area, owing to the hilly topography.

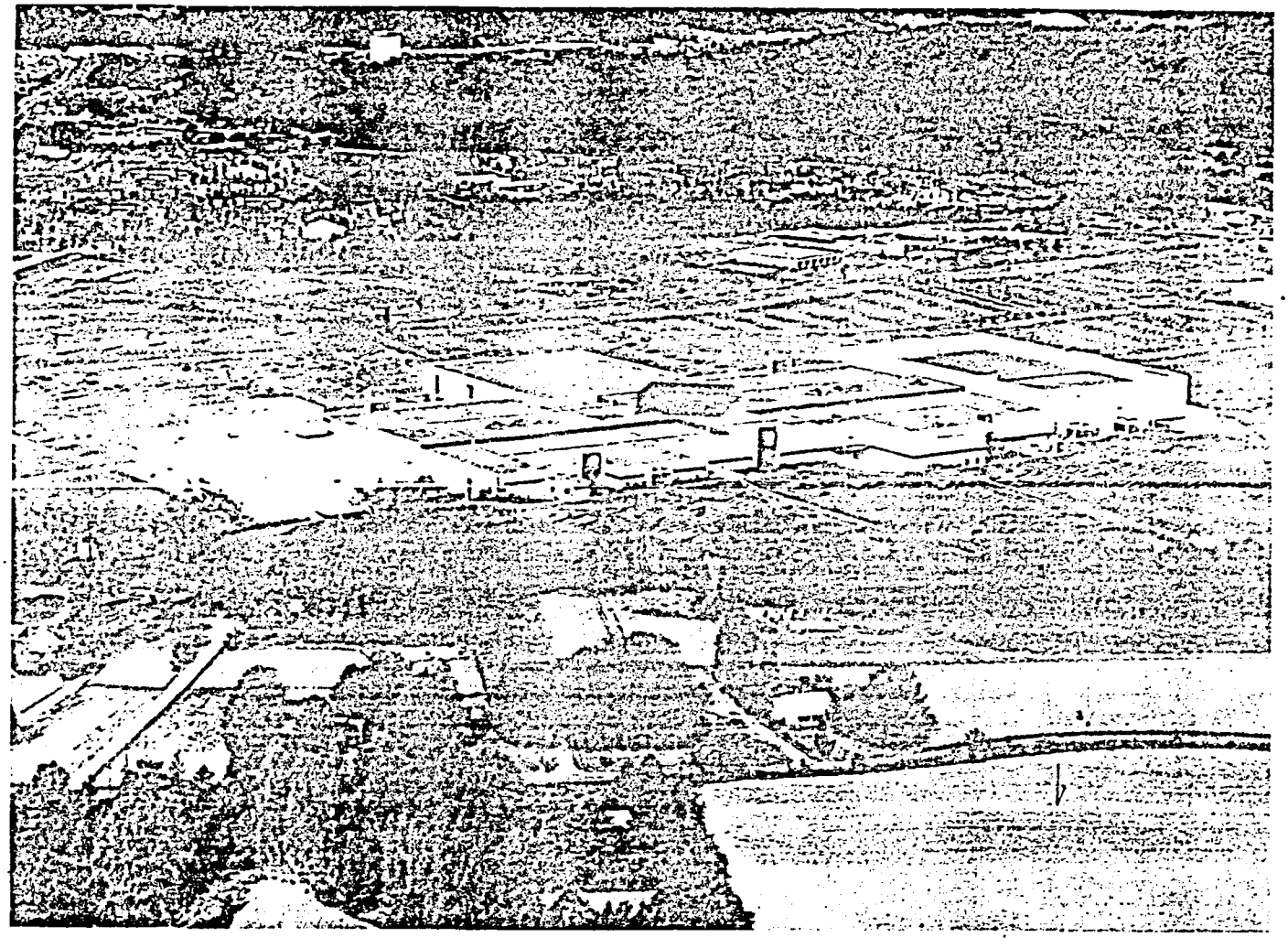
The western and eastern parts of Polk County are underlain by a great series of rocks of which biotite granite gneiss and schist are the most prevelant. These rocks have a persistent northeast trend. Granite, pegmatite, and mica schist are profusely interlayered with the granite gneiss and are locally predominant. Also common in this series is hornblende gneiss, which occurs as thin beds generally conformable with the foliation of the granite gneiss. The amount of hornblende gneiss in this series varies considerably from place to place.

Hornblende gneiss forms the predominant rock in a belt extending northeastward from Tryon through Mill Spring to the Rutherford County line. It has a prevailingly black color where fresh, but as generally

Ref 6

Soil survey of

Mecklenburg County, North Carolina



United States Department of Agriculture
Soil Conservation Service

in cooperation with

Mecklenburg County Board of Commissioners and
North Carolina Agricultural Experiment Station

Todtville
Operations
Center
Charlotte
Reservoir
water
water
COAST
LINE
SEABOARD
Thrift
560 000
FEET
1 440 000 FEET
(Joins sheet 6)

Typically, the surface layer is yellowish brown sandy loam about 8 inches thick. The subsoil is 35 inches thick. The upper part is brownish yellow sandy loam, the middle part is yellowish brown clay, and the lower part is brownish yellow clay. The underlying material to a depth of 66 inches is red, brownish yellow, and white sandy clay loam.

Included with this soil in mapping are a few eroded areas where the surface layer is sandy clay loam and a few areas of similar soils that have a clayey subsoil slightly less than 24 inches thick. Also included are a few intermingled areas of Cecil and Vance soils. The included areas, each less than 5 acres, make up 10 to 20 percent of this map unit.

The organic matter content is low in the surface layer of this Appling soil. Permeability is moderate, the available water capacity is medium, the shrink-swell potential is moderate, and surface runoff is medium. The subsoil is strongly acid or very strongly acid. Depth to bedrock is more than 60 inches. The water table is below 6 feet.

Most of the acreage is used as cropland (fig. 1). Some areas are used for hay or pasture. The rest is forested.

This soil has high potential for corn, soybeans, small grain, pasture, hay, and horticultural crops. Good tilth can be maintained by returning crop residue to the soil. Erosion is a hazard if cultivated crops are grown. Minimum tillage and the use of cover crops, including grasses and legumes, reduce runoff and help to control erosion.

This soil has moderately high potential for broadleaf and needleleaf trees. The dominant trees are yellow-poplar, sweetgum, hickory, ash, white oak, red oak, loblolly pine, and shortleaf pine. The main understory species are dogwood, sourwood, redbud, and black cherry. There are no significant limitations in woodland use and management.

This soil has high potential for most urban uses. The moderate permeability is a limitation for septic tank absorption fields. This limitation can generally be overcome by modifying the field or by increasing the size of the absorption area, or both. The potential is dominantly high for recreation.

The capability subclass is IIe. The woodland group is 3o.

ApD—Appling sandy loam, 8 to 15 percent slopes. This well drained soil is on side slopes on the uplands. Mapped areas are commonly oblong and range from 4 to 25 acres.

Typically, the surface layer is yellowish brown sandy loam about 8 inches thick. The subsoil is 35 inches thick. The upper part is brownish yellow sandy loam, the middle part is yellowish brown clay, and the lower part is brownish yellow clay. The underlying material to a depth of 66 inches is red, brownish yellow, and white sandy clay loam.

Included with this soil in mapping are a few eroded areas where the surface layer is sandy clay loam and a few areas of similar soils that have a clayey subsoil slightly less than 24 inches thick. Also included are a few intermingled areas of Cecil and Vance soils. The included areas, each less than 5 acres, make up 10 to 20 percent of this map unit.

The organic matter content is low in the surface layer of this Appling soil. Permeability is moderate, the available water capacity is medium, the shrink-swell potential is moderate, and surface runoff is medium. The subsoil is strongly acid or very strongly acid. Depth to bedrock is more than 60 inches. The water table is below 6 feet.

Most of the acreage is forest. The rest is used for crops, hay, or pasture.

This soil has moderate potential for corn, soybeans, small grain, pasture, hay, and horticultural crops. Good tilth can be maintained by returning crop residue to the soil. Erosion is a hazard if cultivated crops are grown. Minimum tillage or the use of cover crops, including grasses and legumes, help to control erosion in cultivated areas.

The potential is moderately high for broadleaf and needleleaf trees. Dominant trees are yellow-poplar, sweetgum, hickory, ash, white oak, red oak, loblolly pine, and shortleaf pine. The main understory species are dogwood, sourwood, redbud, black cherry, and sassafras. There are no significant limitations in woodland use and management.

This soil has only moderate potential for most urban uses because of the slope and the moderate permeability. The slope limitation can be reduced or modified by special planning, design, and maintenance. The moderate permeability is a limitation for septic tank absorption fields. This limitation can generally be overcome by modifying the field or by increasing the size of the absorption area, or both. Erosion is a hazard if the ground cover is removed. The potential is low for playgrounds because of the slope. It is high for paths and trails and moderate for most other kinds of recreation.

The capability subclass is IVe. The woodland group is 3o.

CeB2—Cecil sandy clay loam, 2 to 8 percent slopes, eroded. This well drained soil is on broad, smooth ridges on the uplands. Mapped areas are oval and range from 6 to more than 1,000 acres.

Typically, the surface layer is yellowish red sandy clay loam about 6 inches thick. The subsoil is 47 inches thick. The upper part is red clay, and the lower part is red clay loam. The underlying material to a depth of 65 inches is red and yellow loam.

Included with this soil in mapping are a few uneroded areas where the surface layer is brown sandy loam and a few areas of soils that are similar to the Cecil soils but have a clayey subsoil less than 24 inches thick. Also included are many areas of rills and shallow gullies, a

few areas of soils that are less acid than the Cecil soil, and a few intermingled areas of Appling, Mecklenburg, and Vance soils. The included areas, each less than 5 acres, make up to 35 percent of this map unit.

The organic matter content is low in the surface layer of this Cecil soil. Permeability is moderate, the available water capacity is medium, the shrink-swell potential is moderate, and surface runoff is medium. The subsoil is strongly acid or very strongly acid. Depth to bedrock is more than 60 inches. The water table is below 6 feet.

Most of the acreage is used as cropland. Some areas are used for hay and pasture. The rest is forested.

This soil has moderate potential for corn, soybeans, small grain, pasture, hay (fig. 2), and horticultural crops. Keeping this soil in good tilth is difficult because the surface layer is thin. The surface layer commonly forms a crust as it dries after a hard rain and becomes cloddy if worked when wet, both of which affect germination and cause poor or uneven crop growth. Minimum tillage, the return of crop residue to the soil, and the use of cover crops, including grasses and legumes, improve tilth, reduce runoff, and help to control erosion.

The potential is moderate for broadleaf and needleleaf trees. The dominant trees are loblolly pine, shortleaf pine, and Virginia pine. The main understory species are dogwood, sourwood, redbud, and black cherry. The clayey subsoil is the main limitation in woodland use and management.

This soil has high potential for most urban uses. The moderate permeability is a limitation for septic tank absorption fields. This limitation can generally be overcome by modifying the field or by increasing the size of the absorption area, or both. The potential is dominantly moderate for recreation because of the clayey subsoil.

The capability subclass is IIIe. The woodland group is 4c.

CeD2—Cecil sandy clay loam, 8 to 15 percent slopes, eroded. This well drained soil is on side slopes on the uplands. Mapped areas are oblong and range from 6 to 100 acres.

Typically, the surface layer is yellowish red sandy clay loam about 6 inches thick. The subsoil is 47 inches thick. The upper part is red clay, and the lower part is red clay loam. The underlying material to a depth of 65 inches is red and yellow loam.

Included with this soil in mapping are a few uneroded areas where the surface layer is thicker and browner than is typical and a few areas of similar soils that have a clayey subsoil less than 24 inches thick. Also included are many areas of rills and shallow gullies, a few areas of soils that are less acid than the Cecil soils, and a few intermingled areas of Appling, Mecklenburg, and Vance soils. The included areas, each less than 5 acres, make up 10 to 35 percent of this map unit.

The organic matter content is low in the surface layer of this Cecil soil. Permeability is moderate, the available water capacity is medium, the shrink-swell potential is moderate, and surface runoff is medium. The subsoil is strongly acid or very strongly acid. Depth to bedrock is more than 60 inches. The water table is below 6 feet.

Most of the acreage is used for hay or pasture. Some areas are used as cropland. The rest is forested.

This soil has moderate potential for corn, soybeans, small grain, pasture, hay, and horticultural crops. Because the surface layer is thin, this soil is difficult to keep in good tilth. Additional erosion is a severe hazard where cultivated crops are grown. Minimum tillage, the return of crop residue to the soil, and the use of cover crops, including grasses and legumes, improve tilth, reduce runoff, and help to control erosion.

The potential is moderate for broadleaf and needleleaf trees. The dominant trees are loblolly pine, shortleaf pine, and Virginia pine. The main understory species are dogwood, sourwood, redbud, and black cherry. The clayey subsoil is the main limitation in woodland use and management.

This soil has only moderate potential for most urban uses because of the slope and the moderate permeability. The slope limitation can be reduced or modified by special planning, design, or maintenance. The moderate permeability is a limitation for septic tank absorption fields. This limitation can generally be overcome by modifying the field or by increasing the size of the absorption area, or both. Erosion is a hazard if the ground cover is removed. The potential is dominantly moderate for recreation because of the slope and the clayey subsoil.

The capability subclass is VIe. The woodland group is 4c.

CuB—Cecil-Urban land complex, 2 to 8 percent slopes. This map unit consists of areas of Cecil soils and areas of Urban land primarily in the suburban areas of Charlotte. These areas are too small and too intricately mixed to be mapped separately. The undisturbed Cecil soil makes up 50 to 70 percent of each area, and Urban land makes up 15 to 35 percent. The rest of this unit consists of areas where most of the natural soil has been altered or covered as the result of grading and digging.

The undisturbed Cecil soil is well drained. Typically, the surface layer is yellowish red sandy clay loam about 6 inches thick. The subsoil is 47 inches thick. The upper part is red clay, and the lower part is red clay loam. The underlying material to a depth of 65 inches is red and yellow loam.

The organic matter content is low in the surface layer of this Cecil soil. Permeability is moderate, the available water capacity is medium, the shrink-swell potential is moderate, and surface runoff is medium. The subsoil is strongly acid or very strongly acid. Depth to bedrock is more than 60 inches. The water table is below 6 feet.

Ur—Urban land. This map unit consists of areas where more than 85 percent of the surface area is covered with asphalt, concrete, buildings, or other impervious cover. Most of the soil material has been cut, filled, and graded, and the natural characteristics altered or destroyed. The rest is small lawns or shrub gardens near buildings, sidewalks, and parking lots.

Most areas are in or near the business district of Charlotte. Isolated areas mapped are more than 5 acres.

The main problem created in areas of Urban land is that the very high volume of surface runoff can cause flooding in low-lying areas downstream.

Examining and identifying the soils in this unit is impractical. Careful onsite investigation is needed to determine the suitability of any particular area for any proposed use.

VaB—Vance sandy loam, 2 to 8 percent slopes. This well drained soil is on broad ridges and side slopes of the uplands. Mapped areas are commonly oblong and range from 4 to 40 acres.

Typically, the surface layer is yellowish brown sandy loam about 8 inches thick. The subsoil is strong brown clay 25 inches thick. The underlying material to a depth of 50 inches is mottled strong brown, yellow, and red clay loam and loam.

Included with this soil in mapping are a few areas of similar soils that are less acid than the Vance soil and a few eroded areas where the surface layer is sandy clay loam or clay loam. Also included are small areas of Appling, Enon, and Helena soils. The included soils make up about 10 to 25 percent of this map unit.

The organic matter content is low in the surface layer of this Vance soil. Permeability is slow, the available water capacity is medium, the shrink-swell potential is moderate, and surface runoff is medium. The subsoil is strongly acid or very strongly acid. Depth to bedrock is below 60 inches. The water table is below 6 feet.

Most of the acreage is used for crops, hay, and pasture. Some areas are woodland.

This soil has moderately high potential for most crops. Erosion is a hazard if cultivated crops are grown. As the original surface layer is lost, the underlying sticky subsoil becomes part of the plow layer. This process lowers the overall tilth. Minimum tillage, the return of crop residue to the soil, and the use of cover crops, including grasses and legumes, reduce runoff and help to control erosion.

This soil has moderately high potential for broadleaf and needleleaf trees. The dominant trees are loblolly pine, Virginia pine, sweetgum, sycamore, white oak, and yellow-poplar. The dominant understory species are dogwood, redbud, holly, sourwood, and black cherry. There are no significant limitations in woodland use or management.

This soil has low potential for most urban uses because of the slow permeability and the low strength. The slow permeability significantly limits the absorption of effluent in septic tank absorption fields. This limitation generally can be overcome by modifying the field or by increasing the size of the absorption area, or both. Corrective measures commonly used for low strength are increasing the size of the footings and, where appropriate, placing structures on slabs. The potential is only moderate for camp areas and playgrounds because of the slow permeability. It is high for most other kinds of recreation.

The capability subclass is IIIe. The woodland group is 3o.

VaD—Vance sandy loam, 8 to 15 percent slopes. This well drained soil is on side slopes on the uplands. Mapped areas are oblong and range from 4 to 25 acres.

Typically, the surface layer is yellowish brown sandy loam about 8 inches thick. The subsoil is strong brown clay 25 inches thick. The underlying material to a depth of 50 inches is mottled strong brown, yellow, and red clay loam and loam.

Included with this soil in mapping are a few areas of similar soils that are less acid than the Vance soil and a few eroded areas where the surface layer is sandy clay loam or clay loam. Also included are small areas of Appling, Enon, and Helena soils. The included soils make up about 10 to 25 percent of this map unit.

The organic matter content is low in the surface layer of this Vance soil. Permeability is slow, the available water capacity is medium, the shrink-swell potential is moderate, and surface runoff is rapid. The subsoil is strongly acid or very strongly acid. Depth to bedrock is below 60 inches. The water table is below 6 feet.

Most of the acreage is woodland. Some areas are used for crops, hay, and pasture.

This soil has moderately high potential for most crops. Good tilth can be maintained by returning crop residue to the soil. Surface runoff and erosion are hazards if cultivated crops are grown. Minimum tillage or the use of cover crops, including grasses and legumes, helps to control erosion in cultivated areas.

This soil has moderately high potential for broadleaf and needleleaf trees. The dominant trees are loblolly pine, Virginia pine, sweetgum, sycamore, white oak, and yellow-poplar. The dominant understory species are dogwood, redbud, holly, sourwood, and black cherry. There are no significant limitations in woodland use or management.

The potential for most urban uses is low because of the slow permeability, the slope, and the low strength. The slow permeability significantly limits the absorption of effluent in septic tank absorption fields. This limitation generally can be overcome by modifying the field or by increasing the size of the absorption area, or both. The slope limitation can be reduced or modified by special planning, design, and maintenance. Corrective measures commonly used for low strength are increasing the size of the footings and, where appropriate, placing structures

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered, but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. Inadequate strength for supporting loads.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is greater than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are *very slow* (less than 0.06 inch), *slow* (0.06 to 0.20 inch), *moderately slow* (0.2 to 0.6 inch), *moderate* (0.6 to 2.0 inches), *moderately rapid* (2.0 to 6.0 inches), *rapid* (6.0 to 20 inches), and *very rapid* (more than 20 inches).

Phase, soil. A subdivision of a soil series or other unit in the soil classification system based on differences in the soil that affect its management. A soil series, for example, may be divided into phases on the bases of differences in slope, stoniness, thickness, or some other characteristic that affects management. These differences are too small to justify separate series.

pH value. (See Reaction, soil). A numerical designation of acidity and alkalinity in soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from a semisolid to a plastic state.

Productivity (soil). The capability of a soil for producing a specified plant or sequence of plants under a specified system of management. Productivity is measured in terms of output, or harvest, in relation to input.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

NORTH CAROLINA ATLAS

PORTRAIT OF A CHANGING SOUTHERN STATE

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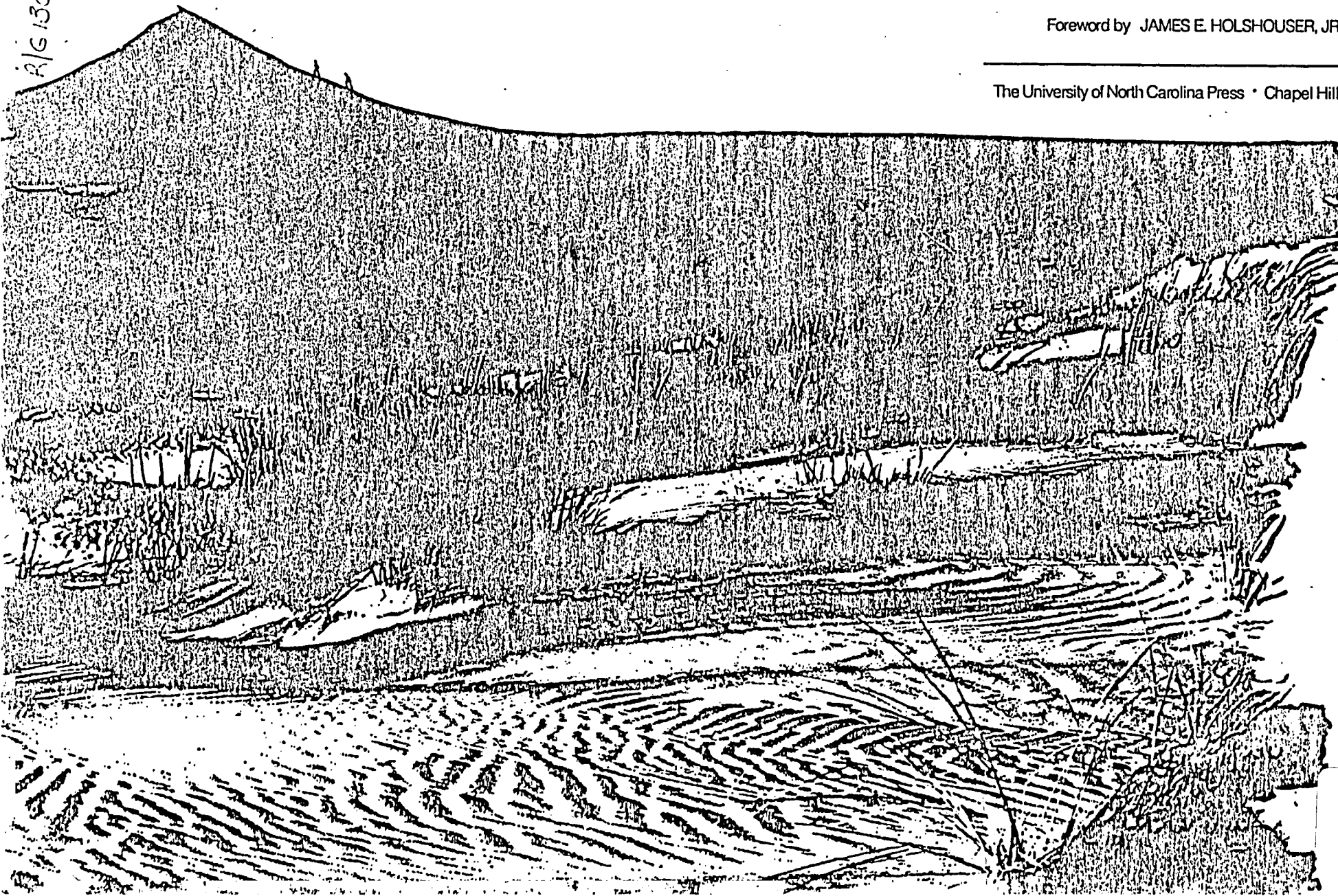

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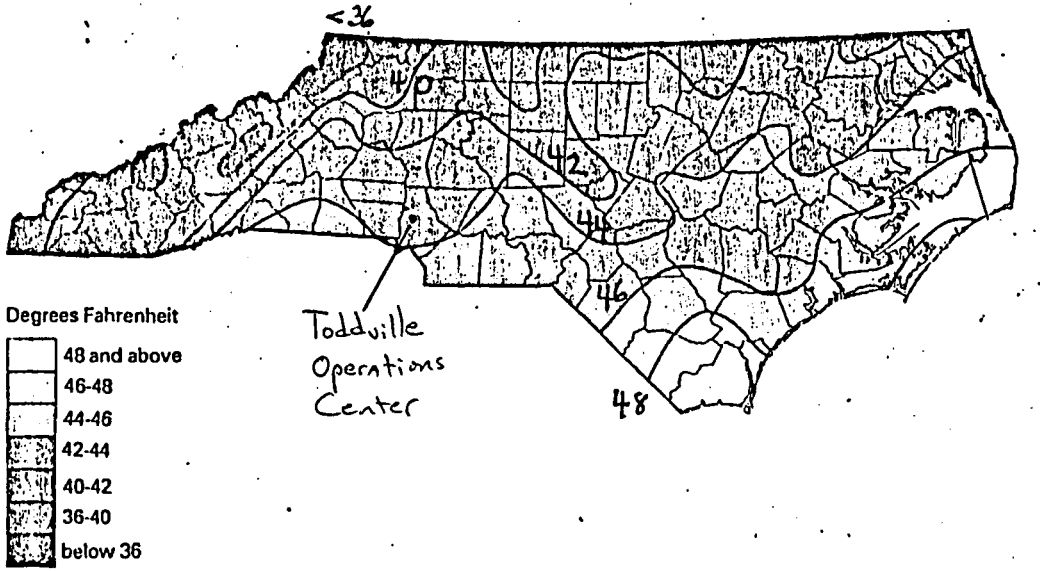
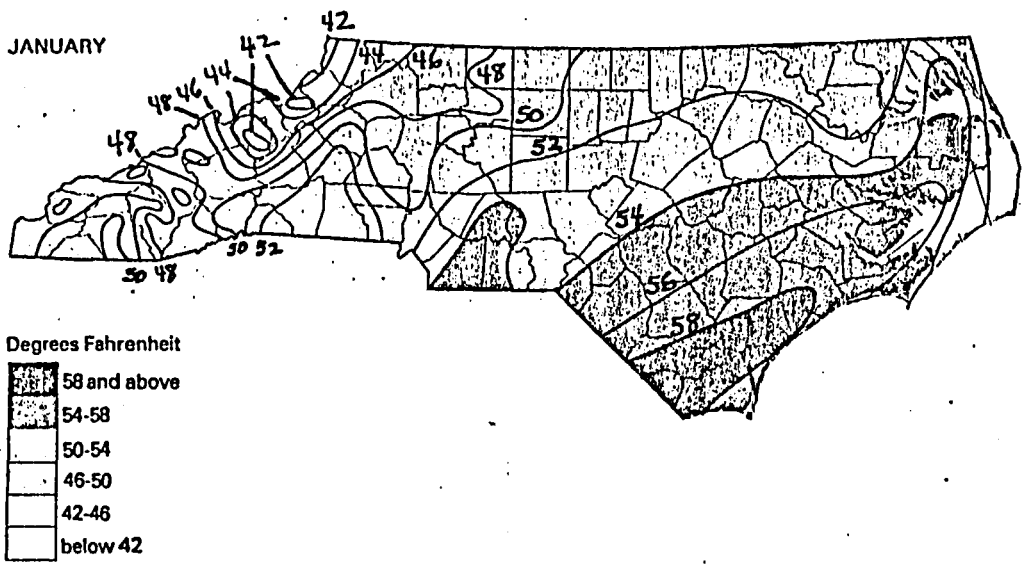


Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

Figure 5.3. Mean Maximum Temperature in N.C.



Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

Winter The alternate passage of low- and high-pressure systems over the state during winter months results in changing weather conditions. Moisture and warmer temperatures are characteristically associated with frequently passing low-pressure cells. Lows are followed by polar highs, which bring lower temperatures and clear skies. However, even when under the influence of these polar highs, temperatures seldom fall below 10° F., and midday temperatures reach into the forties, making the winter season very tolerable by northern standards.

January average temperatures shown in Figure 5.2 illustrate the mildness of winters. Only at the highest elevations do temperatures average below freezing. The mean temperature for January at Mount Mitchell is 28.7° F., the lowest in the state. Yet, at Asheville, located on the lee side of the mountains, temperatures for January average 39.4° F.

Nowhere else in North Carolina is the local contrast in temperatures as great as in the western counties. Temperature contrasts are least where the climate is mildest. Hatteras, on the Outer Banks, has a January mean of 48.0° F., and only thirteen days each year when temperatures of 32° F. and below are recorded.

The tendency for January isotherms to parallel the coast shows the influence of the Atlantic Ocean. Wilmington, in southeastern North Carolina, the most subtropical area in the state, exemplifies the maritime effect. This coastal city has a January mean temperature of 47.8° F., and an average of only eight days during January when temperatures dip to 32° F. or less, as compared with eighteen days at Raleigh and nineteen at Asheville.

In the Piedmont, latitude is the primary control on temperature, and the isotherms maintain a zonal pattern. As might be expected, temperature averages lie between those exhibited by the surrounding regions. Charlotte has a mean January temperature of 42.3° F., Greensboro, 39.0° F., and Raleigh, 42.7° F.

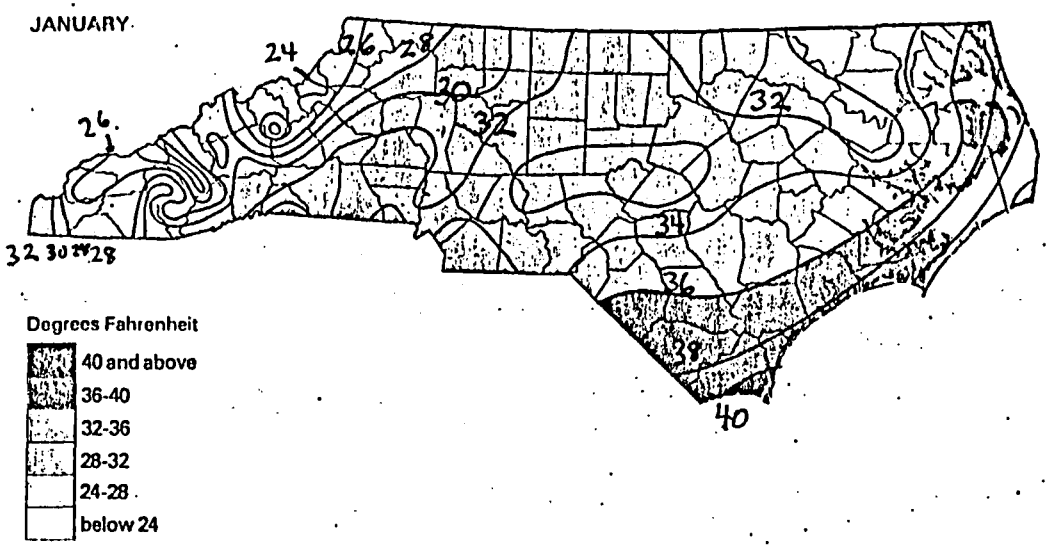
However, whereas Asheville averages eighty-three days each year when temperatures drop below freezing, Winston-Salem has freezing temperatures eighty-eight days annually, and Greensboro has eighty-four days with freezing temperatures.

January Mean Maximum and Minimum Temperatures Figure 5.3 illustrates the temperature pattern across North Carolina on a typical afternoon of the coldest month. The cool waters of the East Coast are responsible for the isotherms taking an abrupt inland turn to the north before resuming the northeast-southwest pattern usually found on temperature maps. This distribution indicates that midday temperatures in January are highest a short distance inland from the coast unlike the pattern of mean temperatures that indicates a smooth gradient from the coast westward. Also, in the mountains, isotherms of mean maximum temperature are more numerous and some "islands" or "pockets" of cool temperatures exist. The greater ranges of temperature are associated with mountain valleys where nights are cold and days are warm, causing patterns of maximum temperatures to contrast significantly with mean temperature distributions.

The moderating effect of the ocean becomes evident in Figure 5.3, where January mean minimum temperatures are shown. Isotherms on this map reflect characteristic nighttime temperatures. The pattern reveals that temperatures are milder along the coast and decrease inland fairly rapidly. Once again, the temperature pattern is more complex in the highlands region. Generally, mean minimum temperatures are well below freezing in the Mountain region, at freezing levels throughout the Piedmont, and above freezing in the Coastal Plain. A comparison of Figures 5.3 and 5.4 indicates that during January the daily range of temperature is about 20° F. everywhere in the state.

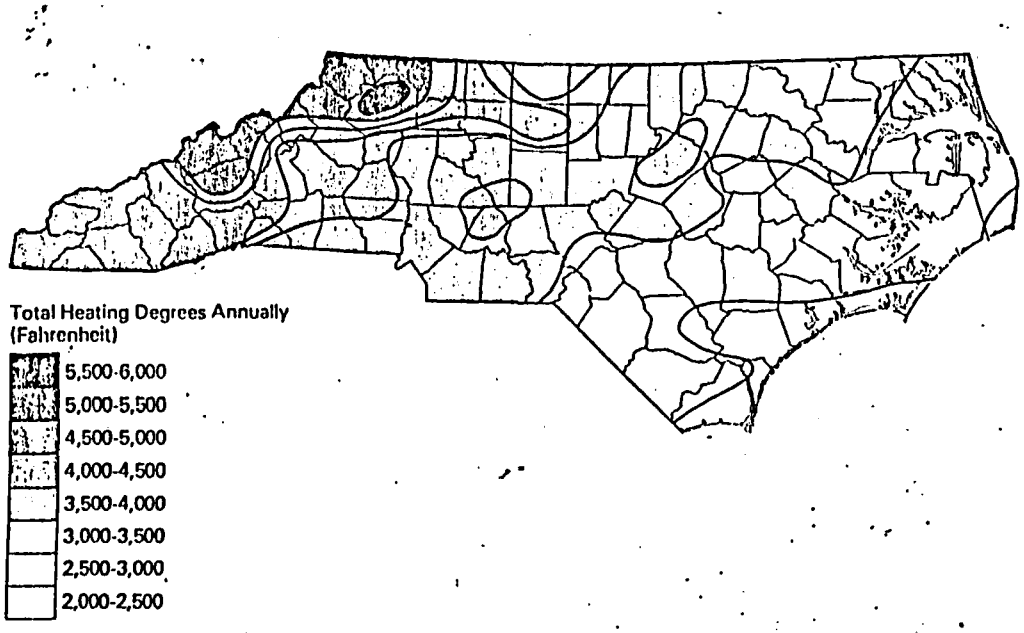
Average Annual Heating Degree Days There are climatically significant measurements of heat energy variation other than the direct determination of temperature, the cyclical occurrence of certain temperature levels, or the periodicity of temperature realms. These measurements relate to temperature efficiency in terms of human comfort or plant growth. One of these less common indexes is the *heating degree day*. This measurement is a cold season index and is based on the assumption that a temperature of 65° F. within a building is the minimum thermal threshold for normal human comfort. The negative departure of daily mean temperature from this standard figure is recorded as heating degree day units. For example, a daily temperature average of 40° F. would be listed as twenty-five heating degree days. Developed by heating engineers, this index permits a relatively accurate measurement of fuel consumption, and removes the guesswork from the calculation of fuel needs. The accumulation of heating degree day units at given locations is totaled annually and averaged for a period of years. To those persons interested in climate, this indirect measurement of heat energy provides additional insight into the thermal environment.

Figure 5.4. Mean Minimum Temperature in N.C.



Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

Figure 5.5. Average Annual Heating Degree Days in N.C.



Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

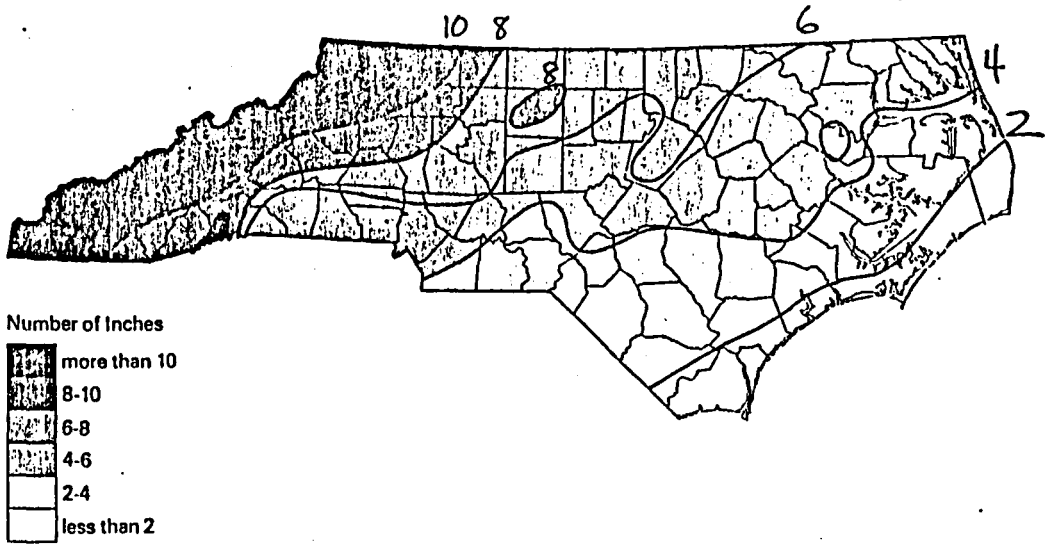
When high-pressure systems (anticyclones) dominate, clear to partly cloudy weather prevails. Receiving, on the average, 50 to 60 percent of total possible sunshine, North Carolina receives more hours of winter sunshine than do states to the north and to the immediate west. Sunshine is more prevalent in the southeast around Wilmington, and diminishes rapidly as the Mountains are approached. The Mountains receive about one-third less sunshine than does the rest of North Carolina.

Spring For many North Carolinians, this season is the most preferable of all. With the northward shifting of the noon sun, the storm track normal to North Carolina during the winter retreats northward and fewer and fewer cyclonic storms occur. Cold spells are less numerous and periods of high temperatures and balmy days become longer and more pronounced. Rainfall diminishes slightly in April, but increases toward the summer as cyclonic activity gives way to thundershowers and their heavy downpours. Although more precipitation is received in the state during May and June, there are fewer hours and days in which rainfall occurs, indicating a higher precipitation intensity.

Mean temperatures range from the fifties in April to the seventies in June for all places save those at high elevations. The days are marked by cool nights and warm afternoons with relative humidities at optimal levels for human comfort. As the daylight period lengthens, sunshine percentages and totals increase to their highest values for the year. For the eastern two-thirds of the state, sunshine during April, May, and June is received approximately 70 percent of the time and in amounts exceeding three hundred hours for the latter part of the season.

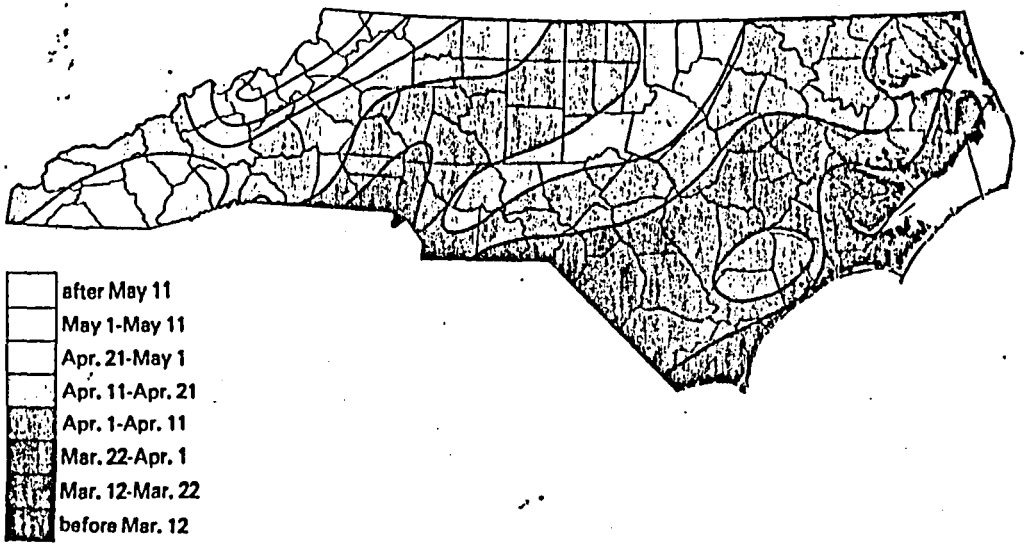
Average Date of the Last Freeze in Spring As illustrated by Figure 5.8, the beginning of the freeze-free season varies across the state from 1 March to 10 May, a difference in time of over two months. As expected, the milder climate along North Carolina's coast engenders early dates, whereas the more severe climate of the Mountains retards the start of the freeze-free period longer than elsewhere. In most areas of the Coastal Plain, the last spring freeze generally occurs by the first of April. The Piedmont has its last freezes between 1 and 10 April, about ten to fifteen days later than the Coastal Plain. In the Mountains, there is greater variation in mean dates for both the beginning and the end of the freeze season. Because air chills more quickly at higher elevations, and because cold air is denser than warm air, the cold air drains into the valleys where it is contained and continues to lose heat by radiation. The result of this process is that in certain Mountain areas some valleys are more often colder than their slopes at intermediate altitudes. Lying between the below-freezing temperatures of the valleys and the higher elevations are "verdant" or "thermal" belts.

Figure 5.7. Average Annual Snowfall in N.C.



Source: U.S. Department of Commerce, *Climatological Summary*, 1966.

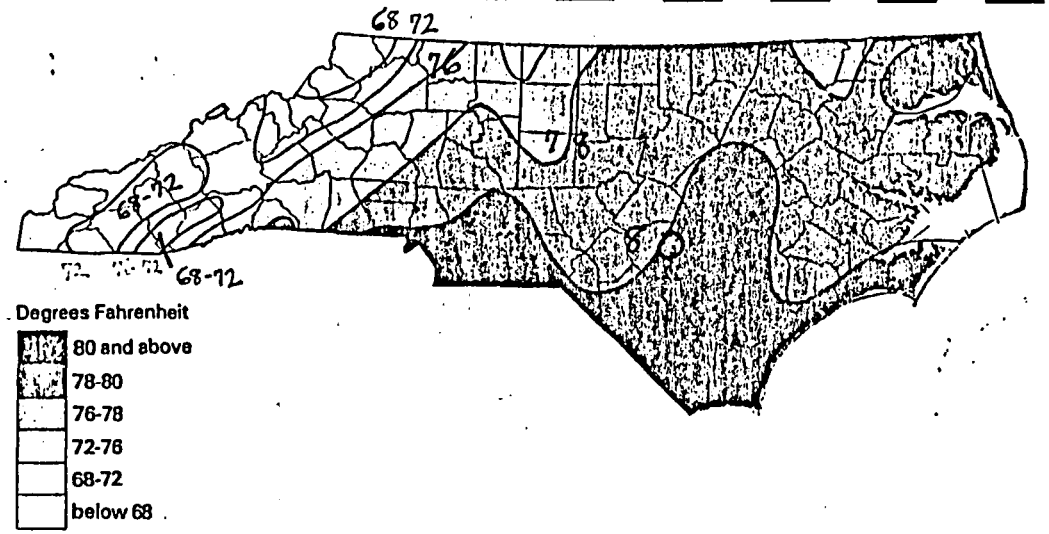
Figure 5.8. Average Date of Last Freezing Temperature in N.C.



Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

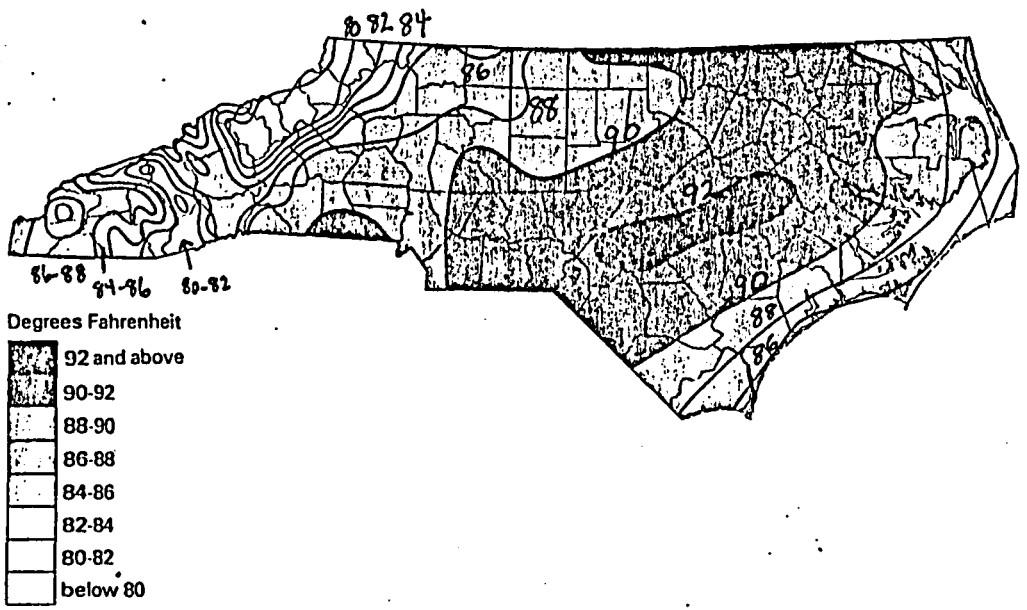
Pg 7

Figure 5.9. Average July Temperature in N.C.



Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

Figure 5.10. Mean Maximum July Temperature in N.C.



Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

These [redacted] like [redacted]s ha[redacted]nger [redacted]-fre[redacted]sons and thereby show earlier dates for the end of the freeze period than their surroundings. They support frost-susceptible vegetation long after the greenery has disappeared in nearby areas. Often in early winter or even in midwinter a contrasting belt of green flanked above and below by brown may be seen. These green belts are characteristically located along slopes that face the winter sun, are protected from cold northern winds, and have cold air drainage to lower valleys. The blossoming of dogwood and redbud moves across the state in a pattern similar to that of the end of the freeze season to blanket North Carolina with color and beauty.

Summer Summer is characterized by its high temperatures, high humidities, high amounts of rainfall, and high physiological stress. Except for the amelioration of these climatic elements in the Mountains, and the relief afforded by sea breezes along the coast, elsewhere in the state summer is a season of extremes. Mean monthly minimum temperatures for July and August are in the upper seventies and eighties and mean maximum temperatures reach into the nineties.

However, to quote a popular adage, "it's not the heat but the humidity," and North Carolina's temperatures in combination with the high water vapor amounts prevalent during the summer months are definitely uncomfortable. In addition, high sunshine percentages and a predominance of southerly winds tend to aggravate an already unpleasant climatic condition. Only the periodic passage of cool, dry air masses from the north and sea breezes in the coastal areas alleviate the discomfort of summer weather for North Carolina's low-lying counties.

July Average Temperatures The pattern of mean temperatures in July is similar to the pattern in January (Figure 5.9). However, in the Piedmont and Coastal Plain, isotherms are fewer in number and farther apart. In the Mountains, the reverse is true. The widespread isotherms east of the Mountains indicate that temperature averages across central and eastern North Carolina exhibit little contrast. From the western Piedmont to the coast, the difference in mean temperatures is only 4° F. Although the influence of the ocean is not evident in the arrangement of isotherms, the high temperatures of the Coastal Plain are made less severe by the cooling power of the sea breeze. Hatteras, on the Outer Banks, records a temperature of 90° F. on the average of only one day each year, while Wilmington, a short distance from the coast, has an occurrence of 90° F. temperatures about twenty-four days annually. In contrast with these locations, Raleigh and Winston-Salem mean temperatures for July are slightly lower, but the average number of days on which a temperature of 90° F. or above is experienced increases to more than forty.

Rep 7

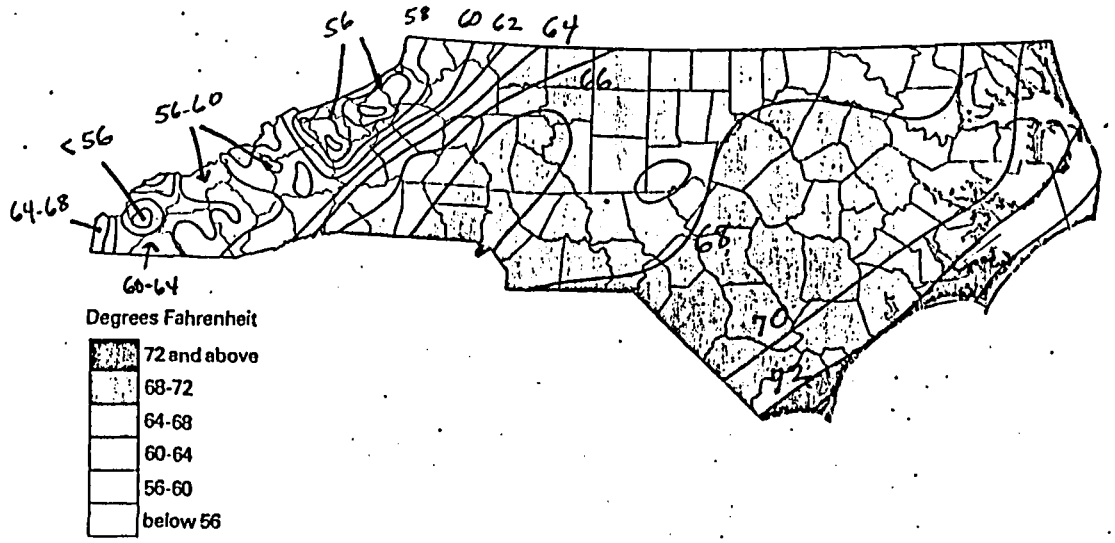
temperature values sharply. The temperature gradient in July is even steeper than in January. East to west across Caldwell County, mean temperatures drop from 76° F. to 68° F. and Mount Mitchell remains the coolest site in the state with a July average of 59° F. At Asheville, the warmest month averages 73.8° F. and only seven days during the summer show temperatures reaching to 90° F. With daily minimum temperatures in the fifties and sixties the allure of the Mountains for summer recreation becomes evident.

July Average Maximum and Minimum Temperatures The temperatures typically recorded during an afternoon in July are shown in Figure 5.10. In the Coastal Plain, isotherms representing mean maximum temperature are aligned parallel to the shoreline signifying the effect of the cool ocean and sea breeze. At Cape Hatteras, the summer daytime maximum is 84° F. Inland, temperatures increase and reach their highest values in the Fayetteville area where scorching temperatures in excess of 92° F. are experienced. In the Piedmont, maximum temperatures average between 88° F. and 92° F. Toward the Mountains, midday highs drop to more pleasant levels. In Swain and Haywood counties, afternoon temperatures are generally in the low seventies and most western counties record mean July maximums under 80° F.

Although isotherms of mean minimum temperature exhibit a pattern similar to the pattern of maximum July temperatures, in the outer Coastal Plain absolute temperature values are reversed (Figure 5.11). Minimum temperatures represent nighttime conditions and their distribution indicates that the effect of the ocean is to warm adjacent areas. Farther inland, the more rapidly cooling land causes the temperatures to be lower. Thus the maps showing average July maximum and minimum temperatures portray the daily relative change in influence from ocean to land and back again along the coastal fringe of North Carolina. Over the Piedmont and the Inner Coastal Plain, July average minimums show little change with distance, ranging only 4° F. from 66° F. to 70° F. In the Mountains, 50° F. and 60° F. temperatures indicate the characteristically cool weather associated with this region during summer nights.

Summer is the season of greatest precipitation in North Carolina. Thunderstorms are the predominant mechanism for precipitation delivery and occur mainly in the afternoon or evening. They come on an average of ten to twelve days per month. July and August show the highest rainfall amounts with many sections of the state reporting 5 to 7 inches of rain for each of these months. The coastal region around Wilmington and the southwestern counties are the rainiest areas in the state

Figure 5.11. [illegible]



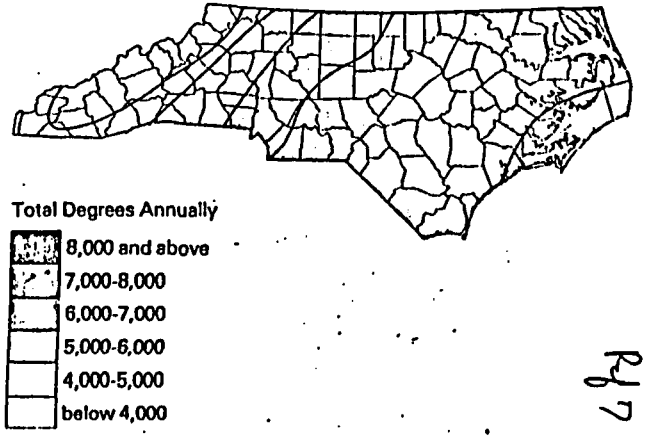
Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

having over 8 inches of precipitation and an average of fourteen rain days in July. By August the hurricane season has arrived and these storms may contribute a significant percentage of rainfall to monthly totals and continue to do so well into the fall.

Average Growing Degree Days Similar in its derivation to the heating degree day concept, the *growing degree day* is based on the positive departure of mean daily temperature from an established temperature value representing the start of the active growth period for plants.

Although each plant has its own base temperature for seed germination and active growth, a mean daily temperature of 40° F. will represent the beginning of the growth period for most crops. To determine growing degree day units for example, a daily mean temperature of 50° F. will indicate ten growing degree days or a 10° F. departure from the base minimum of 40° F. These units are then accumulated for the year and averaged over a period of time to provide us with the data for preparing Figure 5.12. Since each plant requires a certain amount

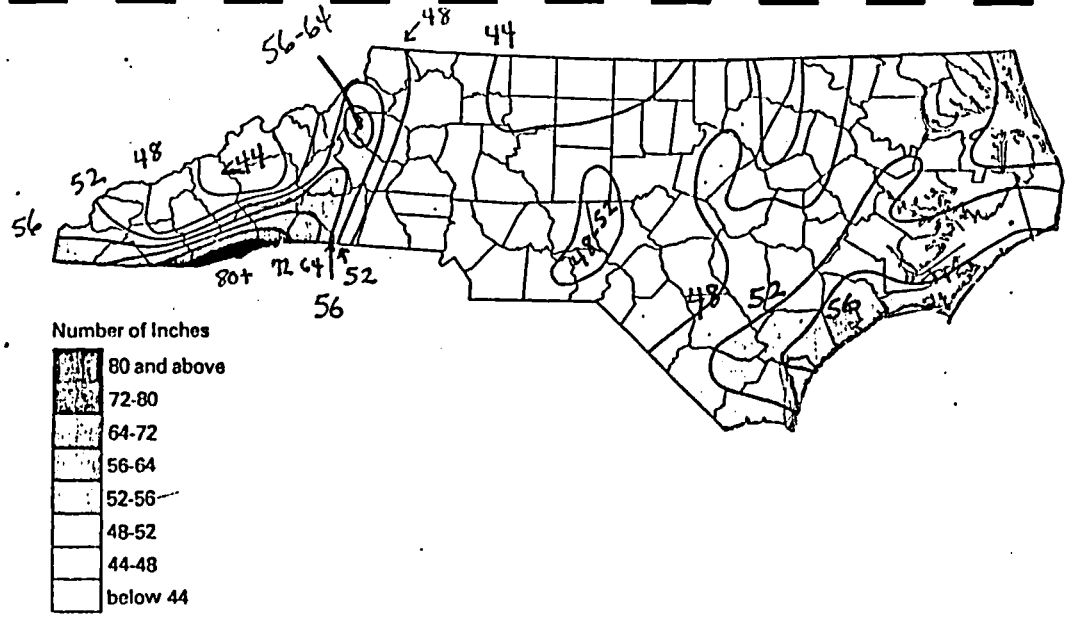
Figure 5.12. Average Annual Growing Degree Days in N.C.



Source: U.S. Department of Commerce, *Climatological Summary*, 1966.

amounts drop below 3 inches throughout central and eastern North Carolina during October and November. Cyclonic activity increases as thunderstorms become less frequent until by late November they seldom occur.

As illustrated in Figure 5.14, freezes begin early in October in the Mountains and slowly move eastward toward the coast. In early December, the freeze-free season reluctantly comes to a close in the Wilmington-Southport area. Deciduous trees begin their dormancy period and the color of the state gradually changes from the quiet greens of summer to the fiery reds and brilliant yellows of fall. By late autumn the highlands, now a mottled brown and green, show an occasional sprinkling of white as temperatures in the Mountains fall below freezing and the possibility of snow increases. However, in the Piedmont and Coastal Plain, tennis, sailing, and picnicking, for example, continue into November and football games played late in the season are often attended by fans dressed in warm-season attire.



Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

Annual Precipitation and Humidity

Although a considerable variation in the distribution of rainfall exists throughout the state, everywhere precipitation is high (Figure 5.15). In the Coastal Plain, rainfall totals average from 44 to 55 inches; the highest amounts were received at the Outer Banks. Across the Piedmont, yearly rainfall averages range from 43 to 48 inches, with the northern and southern sectors having the lower totals. The greatest variability in rainfall distribution is found in the Mountains. Here, south-facing slopes along the North Carolina-South Carolina border receive as much as 80 inches of precipitation each year. Nearby, Asheville, lying in a sheltered valley, records only 37 inches, the lowest rainfall average reported in the state. More commonly, average annual precipitation in the Mountains ranges from 44 to 58 inches. For the state as a whole, an average total of 50 inches is representative.

The distribution of rainfall throughout the year is reasonably uniform. Although there are no pronounced wet and dry seasons, a profile of average annual precipitation indicates a bimodal distribution, i.e., two periods of higher rainfall separated by two periods during the year when rainfall amounts are lower than the norm. Generally, the highest precipitation totals are associated with the summer months. In the fall, the season of the least rainfall, the lowest yearly totals usually occur in October or November. Precipitation increases slightly during the winter season and then decreases to a secondary low in April. This precipitation regime is common to the state and varies only slightly from place to place.

Although rainfall is heaviest in the summer, evaporation and transpiration losses are also great. Consequently, the summer season is deficient in its supply of soil moisture and irrigation may be required to sustain crop needs.

Although it is considered to be a wet state, North Carolina nevertheless has its occasional "bout with drought." Recently, the Piedmont and Inner Coastal Plain suffered through an especially severe drought. In 1968, negative rainfall departures amounting to as much as 26 inches were computed by individual stations within this area. On the other hand, 1972 proved to be an abnormally wet year. During that year, Raleigh, which has an average annual precipitation of 46.35 inches, experienced a total rainfall of 51.74 inches. Raleigh's weather records may be used to illustrate the variations in yearly precipitation amounts. In the capital city, annual totals have varied from a low of 30 inches in 1933 to a high of 64 inches in 1936. On a monthly basis, rainfall variation for July has ranged from 12.36 inches in 1931 to as little as 0.38 inches in 1953. Yet precipitation variability in North Carolina is moderate compared with those states where rainfall totals are significantly less and consequently precipitation patterns and regimes are more unpredictable.

Average Number of Days with 0.01 Inches of Precipitation or More Figure 5.16 shows the pattern of days with measurable precipitation in North Carolina. The Mountains have the greatest number of days with measurable precipitation, averaging 10 to 20 more rainy days per year than the coast and 20 to 30 days more than the southern Piedmont. In the northwest corner of the state precipitation occurs 4 out of every 10 days. By contrast, the sandhills in the Southern Piedmont experiences precipitation on only 30 percent of the days. In fact, a "tongue" of fewer rainy days penetrates the state from south to north, through North Carolina's central counties. For the state as a whole, 125 days with measurable precipitation is a representative figure.

Water Balance

The "wetness" or "dryness" of any region is mirrored by its natural vegetation. Indigenous plant life is an indicator of a region's precipitation effectiveness and its capacity to support plant growth. The minimal moisture requirements of plant communities are quite specific, and in situ vegetation reflects the amounts of water annually and seasonally available for its use. As the size of a bank account depends upon the balance between deposits and withdrawals, so precipitation effectiveness

moisture requirement is satisfied, additional precipitation will drain to the underground water table or run off the land as surplus water.

Figure 5.18 provides the water balance deficits for the state and shows that everywhere except for the Asheville area and the northern Piedmont, the annual water deficit is less than one inch. By contrast, Figure 5.19 gives water balance surpluses. Being a wet state, North Carolina's water budget indicates surpluses exceeding deficits by large amounts. While most of the Piedmont and Coastal Plain have surplus water up to 15 inches, the Outer Banks and the Mountains show surpluses above 15 inches. In the southwest corner of the state, water surpluses amount to as much as 30 inches.

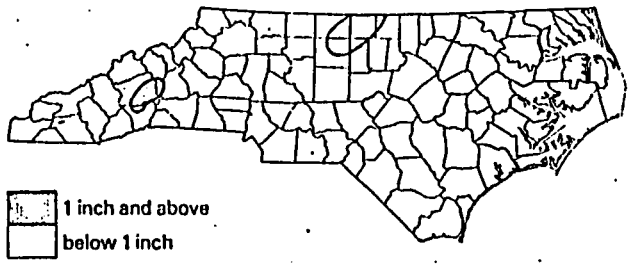
Mean annual evaporation for North Carolina is shown in Figure 5.20. Evaporation rates and totals are related to temperature, wind velocity, and relative humidity. Where temperatures are highest and humidities lowest, evaporation intensities will be greatest. Since temperatures throughout the Coastal Plain and the Piedmont are highest for the state and since humidity percentages are greater in the vicinity of the ocean, evaporation totals are lower in the Mountains and along the coast, and highest in the southern Piedmont and Coastal Plain. A comparison of the maps showing precipitation, evaporation, water surplus, and water deficit will provide the reader with a fairly complete picture of North Carolina's water balance.

Winds and Storms

Three types of storms and their associated winds are common to North Carolina: cyclonic and convectional thunderstorms, hurricanes, and tornadoes. These storms are integral parts of the state's climatic pattern. In analyzing the importance of winds, direction and speed are major considerations.

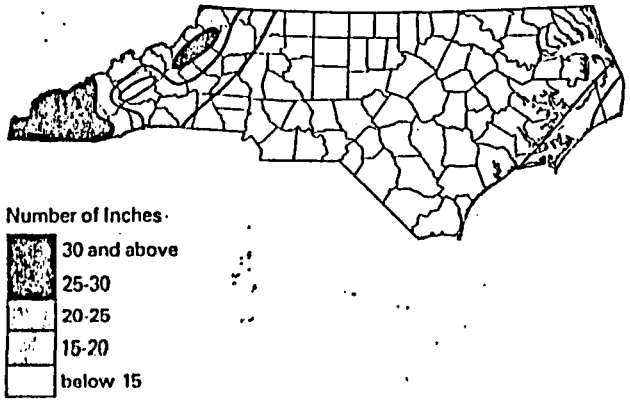
Although prevailing winds (winds that persist in blowing from one direction more so than any other) characterize given geographical areas, wind direction changes frequently. A northwesterly wind (coming from the northwest) will be, relatively speaking, a cooling and drying wind, whereas a southeasterly wind will bring warm, moist air to the state. The passage of cyclones and anticyclones with their characteristic wind patterns will change the wind's direction so that it may come across North Carolina from any point of the compass.

Figure 5.18. Water Balance Deficit in N.C.



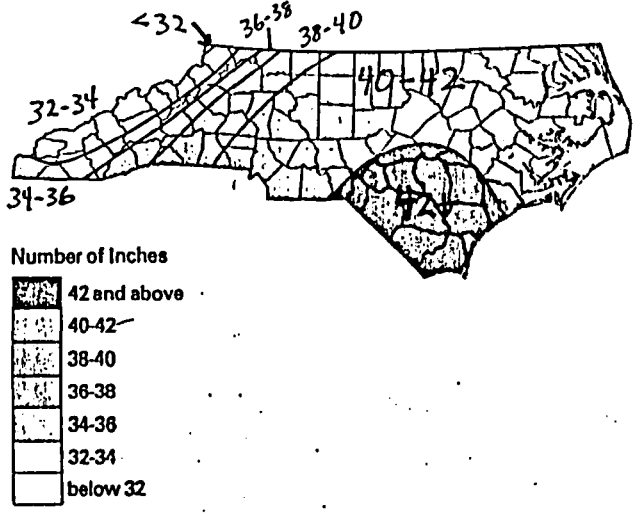
Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

Figure 5.19. Water Balance Surplus in N.C.



Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

Figure 5.20. Mean Annual Evaporation in N.C.

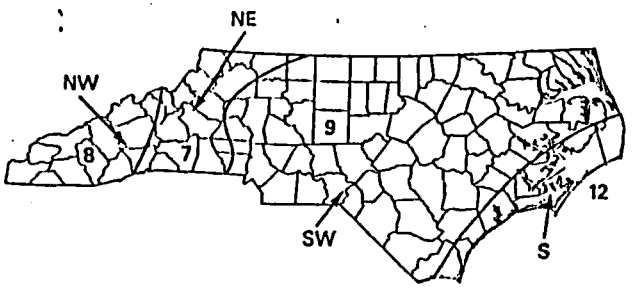


Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

The velocity of the wind is relevant to ventilation of air pollutants, evaporation rates, and thus cooling and chilling indexes. On those occasions when winds reach gale force and higher, their velocities are of singular importance because of their destructive capabilities. Damaging winds are usually associated with infrequent hurricanes and tornadoes and, at times, with severe thunderstorms.

The prevailing winds and mean wind speeds averaged for the year are given in Figure 5.21. For the eastern two-thirds of the state, winds blow most frequently from the southwest and south. Throughout the Mountains and the western Piedmont, winds prevail from northerly directions. This annual pattern of prevailing winds persists for most months of the year except September and October when winds are dominantly from the northeast. During these months, the clockwise flow of air from seasonal anticyclones lying poleward of North Carolina, and the counterclockwise winds associated with an increased number of offshore storms cause northeasterlies to prevail across the state.

Figure 5.21. Prevailing Winds and Mean Annual Wind Speed in N.C.



Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

Note: Wind speeds are noted in miles per hour.

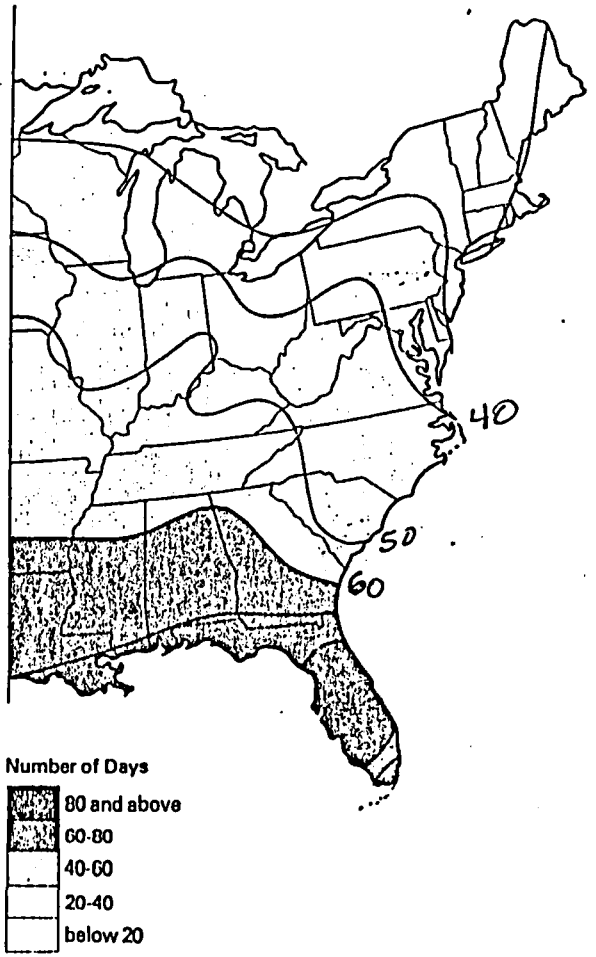
Wind speeds have been averaged for each zone of prevailing winds. Winds tend to diminish in speed westward from the coast where sea breezes and offshore storms contribute to velocities that average twelve miles per hour. Throughout the Inner Coastal Plain and the Piedmont, the mean wind speed is nine miles per hour, and in the western counties, representative wind speeds are seven and eight miles per hour. On a daily basis, wind velocities are lowest before dawn and highest around midafternoon. Seasonally, winter, with greater temperature and pressure contrasts, shows the most rapid air movement and summer is the time of lowest wind speeds.

Thunderstorms Thunderstorms are vertically developed storm systems that involve lightning and thunder. Produced by instability in the atmosphere, these storms are sustained by the conversion of water vapor into rain and hail, which causes the release of enormous amounts of energy. This energy results in vigorous updrafts of rapidly moving air. The intensity and turbulence of an individual thunderstorm is related to the degree of atmospheric instability and the supply of latent energy released by the condensing of water vapor. In structure, the typical thunderstorm is a collection of convective cells each averaging a mile or more in diameter. A cell is comprised of columns of rapidly rising air separated and counterbalanced by downdrafts of slower moving air. Associated with thunderstorms and their bulbous facade are heavy downpours of rain, hail, gusty and squally winds, and of course, lightning and thunder.

Because the thunderstorm development and frequency is enhanced by (1) atmospheric instability that is linked to high surface temperatures, (2) atmospheric moisture that supplies the latent energy requirements, and (3) some triggering device to start the convection process, thunderstorms occur more frequently in regions of warm temperatures and high humidities. North Carolina's climate is conducive to thunderstorm development and the state experiences violent local storms forty to fifty days each year. For the United States, Florida and the Gulf Coast lead in the number of days with thunderstorms. Here, seventy to ninety days per year with thunderstorms is normal. In the northern states and along the West Coast, thunderstorm activity drops off because of colder temperatures over land and coastal waters. North Carolina's pattern of thunderstorm activity shows fewest storms off the northeast coast where coastal waters also are cooler. Inland, thunderstorms are more frequent, increasing to fifty days as the Mountains are approached. In the Mountains, the higher frequency of storm activity (all types) and the triggering supplied by mountain and frontal slopes results in the most thunderous area to be found in the state (Figure 5.22).

Hurricanes In the latter half of the year, the United States is visited by hurricanes. Originating over tropical oceans as small cyclones, under favorable conditions hurricanes become large, intense storm systems. Their winds exceed seventy-five miles per hour and spiral counterclockwise around an "eye" of very low pressure. Sustained by the ocean that breeds them, these storms are driven by the heat released from condensing water vapor. Covering tens of thousands of square miles, hurricanes move slowly and deliberately, at speeds between fifteen and fifty miles per hour, delivering prodigious amounts of precipitation to areas over which they pass. Moving out of the tropics, hurricanes of the Atlantic Ocean generally invade the Gulf of Mexico, or veer northward toward the middle latitudes, occasionally penetrating the continent, or skirting the coastline as far north as New England. Hurricanes are sea monsters and diminish in intensity as they move inland and away from their source of energy. Although capable of great destruction, hurricanes nevertheless benefit the southeastern states to a substantial degree. As the eastern states are subject to periodic summer droughts, the vast amounts of water delivered to this region by these giant tropical storms have served more than once to alleviate or terminate the disastrous effects of drought conditions. However, hurricanes are killer storms, and their long-range benefits are obscured by the more obvious death, destruction, and damage accompanying them. On the average, the Atlantic Ocean generates six hurricanes a

Figure 5.22. Average Number of Days with Thunderstorms

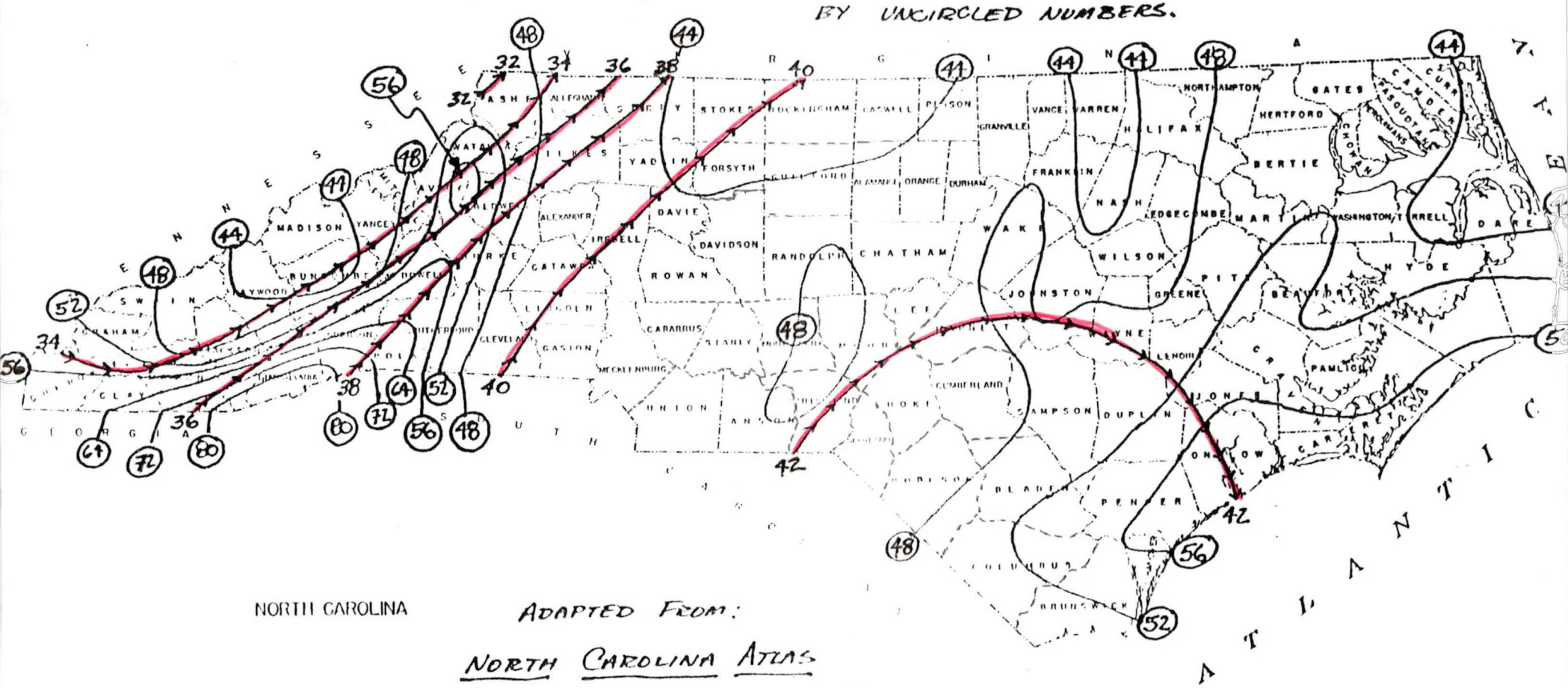


Source: Glenn T. Trewartha, Arthur H. Robinson, and Edwin H. Hammond, eds., *Elements of Geography*, 5th ed. (New York: McGraw-Hill Book Co., 1967).

year, but as many as eleven in one year have been observed. North Carolina has experienced twelve especially disastrous hurricanes since 1900. Cape Hatteras, extending as it does into the ocean, is affected by hurricanes more than any other area of North Carolina (Figure 5.23). Its low-lying sandy surface is especially vulnerable to the combined effects of high winds, high tides, and flooding associated with these storms.

MEAN ANNUAL PRECIPITATION AND MEAN ANNUAL EVAPORATION

NOTE: PRECIPITATION ISOGRAMS ARE SOLID LINES (——) WITH INCHES OF RAINFALL GIVEN BY CIRCLED NUMBERS. EVAPORATION ISOGRAMS ARE NOTCHED LINES (→→→) WITH INCHES OF EVAPORATION GIVEN BY UNCIRCLED NUMBERS.



NORTH CAROLINA

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North Carolina State Government

Statistical Abstract

North Carolina State Data Center

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Table 16

Ref 9

POPULATION DENSITY AND LAND AREA BY COUNTY
1960, 1970 AND 1980

County	Density[a] 1960	Density[a] 1970	Density[a] 1980	1980 Land Area (Sq. Mi.)
State Total	93	104	120	48,843
Alamance	197	226	229	433
Alexander	61	75	97	259
Alleghany	34	36	41	234
Anson	47	44	48	533
Ashe	46	46	52	426
Avery	49	52	58	247
Beaufort	43	44	49	826
Bertie	35	29	30	701
Bladen	33	30	35	879
Brunswick	23	28	42	861
Buncombe	202	221	244	659
Burke	104	118	144	505
Cabarrus	189	206	236	364
Caldwell	104	121	144	471
Camden	23	23	24	241
Carteret	52	59	78	525
Caswell	46	45	49	427
Catawba	180	231	266	396
Chatham	38	42	47	708
Cherokee	36	36	42	452
Chowan	65	62	69	181
Clay	26	25	31	214
Cleveland	142	155	178	468
Columbus	52	50	54	939
Craven	81	89	101	702
Cumberland	225	324	376	657
Currituck	24	28	43	256
Dare	15	18	34	391
Davidson	146	174	207	548
Davie	63	71	92	267
Duplin	49	47	50	819
Durham	375	450	513	298
Edgecombe	106	103	111	506
Forsyth	447	513	592	412
Franklin	58	55	61	494
Gaston	355	417	455	357
Gates	27	25	26	338
Graham	22	22	25	289
Granville	61	61	64	534
Greene	62	56	61	266
Guilford	379	441	487	651
Halifax	82	73	76	724
Harnett	80	82	99	601
Haywood	73	76	84	555
Henderson	95	113	156	375
Hertford	64	69	66	356
Hoke	50	42	52	391
Hyde	9	9	9	624
Iredell	106	126	144	574
Jackson	36	44	53	490
Johnston	79	77	89	795
Jones	24	21	21	470
Lee	104	119	142	259
Lenoir	141	138	149	402
Lincoln	94	110	142	298
McDowell	61	70	80	437
Macon	29	31	39	517
Madison	38	36	37	451
Martin	56	54	56	461
Mecklenburg	502	669	766	528
Mitchell	63	63	65	222
Montgomery	38	39	46	490
Moore	48	55	72	701
Nash	111	109	124	540
New Hanover	370	449	559	185
Northampton	50	43	42	538
Onslow	114	135	148	763
Orange	108	144	193	400
Pamlico	29	28	31	341
Pasquotank	112	118	125	228
Pender	22	21	25	875
Perquimans	35	34	39	246
Person	66	65	73	398
Pitt	107	113	137	656
Polk	49	49	55	238
Randolph	77	96	116	789
Richmond	82	84	95	477
Robeson	94	89	107	949
Rockingham	122	127	147	569
Rowan	160	172	191	519
Rutherford	80	84	95	568
Sampson	50	48	53	947
Scotland	79	84	101	319
Stanly	102	108	123	396
Stokes	49	52	73	452
Surry	90	96	110	539
Swain	16	17	20	526
Transylvania	43	52	62	378
Tyrrell	11	10	10	407
Union	70	86	110	639
Vance	129	131	148	249
Wake	196	267	353	854
Warren	44	37	38	427
Washington	40	41	45	332
Watauga	55	74	101	314
Wayne	148	153	175	554
Wilkes	59	65	78	752
Wilson	155	153	169	374
Yadkin	68	73	85	336
Yancey	45	40	48	314

(a) Population per square mile of land area. Land area calculations for 1960 and 1970 differ slightly from those for 1980.

SOURCE: U.S. Department of Commerce, Bureau of the Census.
Office of State Budget and Management, Research and Planning Services.

Table 18

POPULATION DENSITY[a] OF PLACES WITH 2,500 OR MORE INHABITANTS
YEARS 1960, 1970 AND 1980

Place	1960	1970	1980
Ahoskie	3,274	2,687	1,880
Albemarle	2,151	1,918	1,035
Apex	1,052	NA	1,139
Archdale	1,382	1,130	942
Asheboro	2,197	2,076	1,387
Asheville	2,774	2,587	1,867
Ayden	2,072	2,029	1,817
Beaufort	5,844	3,062	1,594
Belmont	2,635	2,292	1,772
Benson	2,355	NA	2,148
Bessemer City	1,217	1,581	1,496
Black Mountain	1,313	1,001	972
Bonnie Doone (CDP)	953	NA	1,700
Boone	2,304	2,245	2,682
Brevard	2,857	2,497	2,047
Brogden (CDP)	NA	NA	1,358
Burlington	2,677	2,364	2,231
Butner (CDP)	NA	1,220	1,514
Camp Lejeune Central (CDP)	NA	2,107	1,636
Canton	973	2,715	2,437
Carrboro	2,853	1,265[b]	2,934
Cary	1,243	1,161	2,176
Chapel Hill	3,592	3,274	2,594
Charlotte	3,199	3,173	2,251
Cherryville	2,576	1,813	1,794
Clayton	1,660	1,939	1,023
Clemmons (CDP)	NA	NA	705
Clinton	2,487	2,105	1,678
Concord	3,632	2,676	2,017
Conover	2,851	2,237	1,249
Dallas	1,721	2,136	2,386
Davidson	2,573	1,466	1,350
Dunn	3,153	2,025	1,867
Durham	3,676	2,608	2,484
East Flat Rock (CDP)	822	938	990
East Rockingham (CDP)	2,676	2,382	1,442
Eden	NA	1,356	1,339
Edenton	2,026	1,362	1,488
Elizabeth City	3,430	2,814	2,980
Elizabethtown	2,321	NA	986
Elkin	896	906	752
Elon College	2,140	NA	2,394
Elroy (CDP)	NA	NA	590
Enfield	2,482	2,727	2,496
Enka (CDP)	NA	NA	843
Enochville (CDP)	NA	NA	696
Erwin	2,449	2,194	1,768
Fairmont	1,203	1,767	1,477
Fairplains (CDP)	NA	NA	634
Farmville	3,075	2,458	2,241
Fayetteville	3,205	2,287	1,803
Forest City	1,681	825	1,220
Fort Bragg (CDP)	NA	2,701	2,213
Franklin	701	NA	852
Fuquay-Varina	1,093	1,192	972
Garner	1,726	2,140	2,143
Gastonia	3,584	2,369	2,181
Gibsonville	1,784	NA	1,791
Glen Raven (CDP)	1,051	1,499	672
Goldsboro	4,067	2,979	2,213
Gorman (CDP)	NA	NA	256
Graham	2,340	2,335	1,807
Granite Falls	1,469	NA	992
Lumberton	2,834	3,141	1,614
Madison	2,731	NA	510
Malden	NA	NA	1,287
Marion	2,573	2,382	2,047
Mar-Mac (CDP)	NA	NA	732
Masonboro (CDP)	NA	NA	616
Maxton	1,950	NA	1,595
Mayodan	3,380	2,875	1,751
Mebane	1,689	NA	1,855
Mint Hill	NA	NA	574
Mocksville	743	790	733
Monroe	1,727	1,736	1,620
Mooresville	2,096	1,957	1,824
Morehead City	3,722	3,489	2,180
Morganton	2,355	1,841	1,012
Mount Airy	2,822	1,592	1,430
Mount Holly	2,125	1,459	1,562
Mount Olive	3,115	2,730	2,438
Murfreesboro	1,888	2,339	1,769
Myrtle Grove (CDP)	NA	NA	381
Nashville	2,372	NA	1,275
New Bern (CDP)	6,287	3,858	2,510
New Hope (CDP) (Wake County)	NA	NA	602
New Hope (CDP) (Wayne County)	NA	NA	942
New River Station (CDP)	NA	1,192	711
Newton	2,018	2,910	1,588
North Belmont (CDP)	1,028	1,098	1,170
North Wilkesboro	976	746	724
Ogden (CDP)	NA	NA	574
Oxford	2,251	1,795	2,001
Parkwood (CDP)	NA	NA	1,710
Pembroke	1,524	NA	3,373
Pinehurst (CDP)	934	NA	135
Pine Valley (CDP)	NA	NA	929
Piney Green-White Oak (CDP)	NA	NA	556
Plymouth	1,728	1,540	1,203
Poplar Tent (CDP)	NA	NA	461
Pumpkin Center (CDP)	NA	NA	852
Raeford	1,176	1,178	1,344
Raleigh	2,787	2,708	2,793
Red Springs	2,516	1,990	1,202
Reidsville	1,877	1,794	1,666
Roanoke Rapids	2,562	2,289	2,014
Rockingham	1,969	1,773	1,627
Rocky Mount	3,457	2,765	2,281
Rosewood (CDP)	NA	NA	564
Roxboro	2,145	2,238	2,036
Rutherfordton	1,305	1,248	1,374
St. Stephens (CDP)	NA	NA	900
Salem (CDP) (Burke County)	NA	NA	601
Salisbury	3,435	2,649	1,718
Sanford	2,785	2,663	1,252
Scotland Neck	2,704	2,391	1,889
Seagate (CDP)	NA	NA	815
Selma	2,585	2,904	2,381
Shelby	2,493	2,206	1,988
Siler City	1,142	1,172	1,112
Silver Lake (CDP)	NA	NA	541
Smithfield	2,781	2,087	1,157
Southern Pines	1,181	1,142	1,119
South Gastonia (CDP)	1,344	NA	1,362
South Goldsboro (CDP)	NA	NA	791
Southport	1,071	NA	1,569

Pg 9

Ref 9

Table 178

EMISSIONS INVENTORY SUMMARY (IN TONS)
FROM POINT AND AREA SOURCES, BY COUNTY
1979

County	Particulates		Sulfur Dioxide		Nitrogen Oxides		Volatile Organic Compounds and Hydrocarbons		Carbon Monoxide	
	Area Sources	Point Sources	Area Sources	Point Sources	Area Sources	Point Sources	Area Sources	Point Sources	Area Sources	Point Sources
State Total	553,662	222,263	43,247	731,157	334,896	290,035	560,734	114,695	2,416,683	130,670
Alamance	7,718	868	818	1,428	5,890	266	11,748	3	45,688	21
Alexander	2,150	633	173	128	1,150	32	1,634	535	6,880	2
Alleghany	2,168	-	63	-	611	-	924	-	3,931	-
Anson	2,537	201	183	2	1,618	16	2,700	92	10,909	4
Ashe	5,022	422	127	9	1,127	74	1,713	231	7,535	12
Avery	1,785	78	89	83	799	50	797	8	4,116	7
Beaufort	5,334	1,079	307	21,236	2,731	1,145	4,277	23	19,654	51
Bertie	2,927	1,688	144	316	1,598	312	2,107	63	11,434	101
Bladen	3,565	135	191	551	1,935	99	2,731	184	12,777	8
Brunswick	3,293	913	284	16,616	2,818	3,418	3,285	29,359	16,967	10,845
Buncombe	15,826	4,523	1,036	101,654	8,073	34,108	17,219	536	66,409	2,245
Burke	5,906	568	485	1,528	4,066	671	6,335	1,486	27,446	109
Cabarrus	6,136	765	581	2,638	4,775	1,126	8,704	998	45,995	94
Caldwell	6,070	3,850	581	383	3,408	435	4,897	5,680	19,740	69
Camden	707	3	47	-	517	-	825	-	4,021	-
Carteret	1,949	8	270	81	2,269	16	5,080	-	20,446	2
Caswell	2,438	899	124	-	1,160	-	1,516	-	8,438	-
Catawba	7,537	19,814	1,345	75,338	7,829	33,880	13,934	3,016	40,662	1,932
Chatham	4,994	9,679	349	12,208	2,464	5,352	3,999	756	15,675	889
Cherokee	3,332	50	104	1	1,050	6	1,750	1	7,010	1
Chowan	747	54	93	326	795	54	1,405	227	6,347	4
Clay	2,096	-	71	-	1,200	-	2,076	-	17,224	-
Cleveland	6,160	365	945	406	4,030	929	6,461	-	15,717	46
Columbus	5,840	1,406	351	7,735	3,216	2,082	4,170	412	20,162	12,427
Craven	6,501	3,358	399	6,706	3,677	2,614	6,682	1,043	32,514	7,085
Cumberland	17,810	586	1,120	2,927	9,493	681	17,624	834	90,631	74
Currituck	1,100	159	700	-	1,200	2	1,400	-	4,900	-
Dare	605	5	104	240	932	71	3,926	2	14,035	12
Davidson	10,207	355	756	998	6,301	629	10,328	2,470	44,355	144
Davie	2,233	428	149	66	1,259	31	5,206	181	8,938	5
Duplin	4,789	105	273	763	2,949	154	3,668	41	18,942	13
Durham	10,624	836	778	880	6,398	194	12,903	703	58,610	15
Edgecombe	3,302	3,041	491	407	4,010	81	4,720	1,367	21,017	17
Forsyth	17,838	528	2,173	5,837	16,754	2,152	24,192	21,488	95,712	186
Franklin	2,850	-	181	-	1,771	-	5,165	83	13,286	-
Gaston	10,171	7,566	1,145	62,730	8,842	29,610	15,598	687	61,159	1,789
Gates	1,298	-	69	-	729	-	740	-	4,277	-
Graham	842	44	35	60	364	19	479	3	2,231	4
Granville	5,457	78	206	720	2,277	1,028	4,013	515	19,515	188
Greene	1,329	11	87	-	998	-	1,330	-	7,063	-
Guilford	33,493	2,702	2,769	3,330	20,142	989	31,063	14,057	139,198	495
Halifax	5,044	1,306	315	9,556	2,903	2,485	5,316	329	25,552	10,410
Harnett	5,575	143	306	765	3,268	169	4,489	5	24,530	14
Haywood	4,414	682	285	9,768	2,528	4,703	5,531	49	17,166	43,964
Henderson	6,842	308	370	2	3,040	28	5,703	3	21,248	7
Hertford	2,085	885	152	276	1,410	2,615	2,278	54	11,197	111
Hoke	897	31	122	193	979	54	1,834	-	6,977	3
Hyde	828	148	95	-	814	-	3,074	-	11,064	-
Iredell	10,157	2,169	729	916	4,958	665	9,541	1,025	37,946	114
Jackson	4,694	99	153	5	2,007	30	3,203	6	18,948	6
Johnston	7,755	1,671	429	139	4,069	31	5,726	716	24,989	3
Jones	995	-	70	-	862	-	962	-	5,573	-
Lee	1,936	81	329	75	2,459	25	4,465	274	15,602	314
Lenoir	32,597	451	368	2,979	2,828	1,094	4,523	15	22,470	282
Lincoln	2,892	116	275	714	2,126	173	3,292	167	11,732	13
McDowell	2,645	185	179	1,042	1,690	392	2,698	230	12,728	44
Macon	3,282	16	263	-	2,016	-	3,091	-	16,300	-
Madison	3,444	1	160	14	1,165	7	1,442	2	7,027	2
Martin	3,523	3,738	93	18,647	863	7,719	1,039	1,093	5,528	12,789
Mecklenburg	20,607	3,335	3,503	3,631	24,745	813	36,601	5,707	156,662	1,758
Mitchell	1,591	124	106	52	780	13	745	520	4,161	1
Montgomery	1,949	365	190	36	1,465	31	3,339	13	9,172	23
Moore	4,418	97	265	71	2,464	46	4,295	60	18,219	9
Nash	5,322	559	594	1,203	4,373	323	8,567	309	35,371	30
New Hanover	4,042	4,675	1,080	36,483	5,411	13,157	10,379	8,344	40,872	855
Northampton	2,193	232	144	627	1,607	280	1,999	150	10,632	43
Onslow	6,007	39	485	48	4,326	10	7,447	-	35,360	-
Orange	6,169	90	336	1,194	2,929	615	4,846	57	28,470	31
Pamlico	995	-	91	-	773	-	1,635	-	6,356	-
Pasquotank	1,508	432	166	140	1,238	211	2,436	38	11,882	40
Pender	2,248	-	130	-	1,628	-	2,232	-	12,402	-
Perquimans	1,004	21	76	-	755	-	1,065	-	5,249	-
Person	4,221	15,859	195	73,710	1,533	34,504	2,968	593	11,446	1,923
Pitt	8,053	390	423	1,580	3,970	312	6,656	30	37,356	26
Polk	1,917	37	82	34	703	56	970	-	4,441	1
Randolph	11,786	83	627	64	3,543	31	9,203	377	27,791	-
Richmond	2,983	21	485	38	2,663	8	4,786	-	17,374	80
Robeson	9,120	452	621	6,434	5,365	2,634	8,985	631	41,534	154
Rockingham	10,052	34,193	586	7,270	4,726	3,390	8,993	251	36,548	199
Rowan	7,590	3,548	698	10,791	5,126	4,909	9,062	139	39,959	272
Rutherford	6,778	2,994	331	37,872	2,930	14,013	4,912	382	21,356	787
Sampson	5,988	101	345	705	3,321	136	4,839	95	23,036	11
Scotland	1,780	272	171	585	1,663	191	3,385	2,458	12,465	22
Stanly	3,915	1,288	321	2,307	2,745	385	3,764	130	17,428	11,436
Stokes	4,908	38,172	186	146,468	1,627	63,072	2,138	1,052	10,278	3,504
Surry	8,047	1,285	521	1,413	3,908	445	6,333	154	23,729	66
Swain	988	182	53	-	532	-	838	-	3,290	-
Transylvania	2,181	31	116	807	935	201	1,968	3	6,691	12
Tyrrell	674	3	70	-	627	-	1,139	-	4,752	-
Union	6,003	896	534	182	4,126	72	6,294	784	23,997	7
Vance	2,452	267	280	66	2,193	33	3,913	50	16,660	1
Wake	25,540	214	1,839	265	16,875	119	26,854	891	144,690	699
Warren	2,761	-	108	-	1,183	-	1,584	-	8,294	-
Washington	1,494	930	622	26	1,387	173	2,501	36	7,466	35
Watauga	4,143	47	176	585	1,509	140	2,268	33	11,054	9
Wayne	6,682	29,890	564	21,769	5,475	6,828	9,922	144	37,706	1,619
Wilkes	9,765	1,081	415	1,074	3,589	327	3,732	189	17,403	41
Wilson	4,374	202	539	86	4,449	18	8,416	16	30,285	1
Yadkin	3,292	10	189	18	1,718	4	2,171	-	11,255	1
Yancey	1,831	13	95	102	771	19	1,023	-	5,368	2

SOURCE: North Carolina Department of Natural Resources and Community Development, Division of Environmental Management.

Ref 10

31 December 1986

TO: File

FROM: Stan Atwood

RE: Community water systems within three miles of Toddville Operations Center.

A computer search by Leon Pryor, Water Supply Branch, listed six community well systems within an approximate four mile grid of the Toddville site as follows:

Name	Population Served
Burke MHP	228
Lakeside MHP	250
McClure Circle	70
Norman MHP	68
Trexler Park	200
Providence West	196

Follow up calls and file searches found that three of the above systems (Lakeside MHP, Norman MHP, and Providence West) were not located within a three mile radius of the site.

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IARC MONOGRAPHS
ON THE
EVALUATION OF THE CARCINOGENIC RISK OF CHEMICALS TO HUMANS

Polychlorinated biphenyls
and
Polybrominated biphenyls

VOLUME 18

This publication represents the views and expert opinions
of two IARC Working Groups on the
Evaluation of the Carcinogenic Risk of Chemicals to Humans
which met in Lyon,
10-15 October 1977
and
6-13 June 1978

October 1978

INTERNATIONAL AGENCY FOR RESEARCH ON CANCER

Ref 11

2,2',3,4,4',5,5'-Heptachlorobiphenyl

Chem. Abstr. Services Reg. No.: 35065-29-3
Chem. Abstr. Name: 2,2',3,4,4',5,5'-Heptachloro-1,1'-biphenyl

Synonyms

Chlorinated biphenyl; chlorinated diphenyl; chlorobiphenyl; PCB; PCBs; polychlorinated biphenyl; polychlorobiphenyl

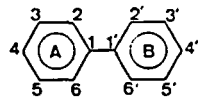
Trade names (The producing country is given in parentheses)

Aroclor (USA); Chlorextol (USA); Clophen (FRG); Dykanol (USA); Fenclor (Italy); Inerteen (USA); Kanechlor (Japan); Noflamol (USA); Phenoclor (France); Pyralene[1] (France); Pyranol (USA); Santotherm (Japan); Sovol (USSR); Therminol[1] (USA)

The approximate molecular compositions of some commercial PCB mixtures are listed in Table 1.

1.2 Structural and molecular formulae and molecular weight

The structural formula of the unsubstituted biphenyl with the numbering of the carbon atoms in the ring is given below.



Chlorobiphenyl	$C_{12}H_9Cl$	Mol. wt:	188.7
Dichlorobiphenyl	$C_{12}H_8Cl_2$	"	223.1
Trichlorobiphenyl	$C_{12}H_7Cl_3$	"	257.6
Tetrachlorobiphenyl	$C_{12}H_6Cl_4$	"	292.0
Pentachlorobiphenyl	$C_{12}H_5Cl_5$	"	326.4
Hexachlorobiphenyl	$C_{12}H_4Cl_6$	"	360.9
Heptachlorobiphenyl	$C_{12}H_3Cl_7$	"	395.3
Octachlorobiphenyl	$C_{12}H_2Cl_8$	"	329.7
Nonachlorobiphenyl	$C_{12}HCl_9$	"	364.1
Decachlorobiphenyl	$C_{12}Cl_{10}$	"	398.5

In all, there are 209 possible PCB isomers (Fig. 1).

---

[1]These products, as now formulated, no longer contain PCBs.

Table 1

Approximate weight percentages of chlorobiphenyls in some commercial PCB mixtures[a]

Number of chlorines	Aroclors[b]													Kanechlors			Fenclors Fenclor (Denmark)
	1221[c]		1232	1016	1242[c]			1248	1254[c]			1260[d]	KC-300	KC-400	KC-500	
0	11	7	6	Tr	Tr	-	-	-	Tr	-	-	-	-	-	-	-
1	51	51	26	1	1	1	Tr	-	Tr	-	-	-	-	-	-	-
2	32	38	29	20	16	17	4	1	0.5	-	-	-	17	3	-	-
3	4	3	24	57	49	40	39	23	1	-	0.5	-	60	33	5	-
4	2	-	15	21	25	32	42	50	21	16	36	-	23	44	27	-
5	0.5	-	0.5	1	8	10	14	20	48	60	45	12	0.6	16	55	-
6	-	-	-	Tr	1	0.5	-	1	23	23	18	46	-	5	13	-
7	-	-	-	-	Tr	-	-	-	6	1	1	35	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100

[a] From Nisbet (1976a)

[b] The Aroclor number designations consist of two parts: the first two digits, 12, indicate that the molecule is a biphenyl (earlier products, no longer available, were represented by 54 for terphenyls and 25 and 44 for blends of biphenyls and terphenyls). The second two digits, 32, 42, 54, etc., represent the approximate weight per cent of chlorine in the product. The only exception to this is Aroclor 1016, which is a biphenyl containing 41% chlorine by weight.

[c] Information derived from several sources

[d] Phenoclor DP6 (from France) and Clophen A60 (from the Federal Republic of Germany) are almost identical in composition to Aroclor 1260.

Tr = trace

Ref 11

Ref 11

Figure 1[a]

Numbers of combinations, according to possible distributions of chlorine atoms in the two rings of the biphenyl

		No. of chlorine atoms on ring A					
		0	1	2	3	4	5
No. of chlorine atoms on ring B	0	1	3	6	6	3	1
	1		6	18	18	9	3
	2			21	36	18	6
	3				21	18	6
	4					6	3
	5						1

[a]From Hutzinger *et al.*, 1974a

1.3 Chemical and physical properties

The outstanding physical and chemical characteristics of PCBs are their thermal stability, resistance to oxidation, acids, bases and other chemical agents, as well as their excellent dielectric (insulating) properties. Chlorobiphenyls are colourless crystals when isolated in pure form by recrystallization from suitable solvents. Commercial products are liquids because the melting point is depressed when PCB components are mixed. The solubility of PCBs in water, an important physical property from an environmental point of view, is extremely low; it ranges from 0.007-5.9 mg/l for the chlorobiphenyl isomers that occur commonly (Hutzinger *et al.*, 1974a). However, all PCBs are soluble in oils and organic solvents. Other physical properties of 38 PCBs are given in Table 2; the physical properties of some Aroclors are given in Table 3. Only those chlorobiphenyls that have been properly characterized and are present in significant concentrations in commercial PCB formulations are listed.

Ref 11

The PCBs are chemically very inert and are stable to conditions of hydrolysis and oxidation encountered in industrial use. Photochemical degradation may be one route of their breakdown in the environment: photochemical experiments conducted under simulated natural conditions on a number of pure chlorobiphenyls and on commercial PCB preparations have indicated several degradative reactions, such as dechlorination, polymerization and solvolysis (Hutzinger *et al.*, 1972a).

Heating of Aroclor 1248 at 300°C in an atmosphere of oxygen has been found to yield about 1000 ppm polychlorodibenzofurans (PCDFs). Major components were dichloro- and trichlorodibenzofurans (Morita *et al.*, 1978).

For data on the persistence of these compounds in the environment, see section 2.2.

1.4 Technical products and impurities

Contamination of PCB mixtures with polychlorinated dibenzofurans (PCDFs) and polychlorinated naphthalenes:

Two reviews on PCDFs have been published recently (Buser, 1978; IARC, 1978a).

Vos *et al.* (1970) were able to identify tetrachlorodibenzofurans, pentachlorodibenzofurans as well as chlorinated naphthalenes in samples of Phenoclor DP-6 and Clophen A-60 (both 60% chlorine), but not in a sample of Aroclor 1260. Bowes *et al.* (1975) examined samples of Aroclor 1248, 1254 and 1260 produced in 1969, samples of Aroclor 1254 from 1970 and Aroclor 1016 from 1972 and the samples of Aroclor 1260, Phenoclor DP-6 and Clophen A-60 that had previously been analysed by Vos *et al.* (1970); they found PCDFs in all Aroclor preparations except Aroclor 1016 and in Clophen A-60 and Phenoclor DP-6 (Table 4).

Nagayama *et al.* (1976) found detectable levels (1-17 µg/g) of PCDFs in samples of Kanechlor (see Table 5); Roach & Pomerantz (1974) found varying concentrations of PCDFs in Kanechlor 400.

Nagayama *et al.* (1976) found about 5 µg/g PCDFs in 3 samples of 'Yusho oil' that were contaminated with Kanechlor 400; the major constituents were tetra- and pentachlorodibenzofurans. Rappe *et al.* (1977) recently confirmed by capillary gas chromatography-mass fragmentography that 2,3,7,8-tetrachlorodibenzofuran was one of the main PCDFs in 'Yusho oil'.

PC
Aroclor 12
Aroclor 12
Aroclor 12
Aroclor 12
Aroclor 12
Aroclor 10
Clophen A-
Phenoclor

ND = not d
[a]Expressed
[b] percent
[b]From Bowe

C
Kanechlor
300
400
500
600

[a]From Naga
[b]Calculate
[c]Calculate

Ref 11

Table 4

Concentrations of chlorinated dibenzofurans[a] in Aroclor, Clophen and Phenoclor[b]

PCB	4-Cl	5-Cl	6-Cl	Total
Aroclor 1248 (1969)	0.5(25)	1.2(60)	0.3(15)	2.0
Aroclor 1254 (1969)	0.1(6)	0.2(12)	1.4(82)	1.7
Aroclor 1254 (1970)	0.2(13)	0.4(27)	0.9(60)	1.5
Aroclor 1260 (1969)	0.1(10)	0.4(40)	0.5(50)	1.0
Aroclor 1260 (lot AK3)	0.2(25)	0.3(38)	0.3(38)	0.8
Aroclor 1016 (1972)	ND	ND	ND	-
Clophen A-60	1.4(17)	5.0(59)	2.2(26)	8.4
Phenoclor DP-6	0.7(5)	10.0(74)	2.9(21)	13.6

ND = not detected (<0.001 μg/g)
[a]Expressed as μg/g PCB. Values in parentheses represent quantity as percentage of total dibenzofurans.
[b]From Bowes *et al.* (1975)

Table 5

Concentrations of chlorinated dibenzofurans in Kanechlors[a]

Kanechlor	Chlorodibenzofurans						Concentration (μg/g)	
	Di-	Tri-	Tetra-	Penta-	Hexa-	Hepta-	*b*	*c*
300			+	+			1	1.5
400	+	+	+	+			18	17
500		+		+	+	+	4	2.5
600			+	+	+	+	5	3

[a]From Nagayama *et al.* (1976)
[b]Calculated from peak heights
[c]Calculated by perchlorination method

Ref 11

as adenofibrosis were observed in all 22 mice fed Aroclor 1254 continuously for 11 months. No hepatomas were seen in controls (Kimbrough & Linder, 1974).

Rat: Groups of 10 male and 10 female 3-4-week-old Sherman rats were fed 0, 20, 100, 500 or 1000 mg Aroclor 1260/kg diet or 0, 20, 100 or 500 mg Aroclor 1254/kg of diet for 8 months. Several animals given the two highest dose levels died before 6 months. In animals fed Aroclor 1260, lesions described as adenofibrosis of the liver occurred in 2 males fed 1000 mg/kg and in 1, 1 and 4 females fed 100, 500 and 1000 mg/kg, respectively. A higher incidence of this lesion occurred in rats fed Aroclor 1254, i.e., in 10 males and 9 females fed 500 mg/kg and in 1 male and 7 females fed 100 mg/kg (Kimbrough *et al.*, 1972).

A group of 10 male and 10 female 10-week-old Donryu rats were fed 38.5-616 mg Kanechlor 400/kg of diet for 400 days; a control group of 5 males and 5 females received a basal diet. Multiple adenomatous nodules of the liver were observed in 6/10 treated females; these lesions did not occur in male rats nor in the controls (Kimura & Baba, 1973).

Groups of 30 8-week-old male Wistar rats were fed Kanechlor 300, 400 or 500 at levels of 0, 100, 500 or 1000 mg/kg of diet. The Kanechlors produced cholangiofibrosis in 2/15, 2/10 and 4/13 rats, respectively, when fed at the 1000 mg/kg level, while lower doses were ineffective. Hepatic nodular hyperplasia occurred with all 3 compounds, the incidence increasing with degree of chlorination and with concentration in the diet: 100 mg/kg Kanechlor 300 produced hyperplasia in 1/22 animals; 100 mg/kg Kanechlor 400 in 2/16, and 1000 mg/kg Kanechlor 400 in 3/10; and with Kanechlor 500, 100 mg/kg produced hyperplasia in 3/25, 500 mg/kg in 5/16 and 1000 mg/kg in 5/13 animals (Ito *et al.*, 1974).

A group of 200 3-4-week-old female Sherman rats were fed a diet containing 100 mg Aroclor 1260/kg of diet for 21-22 months; 200 female rats served as controls. The authors calculated that the PCB intake declined from 11.6 mg/kg bw/day during the first week of exposure to 6.1 mg/kg bw/day at 3 months of exposure and to 4.3 mg/kg bw/day at 20 months. Twenty-six of 184 exposed rats had hepatocellular carcinomas, and 144/184 had liver lesions described as neoplastic nodules. One hepatocellular carcinoma and no neoplastic nodules were observed among 173 control rats. The incidence of extrahepatic tumours did not differ between the treated and control rats (Kimbrough *et al.*, 1975).

3.2 Other relevant biological data

(a) Experimental systems

(i) Toxic effects

LD_{50}'s for the various Aroclors are summarized in Table 8. More detailed reports on the acute toxic effects of PCBs are given by Allen &

Ref 11

Table 8

LD_{50} (mg/kg bw) of Aroclor mixtures

Species (route)	1221	1232	1242	1248	1254	1260	1262
Mouse (oral)[a]					2000		
Rat (oral)[b]	4000[c]	4500[c]	8700[c]	11,000[c]	-	10,000[d]	11,300[d]
Adult rat (oral)[e]					4000-10,000	4000-10,000	
Weanling rat (oral)[f]					1300	1300	
Adult rat (i.v.)[f]					350		
30-Day-old rat (oral)[g]					1300-1400		
120-Day-old rat (oral)[g]					2000-2500		
Rabbit (skin)[b] (MLD)	2000-3200[c]	1300-2000[c]	800-1300[c]	800-1300[c]		1300-2000[d]	1300-3200[d]

[a] From Tanaka *et al.* (1969)
[b] From Panel on Hazardous Trace Substances (1972)
[c] Administration of undiluted compound
[d] Administration of 50% solution in corn oil
[e] From Kimbrough (1974)
[f] From Linder *et al.* (1974)
[g] From Grant & Phillips (1974)

Ref 11

Table 9

Responses of primates and rats to PCBs

Response	Man[a]	Monkey[b]	Rat[c]
Susceptibility to toxicity	High	High	Moderate
Acne	Yes	Yes	No
Hyperpigmentation of skin	Yes	Only infants	No
Alopecia	NA	Yes	No
Hyperactive Meibomian glands	Yes	Yes	No
Conjunctivitis	Yes	Yes	No
Oedema of eyelids	Yes	Yes	No
Subcutaneous oedema	Yes	Yes	No
Keratin cysts in hair follicles	Yes	Yes	No
Hyperplasia of hair follicle epithelium	Yes	Yes	No
Gastric hyperplasia	NA	Yes	No
Thymic atrophy	NA	NA	Yes
Hepatic hypertrophy	Yes	Yes	Yes
Liver enzyme change	NA	Yes	Yes
Decreased no. of red-blood cells	Yes	Yes	No
Decreased haemoglobin	Yes	Yes	No
Serum hyperlipidaemia	Yes	Hypolipidaemia	Yes
Leucocytosis	Yes	Yes	No

NA = not available
[a]From Kuratsune (1972)
[b]From Allen (1975); Allen & Norback (1976); Allen *et al.* (1974a)
[c]From Allen & Abrahamson (1973); Allen *et al.* (1976)

Ref 11

3'-methyl-4-dimethylaminoazobenze, *N*-2-fluorenylacetamide and *N*-nitrosodiethylamine when given orally with these compounds to rats (Makiura *et al.*, 1974). Kanechlor 400 and 500 enhanced the hepatocarcinogenicity of α-BHC in mice (Nagasaki *et al.*, 1975).

(viii) Mutagenicity

Two PCB mixtures (Aroclor 1221 and Aroclor 1268), 2,2',5,5'-tetrachlorobiphenyl and 4-chlorobiphenyl were tested in *Salmonella typhimurium* TA1538 in the presence of a microsomal activation system from rabbit liver. Only 4-chlorobiphenyl and Aroclor 1221 were significantly mutagenic (Wyndham *et al.*, 1976).

Aroclor 1242 when given as a single oral dose of 1250, 2500 or 5000 mg/kg bw or as 4 daily doses of 500 mg/kg bw/day did not produce significant chromosomal abnormalities in rat bone marrow or spermatogonia. Similarly, 5 oral doses of 75, 150 or 300 mg/kg bw/day Aroclor 1254 did not produce significant chromosomal abnormalities in rat bone marrow (Green *et al.*, 1973, 1975a).

Single oral doses of 625, 1250 or 2500 mg/kg bw or 5 daily doses of 125 or 250 mg/kg bw Aroclor 1242 did not increase the number of dead implantations in rats. Aroclor 1254, when given to rats by oral intubation in 5 daily doses of 75, 150 or 300 mg/kg bw or when fed at a dietary level of 25 or 100 mg/kg of diet for 70 days, did not cause an increase in dominant lethal mutations (Green *et al.*, 1975b).

Hoopingarner *et al.* (1972) observed no chromosomal aberrations in human lymphocyte cultures exposed to 100 mg/kg Aroclor 1254.

Clophen 30 and Clophen 50 had no genetic effect in *Drosophila melanogaster*; tests involved determination of loss of sex chromosomes and of non-disjunction (Nilsson & Ramel, 1974).

Peakall *et al.* (1972) have reported that embryos from second generation ring doves fed 10 mg Aroclor 1254/kg of diet exhibited chromosomal aberrations.

(b) Humans

(i) Toxic effects

A comparison of the toxic effects of PCBs in humans and animals is given in Table 9.

Between March 1968 and April 1975, 1291 cases of 'Yusho' (literally, 'oil disease') were reported in the western part of Japan in persons found or presumed to have ingested rice oil contaminated with Kanechlor 400 (Higuchi, 1976; Kuratsune *et al.*, 1976). In the initial (1968) outbreak, samples of oil were found to contain 800-1000 mg/kg PCB and some up to 3000

Ref 11

mg/kg (Kuratsune, 1976), and 5 mg/kg polychlorinated dibenzofurans (PCDFs) (Kuratsune *et al.*, 1976). Thus, the PCB that contaminated the rice contained about 250 times more PCDFs than do normal PCBs. More than ten different PCDFs were found, the most abundant of which was the 2,3,7,8-tetrachlorinated compound (Rappe *et al.*, 1977); however, tissue samples from Yusho patients contained predominantly penta- and hexachloro derivatives of unknown structure (Nagayama *et al.*, 1977). The average total intake of Kanechlor 400 in a group of 146 patients who used the most highly contaminated oil was estimated to be 2.0 g (10 mg PCDF), and the minimal amount of Kanechlor 400 ingested was 0.5 g (Kuratsune, 1976).

The most common clinical features in the early phase of Yusho included ocular discharge and swelling of the upper eyelids, dermatological symptoms, mainly associated with follicular keratosis (Urabe & Koda, 1976), and various nervous and general symptoms (Kuratsune, 1976). In addition, the following were described: hypertriglyceridaemia with normal plasma cholesterol, adrenocortical and ovarian dysfunction, bronchitis (cough and phlegm), hepatomegaly, hypobilirubinaemia, low immunoglobulin levels and (possibly) disturbed calcium metabolism (Hirayama, 1976) (see Table 9). The most marked dermatological and ophthalmic manifestations gradually improved over the years following exposure (Kuratsune *et al.*, 1976).

By May 1974, 24 Yusho patients had died. Five of the dead patients were autopsied between 12 and 46 months after the first appearance of skin lesions. A stillborn baby was also autopsied 4 months after the appearance of skin lesions in the mother. Histopathological changes likely to be due to PCB ingestion included hyperkeratosis of the hair follicles and increased melanin pigment in the basal layer of the epidermis. In addition, 3 of 5 autopsied patients had proliferation of the duct epithelium of the oesophageal glands (Kikuchi & Masuda, 1976). Detectable levels of PCBs were present, particular in fatty tissue (Kuratsune, 1976).

Kuroki & Masuda (1977) found pronounced differences in the levels of various PCBs in Yusho patients and in normal persons. In the blood of Yusho patients, the PCB found most abundantly is the 2,2',3,4,4',5-hexachlorobiphenyl, and that in normal persons 2,3',4,4',5-pentachlorobiphenyl.

Nagayama *et al.* (1977) analysed the liver of a man thought to have ingested 560 mg Kanechlor 400 and 2.8 mg PCDFs. When this patient died, approximately 44 months after use of the toxic rice oil had been discontinued, it was found that 0.22% of the ingested PCDFs but only 0.011% of the ingested PCBs remained in the liver.

Industrial exposure to PCBs and/or chlorinated naphthalenes has resulted in chloracne (Drinker *et al.*, 1937; Greenburg *et al.*, 1939; Jones & Alden, 1936; Meigs *et al.*, 1954; Schwartz, 1936, 1943). Three fatal cases were reported among seven workers with jaundice who were exposed to PCBs and/or chlorinated naphthalenes; one patient also had chloracne, acute yellow liver atrophy and cirrhosis, and one other also had acute yellow liver atrophy (Drinker *et al.*, 1937).

Ref 11

The highest levels of PCBs in 73 Finnish autopsy cases studied were found in the liver or adipose tissue of three persons who had died of cancer: 1 of lung cancer, 1 of leukaemia and 1 of liver cancer (Hattula *et al.*, 1976).

(ii) Exposure *in utero* and during lactation

A study was made of the infants of 11 mothers affected by Yusho and of 2 unaffected wives of patients; 2 of the Yusho mothers had stillbirths. The average amount of oil ingested by the mothers during pregnancy ranged from 0.3-2.6 litres. Ten of the babies had greyish or dark-brown pigmentation of the skin, and 5 had similar pigmentation of the gingiva and/or nails; increased ocular discharge was present in 9; and 12 of the 13 infants were small when compared with the national average (Funatsu *et al.*, 1972; Kikuchi *et al.*, 1969; Kuratsune, 1976; Taki *et al.*, 1969). Histological examinations of one stillborn baby and of four of the small babies showed hyperkeratosis and atrophy of the epidermis and cystic dilatation of the hair follicles, particularly of the head. There was also a marked increase in melanin pigment in the basal cells of the epidermis. Detectable but low levels of PCBs (0.1-1.8 mg/kg on fat basis) were present in the mesenteric fat, skin and liver (Kikuchi & Masuda, 1976; Kikuchi *et al.*, 1969). Babies born to patients even 3 years after severe PCB exposure tended to show pigmentation of the skin on the back and the gingiva, although the degree of pigmentation was less than that of babies born to the same mothers up to one year after the poisoning (Kuratsune, 1976).

Mothers' milk contaminated with PCBs also appears to be a source of exposure for infants: one baby showed signs of Yusho even though the mother had ingested the contaminated rice oil only after the baby was delivered. The infant began to show signs after 3-4 months of breast feeding (Kuratsune, 1976; Yoshimura, 1974).

Developmental abnormalities have also been observed in PCB-intoxicated infants. Premature eruption of teeth was observed in 2 cases, and larger frontal and occipital fontanelles, exophthalmos and the maintenance of an abnormally wide sagittal suture were observed in 3 others. No other obvious malformations were found (Funatsu *et al.*, 1972).

3.3 Case reports and epidemiological studies[1]

Deaths that occurred up to 5½ years after first exposure to PCBs (September, 1973) among 1200 Yusho patients in Japan [see section 3.2 (b)] were reported by Kuratsune (1976) and Urabe (1974). Nine (41%) of 22 deaths were due to malignant neoplasms. Three of the tumours occurred in

[1]The Working Group was aware of two retrospective mortality studies in progress of a cohort of workers exposed occupationally to PCBs (tumours at all sites) (IARC, 1978c).

Ref 11

the stomach, one in the liver (with cirrhosis), two in the lungs and one in the breast, and two were malignant lymphomas. An additional liver cancer was mentioned in connection with one of the stomach cancers, but it is not clear whether this was an additional primary cancer or a metastasis from the stomach. No estimate was given from population rates of the numbers or types of tumours expected in this group. In 1975, 29 deaths were reported among 1291 Yusho patients, but causes of death were not given (Kuratsune, 1976; Omae, 1975).

In another report (Bahn *et al.*, 1976, 1977), two malignant melanomas were diagnosed in 31 workers heavily exposed to Aroclor 1254 and probably to other chemicals [It was estimated from the data of the Third National Cancer Survey (National Cancer Institute, 1975) that 0.04 malignant melanomas would have been expected in this group of individuals]. Among 41 other workers also, but less heavily exposed to Aroclor 1254, one additional melanoma was diagnosed. Among the 31 heavily exposed workers, three other individuals developed 4 cancers at other sites, including 2 in the pancreas.

4. Summary of Data Reported and Evaluation[1]

4.1 Experimental data

Five polychlorinated biphenyl mixtures have been tested in mice and/or rats only by oral administration. Kanechlor 500 and Aroclor 1254 are carcinogenic in mice, and Aroclor 1260 is carcinogenic in rats; all induced benign and malignant liver-cell tumours. In an experiment in rats of only one year's duration, Kanechlor 500, 400 and 300 induced liver lesions described as multiple hyperplastic nodules.

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[1]Subsequent to the finalization of this monograph by the Working Group in October 1977, the Secretariat became aware of a study carried out under the NCI Bioassay Programme (NCI, 1978). Groups of 24 male and 24 female Fischer 344 rats were given Aroclor 1254 at concentrations of 25, 50 or 100 mg/kg of diet for 104-105 weeks, when surviving animals were killed. No statistically significant differences between tumour incidences in experimental and control animals were seen. However, a few carcinomas and adenocarcinomas of the gastrointestinal tract were observed in treated animals; no such tumours occurred in controls. Hepatocellular hyperplastic nodules were observed in 11/48, 17/46 and 29/48 treated animals, compared with none in controls.

Environmental Health Perspectives
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Ref 13

PCBs, PCQs and PCDFs in Tissues of Yusho and Yu-Cheng Patients

by Hideaki Miyata,* Sigehiko Fukushima,* Takashi Kashimoto* and Nobuharu Kunita*

All five samples of oil involved in the recent Yu-Cheng outbreak were heavily contaminated with PCBs, PCQs and PCDFs at levels, on the average, of 62, 20 and 0.14 ppm, respectively. The samples not only had roughly one-tenth of the contamination by PCBs, PCQs and PCDFs but also three to four times lower ratios of PCQs and PCDFs to PCBs than samples of oil involved in Yusho in Japan. PCBs, PCQs and PCDFs present were all composed of similar congeners to the ones found in the Yusho specimens, though some variation of the component ratios of PCBs and PCDFs were observed.

On the other hand, five patients with Yusho who died 1 to 10 years following poisoning had markedly higher tissue levels of PCDFs and PCQs than did a worker occupationally exposed to PCBs. Taking great differences in the process of the healing and the tissue levels of PCBs, PCQs and PCDFs between the two poisoning cases into consideration, PCDFs and PCQs—especially the former—and not PCBs are deduced to be strongly associated with the development of Yusho.

Introduction

In 1968, Yusho occurred in the western part of Japan as a result of ingestion of a rice-bran cooking oil contaminated with a polycholorinated biphenyl (PCB) product. This occurrence affected about 1800 people and was clinically characterized by acnelike dermal lesions and a variety of constitutional symptoms (*1*). Many patients have been suffering from it for over 10 years, though the blood levels of PCBs declined rapidly once oil ingestion was terminated and 5 years later were only a few times larger than those of unexposed persons (*2*). On the other hand, in the cases of workers occupationally exposed to PCBs, only a minority had mild dermal lesions, despite high PCB levels in the blood. Discontinuation of handling PCBs resulted in the rapid disappearance of dermal symptoms in the occupationally exposed group (*3,4*). Thus, Yusho is clearly symptomatically different from the occupational PCB poisoning. In Japan, however, there has been a tendency to treat cases of the latter or the effect of PCBs as general environmental pollutants as being identical to Yusho.

In 1979, another Yusholike disease (Yu-Cheng) occurred in central Taiwan, the Republic of China, with a similar cause as in the case of Yusho (*5*). About 1700 persons have been suffering from obstinate symptoms as in the Japanese patients.

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The purpose of our study is to clarify etiologically the difference between both Yusho and Yu-Cheng on the one hand and simple PCB poisoning on the other.

Experimental and Materials

Five samples of rice-bran oil involved in the Yu-Cheng outbreak, which had been used in Hui-Ming School for Blindness and by the families of the poisoned patients in Taitung Country were collected in 1979. Their production dates were not known. They were kindly presented by Dr. T. C. Tung, Faculty of Medicine, National Taiwan University, and Dr. C. W. Huang, Department of Chemistry, Chung-Yuan University. Samples of the liver and adipose tissue or intestine of five Yusho patients taken at autopsy were obtained from Dr. I. Taki, Faculty of Medicine, Kyushu University. The tissues of normal individuals were obtained at autopsy after accidental death in September 1978. The milk of a female worker occupationally exposed to PCBs was collected for analysis in October 1977, 11 years after she discontinued handling PCBs.

Chemicals

p- and *m*-Quaterphenyls were purchased from Analabs Inc. (North Haven, CT, USA). *o*-Quaterphenyl was obtained from Wako Pure Chemical Co. Ltd. (Osaka, Japan). *o,m'*-, *o,p'*- and *m,p'*-Quaterphenyls were kindly donated by Dr. A. Mochiike, Hiroshima Prefectural

Ref 13

Institute of Health. A polychlorinated dibenzofuran (PCDF) mixture containing 46.3 to 56.8 wt-% chlorine was purchased from Wako Pure Chemical Co. Ltd. The 2,3,6,8-tetrachloro-, 2,3,7,8-tetrachloro-, 1,2,4,7,8-pentachloro-, and 2,3,4,7,8-pentachlorodibenzofurans were kindly presented by Dr. Masuda, Daiichi College Pharmaceutical Sciences. Florisil (60–100 mesh) was activated at 130°C overnight. Alumina (neutral, activation: I) was obtained from Merck Co. Ltd. (Darmstadt, West Germany), and its water content was adjusted to 0.8%. Solvents, reagents, and the polychlorinated quaterphenyl (PCQ) standard used here are described elsewhere (*6*).

Analytical Procedure

The sample was analyzed for PCBs, PCQs and PCDFs according to a modified method described previously (*6*). The method was essentially an alkaline saponification of the sample (5 g) in 50 mL of 1 *N* KOH alcoholic solution for 1 hr under refluxing followed by extraction with *n*-hexane and differential fractionation of PCBs, PCQs and PCDFs with solvents of *n*-hexane (60 mL), 4% diethyl ether in *n*-hexane (40 mL), and acetone (80 mL), respectively, on a Florisil column (6 g, 1 cm ID). The first fraction contained PCBs, the second PCQs and the third PCDFs. Quantification of PCBs followed the procedure reported previously (*6*). A half aliquot of the second eluate was analyzed qualitatively by GC-MS. The rest was perchlorinated with antimony pentachloride and qualitatively analyzed by ECD-GC according to our previous method (*6*). The PCDF fraction was further purified on an almina column and analyzed by ECD-GC and GC-MS.

Results and Discussion

Comparison of PCBs, PCQs and PCDFs in Yusho and Yu-Cheng Oils

Chen et al. (*7*) have already determined PCBs and PCDFs in five samples of Yu-Cheng oil collected from a factory and school cafeterias and families of the poisoned patients in Taichung Country. They, however, failed to give quantitative data on PCQs for lack of standard compounds, despite their confirming the presence of PCQs by GC-MS fragmentography. In this study, we performed qualitative analysis for all PCBs, PCQs and PCDFs in another specimen of Yu-Cheng oil and investigated qualitatively and quantitatively the chemicals in this oil and the oil involved in Yusho.

As shown in Table 1, all five samples of Yu-Cheng oil collected from Hui-Ming school and the victims' homes were heavily contaminated with PCBs, PCQs and PCDFs at average levels of 62, 20, 0.14 ppm, respectively. The contamination by PCBs and PCDFs was of the same order as that (on that average 80 and 0.29 ppm, repectively, for PCBs and PCDFs) reported by Chen et al. (*7*). In addition, the concentration ratio (2.4×10^{-3}) of PCDFs to PCBs was rather close to the value (3.6×10^{-3}) reported by Chen. In the Yusho incident, most of the patients were reported to be residents of Fukuoka and Nagasaki Prefectures and to have ingested

Table 1. Concentrations of PCBs, PCQs and PCDFs and their ratios in various materials.

Sample	PCBs, ppm	PCQs, ppm	PCDFs, ppm	PCQs/PCBs, g/g	PCDFs/PCBs, g/g
Yu-Cheng oil					
Y-1[a]	51	10	0.14	2.0×10^{-1}	2.7×10^{-3}
Y-2[b]	54	18	0.10	3.3×10^{-1}	1.9×10^{-3}
Y-3[b]	69	24	0.18	3.5×10^{-1}	2.6×10^{-3}
Y-4[a]	22	9	—[c]	4.1×10^{-1}	—
Y-5[b]	113	38	—[c]	3.4×10^{-1}	—
Average	62	20	0.14	3.3×10^{-1}	2.4×10^{-3}
Yusho oil[d]					
Feb. 5, 1968[e]	968	866	7.40	8.9×10^{-1}	7.6×10^{-3}
Feb. 9, 1968[e]	151	490	1.90	3.2	1.3×10^{-2}
Feb. 10, 1968[e]	155	536	2.25	3.5	1.4×10^{-2}
Average	430	630	3.85	1.5	9.0×10^{-3}
Kanechlor 400[d]	999,800	209	33	2.1×10^{-4}	3.3×10^{-5}
Used Kanechlor 400[d]					
U-1[f]	968,400	31,000	510	3.2×10^{-2}	5.2×10^{-4}
U-2[g]	999,000	690	277	6.9×10^{-4}	2.8×10^{-4}
U-3[h]	961,900	28,000	20	2.9×10^{-2}	2.1×10^{-5}
Average	979,800	19,00	269	2.0×10^{-2}	2.7×10^{-4}

[a,b]Samples collected from a school cafeteria and victims' home, respectively.
[c]No analysis.
[d]Data in our early study (*8*).
[e]Production date.
[f,g,h]Kanechlor 400 used as a heat exchanger liquid for 14 years at 180–270°C, for 3 years at 200–220°C, and under unknown condition, respectively.

Ref 13

Table 2. Component ratio (%) of PCBs in samples of Yu-Cheng and Yusho oils.

Sample	Number of chlorine					
	3	4	5	6	7	8
Yu-Cheng oil						
Y-1	2	33	36	19	10	0
Y-2	2	34	36	19	10	0
Y-3	1	31	39	19	10	0
Y-4	2	32	39	18	9	0
Y-5	2	32	39	18	9	0
Yusho causal oil						
Feb. 5, 1968	8	45	32	12	4	0
Feb. 9, 1968	6	39	32	15	8	0
Feb. 10, 1968	3	33	38	17	8	0
Feb. 15, 1958	8	34	34	16	8	0
Unused Kanechlor 400	22	59	18	0	0	0

bottled and canned products containing a rice-bran oil manufactured on February 5, 1968, until the middle of the same month by K-Company (*9*). Although the number of Yu-Cheng samples examined was limited, from our analytical data and those of Chen et al. (*7*), they were found to have only roughly one-tenth of the contamination by PCBs, PCQs and PCDFs found in the Japanese Yusho samples (Table 1).

Both the Yusho and Yu-Cheng oils were reported to be contaminated with PCB products which had been used as a heat exchange liquid in the deodorization process of the oil (*7,9*). In the case in Japan, Kanechlor 400 (Kanegafuchi Chemical Industry Co. Ltd., Japan; chlorine content: 48 wt-%) had been used as the medium. When Kanechlor 400 (KC-400) is heated, as in use as a heat exchanger, for a prolonged period at temperatures exceeding 200°C, both PCQs and PCDFs are generated thermochemically from PCBs, resulting in the elevated levels of PCQs and PCDFs compared to the original sample (*8*) (see Table 1). Yusho samples, however, further had concentration ratios of PCQs and PCDFs to PCBs higher than did the used PCB products (Table 1). Our early study (*10*) revealed that the phenomenon was produced during the deodorization process at a temperature of 230°C at a reduced pressure of 2–3 mm Hg because of a difference in the vapor pressure of PCBs, PCQs, PCDFs (PCBs > PCDFs >> PCQs). Yu-Cheng samples were also found to have higher concentration ratios (3.3×10^{-1} and 2.4×10^{-3}, respectively) of PCQs and PCDFs to PCBs than those (2.0×10^{-2} and 2.7×10^{-4}, respectively) of used Kanechlor 400s (Table 1). This might be attributed to the same cause as seen in the Yusho case.

As shown in Table 2, Yusho samples contained quite different compositions of PCBs from that of the original Kanechlor 400, showing the higher chlorinated biphenyl congeners than tetrachlorinated biphenyl to increase in relative quantity. This was also found to occur during the deodorization process due to a great difference in the evaporation rate of the various PCB congeners from the processed oil (*10*). The composition of PCBs varied depending on the production date (Table 2),

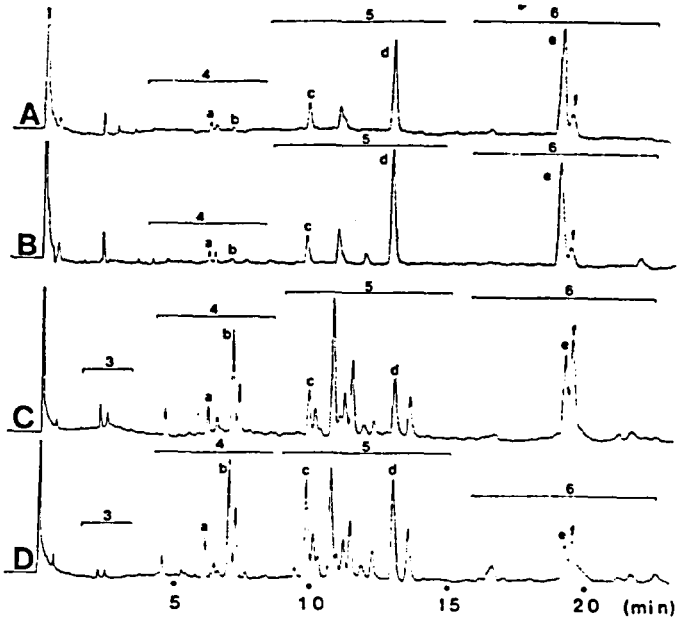

FIGURE 1. Capillary GC chromatograms, PCDFs in various materials: (*A,B*) PCDFs from the liver and adipose tissue, respectively, of a deceased patient with Yusho (case 1 in Table 3); (*C,D*) PCDFs from a sample of Yusho oil manufactured on February 5, 1968, and from a sample of Yu-Cheng oil, respectively. Numbers above the peaks designate the number of chlorine substituents as derived from GC–MS. Peaks a, b, c and d were identified as 2,3,6,8-tetrachloro-, 2,3,7,8-tetrachloro-, 1,2,4,7,8-pentachloro-, and 2,3,4,7,8-pentachlorinated dibenzofuran isomers, respectively; peaks e and f were deduced to be 1,2,3,4,7,8-hexachloro- and 1,2,3,6,7,8-hexachlorinated isomers, respectively, from the data of Rappe et al. (*16*). GC conditions: Varian Aerograph 2100 gas chromatograph equipped with ^{63}Ni-ECD; column, 25 m OV-17 capillary column; column, injector and detector temperatures 230, 240 and 300°C, respectively; carrier gas, N_2 (1 mL/min).

presumably due to a difference in the deodorizing conditions, especially deodorizing temperature. On the contrary, the Yu-Cheng specimens contained almost uniform compositions of PCBs in each of them (Table 2), indicating that the deodorizing conditions were constant thoughout the period when the PCB heat exchanger was leaking into the processed oil. PCBs present were composed of relatively larger quantities of higher chlorinated isomers than those in a Yusho oil of February 5, 1968, which was responsible for the majority of victims in Fukuoka Prefecture and rather similar to the oil produced on February 10, 1968 (Table 2).

As shown in Figure 1, both Yusho and Yu-Cheng specimens contained numerous isomers of trichlorinated to hexachlorinated dibenzofurans. A comparison between the gas chromatographic pattern of the PCDFs found in the two samples showed similarities although in some different proportions of several congeners. It is noteworthy that 2,3, 7,8-tetrachloro-, 2,3,4,7,8-pentachloro-, and 1,2,3,4,7,8-hexachlorinated dibenzofuran isomers were largely present in both purified sample extracts of both Yusho and Yu-Cheng oil, because they were all confirmed to be highly toxic (*11,12*).

Figure 2 shows GC–MS chromatograms showing the

Ref 13

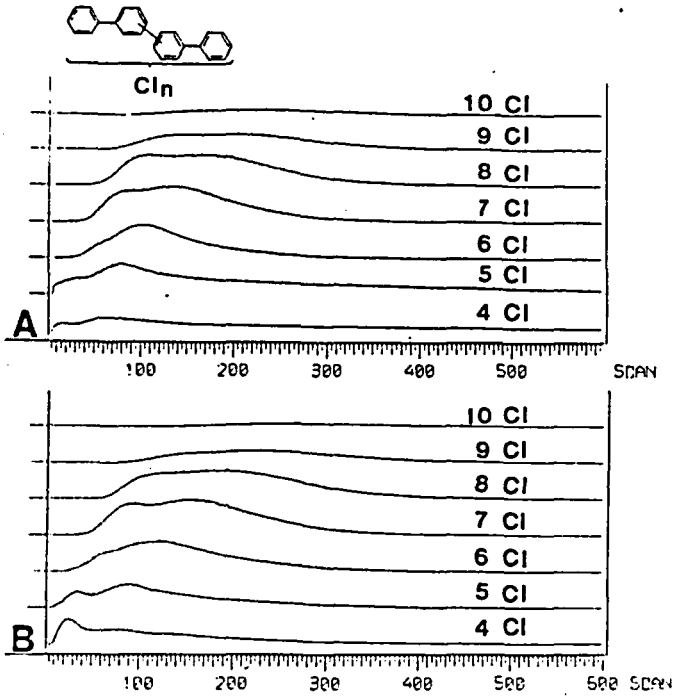

FIGURE 2. GC–MS chromatograms showing elution of PCQs in samples of Yusho and Yu-Cheng oils: (*A*,*B*) PCQs from a sample of Yusho oil manufactured on February 5, 1968, and from a sample of Yu-Cheng oil, respectively. GC–MS conditions: Hewlett Packard 5710A gas chromatograph-JEOL DX 300 mass spectrometer; column, 0.5 m × 2.2 mm glass column containing 2% OV-210 on Gaschrom Q (100/120); column injection, and ion source temps., 270, 270, and 290°C, respectively; electron energy, 70 eV; accelerator voltage, 3.0 kV; carrier gas, He_2 (30 mL/min).

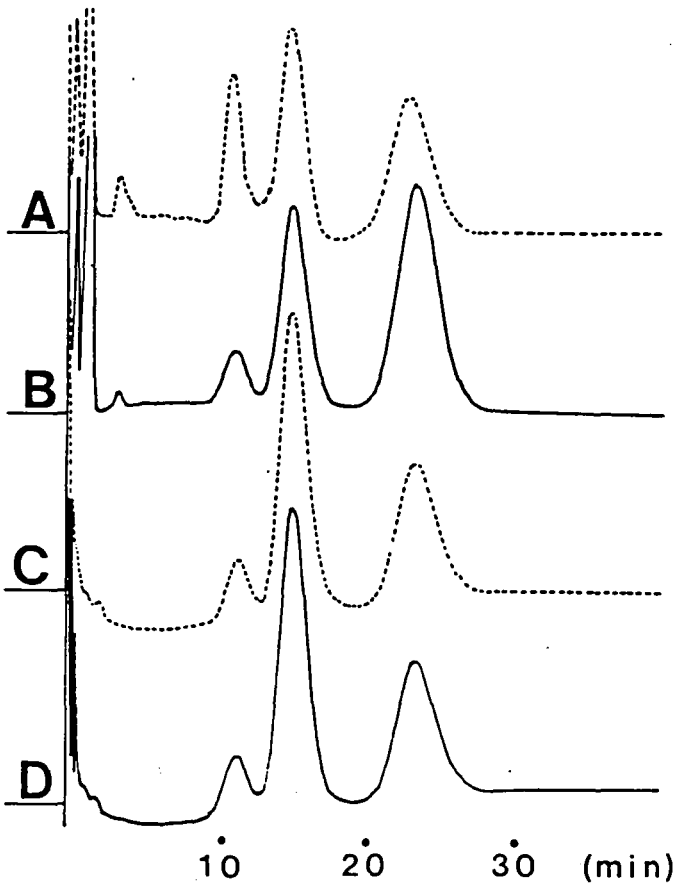

FIGURE 3. Gas chromatograms of PCQs in various materials after perchlorination: (*A*,*B*) perchlorinated PCQs from the adipose tissue and liver, respectively, of deceased patient with Yusho (case 1, Table 3) perchlorinated PCQs from a sample of Yusho oil produced on February 5, 1968, and from a sample of Yu-Cheng oil, respectively. GC condition: Shimadza GC-6A gas chromatograph eqipped with ^{63}Ni-ECD; column, 0.5 m × 2.6 mm glas column containing 2% SE-54 on Gaschrom Q (100/120); column injector and detector temperatures, 290, 300 and 300°C, respectively; carrier gas, N_2 (40 mL/min).

elutions of tetra- to decachlorinated quaterphenyl, respectively, in Yusho and Yu-Cheng oils. Each GC-MS chromatogram showed an unseparated broad peak, because of the failure to separate individual PCQ isomers on the GC column; in all there may exist more than hundreds of thousands of congeners. As shown in Figure 2, the oils involved in both incidents contained similar compositions of PCQs including hexachlorinated through octachlorinated congeners as the major components. In our study (*10*), no PCQ congeners were removed from the processed oil in the deodorization tank during the deodorization process. Therefore, the compositions of PCQs present in the two oils might be identical to those in the original PCB products used as heat exchanger liquid for the deodorization of the respective oils.

An aliquot of purified PCQ extract from both oils was perchlorinated with antimony pentachloride in order to convert the numerous PCQ congeners into six octadecachlorinated quaterphenyls ($C_{24}Cl_{18}$, molecular weight: 927). After perchlorination, three peaks showed up in gas chromatograms as illustrated in Figure 3. The first the second and the third peaks were identified as their retention time, ion clustering due to the chlorine isotope and the major fragmentation products ($M^+ - Cl$, $M^+ - 2Cl$, $M^+ - 4Cl$, etc.) compared to authentic standards for octadecachlorinated *o*-quaterphenyl, a complex of octadecachlorinated *o,m'*- and *o,p'* isomers and a complex of octadecachlorinated *m*-, *m,p'*- and *p*-isomers. A similar result was reported in PCQs from a sample of used Kanechlor 400 by Mochiike et al. (*14*), indicating the concentration ratios of octadecachlorinated *o*- isomer, *o,p'*-, + *o,m'*- isomer, *p*- isomer, *o,p'*- isomer, and *m*-isomer to be 9.2, 57.8, 0.6, 16.7, and 16.7%, respectively. As shown in Figure 3, gas chromatographic patterns of perchlorinated PCQs were strikingly similar for the Yusho and Yu-Cheng samples, suggesting PCQs from both samples to have similar ratios of the six types in their basic makeup.

Taking all the above results into consideration, PCBs, PCQs and PCDFs in the Yu-Cheng samples were composed of similar congeners to the respective ones found in the Yusho oils, though some variations of the component ratios of PCBs and PCDFs were observed.

Ref 13

Table 3. Concentrations of PCBs, PCDFs, and, PCQs in the tissues of Yusho patients, unexposed individuals and in the milk fat of a worker occupationally exposed to PCBs.

Case	Age	Sex	Time after exposure yr.	Tissue (or fluid)	Concentration, ppb PCBs[a]	PCDFs	PCQs[a]
Yusho patients							
1	25	M	1	Adipose tissue	5090	5.3	2400
				Liver	226	70.1	218
2	46	F	4	Adipose tissue	6091	9.6	1444
				Liver	68	15.5	144
3	72	M	7	Intestine	3472	2.5	1770
				Liver	114	6.2	51.7
4	59	M	9	Intestine	3630	2.2	416
				Liver	64	6.1	6.3
5	59	M	9	Intestine	1273	0.2	24.5
				Liver	18	0.02	0.97
Unexposed individuals							
Avg.	53	M,F	–	Adipose tissue	803[b]	0.019[b]	1.53[b]
				Liver	33[b]	0.006[b]	0.41[b]
PCB worker							
	37	F	11	Milk fat	6241	0.02	0.2

[a]Data in our early study (*15*).
[b]Average concentration from 14 persons.

Differences in the Amounts of Tissue PCBs, PCQs and PCDFs in Exposed and Unexposed Workers

The concentrations of PCBs in the tissues of patients with Yusho (cases 1 and 2) who died within a few years following poisoning were only several times those in unexposed individuals (Table 3). The tissue level gradually decreased with time following the intoxication, and in one patient (case 5) who died in 1979, the level was close to that of the control group. The levels of PCQs and PCDFs, as well as PCBs, in the tissues of deceased patients gradually declined subsequent to the incident (Table 3). The tissue levels of PCQs and PCDFs, as well as PCBs, however remained extremly elevated for 10 years compared to those of the control group. For example, even a patient (case 4) who died 9 years following poisoning, had a PCDF level 1016 times higher and PCQ level 15 times higher in his liver than did unexpsed individuals. On the other hand, in an exposed worker (Table 3) diagnosed as a case of an occupational PCB poisoning, the dermal lesions—chloracne and dark-colored pigmentation—disappeared quickly after discontinuation of handling PCBs. Even 11 years after the termination of exposure, however, the level of PCBs in her milk fat was fairly high, whereas the level of PCDFs or PCQs was similar or lower, respectively, compared to that in the adipose tissue of the control individuals. Therefore, the high contamination by PCQs and PCDFs is thought to be characteristic of Yusho patients.

A rapid reversal of clinical symptoms after termination of PCB exposure was reported as common in occupationally exposed workers whose daily intake (4–12 mg) (*3*) of PCBs was similar in quantity to that (7.9 mg) (*16*) ingested by Yusho patients, despite high blood levels of PCBs as much as 10 to 100 times that of the control (*3,4*).

From all the above facts, PCDFs and PCQs (other than PCBs) are deduced to be strongly associated with the development of Yusho.

When compared to original PCDFs ingested by the patients which contained 20 to 40 congeners, their number in the tissues was markedly decreased to about 10 (Fig. 1). The tissue PCDFs were composed of 2,3,4,7,8-pentachloro- and 1,2,3,4,7,8-hexachloro isomers as the major components and 2,3,6,8-tetrachloro-, 2,3,7,8-tetrachloro-, 1,2,4,7,8-pentachloro-, and 1,2,4,6,7,8-hexachloro- isomers as the minor components. A similar result was also reported in the adipose tissue and liver of a deceased patient with Yusho by Rappe et al. (*16*). Considering the extremely high toxicity (*11,12*) and strong hepatropism (Table 3) (*12,16,17*) of the two major constituents, they might be responsible agents for the lingering symptoms seen in the patients.

PCQs in the liver of deceased patients gave a much broader gas chromatographic peak including highly chlorinated quaterphenyl congeners, while in the adipose tissue there was a sharper peak composed of mainly lower chlorinated congeners. After perchlorination, there was also a difference in the gas chromatographic pattern of the two tissues, showing an increase of the third peak in the liver and first peak in the adipose tissue compared to that of the original PCQs (Fig. 3). In our experiment (*18*), both after and before perchlorination, the gas chromatographic pattern of PCQs retained in the treated monkeys' body varied from tissue to tissue, showing to be distinguishable from the case of PCBs.

From these results, the tissue distribution of PCQs is surmised to be closely related not only to the number of chlorine substitution but also to the nature of the carbocylic structure.

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Environmental Health Perspectives
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Ref 14

Biological Effect of PCBs, PCQs and PCDFs Present in the Oil Causing Yusho and Yu-Cheng

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Male Sprague-Dawley rats were daily given orally for 22 days a regimen consisting of polychlorinated biphenyls (PCBs), 1 mg/day; polychlorinated quaterphenyls (PCQs), 1 mg/day; polychlorinated dibenzofurans (PCDFs), 10 μg/day; or a mixture of PCBs, PCQs and PCDFs (Mix-1, 1 mg + 1 mg + 10 μg/day).

Female Cynomolgus monkeys were daily administered PCBs (5 mg), PCQs (5 mg) or a mixture (Mix-2) containing 5 mg PCBs + 20 μg PCDFs for 20 weeks. The PCBs, and PCDFs had the components of PCBs, PCQs and PCDFs similar to those contained in Japanese Yusho oils, respectively.

The PCB-treated rats and monkeys showed hepatic hypertrophy, immunosuppression and increased drug-metabolizing enzyme activities in hepatic microsomes, but were devoid of the dermal symptoms characteristic of Yusho. PCQs caused an increase in drug-metabolizing enzyme activities in hepatic microsomes and immunosuppression in monkeys, but these effects were much smaller than those found with PCBs treatment.

On the other hand, treatment with PCDF or Mix-1 or Mix-2 caused hypertrophy of the liver, immunosuppression, increase in drug-metabolizing enzyme activities of hepatic microsome to much greater extent than observed with PCBs, being more than 100 times as effective as PCBs. In addition PCDFs and the mixtures containing PCDFs caused weight loss and thymic atrophy.

PCDFs and Mix-2-treated monkeys showed the dermal symptoms that are characteristic of Yusho patients but were not observed in monkeys treated with PCBs and PCQs alone. These results suggest that PCDFs are the primary causative agent of Yusho.

Introduction

Yusho is a complicated polychlorinated biphenyl (PCB) poisoning (*1*), since PCBs, which have been regarded as the principal causative substance of this poisoning, are composed of a number of isomers of different nature, and since the toxic rice oil causing Yusho contains, in addition, polychlorinated quaterphenyls (PCQs) (*2*) and highly toxic polychlorinated dibenzofurans (PCDFs) (*3*). Recently, it has been found that PCB isomers vary greatly in toxicity (*4–6*). Moreover, PCQs (*7*) and PCDFs (*8*) have been detected in samples of blood and some organs of patients with Yusho.

Therefore, to understand the nature of the chemical substances responsible for Yusho, PCB, PCQ and PCDF samples resembling in composition the PCBs, PCQs and PCDFs found in the toxic rice oil were prepared in our laboratory by distilling KC-400 under reduced pressure. The present paper reports an experimental study of the toxicity of these PCBs, PCQs and PCDFs to rats and monkeys and presents a possible interpretation of human intoxication by the polychlorinated compounds.

Experimental

Rats

Male Sprague-Dawley rats (5 weeks old, weighing about 150 g) were raised in stainless-steel cages without bedding in an air-conditioned room with water and rat chow (Oriental Yeast Co. Ltd., Japan) *ad libitum*.

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Ref 14

For oral administration, the PCBs, PCQs, PCDFs or Mix-1 were dissolved in olive oil. The daily dose of each sample of PCBs, PCQs, PCDFs or mix is listed in Table 1. All rats were observed daily for evidence of changes in demeanor and appearance. Body weights were recorded daily during treatment and thereafter. Each group was divided into five subgroups of six each and sacrificed at 5, 10 and 22 days of treatment and 10 and 24 days after cessation of treatment.

Monkeys

Ten female Cynomolugus monkeys (*Macaca fascicularis*) weighing approximately 2.5 kg were obtained from Malaya, and reared for 3 months in individual cages in air-conditioned rooms before starting experiments. During the 20-week experimental period, monkeys were daily fed bread (30 g), monkey chow (100 g, Oriental Yeast Co., Japan) and bananas (50 g), and were given water *ad libitum*.

For oral administration, the PCBs, PCQs, PCDFs and Mix-2 were dissolved in olive oil, and the daily dose (Table 1) was injected into a piece of banana (50 g) given to the monkeys once a day, except Sundays, for 20 weeks.

The monkeys were observed daily for physical and clinical signs, and were weighed and bled at 4-week intervals throughout the experimental feeding period. Finally they were examined by autopsy for pathologic changes in their internal organs. The monkeys fed PCDFs (Nos. 4, 5 and 6) were killed in week 16, because they appeared to be close to death.

Chemicals

KC-400 and PY-PCQs were obtained from Kanegafuchi Chemical Ind. Co. (Kyogo, Japan).

PY-PCBs and PY-PCDFs were prepared from a KC-400 as described in Table 1 and the previous report (*9*).

PY-PCBs, PY-PCQs and PY-PCDFs had composition of PCBs, PCQs and PCDFs similar to those contained in the Japanese toxic rice oils. Mixture 1 (abbreviated Mix-1) was a complex mixture of PY-PCBs, PY-PCQs and PY-PCDFs in proportions of 1:1:0.01 (the approximate proportion of these compounds in toxic rice oil), and Mixtures 2 (abbreviated Mix-2) was a complex of PY-PCBs and PY-PCDFs, 1:0.0004.

Immunization and Assay for Anti-Sheep Red Blood Cell (SRBC) Antibodies

All rats or monkeys were immunized three times with 0.5 mL and 1.5 mL of 10% SRBC in physiological saline. Blood samples were collected 12 days after each immunication. Serum samples were stored at – 20°C until assayed for anti-SRBC antibody and immunoglobulin (IgG) levels.

The hemolysin titer was measured by 100% hemolysis method (*10*). The quantitation of IgG was carried out according to the method described by Otake et al. (*11*).

Enzyme Assays

Microsomal protein concentration was measured according to the method of Lowry et al. (*12*). Cytochrome P-450 content was determined by the method of Omura and Sato (*13*). Microsomal *N*-demethylation of aminopyrine and *O*-demethylation of *p*-nitroanisole and NADPH-cytochrome c reductase were quantified by the method described the previous report (14). Benzo(a)pyrene hydroxylase activity was measured by the method of Nebert and Gelboin (*15*).

Table 1. Experimental groups.

Animal	Compounds	Daily dose fed per animal	Feeding periods
Rats[a]	PY-PCBs[b]	1 mg	22 days
	PY-PCQs[c]	1 mg	22 days
	PY-PCDFs[d]	10 μg	22 days
	Mix-1 (PY-PCBs + PY-PCQs + PY-PCDFs)[e]	1 mg + 1 mg + 10 μg	22 days
	None (control)	—	22 days
Monkeys[f]			
No. 1	PY-PCBs	5 mg	20 weeks
Nos. 2,3	PY-PCQs	5 mg	20 weeks
Nos. 4,5,6	PY-PCDFs	20 μg	16 weeks[g]
Nos. 7	Mix-2[h]	5 mg	20 weeks
Nos. 8,9,10	None (control)	—	20 weeks

[a]Male Sprague-Dawley rats (5 weeks old); six rats per group.
[b]PY-PCBs were prepared from KC-400 by distillation under reduced pressure; PCDFs and PCQs were removed by Florisil column chromatography. The composition of PCBs in the PY-PCBs is similar to that of the PCB-contaminated Kanemi rice oil sample which caused Yusho (toxic rice oil).
[c]The composition of PCQ in the PY-PCQs is similar to that of the PCQ-contaminated toxic rice oil.
[d]PY-PCDFs were prepared from KC-400 by distillation under reduced pressure and PCBs and PCQs were removed by Florisil column chromatography. The composition of PCDF in the PY-PCDFs is similar to that of the PCDF-contaminated toxic rice oil.
[e]Mix-1 is similar to the proportions of PCBs, PCQs and PCDFs in the toxic rice oil.
[f]Female Cynomolgus monkeys weighing approximately 2.5 kg.
[g]Monkeys 4, 5, and 6 became moribund and were killed on week 16 of feeding.
[h]Mix-2 is the PY-PCBs with PCDFs of 400 ppm.

Results

Rat

The inhibition of the increase in body weight was noted only in the PY-PCDFs group and Mix-1 group with PY-PCDFs. The tendency continued also following discontinuance of administration.

Changes in the weight ratios of the organs were noted for the liver and the thymus: namely, the ratio for the liver increased in each group except for the PY-PCQs group, especially in the Mix-1 group. On the other hand, marked atrophy of the thymus was noted in the PY-PCDFs group and Mix-1 group. This atrophy was still observed on the day 24 after administration was discontinued.

The PY-PCBs group showed increased alkaline phosphatase (AlP), glutamic oxaloacetic transaminase (GOT) and cholesterol levels. By contrast, the Mix-1 group (a toxic rice oil minic) showed a significant decrease in glutamic pyruvic transaminase (GPT) and a significant increase in cholesterol level. The groups administered PCBs, PCQs and PCDFs showed no significant increase in triglycerides, a value which was reported to increase in Yusho patients, but the Mix-1 group showed a significant increase in that value.

Rats of each group were immunized three times with SBRC and 12 days after each challenge their ability to produce anti-SRBC antibody and blood IgG level was determined. The suppression of the anti-SRBC antibody production was seen on day 22 of administration in the groups of Mix-1, PY-PCBs and PY-PCDFs, among which the Mix-1 group showed the most marked suppression. Blood IgG level and leukocytes also tended to decrease. In addition the suppression was still noted even on day 24 after discontinuance of administration of the toxic oil components. On the contrary, the PY-PCQs group scarcely exhibited suppression of the anti-SRBC antibody production (Fig. 1).

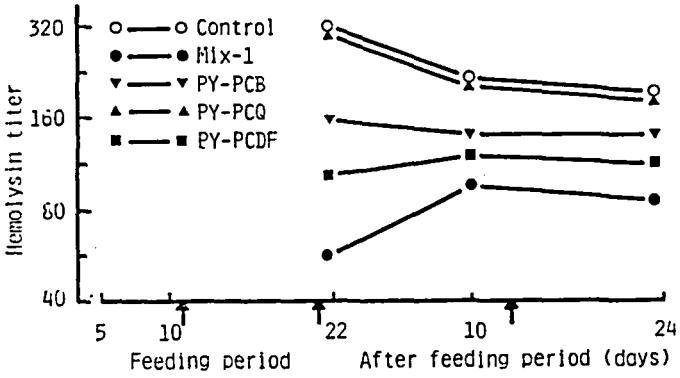

FIGURE 1. Effects of PY-PCBs, PY-PCQs, PY-PCDFs and Mix-1 on hemolysin titer of rats. Rats were immunized three times with 0.5 mL of 10% SRBC in physiological saline and blood samples were collected 12 days after each immunization. PY-PCBs (1 mg/day), PY-PCQs (1 mg/day), PY-PCDFs (10 μg/day) or Mix-1 (PY-PCBs 1 mg + PY-PCQs 1 mg + PY-PCDFs 10 μg/day) were given orally to each rat.

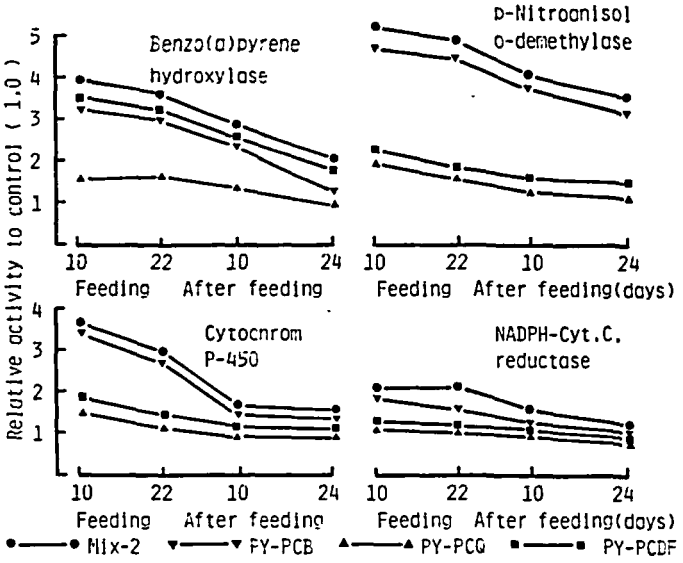

FIGURE 2. Comparative effects of pretreatment with PY-PCBs, PY-PCQs, PY-PCDFs and Mix-1 on liver enzyme activities in rats. PY-PCBs (1 mg day), PY-PCQs (1 mg/day), PY-PCDFs (10 μg/day) or Mix-1 (PY-PCBs 1 mg + PY-PCQs 1 mg + PY-PCDFs 10 μg/day) were given orally to each rat.

Figure 2 shows the activities of induction of hepatic microsomal drug metabolizing enzymes. PCBs increased the activity of cytochrome P-450, *p*-nitroanisole *O*-demethylase, aminopyrine *N*-demethylase and benzo(a) pyrene hydroxylase. The pattern of the enzyme induction showed a mixture of phenobarbital (PB)- and 3-methylcholanthrene (MC)-types, in good agreement with the observed shift of the absorption maximum to 449 nm in the CO-difference spectra. The enzyme-inducing ability of PCQs was weaker than that of other test substances and showed a mixed-type induction of PB and MC. PCDFs strongly induced benzo(a)pyrene hydroxylase, showing MC-type induction, whereas Mix-1 showed strong inducing effects upon all the enzymes.

The effects of PCQs on rats were far weaker than those of PCBs. PCDFs, however, had intensive effects on rats, despite the fact that the dose was only one-hundredth that of PY-PCBs or PY-PCQs. In other words, the toxicity of PY-PCDFs in rats is 100 times that of PCBs or PCQs. However, even with PCDFs and Mix-1 it was not possible to evoke cutaneous symptoms such as the dermal acneform lesions characteristic of Yusho.

Therefore, we studied the influence of Yusho-related compounds on female monkeys which were assumed to be more susceptible to PCBs than rats and attempted to reproduce Yusho symptoms in these animals.

Monkey

Monkeys treated with Mix-2 and PCDFs showed a decrease in body weight; approximately a 15% decrease in both groups 12 weeks after the beginning of the experiment. The food consumption of these monkeys

Ref 14

during the experimental perod was not different from that of the monkeys fed PCBs, PCQs and control monkeys. The monkeys on PCBs and PCQs kept the initial body weight or had a slight weight gain.

Figure 3 shows the organ weight per unit body weight of monkeys and activities of hepatic drug-metabolizing enzymes. Among the organs tested, liver was the most profoundly influenced by the test substances. The Mix-2-treated monkey showed markedly increased liver weight, about 2.4 times that of control monkeys, and also showed hypertrophy of kidney and spleen. Further, PCDF-treated monkeys showed greater hypertrophy of spleen than was found in other test animals.

As shown in Figure 3, activities of cytochrome P-450, benzo(a)pyrene hydroxylase and aminopyrine *N*-demethylase increased in all the monkeys except PCDF-treated monkeys. In particular, this tendency was the most marked with the Mix-2 animal. In contrast, in monkeys fed PCDFs, the activities of cytochrome P-450, aminopyrine *N*-demethylase, and benzo(a)pyrene hydroxylase were 80, 50 and 50%, respectively, of those of the control monkeys. We consider the observed low enzymatic activities of PCDF-treated monkeys were due to the extreme asthenia of these monkeys at the time of dissection.

On immunological study, Mix-2 and PY-PCB-treated monkeys showed marked suppression of anti-SRBC antibody production, the antibody titer being less than 5 before the second immuization. The monkey fed PCBs (without PCDFs) showed increased antibody production after the second immunization, while administration of Mix-2 (with PCDFs) caused suppression of antibody-producing ability throughout the experimental period (Fig. 4). Further, in contrast to monkeys treated with PY-PCBs, PY-PCDF-treated monkeys showed continuous decrease in antibody production with time, reaching about the same extent of suppression after 16 weeks as that of Mix-2-treated monkey. PCQs were also found to suppress antibody-producing ability (Fig. 4).

Monkeys treated with PY-PCDFs or Mix-2 (with PCDF) showed hair loss, periorbital edema, Meibomian retention cysts, and acneforms lesions on faces—all characteristic symptoms of Yusho disease. Further, these monkeys showed the enlargement of hyperkeratinosis of pilar pores, and the degeneration of hair root on the dorsal skin.

In contrast, the control monkeys and those treated with PY-PCBs or PY-PCQs did not show any of the clinical symptoms characteristic of Yusho as were observed in monkeys treated with PY-PCDFs and Mix-2 (with PCDFs).

Discussion

It is well known that PCBs have a strong inducing effect on the drug-metabolizing enzymes of hepatic

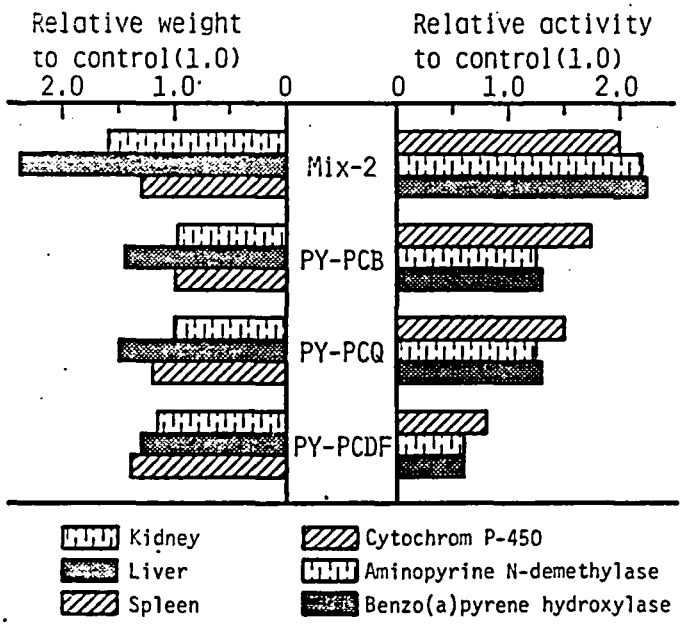

FIGURE 3. Comparative effects of pretreatment with PY-PCBs, POY-PCQs, PY-PCDFs and Mix-2 on liver enzyme activities and organ weights in monkeys. PY-PCBs (5 mg/day), PY-PCQs (5 mg/day) or Mix-2 (5 mg/day) were given orally for 20 weeks. PY-PCDFs (20 μg/day) were given orally for 16 weeks.

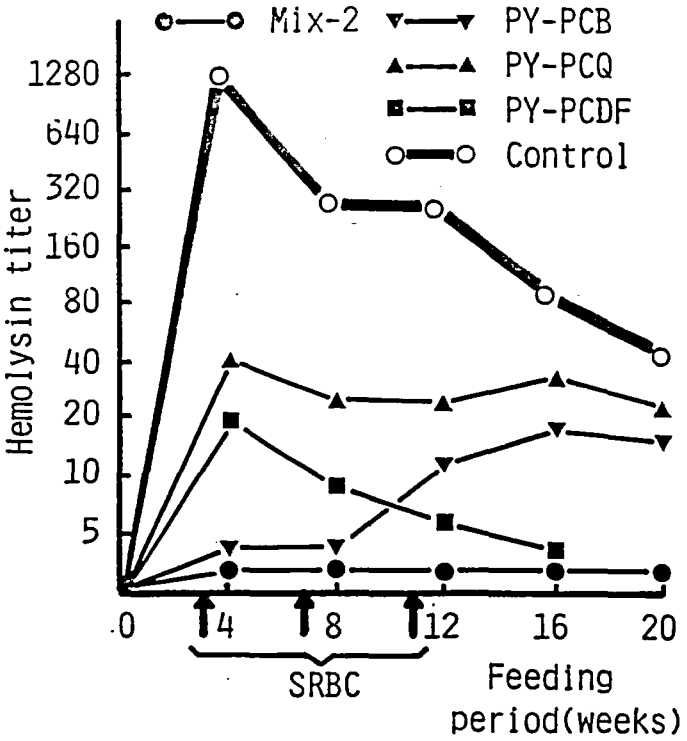

FIGURE 4. Effects of PY-PCBs, PY-PCQs, PY-PCDFs and Mix-2 feeding on anti-SRBC antibody. Monkeys were immunized with 1.5 mL of 10% SRBC in physiological saline on days 16, 44 and 72 of feeding. The blood samples were collected 12 days after each immunization. PY-PCBs (5 mg/day), PY-PCQs (5 mg/day) or Mix-2 (5 mg/day) were given orally for 20 weeks. PY-PCDFs (20 μg/day) were given orally for 16 weeks.

Ref 14

microsomes (*16,17*), and Kanechlor and other PCB products are mixtures of phenobarbital (PB) and 3-methylcholanthrene (MC) type PCBs (*16*). Recently, Yoshimura et al. (*4*) demonstrated that MC-type PCBs exhibited marked toxic effects that PB-type PCBs did not share: hypertrophy of liver and atrophy of thymus. They also clearly showed a positive correlation between the ability of MC-type PCBs to induce activity of liver enzymes and toxicity. The present study revealed that PY-PCBs, which have similar composition to the PCBs in the toxic rice oil, have mixed type inducing ability, as is the case with commercial PCB products. The enzyme-inducing ability of PY-PCBs is stronger than that of KC-400 as judged by our experiments with KC-400 administered to rats (unpublished data) and monkeys (*9,14*). PY-PCQs, which have similar composition to PCQs in the toxic rice oil, also caused enzyme induction of the same type as PY-PCBs, but to a much smaller extent. On the other hand, PY-PCDFs and mixtures containing PCDFs (Mix-1 and Mix-2) caused MC-type enzyme induction and further brought about decrease in body weight and marked atrophy of thymus which were not observed in PY-PCB- or PY-PCQ-treated animals. These results are consistent with the report of Yoshimura et al. (*4*) described above.

Loose et al. (*18*) reported that administration of Aroclor to mice caused a decrease in anti-SRBC antibody-producing ability and serum IgG level. The present study demonstrates the suppression of immune system in PY-PCB-treated rats and monkeys, in agreement with the report of Loose (*18*) and Thomas (*19*). The fact that PY-PCQ-treated monkey showed suppression of anti-SRBC antibody-producing ability that was not observed in similarly treated rats indicates that monkeys are highly susceptible to these organochlorine compounds. Administration to rats and monkeys of PY-PCDFs of composition analogous to that of PCDFs in the toxic rice oil produced more marked immunosuppression than PY-PCBs, in spite of the 100-fold difference in amount administered.

As demonstrated above, PY-PCDFs and Mix-1 exhibited marked effects on rats with respect to body weight increase, immunosuppression, enzyme induction, and blood biochemical finding, but the dermal symptoms characteristic of Yusho patients could not be observed. However, administration of PY-PCDFs and Mix-2 to monkeys made it possible to reproduce Yusho symptoms. Thus, administration of PY-PCBs or PY-PCQs alone to monkeys did not cause Yusho symptoms. These results indicate that PCDFs are the compounds responsible for the developoment of Yusho symptoms.

In our experiments, the calculated doses of PY-PCBs and PY-PCDFs required for the induction of the dermal symptoms in monkey fed Mix-2, as converted to the dose per average human body weight (50 kg), were 600 mg and 2.4 mg. Hayabuchi et al. (*20*) who investigated the biochemical aspects, estimated the critical doses as 466 mg for PCBs, 439 mg for PCQs, and 2.5 mg for PCDFs, which values agree quite well with the data from monkeys. Further, even administration of PY-PCDFs alone caused Yusho symptoms, while administration to monkeys of PY-PCBs or PY-PCQs which contained no PCDFs did not cause Yusho symptoms even at a dose approximately 13 times the dose ingested by Yusho patients.

Hara et al. (*21*) and other investigators (*22*) reported that the clinical symptoms of patients occupationally exposed to PCBs were much milder than those of Yusho patients, and the blood PCB composition of the former patients was clearly different from that of Yusho patients. Further, Yu-Cheng patients of Taiwan show much graver symptoms than the patients occupationally exposed to PCBs, in spite of the fact that the blood PCB level of the former is less than or at most in the same range as that of the latter (*22,23*).

The present study with monkeys clearly indicates that the observed differences between the symptoms of the patients occupationally exposed to PCBs and Yusho patients are due not to a difference in the composition between commercial PCB products and toxic rice oil, but to the presence of PCDFs in the toxic rice oil and suggests that PCDFs are the primary causative agents of Yusho.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET
ATLANTA, GEORGIA 30365

AUG 5 1986

Ref 15

RECEIVED
AUG 11 1986
SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH

MEMORANDUM

SUBJECT: EPA Guidance & Policy

FROM: Chief, Waste Planning Section
Residuals Management Branch

TO: All State Directors
EPA Region IV

Attached is a letter titled, "Recommendation on Removal Action Level for PCB's in Soil Based on Health Effect." Sites contaminated with polycholorinated biphenyls (PCBs) are regulated under CERCLA.

If there are any questions regarding this letter, please feel free to direct them to Joe Sangster of my staff at (404) 347-7603.

Otis Johnson, Jr.

Attachment

(WP) cc ~~WES~~ ~~WES~~ STATES

BMB FRPL Ref 15

RECOMMENDATION ON REMOVAL ACTION LEVEL FOR PCBs IN SOIL

BASED ON HEALTH EFFECT

This memo sets forth the advisory limitations of polychlorinated biphenyls (PCBs) in soil considered permissible in protecting the health of the public affected by contaminated sites regulated under CERCLA. This is prepared in response to a request by the Office of Emergency and Remedial Response to provide a recommendation concerning the limitations based on exposure and health assessments as described in detail in the draft Office of Health and Environmental Assessment (OHEA) report entitled "Development of Health Advisories for Polychlorinated Biphenyls (PCBs)" dated July 25, 1985, updated as "Development of Advisory Levels for Polychlorinated Biphenyls (PCB) Cleanup" in December 1985; and subsequently revised to delete the 1-day advisory levels and to include the 10-day advisory levels.

Human intakes of PCBs from drinking water and soil are assumed to occur independent of each other, because drinking water can come from a clean public water system. The main focus of this exposure analysis is to define the levels of PCBs which will require soil removal action or up to which the soil should be cleaned. The OHEA report summarizes ten-day, noncancer, and long-term oncogenic advisory levels for PCB cleanup in terms of the ranges of the permissible PCB concentration in soil. These ranges resulted due to several types of commercial PCBs evaluated with different vapor pressures and the variations in soil-air partition coefficients of PCBs affecting their environmental distribution. One-day and long-term noncancer advisory levels could not be developed at this time mainly due to lack of health effect information.

Ref 15

The permissible PCB levels in soil are obtained by setting the average daily intake rates from pertinent pathways for short-term and long-term exposures equal to acceptable intake rates corresponding to each exposure period. The levels thus estimated may represent the minimum levels to which PCBs must be cleaned up not to exceed the acceptable intake rates. The acceptable intake rates are determined by analyzing animal data for short-term and chronic health effects. Estimation of the combined intake rates from all pathways considered requires exposure evaluations which include the use of fate and transport models to estimate exposure concentrations. The pathways considered in evaluating exposures relative to soil PCB limits are ingestion of soil, inhalation of contaminated air, dermal contact with contaminated soil, and ingestion of contaminated food. Since soil ingestion occurs only during childhood, exposure occurring during this period needs to be averaged over an individual's lifetime to estimate the daily intake rate for lifetime exposure.

The depletion of PCBs from soil caused by volatilization is accounted for in the exposure analysis by solving a partial differential equation simulating PCB vapor diffusion through the soil air-phase pores, and the distribution of PCBs between air and soil phases. Boundary conditions assume that the air-phase resistance is relatively small compared to the diffusional resistance in the soil air-phase pores. The available experimental data reasonably follow the time-emission rate relationship predicted from the models based on this assumption. Since the depletion rate varies over time, it is averaged over the exposure period. Depletion averaged over a time should lead to a lesser inhalation exposure than that based on the model assuming that depletion does not occur.

Ref 15

For the purpose of applying different levels of stringency for PCB cleanup from soils, the areas of potential exposures are classified into two categories according to the types of exposure pathways. The most stringent requirements for protecting human health are applied to the area where exposure pathways are soil ingestion, inhalation, and dermal contact. The less stringent requirements are applied to the area where human exposure occurs by inhalation only. In the former case, related human activities and the likelihood of human contact with contaminants are highest, and hence, in all likelihood the affected population is located on the contaminated site. Examples include areas occupying residential communities. In the latter case, there is no likelihood of human contact with the contaminated soil, the entrance to the contaminated site is prohibited or the area is remotely located from human population. Prohibition of entrance to the site could require special precautionary measures such as installing fences.

Permissible levels of PCBs in soil can be determined on a site-specific basis as a function of the type of PCBs at the site, soil-air partitioning characteristics, and potential of human ingestion and dermal contact. Since the application of the methodology is cumbersome, if not difficult, for use in each site evaluation, the limitations set forth in this memo are intended to alleviate such burden on regulators within the framework of stringency requirements enumerated above. However, each regulator may perform site-specific evaluation, once detailed information is available.

The attached table shows advisory values for soil according to the classes

Ref 15

of the area where the sites are located. The upper limits of the ranges of permissible PCB concentration in soil are selected for long-term advisory levels; these may be most applicable to sites abandoned some time ago. The lower limits are selected for 10-day advisory levels because the PCB depletion will be small during the short-term period. The permissible PCB levels in soil for lifetime intake are based on the current Agency policy recommending the upper bound estimate of 10^{-6} risk for known or suspected carcinogens to protect the public in populated areas.

For the area subject to potential of exposure by soil ingestion, inhalation, and dermal contact, the 10-day noncancer advisory level is 42 ug/g if the site becomes accessible to population immediately after spill or cleanup. The long-term oncogenic health advisory corresponding to the upper bound estimate for 10^{-6} risk is 6 ug/g with at least 25 cm (10 inches) thick soil cover material initially free of PCB contamination below the detection limit (normally about 0.1 ug/g). The use of soil or its equivalent cover material will reduce the health risk by an order of magnitude (i.e., from 10^{-5} to 10^{-6}).

Advisory levels for PCB cleanup for the other areas assume that exposure pathways are totally by inhalation. Since the remotely located area cannot be completely inaccessible to human activities, because maintenance personnel or on-site workers should be present on the facility or near the property fence area, permissible levels for this area are assumed to be the same as those based on on-site inhalation only. If any other pathways are a possibility, a case-by-case assessment will be needed to arrive at an acceptable level of PCBs in soil.

The 10-day advisory level for on-site exposure by inhalation only is

Ref 15

47 ug/g if exposure occurs immediately after spill or clean-up. The long-term advisory levels are 2 ug/g when no cover is applied and 20 ug/g when at least 25 cm thick soil cover or equivalent material initially free of PCBs (or below the detection limit) is used. Although a higher permissible level may be theoretically possible for some PCBs, as shown in the OHEA report when soil cover is used, capillary tension between contaminant and soil could cause the contaminant level to rise towards the soil surface, and result in emission rates higher than what can be predicted from the soil cover thickness applied. Currently, no comprehensive data base exists to evaluate the effect of capillary tension on the extent of emission rate increase. Until this uncertainty is better defined, it is difficult to assess how a level higher than 20 ug/g will cause unacceptable exposures for on-site inhalation once a 25 cm cover has been applied.

Lack of health effect data prevents development of 1-day advisory levels. In the absence of such data, it is recommended that the 10-day advisories be also used as the 1-day advisory levels.

A need may arise for applying less stringent risk requirements for some areas such as sparsely-populated or remotelylocated areas. Some contaminated areas may be made inaccessible to the public so that population could be subject to off-site inhalation rather than on-site inhalation. These are a few examples for which soil PCB levels higher than those shown in the attached table could be allowed. This situation needs to be evaluated on a case-by-case basis. For example, if the acceptable level is considered at 10^{-5} risk for the area remotely located, the cleanup level can be as high as 20 ug/g without applying cover material.

Ref 15

RECOMMENDED ADVISORY LEVELS FOR PCB CLEANUP FROM SOIL

Area According to Route of Human Exposure	Permissible Levels (ug/g) for		
	10-Day Advisory	Chronic Intake Advisory[a]	
		No Cover	25 cm Cover
Soil Ingestion, Inhalation, Dermal Contact[b]	42	0.6	6[c]
Inhalation Only[d]	47	2	20[c]

[a]Corresponding to 10^{-6} risk.

[b]Exposure is assumed to occur on the contaminated site.

[c]Advisory levels for chronic intake based on applying 25 cm of clean cover containing PCBs below detection limit (about 0.1 ppm).

[d]Based on inhalation exposure on site or at the fence line.

Appendix D

Site Inspection Form

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 1 - SITE LOCATION AND INSPECTION INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981478480

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site)	02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER
Toddville Operations Center	610 Toddville Road

03 CITY	04 STATE	05 ZIP CODE	06 COUNTY	07 COUNTY CODE	08 CONG DIST
Charlotte	NC	28242	Mecklenburg	60	9

09 COORDINATES LATITUDE	LONGITUDE	10 TYPE OF OWNERSHIP (Check one)
35 16 32 .	80 54 58 .	☒ A. PRIVATE ☐ B. FEDERAL ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL ☐ F. OTHER ☐ G. UNKNOWN

III. INSPECTION INFORMATION

01 DATE OF INSPECTION	02 SITE STATUS	03 YEARS OF OPERATION
11 / 19 / 86 (MONTH DAY YEAR)	☐ ACTIVE ☐ INACTIVE	1956 (BEGINNING YEAR) / present (ENDING YEAR) ___ UNKNOWN

04 AGENCY PERFORMING INSPECTION (Check all that apply)

☐ A. EPA ☐ B. EPA CONTRACTOR ___ (Name of firm) ☐ C. MUNICIPAL ☐ D. MUNICIPAL CONTRACTOR ___ (Name of firm)
☒ E. STATE ☐ F. STATE CONTRACTOR ___ (Name of firm) ☐ G. OTHER ___ (Specify)

05 CHIEF INSPECTOR	06 TITLE	07 ORGANIZATION	08 TELEPHONE NO.
Jack Butler	Environmental Engineer	S&HW Mgmt. Br.	919) 733-2801
09 OTHER INSPECTORS	**10 TITLE**	**11 ORGANIZATION**	**12 TELEPHONE NO.**
Stan Atwood	Toxicologist	"	( ) "
Cheryl McMorris	Environmental Chemist	"	( ) "
Alan Giles	Sanitarian	Mecklenburg Env. Health	(704 376-4603
			( )
			( )

13 SITE REPRESENTATIVES INTERVIEWED	14 TITLE	15 ADDRESS	16 TELEPHONE NO
Michael Lascara		Duke Power Company P.O. Box 33189 Charlotte	(704 372-5201
Dave Anderson		"	(704 373-4976
John Mease		"	( )
Jay Perkins		"	( )
Warren Baker		"	( )
			( )

17 ACCESS GAINED BY (Check one)	18 TIME OF INSPECTION	19 WEATHER CONDITIONS
☐ PERMISSION ☐ WARRANT	1015-1400	sunny 50's

IV. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF (Agency/Organization)	03 TELEPHONE NO.
Joe Harwood, Env. Affairs Spec.	Duke Power Co.	(704) 373-8494

04 PERSON RESPONSIBLE FOR SITE INSPECTION FORM	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NO.	08 DATE
Stan Atwood	NC DHR/DHS	S&HW-CERCLA	(919) 733-2801	2 / 27 / 87 (MONTH DAY YEAR)

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 2 - WASTE INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS

01 PHYSICAL STATES (Check all that apply)

- ☐ A. SOLID
- ☐ B. POWDER, FINES
- ☐ C. SLUDGE
- ☐ D. OTHER _____ (Specify)
- ☐ E. SLURRY
- ☒ F. LIQUID
- ☐ G. GAS

02 WASTE QUANTITY AT SITE (Measures of waste quantities must be independent)

TONS _____
CUBIC YARDS unknown
NO. OF DRUMS _____

03 WASTE CHARACTERISTICS (Check all that apply)

- ☒ A. TOXIC
- ☐ B. CORROSIVE
- ☐ C. RADIOACTIVE
- ☒ D. PERSISTENT
- ☐ E. SOLUBLE
- ☐ F. INFECTIOUS
- ☐ G. FLAMMABLE
- ☐ H. IGNITABLE
- ☐ I. HIGHLY VOLATILE
- ☐ J. EXPLOSIVE
- ☐ K. REACTIVE
- ☐ L. INCOMPATIBLE
- ☐ M. NOT APPLICABLE

III. WASTE TYPE

CATEGORY	SUBSTANCE NAME	01 GROSS AMOUNT	02 UNIT OF MEASURE	03 COMMENTS
SLU	SLUDGE			
OLW	OILY WASTE	unknown		Transformer oil
SOL	SOLVENTS			
PSD	PESTICIDES			
OCC	OTHER ORGANIC CHEMICALS	unknown		PCBs in oil
IOC	INORGANIC CHEMICALS			
ACD	ACIDS			
BAS	BASES			
MES	HEAVY METALS			

IV. HAZARDOUS SUBSTANCES (See Appendix for most frequently cited CAS Numbers)

01 CATEGORY	02 SUBSTANCE NAME	03 CAS NUMBER	04 STORAGE/DISPOSAL METHOD	05 CONCENTRATION	06 MEASURE OF CONCENTRATION
OCC	PCBs	1336-36-3	Spills, dust suppression	0.3-11	ppm

V. FEEDSTOCKS (See Appendix for CAS Numbers)

CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER	CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER
FDS			FDS		
FDS			FDS		
FDS			FDS		
FDS			FDS		

VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

1. Permanent files, Solid & Hazardous Waste Mgmt. Br.,CERCLA Unit, Raleigh, NC
2. USGS 7.5' Quad., Mountain Island Lake--1969

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 [X] A. GROUNDWATER CONTAMINATION — 02 [ ] OBSERVED (DATE: ____) — [ ] POTENTIAL — [X] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ____ — 04 NARRATIVE DESCRIPTION

Site has been used to store transformers for 30 years. Grab sample from on-site well contained detectable level of PCBs (~1ppb).

01 [ ] B. SURFACE WATER CONTAMINATION — 02 [ ] OBSERVED (DATE: ____) — [ ] POTENTIAL — [ ] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ____ — 04 NARRATIVE DESCRIPTION

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: 11-19-86) — [ ] POTENTIAL — [ ] ALLEGED
03 AREA POTENTIALLY AFFECTED: ____ (Acres) — 04 NARRATIVE DESCRIPTION

Up to 11ppm PCBs measured in surface soil

01 [X] G. DRINKING WATER CONTAMINATION — 02 [ ] OBSERVED (DATE: ____) — [X] POTENTIAL — [ ] ALLEGED
03 POPULATION POTENTIALLY AFFECTED: ____ — 04 NARRATIVE DESCRIPTION

Several drinking water wells are located near the site--about 2500 people within 3 miles of the site using ground water

01 [X] H. WORKER EXPOSURE/INJURY — 02 [ ] OBSERVED (DATE: ____) — [X] POTENTIAL — [ ] ALLEGED
03 WORKERS POTENTIALLY AFFECTED: ____ — 04 NARRATIVE DESCRIPTION

Contact with oil, comtaminated soil, or inhalation of vapors and dusts

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

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II. HAZARDOUS CONDITIONS AND INCIDENTS *(Continued)*

01 ☐ J. DAMAGE TO FLORA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ K. DAMAGE TO FAUNA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION *(Include name(s) of species)*

01 ☐ L. CONTAMINATION OF FOOD CHAIN — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ M. UNSTABLE CONTAINMENT OF WASTES *(Spills/Runoff/Standing liquids, Leaking drums)* — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION

01 ☐ N. DAMAGE TO OFFSITE PROPERTY — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ O. CONTAMINATION OF SEWERS, STORM DRAINS, WWTPs — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ P. ILLEGAL/UNAUTHORIZED DUMPING — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS

III. TOTAL POPULATION POTENTIALLY AFFECTED: _____

IV. COMMENTS

As previously cited

V. SOURCES OF INFORMATION *(Cite specific references, e.g., state files, sample analysis, reports)*

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION
PART 4 - PERMIT AND DESCRIPTIVE INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981478480

II. PERMIT INFORMATION

01 TYPE OF PERMIT ISSUED (Check all that apply)	02 PERMIT NUMBER	03 DATE ISSUED	04 EXPIRATION DATE	05 COMMENTS
☐ A. NPDES				
☐ B. UIC				
☐ C. AIR				
☐ D. RCRA				
☐ E. RCRA INTERIM STATUS				
☐ F. SPCC PLAN				
☐ G. STATE (Specify)				
☐ H. LOCAL (Specify)				
☐ I. OTHER (Specify)				
☒ J. NONE				

III. SITE DESCRIPTION

01 STORAGE/DISPOSAL (Check all that apply)	02 AMOUNT	03 UNIT OF MEASURE
☐ A. SURFACE IMPOUNDMENT		
☐ B. PILES		
☐ C. DRUMS, ABOVE GROUND		
☐ D. TANK, ABOVE GROUND		
☐ E. TANK, BELOW GROUND		
☐ F. LANDFILL		
☐ G. LANDFARM		
☐ H. OPEN DUMP		
☐ I. OTHER (Specify)		

04 TREATMENT (Check all that apply)

- ☐ A. INCENERATION
- ☐ B. UNDERGROUND INJECTION
- ☐ C. CHEMICAL/PHYSICAL
- ☐ D. BIOLOGICAL
- ☐ E. WASTE OIL PROCESSING
- ☐ F. SOLVENT RECOVERY
- ☐ G. OTHER RECYCLING/RECOVERY
- ☐ H. OTHER (Specify)

05 OTHER

- ☒ A. BUILDINGS ON SITE

06 AREA OF SITE: 115 (Acres)

07 COMMENTS

Site is used to store and service transformers and capacitors. Soil contamination has resulted from past leaks, spills, or surface application of PCB containing oils.

IV. CONTAINMENT

01 CONTAINMENT OF WASTES (Check one)

☐ A. ADEQUATE, SECURE ☒ B. MODERATE ☐ C. INADEQUATE, POOR ☐ D. INSECURE, UNSOUND, DANGEROUS

02 DESCRIPTION OF DRUMS, DIKING, LINERS, BARRIERS, ETC.

None.

V. ACCESSIBILITY

01 WASTE EASILY ACCESSIBLE: ☐ YES ☒ NO

02 COMMENTS

Property is fenced.

VI. SOURCES OF INFORMATION (Cite specific references, e.g. state files, sample analysis, reports)

As previously cited.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981478480

II. DRINKING WATER SUPPLY

01 TYPE OF DRINKING SUPPLY (Check as applicable)

	SURFACE	WELL
COMMUNITY	A. ☒	B. ☒
NON-COMMUNITY	C. ☐	D. ☒

02 STATUS

ENDANGERED	AFFECTED	MONITORED
A. ☐	B. ☐	C. ☐
D. ☒	E. ☐	F. ☐

03 DISTANCE TO SITE

A. 1.2 (mi)
B. 0 (mi)

III. GROUNDWATER

01 GROUNDWATER USE IN VICINITY (Check one)

☐ A. ONLY SOURCE FOR DRINKING
☒ B. DRINKING (Other sources available)
COMMERCIAL, INDUSTRIAL, IRRIGATION (No other water sources available)
☐ C. COMMERCIAL, INDUSTRIAL, IRRIGATION (Limited other sources available)
☐ D. NOT USED, UNUSEABLE

02 POPULATION SERVED BY GROUND WATER 2500

03 DISTANCE TO NEAREST DRINKING WATER WELL ~0.02 (mi)

04 DEPTH TO GROUNDWATER	05 DIRECTION OF GROUNDWATER FLOW	06 DEPTH TO AQUIFER OF CONCERN	07 POTENTIAL YIELD OF AQUIFER	08 SOLE SOURCE AQUIFER
16 (ft)	SE	16 (ft)	(gpd)	☒ YES ☐ NO

09 DESCRIPTION OF WELLS (Including usage, depth, and location relative to population and buildings)

Shallow wells (35 to 100 ft deep) located across the street from the site which serve single family homes. On-site well no longer used: depth 250 ft., water level 16 ft, located north of transformer storage area.

10 RECHARGE AREA		11 DISCHARGE AREA	
☒ YES ☐ NO	COMMENTS: Interstream area	☐ YES ☐ NO	COMMENTS

IV. SURFACE WATER

01 SURFACE WATER USE (Check one)

☐ A. RESERVOIR, RECREATION DRINKING WATER SOURCE
☐ B. IRRIGATION, ECONOMICALLY IMPORTANT RESOURCES
☐ C. COMMERCIAL, INDUSTRIAL
☒ D. NOT CURRENTLY USED

02 AFFECTED/POTENTIALLY AFFECTED BODIES OF WATER

NAME:	AFFECTED	DISTANCE TO SITE
Paw Creek	☐	0.5 (mi)
	☐	(mi)
	☐	(mi)

V. DEMOGRAPHIC AND PROPERTY INFORMATION

01 TOTAL POPULATION WITHIN

ONE (1) MILE OF SITE	TWO (2) MILES OF SITE	THREE (3) MILES OF SITE
A. 2000-7000 NO. OF PERSONS	B. 9600-28000 NO. OF PERSONS	C. 21600-63600 NO. OF PERSONS

02 DISTANCE TO NEAREST POPULATION 0.02 (mi)

03 NUMBER OF BUILDINGS WITHIN TWO (2) MILES OF SITE 1000+

04 DISTANCE TO NEAREST OFF-SITE BUILDING 0.02 (mi)

05 POPULATION WITHIN VICINITY OF SITE (Provide narrative description of nature of population within vicinity of site, e.g., rural, village, densely populated urban area)

Population is largely urban with approximately 65% of the area within three miles of the site inside the Charlotte city limits. The remaining 35% is suburban with some rural residential areas.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

VI. ENVIRONMENTAL INFORMATION

01 PERMEABILITY OF UNSATURATED ZONE (Check one)

☐ A. $10^{-6} - 10^{-8}$ cm/sec ☐ B. $10^{-4} - 10^{-6}$ cm/sec ☒ C. $10^{-4} - 10^{-3}$ cm/sec ☐ D. GREATER THAN 10^{-3} cm/sec

02 PERMEABILITY OF BEDROCK (Check one)

☐ A. IMPERMEABLE (Less than 10^{-6} cm/sec) ☐ B. RELATIVELY IMPERMEABLE ($10^{-4} - 10^{-6}$ cm/sec) ☒ C. RELATIVELY PERMEABLE ($10^{-2} - 10^{-4}$ cm/sec) ☐ D. VERY PERMEABLE (Greater than 10^{-2} cm/sec)

03 DEPTH TO BEDROCK	04 DEPTH OF CONTAMINATED SOIL ZONE	05 SOIL pH
~40 (ft)	<1 (ft)	4.5-5.5

06 NET PRECIPITATION	07 ONE YEAR 24 HOUR RAINFALL	08 SLOPE: SITE SLOPE	DIRECTION OF SITE SLOPE	TERRAIN AVERAGE SLOPE
5 (in)	<3 (in)	<3 %	SSE	5 %

09 FLOOD POTENTIAL

SITE IS IN _____ YEAR FLOODPLAIN

10 ☐ SITE IS ON BARRIER ISLAND, COASTAL HIGH HAZARD AREA, RIVERINE FLOODWAY

11 DISTANCE TO WETLANDS (5 acre minimum)

ESTUARINE: A. _____ (mi) OTHER: B. _____ (mi)

12 DISTANCE TO CRITICAL HABITAT (of endangered species)

_____ (mi)

ENDANGERED SPECIES: None identified.

13 LAND USE IN VICINITY

DISTANCE TO:

COMMERCIAL/INDUSTRIAL	RESIDENTIAL AREAS; NATIONAL/STATE PARKS, FORESTS, OR WILDLIFE RESERVES	AGRICULTURAL LANDS: PRIME AG LAND	AGRICULTURAL LANDS: AG LAND
A. 0 (mi)	B. 0.02 (mi)	C. _____ (mi)	D. 3 (mi)

14 DESCRIPTION OF SITE IN RELATION TO SURROUNDING TOPOGRAPHY

The site has been graded flat. Areas east and north of the site are higher; areas south and west are lower.

VII. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

1. As previously cited.
2. Clay et al. 1975. North Carolina Atlas: Portrait of a Changing Southern State.
3. USGS & NC NRCD. 1980. Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina.
4. Soil Survey of Mecklenburg County. 1977. Soil Conservation Service.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 6 - SAMPLE AND FIELD INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II. SAMPLES TAKEN

SAMPLE TYPE	01 NUMBER OF SAMPLES TAKEN	02 SAMPLES SENT TO	03 ESTIMATED DATE RESULTS AVAILABLE
GROUNDWATER	3	NC Laboratory of Public Health	1-87
SURFACE WATER			
WASTE			
AIR			
RUNOFF			
SPILL			
SOIL	24	NC Laboratory of Public Health	1-87
VEGETATION			
OTHER			

III. FIELD MEASUREMENTS TAKEN

01 TYPE	02 COMMENTS
pH	
water temperature	
water level	

IV. PHOTOGRAPHS AND MAPS

01 TYPE ☒ GROUND ☐ AERIAL

02 IN CUSTODY OF NC CERCLA Unit, Solid and Haz. Waste Mgmt. Branch
(Name of organization or individual)

03 MAPS ☒ YES ☐ NO

04 LOCATION OF MAPS Included with report.

V. OTHER FIELD DATA COLLECTED (Provide narrative description)

VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

1. Permanent files, NC Solid and Hazardous Waste Mgmt. Branch, CERCLA Unit, Raleigh, NC.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 7 - OWNER INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II. CURRENT OWNER(S)

01 NAME	02 D+B NUMBER	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	05 CITY	06 STATE	07 ZIP CODE
Duke Power Co.		P.O. Box 33189		Charlotte	NC	28242

PARENT COMPANY (If applicable)

08 NAME	09 D+B NUMBER	10 STREET ADDRESS (P.O. Box, RFD #, etc.)	11 SIC CODE	12 CITY	13 STATE	14 ZIP CODE

III. PREVIOUS OWNER(S) (List most recent first)

01 NAME	02 D+B NUMBER	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	05 CITY	06 STATE	07 ZIP CODE

IV. REALTY OWNER(S) (If applicable; list most recent first)

01 NAME	02 D+B NUMBER	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	05 CITY	06 STATE	07 ZIP CODE

V. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

As previously cited.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 8 - OPERATOR INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II. CURRENT OPERATOR (Provide if different from owner)			OPERATOR'S PARENT COMPANY (If applicable)		
01 NAME: Toddville Operations Center		02 D+B NUMBER	10 NAME: Duke Power Co.		11 D+B NUMBER
03 STREET ADDRESS (P.O. Box, RFD #, etc.): 610 Toddville Road		04 SIC CODE	12 STREET ADDRESS (P.O. Box, RFD #, etc.): P.O. Box 33189		13 SIC CODE
05 CITY: Charlotte	06 STATE: NC	07 ZIP CODE: 28242	14 CITY: Charlotte	15 STATE: NC	16 ZIP CODE: 28242
08 YEARS OF OPERATION	09 NAME OF OWNER				

III. PREVIOUS OPERATOR(S) (List most recent first; provide only if different from owner)			PREVIOUS OPERATORS' PARENT COMPANIES (If applicable)		
01 NAME		02 D+B NUMBER	10 NAME		11 D+B NUMBER
03 STREET ADDRESS (P.O. Box, RFD #, etc.)		04 SIC CODE	12 STREET ADDRESS (P.O. Box, RFD #, etc.)		13 SIC CODE
05 CITY	06 STATE	07 ZIP CODE	14 CITY	15 STATE	16 ZIP CODE
08 YEARS OF OPERATION	09 NAME OF OWNER DURING THIS PERIOD				
01 NAME		02 D+B NUMBER	10 NAME		11 D+B NUMBER
03 STREET ADDRESS (P.O. Box, RFD #, etc.)		04 SIC CODE	12 STREET ADDRESS (P.O. Box, RFD #, etc.)		13 SIC CODE
05 CITY	06 STATE	07 ZIP CODE	14 CITY	15 STATE	16 ZIP CODE
08 YEARS OF OPERATION	09 NAME OF OWNER DURING THIS PERIOD				
01 NAME		02 D+B NUMBER	10 NAME		11 D+B NUMBER
03 STREET ADDRESS (P.O. Box, RFD #, etc.)		04 SIC CODE	12 STREET ADDRESS (P.O. Box, RFD #, etc.)		13 SIC CODE
05 CITY	06 STATE	07 ZIP CODE	14 CITY	15 STATE	16 ZIP CODE
08 YEARS OF OPERATION	09 NAME OF OWNER DURING THIS PERIOD				

IV. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

As previously cited.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 9 - GENERATOR/TRANSPORTER INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II. ON-SITE GENERATOR

01 NAME	02 D+B NUMBER	
03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	
05 CITY	06 STATE / 07 ZIP CODE	

III. OFF-SITE GENERATOR(S)

01 NAME	02 D+B NUMBER	01 NAME	02 D+B NUMBER
03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE
05 CITY	06 STATE / 07 ZIP CODE	05 CITY	06 STATE / 07 ZIP CODE
01 NAME	02 D+B NUMBER	01 NAME	02 D+B NUMBER
03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE
05 CITY	06 STATE / 07 ZIP CODE	05 CITY	06 STATE / 07 ZIP CODE

IV. TRANSPORTER(S)

01 NAME	02 D+B NUMBER	01 NAME	02 D+B NUMBER
03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE
05 CITY	06 STATE / 07 ZIP CODE	05 CITY	06 STATE / 07 ZIP CODE
01 NAME	02 D+B NUMBER	01 NAME	02 D+B NUMBER
03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE
05 CITY	06 STATE / 07 ZIP CODE	05 CITY	06 STATE / 07 ZIP CODE

V. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 10 - PAST RESPONSE ACTIVITIES

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II. PAST RESPONSE ACTIVITIES

01 ☐ A. WATER SUPPLY CLOSED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ B. TEMPORARY WATER SUPPLY PROVIDED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ C. PERMANENT WATER SUPPLY PROVIDED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ D. SPILLED MATERIAL REMOVED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ E. CONTAMINATED SOIL REMOVED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ F. WASTE REPACKAGED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ G. WASTE DISPOSED ELSEWHERE — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ H. ON SITE BURIAL — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ I. IN SITU CHEMICAL TREATMENT — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ J. IN SITU BIOLOGICAL TREATMENT — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ K. IN SITU PHYSICAL TREATMENT — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ L. ENCAPSULATION — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ M. EMERGENCY WASTE TREATMENT — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ N. CUTOFF WALLS — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ O. EMERGENCY DIKING/SURFACE WATER DIVERSION — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ P. CUTOFF TRENCHES/SUMP — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ Q. SUBSURFACE CUTOFF WALL — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 10 - PAST RESPONSE ACTIVITIES

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II PAST RESPONSE ACTIVITIES *(Continued)*

01 ☐ R. BARRIER WALLS CONSTRUCTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ S. CAPPING/COVERING — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ T. BULK TANKAGE REPAIRED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ U. GROUT CURTAIN CONSTRUCTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ V. BOTTOM SEALED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ W. GAS CONTROL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ X. FIRE CONTROL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ Y. LEACHATE TREATMENT — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ Z. AREA EVACUATED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ 1. ACCESS TO SITE RESTRICTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ 2. POPULATION RELOCATED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ 3. OTHER REMEDIAL ACTIVITIES — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

III. SOURCES OF INFORMATION *(Cite specific references, e.g., state files, sample analysis, reports)*

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 11 - ENFORCEMENT INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D981478480

II. ENFORCEMENT INFORMATION

01 PAST REGULATORY/ENFORCEMENT ACTION ☐ YES ☒ NO

02 DESCRIPTION OF FEDERAL, STATE, LOCAL REGULATORY/ENFORCEMENT ACTION

III. SOURCES OF INFORMATION *(Cite specific references, e.g., state files, sample analysis, reports)*

Appendix E

Site Safety Plan

SITE SAFETY PLAN

A. GENERAL INFORMATION

Site Name Toddville Operations Center Site Number NC D981478480

Location 610 Toddville Road Date 9/29/86

Charlotte, NC

Purpose of Visit ____ PA X SI ____ Other

Proposed Date of Inspection 11/19/86

Date of Briefing 11/18/86

Priority Ranking ____ Low X Medium ____ High

Site Investigation Team

Personnel	Responsibilities
Stan Atwood	Sampling
Jack Butler	Sampling
Cheryl McMorris	Sampling

PLAN PREPARATION:

Prepared By Mary Figueroa CIH

Approved By Lee Crosby

B. SITE/WASTE CHARACTERISTICS

Waste Type(s) X Liquid ____ Solid ____ Sludge ____ Gas

Characteristics ____ Corrosive ____ Ignitable ____ Radioactive
____ Volatile X Toxic ____ Reactive ____ Other

List Known or Suspected Hazards (physical,chemical biological or radioactive) on Site and their toxicological effects. Also, if known, list chemical amounts

HAZARD	EFFECT(S)
PCB's	mild hydrocarbon odor, irritating to eyes and skin, see attached sheets for more information

Facility Description: Size 115 acres Buildings 1 warehouse

Disposal Methods Being Investigated surface contamination

Unusual Features on Site (dike integrity, power lines, terrain etc.):

History of the Site: For approx. 30 years this site has been used by Duke Power. An area of several acres has been used to store capacitors and transformers. In the past the capacitors and transformers were reported to contain fluid with high concentrations of PCB's. There is no record of burial on this site.

C. HAZARD EVALUATION

Sampling is to include well samples, surface and subsurface soil samples and surface run-off water. The wells will be uncapped by Duke Power personnel. All sampling on this site can be done in Level D. Skin and clothing protection will be worn when collecting soil and surface water samples. Goggles will also be worn for any sample collected where acid is used as a preservative.

D. WORK PLAN INSTRUCTION

Map or Sketch Attached? No
Perimeter Identified? No
Command Post Identified? No
Zones of Contamination Identified? No

Personal Protective Equipment

Level of Protection ____A ____B ____C X D

Modifications Protection for skin and clothing while collecting soil and surface water samples: saranex tyvek, boots, PE gloves.

Surveillance Equipment:

_____ H Nu
_____ Explosimeter
_____ TLD
_____ Detector Tubes and Pumps
_____ O2 Meter
_____ (Radiation Monitor)

Decontamination Procedures

_____ Level A Segregated equipment drop, boot cover and glove wash, boot cover and glove rinse, tape removal, suit and hard hat removal, SCBA backpack removal, inner glove wash, inner glove removal, inner clothing removal, field wash, redress

_____ Level B Segregated equipment drop, boot cover and glove wash,boot cover and glove rinse, tape removal. boot cover removal outer glove removal, suit/safety removal, SCBA backpack removal, inner glove wash, inner glove rinse, facepiece removal, inner glove removal, inner clothing removal, field wash, redress.

_____ Level C Segregated equipment drop, boot cover and glove wash, boot cover and glove rinse, tape removal, boot cover removal, outer glove removal,suit/safety boot wash, suit/safety boot rinse (Canister or Mask Change), safety boot removal, splash suit removal, inner glove wash, inner glove rinse, facepiece removal, inner glove removal, inner clothing removal. field wash redress.

__X__ Level D Segregated equipment drop. boot and glove wash, boot and glove rinse.

Modifications dispose of trash on site if possible.

Work Schedule/ Limitations Auger sampling should be done in teams of two.

EMERGENCY PRECAUTIONS

Acute Exposure Symptoms	First Aid
eyes	flush with water
skin	soap and water wash
inhalation	fresh air and artificial resp.
ingestion	medical attention

Hospital (Address and Phone Number)

Mercy Hospital (704) 379-5827

2001 Vail Avenue, Charlotte, NC

Emergency Transportation Systems (Phone Numbers)

Fire use 911

Ambulance use 911

Rescue Squad use 911

Emergency Route to Hospital Take Toddville Rd. back to Hwy. 27. Take Hwy. 27 into Charlotte. Freedom Dr. & Independence Blvd. come together (called Independence Blvd.). Take the east Morehead St. exit ((Hwy. 521). Take a left onto Queen's Road, this becomes Hawthorne. Take a right onto 5th St. Hospital will be on the right. SEE ATTACHED MAP.

PREVAILING WEATHER CONDITIONS AND FORECAST Partly cloudy with highs in the 60's and lows in the 40's.

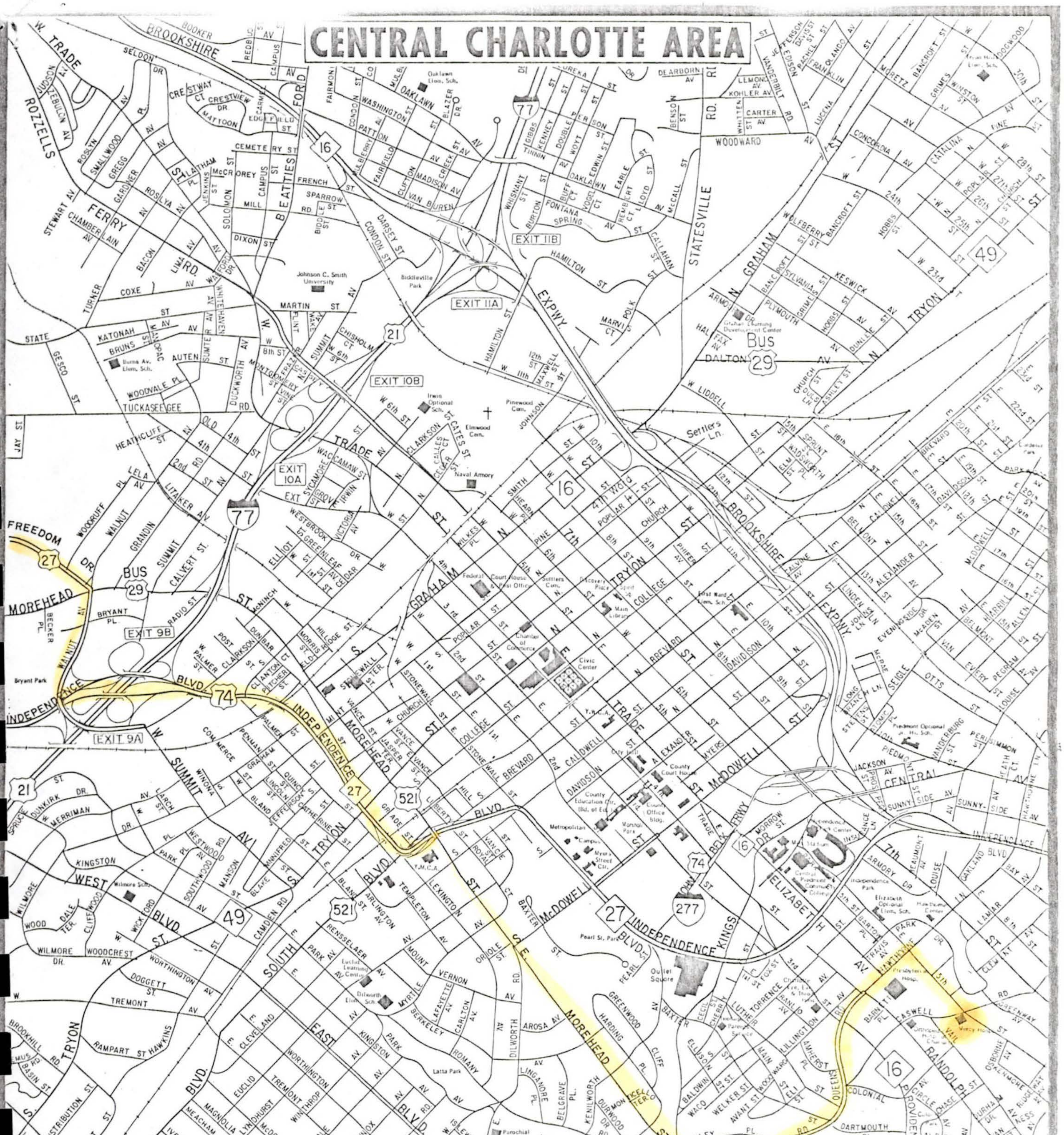
EQUIPMENT CHECKLIST

	Air purifying respirator	X	First Aid Kit
	Cartridges for respirator	X	3 gal. Distilled H2O
	3M 8710 Respirator	X	Personal Protective Clothing
	02 Indicator		
	Detector Tube & Pump	X	Boots or Boot Covers
X	Eye Wash Unit	X	Coveralls (tyvek)
	H Nu	X	Eye Protection
	pH Meter		Hard Hat
	Explosimeter		Decontamination Materials.
	Radioactive Monitor		

Poison Control Center - State Coordinator

Duke University Medical Center
Telephone: 1-800-672-1697
Box 3024
Durham, NC 27710

ASHEVILLE 704-255-4490	Western NC Poison Control Center Memorial Mission Hosp. 509 Biltmore Ave. 28801	HENDERSONVILLE 704-693-6522 Ext. 555, 556	Margaret R. Pardee Memorial Hospital Fleming St., 28739
CHARLOTTE 704-379-5827	Mercy Hospital 2001 Vail Ave, 28207	HICKORY 704-322-6649	Catawba Mem. Hosp. Fairgrove Chur. Rd 28601
DURHAM 1-800-672-1697	Duke Univ Medical Center Box 3007, 27710	JACKSONVILLE 919-577-2555	Onslow Mem. Hospital Western Blvd. 28540
GREENSBORO	Moses Cone Hospital	WILMINGTON	New Hanover Mem. Hospital



CENTRAL CHARLOTTE AREA
W. TRADE
BROOKSHIRE
ROZZELLS FERRY
BEATTIES FORD
STATESVILLE
N. GRAHAM
N. TRYON
Johnson C. Smith University
EXIT 11A
EXIT 11B
EXIT 10B
EXIT 10A
EXIT 9B
EXIT 9A
Irwin Optional Sch.
Elmwood Cem.
Pinewood Cem.
Naval Armory
FREEDOM DR
MOREHEAD
BUS 29
Bryant Park
INDEPENDENCE BLVD.
W. TRADE
N. TRYON
Federal Court House & Post Office
Settlers Cem.
Main Library
Chamber of Commerce
Civic Center
County Court House
McDOWELL
ELIZABETH
KINGS
CENTRAL AV
WEST BLVD.
WILMORE
SOUTH BLVD.
EAST BLVD.
DILWORTH RD.
Latta Park
Pearl St. Park
Outlet Square
QUEENS RD
PROVIDENCE RD
RANDOLPH
HAWTHORNE
Presbyterian Hosp.
Mercy Hosp.
Charlotte Mem. Hospital & Rehab. Ctr.
Edgehill Park
EDGEHILL RD. N
1000 0 1000 2000
Approximate SCALE OF FEET

I. CHEMICAL IDENTITY

Common name: Chlorodiphenyl (42% chlorine)
Formula: $C_{12}H_5Cl_5$ (approximately)
Synonyms: Polychlorinated biphenyls PCB
CAS No: 1336-36-3
Carcinogen: IARC animal positive

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: EPA
DOT Hazard Class: ORM-E

III. PHYSICAL CHARACTERISTICS

Boiling point: 325-366 C (617-691 F)
Specific gravity: 1.38
Vapor density: At boiling point, 8.9
Melting point: −19 C (−2 F)
Vapor pressure: at 20 C, 0.001 mm Hg
Solubility in water: at 20 C, insoluble
Evaporation rate: Much less than 1
Appearance and odor: Colorless to dark liquid with a mild hydrocarbon odor.

IV. PHYSICAL HAZARDS

Flash point: 176 C (349 F)
Autoignition temperature: None to boiling point
Flammable limits in air (% by vol.): Data not available.
Extinguishants: Foam, dry chemical, carbon dioxide.

V. HEALTH HAZARDS

Irritation of the eyes, nose, and throat, and an acne-like rash. May also injure liver. Repeated skin contact may cause skin irritation. Has caused liver tumors and adverse reproductive effects in experimental animals.

VI. EMERGENCY FIRST AID

Eyes: Wash with large amounts of water, lifting the lids occasionally. Get medical attention as soon as possible. Do not wear contacts when working with the substance.
Skin: Wash with soap or mild detergent. Remove contaminated clothing. If there is skin irritation, get medical attention.
Breathing: Move patient to fresh air. Perform artificial respiration if needed. Keep patient warm and at rest. Get medical attention as soon as possible.

Swallowing: Get medical attention immediately. If not available, induce vomiting mechanically with finger or by giving syrup of ipecac.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 1 mg/m^3
ACGIH STEL: 2 mg/m^3
IDLH: 10 mg/m^3

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: Heat.
Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
Hazardous decomposition products: Toxic gases (such as hydrogen chloride and carbon monoxide) may be released in a fire.
Special precautions: Will attack some forms of plastics, rubber, and coatings.

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Persons not wearing protective equipment and clothing should stay out of spill area. Remove all ignition sources. Ventilate area. Reclaim or collect by absorbing in vermiculite, dry sand, earth, or a similar material.

X. PROTECTIVE EQUIPMENT

Impervious clothing, gloves, face shields (eight-inch minimum) to prevent prolonged or repeated skin contact. Contaminated clothing should be removed and not reworn until cleaned. Splash-proof safety goggles where there is danger of eye contact.

Respirators–

$<$10 mg/m^3: SAF; SCBAF
$>$10 mg/m^3: SCBAF:PD, PP; comb SAF:PD, PP,CF w/SCBA:PD, PP
Fire fighting: SCBAF:PD, PP
Escape: Any gas mask providing protection against pesticides; escape SCBA.

I. CHEMICA
Common na
Formula: C
Synonyms: F
CAS No.: 13
Carcinogen:

II. REGULAT
Hazardous s
Hazardous w
DOT Hazard

III. PHYSICA
Boiling point
Specific gravi
Vapor densit
Melting poin
Vapor pressu
Solubility in
Evaporation
Appearance
hydrocarbo

IV. PHYSICA
Flash point: 2
Autoignition
Flammable li
Extinguishan

V. HEALTH H
Irritation of t
also injure

VI. EMERGEN
Eyes: Wash
ly. Get m
contacts wh
Skin: Wash
clothing. If
Breathing: M
if needed.
as soon as

I. CHEMICAL IDENTITY

Common name: Chlorodiphenyl (54% chlorine)
Formula: $C_{12}H_5Cl_5$ (approximately)
Synonyms: Polychlorinated biphenyl; PCB
CAS No.: 1336-36-3
Carcinogen: IARC animal positive

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: EPA
DOT Hazard Class: ORM-E

III. PHYSICAL CHARACTERISTICS

Boiling point: 365-390 C (689-734 F)
Specific gravity: 1.5
Vapor density: At boiling point, 11.2
Melting point: 10 C (50 F) (pour point)
Vapor pressure: at 20 C, 0.00006 mm Hg
Solubility in water: at 20 C, insoluble
Evaporation rate: Much less than 1
Appearance and odor: Pale yellow viscous liquid with a mild hydrocarbon odor.

IV. PHYSICAL HAZARDS

Flash point: 222 C (432 F)
Autoignition temperature: None to boiling point
Flammable limits in air (% by vol.): Data not available
Extinguishants: Foam, dry chemical, carbon dioxide.

V. HEALTH HAZARDS

Irritation of the eyes, nose, and throat, and an acne-like rash. May also injure liver. Repeated skin contact may cause skin irritation.

VI. EMERGENCY FIRST AID

Eyes: Wash with large amounts of water, lifting the lids occasionally. Get medical attention as soon as possible. Do not wear contacts when working with the substance.
Skin: Wash with soap or mild detergent. Remove contaminated clothing. If there is skin irritation, get medical attention.
Breathing: Move patient to fresh air. Perform artificial respiration if needed. Keep patient warm and at rest. Get medical attention as soon as possible.

Swallowing: Get medical attention immediately. If not available, induce vomiting mechanically with finger or by giving syrup of ipecac.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 0.5 mg/m^3
ACGIH STEL: 1.0 mg/m^3
IDLH: 5 mg/m^3

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: Heat.
Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
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Special precautions: Will attack some forms of plastics, rubber, and coatings.

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Persons not wearing protective equipment and clothing should stay out of spill area. Remove all ignition sources. Ventilate area. Reclaim or collect by absorbing in vermiculite, dry sand, earth, or a similar material.

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Respirators–

<5 mg/m^3: SAF; SCBAF
>5 mg/m^3: SCBAF:PD, PP; comb SAF:PD, PP,CF w/SCBA:PD, PP
Fire fighting: SCBAF:PD, PP
Escape: Any gas mask providing protection against pesticides; escape SCBA.