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600SERBSF10,635

Site Name (Subject):	ULAH BATTERY/BATTERY PILES
Site ID (Document ID):	NCD981864614
Document Name (DocType):	Preliminary Assessment/Site Inspection (PA/SI)
Report Segment:	
Description:	Site Inspection Report
Date of Document:	5/12/1987
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Access Level:	PUBLIC
Division:	WASTE MANAGEMENT
Section:	SUPERFUND
Program (Document Group):	SERB (SERB)
Document Category:	FACILITY

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

SITE INSPECTION REPORT

Ulah Battery Lead Reclaiming
NC D981864614
Route 7
Asheboro, NC 27203

CERCLA

12 May 1987

By

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

EXECUTIVE SUMMARY

The Ulah Battery Lead Reclaiming site is located in a rural residential section about two miles south of Asheboro, NC. Automotive batteries were broken on site from about 1965 until 1981. Battery acid was spilled on the ground; recovered lead was melted; and battery casings were burned, used as driveway fill, or piled up. There are presently two large piles of battery casings on site with an estimated combined volume of 1400 yd^3. One of these waste piles is directly behind a home. All residents use wells.

Samples collected in 1981 and 1986 show high lead concentrations in the soil (up to 14%). Ground water and surface water samples collected on 29 January 1987 during a CERCLA site investigation were not contaminated. Blood samples were also collected from several children at the site in 1986. One child was found to have Class III lead poisoning (blood lead 40-50 ug/dl, low 20's normal; erythrocyte protoporphyrin level 140-150 ug/dl, 35 normal). This child is receiving treatment and no longer lives at the site.

BACKGROUND

Location

Ulah Battery Lead Reclaiming is located in Randolph County about two miles south of Asheboro in the Ulah community. The address is Route 7, Asheboro, NC 27203 and the coordinates are: latitude 35° 38' 20", longitude 79° 49' 45".

Site Layout

The site occupies 20 to 25 acres of residential and undeveloped land. The locations of buildings, wells, processing areas, disposal areas, drainage paths, and surface waters are shown in figure 1. Access is from Business 220, which borders the site on the east. The head waters of Little River form the western border. Woodland and old fields border on the north and south.

Ownership History

Because the site includes most of a residential area, ownership would likely be shared by the residents. One of the battery casing disposal areas is located on the property of Glen Hoskins. Elbert and Daisy Caviness probably own the largest share of the property. The principle operators included Glen Hoskins, Marvin Caviness, and Elbert Caviness (1,2,3,4).

Site Use History

Lead was reclaimed from used automobile batteries at the site for approximately 16 years between 1965 and 1981 (1,3). Lead was melted in drums and broken battery casings were used to pave driveways or were accumulated in waste piles. Battery acid was allowed to spill onto the ground (4,5).

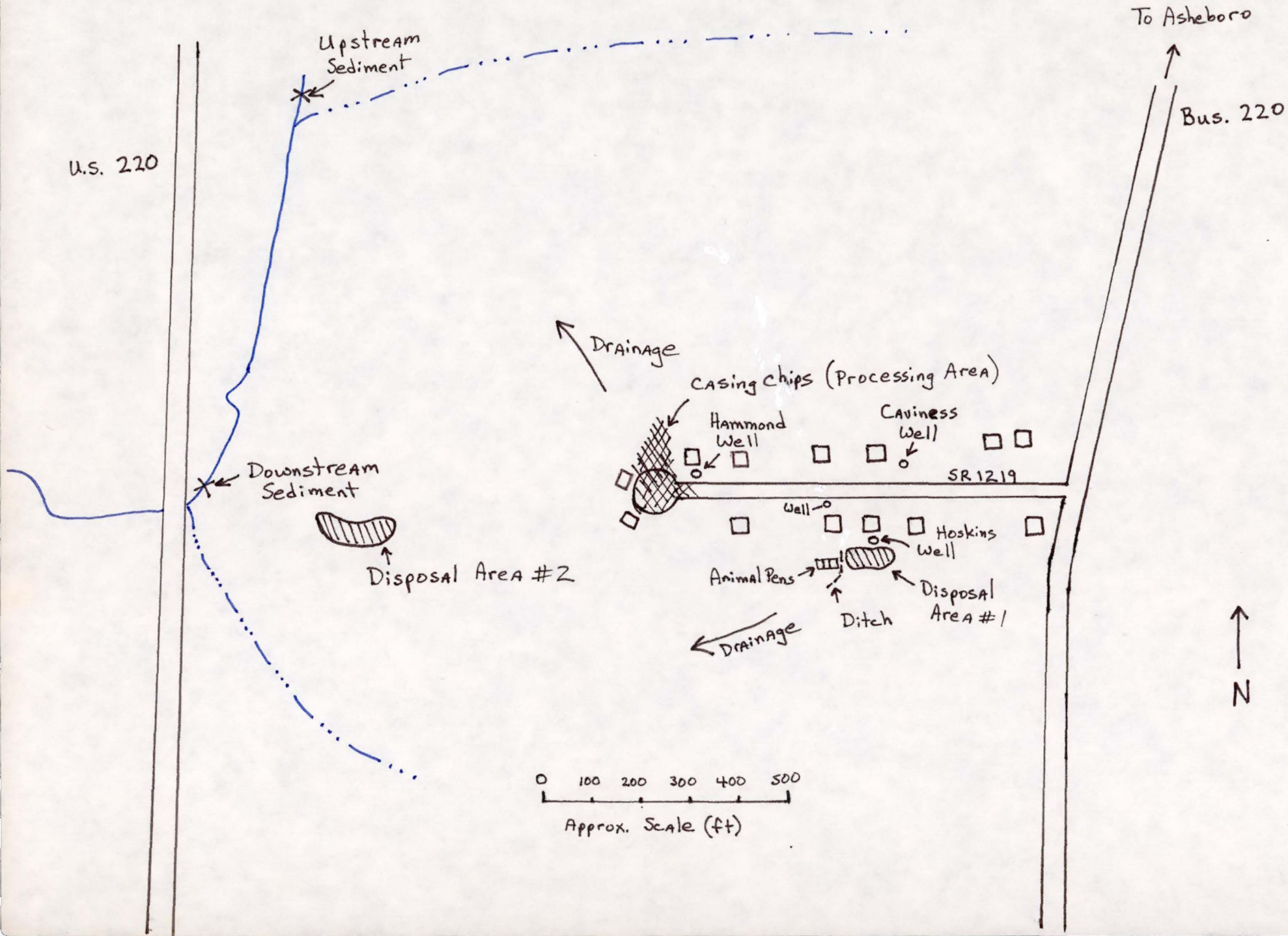
Permit and Regulatory History

None identified.

Remedial Actions to Date

None identified.

Figure 1. Site layout: Ulah Battery Lead Reclaiming.



Summary Trip Report

On 29 January 1987 a CERCLA site investigation was conducted at this site by Stan Atwood and Jack Butler. The County Health Department was contacted prior to the visit and a meeting was arranged for 10:00 a.m. on the 29th. Arrangements were also made to pick up a copy of the Asheboro water distribution map at the city water department.

The water distribution map was picked up at 9:30 a.m. We then met with Jim Martin, Sanitarian Supervisor; J.D. Smith, Sanitarian; Galenda Sandlin, County Nurse; and Yvonne Chilcoat, Director Public Health Division; at the Health Department. We briefly discussed the site history and the sampling plans before driving to the site at 10:30.

Figure 1 is a sketch of the site layout and sampling locations. A pile of battery casings (approx. 100 ft. x 30 ft. x 15 ft.) is located within 20 ft. of the nearest well. There is a small drainage ditch along the western edge of the pile. Livestock (chickens, turkeys, and goats) are kept in pens adjacent to the disposal area.

Two wells were sampled during the inspection (Figure 1). Conductivity and pH readings for the Hammond well were 73.5 and 7.27. Readings for the Caviness well were 175.3 and 6.68. This well was reported to be about 150 feet deep. We were unable to sample the well nearest the disposal area, however, it will be sampled by Randolph County Health Department personnel.

We then drove to the stream draining the site. Upstream and downstream sediment samples were collected. An additional battery casing disposal area (measuring 150 feet long, 10 to 60 feet wide, and 3 to 10 feet deep) was discovered about 200 feet above the stream.

Photographs of the sampling points and the site in general were taken, including both disposal areas. The investigation was concluded at 12:30 p.m.

ENVIRONMENTAL SETTING

Topography

The site drops about 50 ft. in elevation toward the west and extends over 1000 ft. from near the top of a knoll. The intervening terrain between the site and the nearest surface water has an average slope of about eight percent (Topo maps - Appendix A).

Surface Waters

The site is drained by an unnamed tributary of Little River. This tributary flows about one mile before reaching Little River. Little River flows south to the Pee Dee River on the Anson-Richmond County line. Little River is a class C stream (6).

Geology and Soils

Most of Randolph County is underlain by rocks of the metavolcanic unit. This unit includes felsic to mafic tuffs and flows of volcanic origin interbedded with thin beds of argillaceous tuff and graywacke. The central part of the county south of Asheboro is underlain by the more felsic rocks of this unit. The metavolcanic unit in the vicinity of Asheboro has been intruded by gabbro dikes and sills (7).

The bedrock is overlain by saprolite which is estimated to be 30 to 40 feet thick at the site (4,8). Hydraulic conductivity of the saprolite and fractured bedrock is about 5 ft./day or about 2×10^{-3} cm/sec (8).

Ground Water

Ground water in Randolph County comes from fractured bedrock or from the overlying saprolite. These units are connected and therefore function as a single aquifer (7,8).

Ground water probably flows west from the site to an unnamed tributary of Little River. Well yields can be expected to exceed 0.1 gpm/ft. of uncased hole in the site vicinity. The water table may fluctuate as much as 10 ft. or more between highs in March or April to lows in October or November. Ground water quality in Randolph County is usually good. Iron concentrations may exceed recommended limits in some areas (7).

Climate and Meteorology (9,10)

Seasonal Temperatures:	(°F)	January	July
	Mean Max.	52	90
	Mean Min.	32	67
	Mean	42	78

Precipitation:	(inches)	
	Mean annual precipitation:	48
	Mean annual evaporation:	41
	Net annual precipitation:	7
	Mean annual snowfall:	5
	1 year 24-hour rainfall:	2.9

Storm Events:		
	Mean days/year with thunderstorms:	45
	Prevailing winds and wind speeds:	SW at 9 mph

Emissions Inventory Summary for Randolph County (Tons/yr) (11)

Type	Area Sources	Point Sources
Particulates	11,786	83
Sulfur Dioxide	627	64
Nitrogen Oxides	3,543	31
Volatile Organics & Hydrocarbons	9,203	377
Carbon Monoxide	27,791	---

Land Use

Land use in the site vicinity is predominantly undeveloped woodland with scattered residential areas and farmland (Topo Map, Appendix A).

Population Distribution

About 70% of the population of Randolph County is rural with an average population density of 116 people per square mile (11). Population estimates within three miles of the site were derived by multiplying house counts taken from USGS topographic maps by 3.8 as follows (10):

Radius	House Count	Population
one mile	218	828
two miles	678	2576
three miles	1389	5278

Water Supply

Of the above 1389 homes counted within a three mile radius of the site, only 206 are served by the Asheboro water system which draws from Back Creek Lake. It was assumed that all houses along streets with water lines were using the Asheboro system (12, Topo map - Appendix A, Asheboro City Water System Map, Appendix A). This leaves an estimated 4500 people who rely on wells as their only water source. Eight community wells were also identified within three miles of the site (13, Topo map - Appendix A). Surface waters draining the site are not used other than for watering cattle (5).

Critical Environments

There are no critical habitats within one mile of the site (14,15).

WASTE TYPES AND QUANTITIES

Waste Quantities (Photographs - Appendix A, 16,17)

Waste quantities were calculated by volume estimation of the two waste piles of battery casings on site. Previous testing of these battery casings found an average of 2580 ppm lead. Calculations were made as follows:

Waste Pile #1 (behind Hoskins home)
Approximate dimensions: length (100 ft), width (30 ft), height (15 ft)
Mid cross sectional area: 1/2 (30)(15) = 225 ft^2
Mid longitudinal section length: 90 ft.
Volume = 90 ft. x 225 ft^2 = 20,250 ft^3 or 750 yd^3

Waste Pile #2
Approximate dimensions: length (150 ft), width (10-60 ft), height (3-10 ft)
Longitudinal section area: 1/2 (150)(60) = 4500 ft^2
Average height: 4 ft.
Volume = 4500 ft^2 x 4 ft = 18,000 ft^3 or 667 yd^3

Total waste quantity = 750 + 667 = 1417 yd^3

Waste Disposal Methods and Locations (1,2,3,4,5,17)

Figure 1 shows the location of the main processing area and disposal areas. Batteries were broken on site for 15 years. Lead was melted on site; casings were burned, used as driveway fill, or piled up. Battery acid was allowed to run onto the ground. It was reported that an axe was commonly used to open batteries.

Waste Types (Appendix B, 3)

Soil samples show lead concentrations as high as 14%.

LABORATORY DATA

Summary

Well and surface water samples did not show evidence of contaminant migration (Appendix B). Surface soil lead content is summarized in Table 1; sample locations are shown in Figure 2.

Table 1. Surface soil lead content at Ulah Battery Lead Reclaiming.

Sample Number	Date	Lead (ppm)
1	7-23-86	106,811
2	7-23-86	20,906
3	7-23-86	1,246
4	7-23-86	6,787
5	7-23-86	144,184
6	7-23-86	262
7	7-23-86	4,134
1	10-3-86	126
2	10-3-86	37

One four year old child living at the site had a blood lead concentration greater than 40 ug/dl. The normal range is about 20 ug/dl (3,18).

Quality Assurance Review

All samples were collected according to established protocol. Water samples were preserved in the field and stored on ice (19).

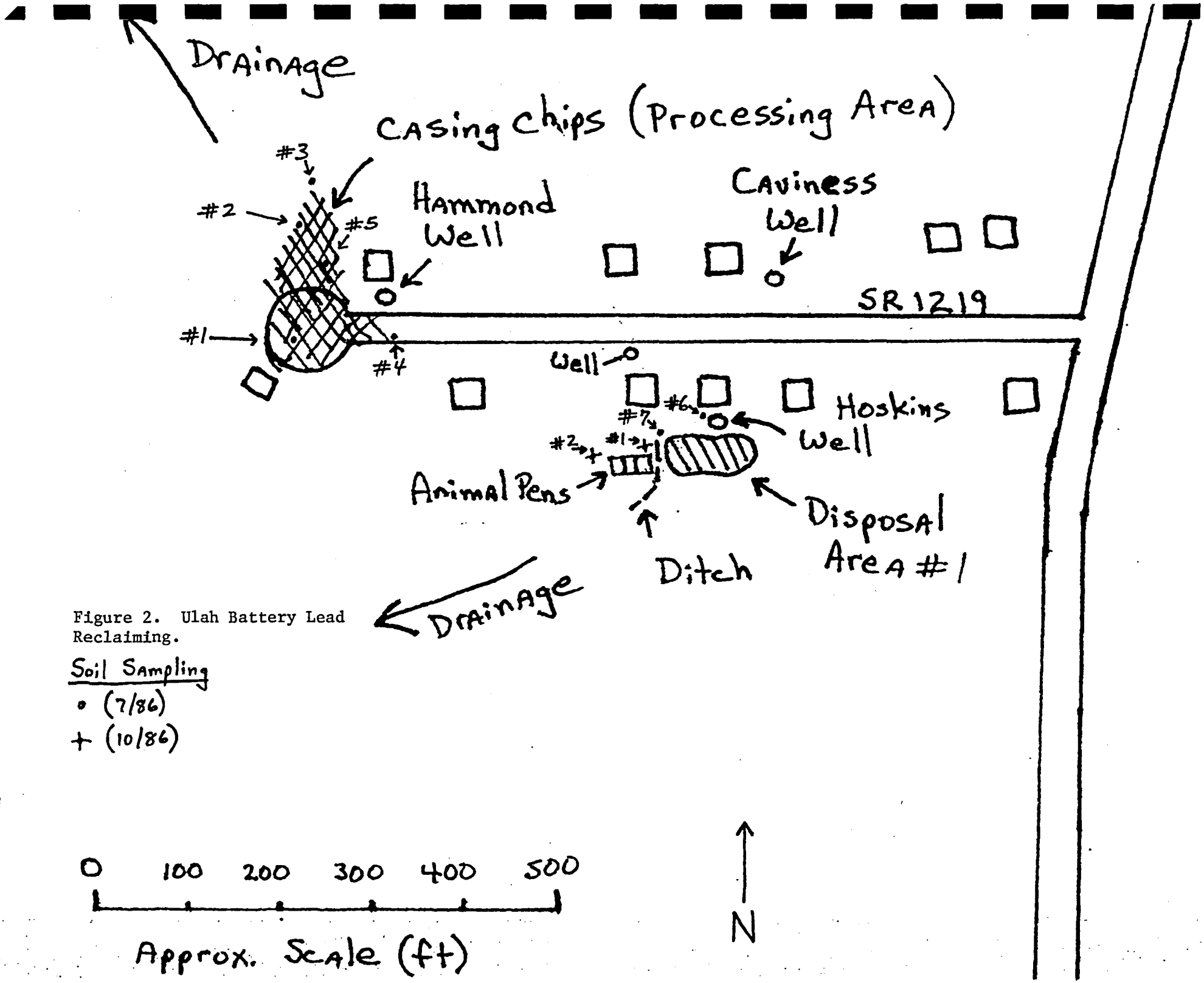


Figure 2. Ulah Battery Lead Reclaiming.

TOXICOLOGICAL/CHEMICAL CHARACTERISTICS

Lead exposure produces a number of toxic effects. The four major target organs are the central nervous system, the peripheral nervous system, the kidney, and the hematopoietic system (20). Blood lead levels (PbB) are considered to be the best indicator of total lead exposure. Table 2 summarizes PbB levels associated with increased risks for various health effects (20,21,22,23). Table 3 summarizes chemical and toxicological data for lead (21,24,25).

Table 2. Probable health effects associated with blood lead levels in adults*.

PbB (ug/dl)	Health Effect
15 - 25	Normal: non-occupationally exposed
20 - 40	Altered heme metabolism
	Peripheral Nerves
30 - 50	- Minor dysfunction
80	- Paralysis
	Central Nervous System
50	- Minor dysfunction
100	- Encephalopathy
60	Kidney damage
80	Colic

* Children are more sensitive to lead toxicity.

Table 3. Some chemical and toxicological data for lead.

Solubility	insoluble *
Melting Point	327.4°C
Boiling Point	1755°C
Vapor Pressure	1 mm @ 970°C
Acute Tox (Oral)	TD_{LO} 790 mg/kg (rat)
Toxicity/Persistence	18

* Slight solubility in water containing a weak acid.

Appendix A

Maps and Photographs

USGS Topographic Map inside back cover

Sample #1: Hammond Well

Sample #2: Caviness Well

Sample #2: Caviness Well (Hoskins house and casing pile are in the background)

Sample #5: Hoskins Well

Casing pile behind Hoskins residence

Casing pile behind Hoskins residence

Drainage ditch west side of casing pile behind Hoskins residence

Hoskins livestock pens below casing pile

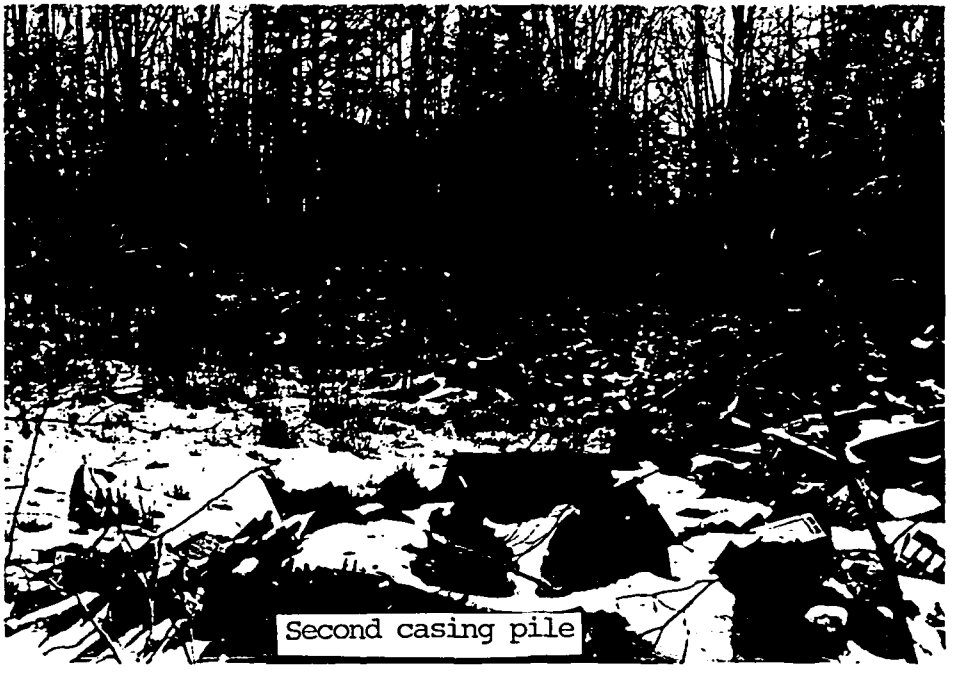
Sample #3: Downstream Sediment

Sample #4: Upstream Sediment

Ulah Battery Lead Reclaiming
NCD981864614

Second casing pile

1-29-87



Second casing pile

Appendix B

Laboratory Data

File

North Carolina Department of Human Resources
Division of Health Services
Laboratory Section
P.O. Box 28047, Raleigh, N.C. 27611

Environmental Sciences Analysis Report

Name of Owner, Patient or Supply: GLEN HOSKINS

Address: Rt 7, Box 376, Asheboro, NC.

County: Randolph

Report to: Joel Crawford / Jim Martin

Address: Randolph Cty Hlth Dept
Asheboro

Date Collected: 30 JAN. 87 9:15 AM Date Received: 2-2-87 AA Date Analyzed: Ext 2-2-87 AA EDB 2-9-87 RB
Extracted 2-2-87 AA PET 2-4-87 MW

Analysis Desired:

Laboratory Number	Sample Number	Sample Description or Remarks	Results In
7 0320			No petroleum
			products
			identified.

2/11/87
Reported By: John O'Neal

DHS Form 2364 Revised (1/87)
Laboratory

Mildred A. Kerbaugh
Director

1-2 l. amber bottle 2 VOA vials

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

File

INORGANIC CHEMICAL ANALYSES-PRIVATE WATER SYSTEM

Complete All Items Above Heavy Line
(See Instructions on Reverse Side)

Name of System: Glen Hoskin's

Address: Rt 7, Box 376
Asheboro N.C. ZIP 27203

County: Randolph

Report To: Joel Cranford / Jim Martin

Address: Randolph Cty Hlth Dept
Asheboro N.C.
ZIP

Collected By: Joel Cranford

Date Collected: 30 Jan. 87 Time: 9:15 AM PM

Location of Sampling Point: Kitchen tap

Source of Water:
(✓) Ground ( ) Both
( ) Surface ( ) Purchased

Source of Sample:
(✓) House Tap (Kitchen)
( ) Well Tap

Type of Sample:
(✓) Raw ( ) Treated

Type of Treatment:
(✓) None ( ) Lime
( ) Chlorinated ( ) Soda Ash
( ) Fluoridated ( ) Polyphosphate
( ) Filtered ( ) Water Softener
( ) Alum ( ) Other

Type of Analysis Desired:
( ) Regular Parameters ( ) Both
( ) Optional Parameters

Remarks: SAMPLE COLLECTED AS requested by Stan Atwood, Toxicologist

Regular Parameters	Results		Optional Parameters (List as needed)	Results
pH	6.4	units		
Arsenic	<0.01	mg/l		
Lead	<0.03	mg/l		
Iron	<0.05	mg/l		
Manganese	0.04	mg/l		
Copper	<0.05	mg/l		
Zinc	0.06	mg/l		
Calcium	16.3	mg/l		
Magnesium	5.3	mg/l		
Hardness-$CaCO_3$ (Ca, Mg)	62	mg/l		
Alkalinity-$CaCO_3$	28	mg/l		
Chloride	2	mg/l		
~~Color~~		units		
~~Turbidity~~	~~NTU~~	units		
Fluoride	<0.10	mg/l		

Date Received _____ Date Reported 2/5/87 Reported By _____

Date Analyzed _____ Laboratory Number COLLECTED 20

DHS Form 1441 Rev. 10/79
Laboratory

HEALTH DEPARTMENT

Mildred A. Kerbaugh
Director

C Department of Human Resources
ision of Health Services

SAMPLE ANALYSES REQUEST

Received 3-31-87

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

c umber 76D981864614 Field Sample Number 3834

me of Site Utah Battery Lead Reclaiming Site Location Asheboro

lected By Stan Atwood ID# 45 Date Collected 1-29-87 Time 1100

pe of Sample:

Corrected Copy

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Hammond Well
___ 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/1
Arsenic		✓ Arsenic	<0.01	Silver	
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/1
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 FEB 19 1987 SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH

te Received ___ Date Reported 2-5-87

Extracted ___ Date Analyzed ___

ported By ___ Lab Number 002039 FEB 287

S 3191 (Revised 7/85)

CLKCLA

C Department of Human Resources
is n of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 2804
306 N. Wilmington Street
Raleigh, 27611

Received 3-3-87

e umber 76D981864614-87 Field Sample Number 3835

me of Site Utah Battery Lead Reclaiming Site Location Asheboro

ll ted By Stan Atwood ID# 45 Date Collected 1-29-87 Time 1130

Corrected Copy

pe of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	Solid (5)	Caviness Well
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/1
Arsenic		✓ Arsenic	<0.01	Silver	
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/1
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 FEB 19 19 HAZARDOUS WASTE MANAGEMENT BRANCH

te Received

Date Reported 2-5-87

Extracted

Date Analyzed

ported By

Lab Number

UU2040 FEB 287

427

DIVISION OF HEALTH SERVICES
SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH

Chain of Custody Record

Hazardous Waste Materials

Location of Sampling: ____Generator ____Transporter ____Treatment Facility
____Storage Facility ____Disposal Facility ____Landfill
____Other: _____

Company's Name Utah Battery Lead Reclaiming Telephone(____) _____

Address Ashebaro

Collector's Name _____ Telephone(____) _____
signature

Date Sampled _____ Time Sampled _____

Type of Process Generating Waste _____

Field Information

_____

_____

Field Sample No. 3836 3837 ____ ____ ____ ____ ____

____ ____ ____ ____ ____ ____ ____

Chain of Possession:

	signature	title	inclusive dates
1.	Stan Atwood	Toxicologist	Jan 29-30 1987
2.	Annette L. Jay	Lab Tech	30 Jan 87
	Annette L Jay	Lab Tech	6 Feb 87

Results reported

signature	title	date

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

C. Department of Human Resources
ision of Health Services

received
2-9-87

SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 76D981864614 Field Sample Number 3836

of Site Utah Battery Lead Reclaiming Site Location Asheboro

llected By Stan Atwood ID# 45 Date Collected 1-29-87 Time 1150

f Sample:

nvironmental	Concentrate	Comments
___ Groundwater (1)	___ Solid (5)	Downstream Sed
___ Surface Water (2)	___ Liquid (6)	
✓ Soil (3)	___ Sludge (7)	
___ Other (4)	___ Other (8)	

INORGANIC CHEMISTRY

Extractables		Total			
arameter	Results mg/1	Parameter	Results mg/Kg	Parameter	Results mg/1
Arsenic		Arsenic		Silver	
arium		Barium		✓ Sulfates	<6
admium		Cadmium		Zinc	
Chromium		Chloride		✓ Ph	5.9
✓ Lead	<0.1	Chromium		Conductivity	
lercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		✓ Lead	9.8		
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

arameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/1
P&T:GC/MS		EDB		Methoxychlor	
cid: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 SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH FEB 6 1987

Received

Date Reported 6 Feb 87

xtracted

Date Analyzed

rted By

Lab Number 002002 JAN 20 87

CLKCLT

. Department of Human Resources
ion of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 76D981864614 Field Sample Number 3837

of Site Ulah Battery Lead Reclaiming Site Location Asheboro

lected By Stan Atwood ID# 45 Date Collected 1-29-87 Time 1200

of Sample:

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

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/Kg	Parameter	Results mg/1
Arsenic		Arsenic		Silver	
Barium		Barium		✓ Sulfates	<6
Cadmium		Cadmium		Zinc	
Chromium		Chloride		✓ Ph	6.3
Lead	<0.1	Chromium		Conductivity	
Mercury		Copper		TDS	
Selenium		Fluoride		TOC	
Silver		Iron			
		✓ Lead	5.6		
		Manganese			
		Mercury			
		Nitrate			
		Selenium			

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/1
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
FEB 6 1987
SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH

Received Date Reported 6 Feb 87

xtracted Date Analyzed

rted By Lab Number 002003 JAN 20 87

N. C. DEPARTMENT OF HUMAN RESOURCES
DIVISION OF HEALTH SERVICES
SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH

Chain of Custody Record

Hazardous Waste Materials

Location of Sampling: ____Generator ____Transporter ____Treatment Facility
____Storage Facility ____Disposal Facility ____Landfill
____Other: _____

Company's Name _____ Telephone(____) _____

Address _____

Collector's Name _____ Telephone(____) _____
signature

Date Sampled _____ Time Sampled _____

Type of Process Generating Waste Lead reclaiming from automotive batteries

Field Information

_____

_____

Field Sample No. 3530 3531 3532 3533 _____ _____ _____

_____ _____ _____ _____ _____ _____ _____

Chain of Possession:

	signature	title	inclusive dates
1.	Stan Atwood	Toxicologist	JAn 29-30 1987
2.	Vicki S. Painter	Chemical Analyst II	1-30-87
3.			

Results reported

signature	title	date

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

E'T O ' RESOURCES
DIVISION OF HEALTH SERVICES
SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH

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.

Inspector's Name _____ Inspector's Address _____

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:

Signature of Inspector _____

Title _____

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

Signature of Firm Owner, Operator, or Agent _____

Title _____

COMMENTS _____

CERCLA

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

SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Site Number 76D981864614 Field Sample Number 3530

Name of Site Utah Battery Lead Reclaiming Site Location Asheboro

Collected By Stan Atwood ID# 45 Date Collected 1-29-87 Time 1100

Type of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Hammond Well
___ 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/1
___ 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/1
___ 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 1-30-87 V.P. Date Reported 2/6/87

Date Extracted 2-2-87 BD Date Analyzed BNA 2-3-87 BD

Reported By John L. Neal Lab Number 700212

#700212-700215

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

CERCLA

. C. Department of Human Resources
vision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

te Number 76D981864614 Field Sample Number 3531

ame of Site Utah Battery Lead Reclaiming Site Location Asheboro

llected By Stan Atwood ID# 45 Date Collected 1-29-87 Time 1100

pe of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Hammond Well
___ 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/1
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/1
✓ 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	

ate Received 1-30-87 V.P. Date Reported

ate Extracted Date Analyzed

eported By Lab Number 70213

HS 3191 (Revised 7/85)

CERCLA

C. Department of Human Resources
ision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Number 76D981864614 Field Sample Number 3532

of Site Ulah Battery Lead Reclaiming Site Location Asheboro

llected By Stan Atwood ID# 45 Date Collected 1-29-87 Time 1130

of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Caviness Well
___ 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/1
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/1
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	

te Received 1-30-87 V.P. Date Reported

te Extracted 2-2-87 BD Date Analyzed

ted By Lab Number 7 0214

S 3191 (Revised 7/85)

CERCLA

. C. Department of Human Resources
ivision of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

te Number 76D981864614 Field Sample Number 3533

a of Site Utah Battery Lead Reclaiming Site Location Asheboro

ollected By Stan Atwood ID# 45 Date Collected 1-29-87 Time 1130

of Sample:

Environmental	Concentrate	Comments
✓ Groundwater (1)	___ Solid (5)	Caviness Well
___ 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/1
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/1
✓ 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	

a Received 1-30-87 V.P. Date Reported

ate Extracted Date Analyzed

orted By Lab Number 7 0235

IS 3191 (Revised 7/85)

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	706212	700214				
	FIELD #	3530	3532				
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
N-nitrosodimethylamine	10	4	4				
bis(2-chloroethyl)ether							
2-chlorophenol							
phenol							
1,3-dichlorobenzene							
1,4-dichlorobenzene							
1,2-dichlorobenzene							
bis(2-chloroisopropyl)ether							
hexachloroethane							
N-nitroso-di-n-propylamine							
nitrobenzene							
isophorone							
2-nitrophenol							
2,4-dimethylphenol							
bis(2-chloroethoxy)methane							
2,4-dichlorophenol							
1,2,4-trichlorobenzene							
naphthalene							
hexachlorobutadiene							
4-chloro-m-cresol							
hexachlorocyclopentadiene							
2,4,6-trichlorophenol							
2-chloronaphthalene							
acenaphthylene							
dimethyl phthalate							
2,6-dinitrotoluene							
acenaphthene							
2,4-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	700212	700214				
	FIELD #	3530	3532				
COMPOUND	TYPE	(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
pyrene	10						
benzidine	50	U	U				
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	50						
benzo(a)pyrene	50						
indeno(1,2,3-cd)pyrene	50						
dibenzo(a,h)anthracene	50						
benzo(g,h,i)perylene	50						
aniline	50	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.
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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	700212	700214				
	FIELD #	3530	3532				
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
N-nitrosodimethylamine		10	4	4			
bis(2-chloroethyl)ether							
2-chlorophenol							
phenol							
1,3-dichlorobenzene							
1,4-dichlorobenzene							
1,2-dichlorobenzene							
bis(2-chloroisopropyl)ether							
hexachloroethane							
N-nitroso-di-n-propylamine							
nitrobenzene							
isophorone							
2-nitrophenol							
2,4-dimethylphenol							
bis(2-chloroethoxy)methane							
2,4-dichlorophenol							
1,2,4-trichlorobenzene							
naphthalene							
hexachlorobutadiene							
4-chloro-m-cresol							
hexachlorocyclopentadiene							
2,4,6-trichlorophenol							
2-chloronaphthalene							
acenaphthylene							
dimethyl phthalate							
2,6-dinitrotoluene							
acenaphthene							
2,4-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.
[illegible] - Actual value is known to be greater than value given.
[illegible] - 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	700212	700214				
	FIELD #	3530	3532				
COMPOUND	TYPE	(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
pyrene	10	4	4				
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	50						
benzo(a)pyrene	50						
indeno(1,2,3-cd)pyrene	50						
dibenzo(a,h)anthracene	50						
benzo(g,h,i)perylene	50						
aniline	50	4	4				
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.
< - Actual value is known to be less than value given.
> - Actual value is known to be greater than value given.
[illegible] - 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	700213	700215				
	FIELD #	3531	3533				
COMPOUND	TYPE	(I)	(I)	( )	( )	( )	( )
	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				
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				
2-butanone	10						
carbondisulfide	5						
2-hexanone	10						
4-methyl-2-pentanone	10						
styrene	5						
vinyl acetate	10						
x-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 3068-0 (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	700213	700215				
	FIELD #	3531	3533				
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
chloromethane	10		u				
romomethane	10						
chlorodifluoromethane	20						
vinyl chloride	10						
hloroethane	10						
ethylene chloride	5						
trichlorofluoromethane	20						
ethene, 1,1-dichloro	5						
thane, 1,1-dichloro-							
,2-trans-dichloroethene							
chloroform							
thane, 1,2-dichloro-							
thane, 1,1,1-trichloro-							
carbontetrachloride							
romodichloromethane							
ropane, 1,2-dichloro-							
,3-trans-dichloropropene							
trichloroethylene							
hlorodibromomethane							
enzene							
ethane, 1,1,2-trichloro-							
,3-cis-dichloropropene							
-chloroethyl vinyl ether	10						
bromoform	5						
ethane, 1,1,2,2-tetrachloro-							
thene, tetrachloro-							
oluene							
chlorobenzene							
thylbenzene							
acetone	10	u	u				
-butanone	10						
arbondisulfide	5						
-hexanone	10						
4-methyl-2-pentanone	10						
tyrene	5						
inyl acetate	10						
-xylenes (total)	5						

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

.C. Division of Health Services

DHS 3068-0 (4/86 Laboratory)

North Carolina Department of Human Resources
Division of Health Services
Occupational Health Laboratory

ANALYSIS REPORT

Company: Private Residence - Site of Battery Salvage Operation

Address: Rt. 7, Asheboro, NC Randolph Co.

Service Requested: Lead Analysis on Soil Samples

Sample Taken On: 7-23-86 [REC'D. 7-25-86 V.P.] By: C Wiggins

Submitted To Laboratory On: _____ By: _____

Date of Analysis: 7-31-86 Date Reported: 7-31-86

Analyzed By: V.P.

RECEIVED OCT 22 1986 DOS HAZARDOUS WASTE MANAGEMENT BRANCH

LABORATORY NUMBER	SAMPLE NUMBER	DESCRIPTION	REMARKS	RESULTS IN ppm Pb
6:2118	#1	driveway - near melting location - paved with casings		106,811
6:2119	#2	Area near melting location at oldest dump site		20,906
6:2120	#3	Area downhill of dump site		1,246
6:2121	#4	Edge of driveway lined with battery casings		6,787
6:2122	#5	Area batteries were melted at + drums were stored		144,184
6:2123	#6	Soil beside workbench at Hammond home		262
6:2124	#7	Rear of Hammond site - behind drainage ditch		4,134

COMMENTS: Send to Charlene Wiggins
Environmental Epi

REPORTED BY: John L. Neal
Chief, Occupational Health Lab

DHS Form 1440 (Rev. 2-75)
Occupational Health

North Carolina Department of Human Resources
Division of Health Services
Occupational Health Laboratory

ANALYSIS REPORT

OCT 1986

Company: Private Residence - Site of Battery Salvage Operation

Address: Rt. 7 Asheboro, NC Randolph Co.

Service Requested: Lead Analysis on Soil Samples

Sample Taken On: 10-3-86 By: C Wiggins

Submitted To Laboratory On: 10-6-86 (RECD. 10-7-86 V.P.) By:

Date of Analysis: 10-8-86 Date Reported: 10-8-86

Analyzed By: V.P.

LABORATORY NUMBER	SAMPLE NUMBER	DESCRIPTION	REMARKS	RESULTS IN ppm Pb
6[illegible]710	#1	Soil in backyard - 15 ft. from dump - across drainage ditch	Clay	126 ppm
6[illegible]711	#2	Soil from garden approx. 75 feet from dump	Clay	37 ppm

COMMENTS: Send report to: Charlene Wiggins
Env. Epi.

REPORTED BY: John L. Neal
Chief, Occupational Health Lab

NIOSH Analytical Method: P&CAM 173: GENERAL PROCEDURES FOR METALS. Filter collection, atomic absorption analysis. 1977

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

TUESDAY JUL 15.

INORGANIC CHEMICAL ANALYSES-PRIVATE WATER SYSTEM

Complete All Items Above Heavy Line
(See Instructions on Reverse Side)

Name of System: Marvin Elliott Camp

Address: Rt 7
Asheboro ZIP 27203

County: Randolph

Report To: Robert C Tyler

Address: Randolph County Health Dept
Box 1107
Asheboro ZIP 27203

Collected By: Robert C Tyler

Date Collected: 7-7-90 Time: 1111 AM PM

Location of Sampling Point: HSE TAP

Source of Water:
(X) Ground ( ) Both
( ) Surface ( ) Purchased

Source of Sample:
(X) House Tap
( ) Well Tap

Type of Sample:
(X) Raw ( ) Treated

Type of Treatment:
(X) None ( ) Lime
( ) Chlorinated ( ) Soda Ash
( ) Fluoridated ( ) Polyphosp
( ) Filtered ( ) Water Sof
( ) Alum ( ) Other

Type of Analysis Desired:
( ) Regular Parameters ( ) Both
( ) Optional Parameters

Remarks:

Regular Parameters	Results		Optional Parameters (List as needed)	Results
pH	6.5	units		
Arsenic	<0.01	mg/l		
Lead	<0.03	mg/l		
Iron	<0.05	mg/l		
Manganese	<0.03	mg/l		
Copper	<0.05	mg/l		
Zinc	<0.05	mg/l		
Calcium	5.8	mg/l		
Magnesium	1.5	mg/l		
Hardness-$CaCO_3$ (Ca, Mg)	21	mg/l		
Alkalinity-$CaCO_3$	22	mg/l		
Chloride	3	mg/l		
Color	0	units		
Turbidity	0.32	NTU units		
Fluoride	<0.10	mg/l		

Date Received JUL 9 1990 Date Reported JUL 1 - 1990 Reported By

Date Analyzed Laboratory Number .014

DHS Form - 1441 Rev. 10/79
Laboratory

HEALTH DEPT.

Mildred A. Ke
Director

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

TUESDAY JUL 15

INORGANIC CHEMICAL ANALYSES-PRIVATE WATER SYSTEM

Complete All Items Above Heavy Line
(See Instructions on Reverse Side)

Name of System: Glenn Hoskins

Address: Rt 7 Box 376
Asheboro N.C ZIP 27203

County: Randolph

Report To: Robert C Tolen

Address: Randolph C Health Dept
Box 1007
Asheboro ZIP

Collected By: Robert C Tolen

Date Collected: 7-7-80 Time: 10:00 AM PM

Location of Sampling Point: Well Tap

Source of Water:
(X) Ground ( ) Both
( ) Surface ( ) Purchased

Source of Sample:
( ) House Tap
(X) Well Tap

Type of Sample:
(X) Raw ( ) Treated

Type of Treatment:
(X) None ( ) Lime
( ) Chlorinated ( ) Soda Ash
( ) Fluoridated ( ) Polyphospha
( ) Filtered ( ) Water Softe
( ) Alum ( ) Other

Type of Analysis Desired:
( ) Regular Parameters ( ) Both
( ) Optional Parameters

Remarks:

Regular Parameters	Results		Optional Parameters (List as needed)	Results
pH	6.6	units		
Arsenic	<0.01	mg/l		
Lead	<0.03	mg/l		
Iron	<0.05	mg/l		
Manganese	0.03	mg/l		
Copper	<0.05	mg/l		
Zinc	<0.05	mg/l		
Calcium	6.9	mg/l		
Magnesium	1.6	mg/l		
Hardness-$CaCO_3$ (Ca, Mg)	20	mg/l		
Alkalinity-$CaCO_3$	20	mg/l		
Chloride	2	mg/l		
Color	0	units		
Turbidity	0.[illegible]	NTU units		
Fluoride	<0.10	mg/l		

Date Received [illegible] Date Reported JUL 11 1980 Reported By [illegible]

Date Analyzed _____ Laboratory Number _____

DHS Form - 1441 Rev. 10/79
Laboratory

HEALTH DEPT.

Mildred A. Kerba
Director

Appendix C

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NORTH CAROLINA
DEPARTMENT OF HUMAN RESOURCES
DIVISION OF HEALTH SERVICES
OCCUPATIONAL HEALTH BRANCH
RALEIGH, NORTH CAROLINA

Ref.1

TECHNICAL REPORT

REPORT OF VISIT TO Glen Hoskins/Marvin & Elbert Cayiness Battery Dealers

Address Route 7, Box 376 Location

Asheboro, N. C. 27203

Visit made by Pat Curran and Kathy Douglas Date Sept. 10, 1981

Persons Contacted Mr. Martin & Mr. Workman - Randolph County Health Department

Reason for visit Follow-up to letter from county health department concerning this operation.

Product Mfg. --- No. Employees ---

Plant Medical Services ---

Copies to: Dr. Ronald H. Levine
Dr. Martin P. Hines
C. Dan Baucom
Randolph County Health Department
Files

REPORT:

A site visit was made to this battery/lead and scrap metal reclaiming operation as a result of the Randolph County Health Department's response to a July 17, 1981 N. C. Division of Health Services' letter inquirying about such operations. This letter was sent to all health departments throughout the state. The visit was made with Mr. Martin and Mr. Workman of the Randolph County Health Department. Since no one responsible for the operation was home, no contact was made.

Site Visit Findings

This is apparently a small family type battery/lead salvage and reclaiming operation which has been in operation for approximately 16 years. It is located on a dirt road off Highway 220 in Asheboro. Eleven (11) houses or trailers are along the road. Apparently, these families are all related in some manner and some are involved with the reclaiming operation. There are two large piles of scrap battery casing parts along the road. The largest scrap pile (20 feet high x 75-100 feet in diameter) is located behind a trailer and consist mostly of casing bottoms. Next to this pile is a well with a work bench built onto the well house. (A battery dripping acid was on the bench.) The slope of the land is such that any rain run-off from the scrap pile could run into a family garden located in a near by field. The other scrap pile (30 feet in diameter) is farther down the road and consists mostly of casing tops. Apparently, lead from the batteries is melted here (possibly to remove seperator plates), since rusted 55-gallon drums and slag were noted. Rain run-off

Ref. 1

is down a 1 1/2 - 2 feet wide gully. The gully was followed a short distance but it could not be determined where it leads. Broken battery casings are scattered along driveways and the dirt road as fill. It was not apparent how acid from the batteries is handled. No containers, drums, or tanks were seen in any of the areas.

At the end of the visit, a wife of one of the men involved with the operation came out and said batteries were no longer being reclaimed because they found out it would hurt their children. However, some yet to be reclaimed batteries were seen. So it is doubtful the operation has completely stopped.

An initial investigation was conducted by the County Health Department in July, 1980 in which water samples (from the well and trailer beside the large pile of casings) and soil samples were taken. Results of the water samples are attached and show normal pH levels and no lead content. No written report of the soil samples has been received by the county from the N. C. Division of Health Services' Laboratory Section. Telephoned results of two (2) soil samples showed 3000 ppm and 2500 ppm of lead. Blood samples were also taken on two (2) residents and found to be negative. (No numerical results are in the report.) These results are also attached. The Solid and Hazardous Waste Section of the N. C. Division of Health Services was contacted and has additional information pertaining to the operation.

Conclusions

There is a potential for lead exposure to the residents and adverse environmental effects are present from the reclaiming process, the storage of casings, the handling of acid, lead residue on the roads, driveways and yards, and lead contamination of homes (from clothes and shoes), food from gardens and water. A coordinated evaluation should be made by appropriate local and state agencies (Randolph County Health Department, Lead Screening Committee, and Hazardous Waste Section of the N. C. Division of Health Services and the N. C. Department of Natural Resources and Community Development) to determine the health and environmental effects of this operation. The Occupational Health Branch will provide any technical assistance needed in this evaluation.

Pat Curran

John "Pat" Curran
Industrial Hygiene Consultant
Occupational Health Branch

PC:ng

Randolph County Health Dept.
ASHEBORO, NORTH CAROLINA 27203

Personal Health
Emergency Medical Services
Environmental Health
Building Inspections

Ira McDowell Governmental Center
2222 South Fayetteville Street
Telephone (919) 629-2131
Archdale Office (919) 431-2116

Do you know this one? Please forward to Dr. Rh

Ref 2

August 13, 1981

Dr. Rhyne
Please add to local file.
MPH

AUG 14 1981

Dr. Martin P. Hines
Chief, Epidemiology Section
Department of Human Resources
Division of Health Services
P.O. Box 2091
Raleigh, NC 27602

Dear Dr. Hines:

In reply to your letter dated July 17, 1981, we can supply you with the following list of names and results of our preliminary investigation:

Battery Dealers

Glen Hoskins Rt. 7, Box 376 Asheboro, NC 27203 Phone: 625-4510	Marvin & Elbert Caviness Rt. 7 Asheboro, NC 27203 Phone: 625-3230

Blood Samples Taken

Rita Williams, Mother, 08-14-80 - Neg. (9)
Homer L. Williams, Son, 08-21-80 - Neg. (11)

Enclosed you will find copies of water samples, maps, and notes from our investigation. Mr. Bill Myers, Solid & Hazardous Waste Section, phone 733-2178, has additional information regarding this operation.

If we may be of further service to you regarding this problem, please let us know.

Sincerely,

J. D. Workman Jr.

J. D. Workman, Jr.
Sanitarian Supervisor I

JDW,JR./dlc

Enclosures

Ref 2

NOTES

August 7, 1980

Jim Martin & Robert Tolen visited the following houses for the purpose of notifying the occupants of the possible contamination of lead from being exposed to the burning of battery casing & battery casing being used as a fill on drives and yards.

House #1 Rita Williams
House #2 Vacant: However previous occupants were notified. (Hayes)
House #3 Howard Strickland
House #4 No one home. ~~7-7-3-13~~

Ref 3

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

RECEIVED
OCT 22 1986
SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH

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

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

MEMORANDUM

TO: William Meyer, Head
Solid and Hazardous Waste Management Branch

FROM: John I. Freeman, D.V.M., M.P.H., Head
Environmental Epidemiology Branch

SUBJECT: Battery Dump Site in Randolph County

DATE: October 20, 1986

The Environmental Epidemiology Branch was recently informed of an area in Randolph County that had been used as a dump site for discarded battery casings. Several residents of the Ula community had previously been involved in salvaging lead from the batteries and discarding the casings or crushing them to be spread over the dirt road on which the dump is located. The operation was discontinued five years ago when the county health department became aware of it and explained the hazards to the parties involved. Although the problem was brought to the attention of the Solid and Hazardous Waste Management Branch in 1981, no further action was taken other than the collection of soil and water samples.

On July 23, 1986, Charlene Wiggins, Lead Epidemiologist with the Environmental Epidemiology Branch, visited the site with two representatives of the Randolph County Health Department. The scrap pile is located behind a house trailer and is approximately 25 feet high and 75 to 100 feet in diameter. It appears to mainly be composed of casing bottoms. Farther down the road, a second area approximately 40 feet in diameter was found coated in broken pieces of casing tops. This was the area originally used to melt the lead from the batteries. Small pieces of casings were also observed along the dirt path and the driveways along it.

During the visit, Ms. Wiggins collected soil samples near the scrap pile, the area where the lead was melted, and along the road. The lead content in these areas ranged from 0.6% to 14.4% (see attached). As you are aware, soil containing greater than 0.05% is considered to be a hazard.

Since children are particularly susceptible to lead poisoning due to their high rate of intestinal absorption and natural hand-to-mouth habits, Ms. Wiggins

Ref 3

attempted to identify all children living along the dirt road. Six children were identified at the five houses where someone was home. There was no answer at the remaining five houses. The parents were informed of the hazards of lead and advised to have their children tested for lead at the county health department. All six of these children have been tested, and one was found to have Class III lead poisoning (with Class IV being the most severe). This child has been living in a house trailer which is free of lead hazards for approximately one year. Her mother admitted that the child frequently eats dirt, and a soil sample collected from her driveway contained 10.6% lead. The child is presently being treated at Memorial Hospital in Chapel Hill.

In further investigation, three more children were found to live in the area. The county health department is trying to arrange testing for these children at this time.

Due to the high levels of lead in the soil and the presence of young children in the area, the Environmental Epidemiology Branch feels the situation requires further discussion with members of the Solid and Hazardous Waste Management Branch. Please contact Charlene Wiggins or me at 733-3410 at your earliest convenience to arrange a meeting.

JIF:CW:lp

Attachment

c: Mr. George Elliott, Health Director
Randolph County Health Department

Ref 3

North Carolina Department of Human Resources
Division of Health Services
Occupational Health Laboratory

ANALYSIS REPORT

Company: Private Residence - Site of Battery Salvage Operation

Address: Rt. 7, Asheboro, NC Randolph Co.

Service Requested: Lead Analysis on Soil Samples

Sample Taken On: 7-23-86 [RECD. 7-25-86 V.P.] By: C Wiggins

Submitted To Laboratory On: _____ By: _____

Date of Analysis: 7-31-86 Date Reported: 7-31-86

Analyzed By: V.P.

RECEIVED OCT 22 1986 DOS & HAZARDOUS WASTE MANAGEMENT BRANCH

LABORATORY NUMBER	SAMPLE NUMBER	DESCRIPTION	REMARKS	RESULTS IN ppm Pb
6:2118	#1	driveway - near melting location - paved with casings		106,811
6:2119	#2	Area near melting location at oldest dump site		20,906
6:2120	#3	Area downhill of dump site		1,246
6:2121	#4	Edge of driveway lined with battery casings		6,787
6:2122	#5	Area batteries were melted at + drums were stored		144,184
6:2123	#6	Soil beside workbench at Hammond home		262
6:2124	#7	Rear of Hammond site - beside drainage ditch		4,134

COMMENTS: Send to Charlene Wiggins
Environmental Epi

REPORTED BY: John L. Neal
Chief, Occupational Health Lab

DHS Form 1440 (Rev. 2-75)
Occupational Health

Ref 3

North Carolina Department of Human Resources
Division of Health Services
Occupational Health Laboratory

ANALYSIS REPORT

OCT 1986

Company: Private Residence - Site of Battery Salvage Operation

Address: Rt. 7 Asheboro, NC Randolph Co.

Service Requested: Lead Analysis on Soil Samples

Sample Taken On: 10-3-86 By: C Wiggins

Submitted To Laboratory On: 10-6-86 (REC'D. 10-7-86 V.P.) By:

Date of Analysis: 10-8-86 Date Reported: 10-8-86

Analyzed By: V.P.

LABORATORY NUMBER	SAMPLE NUMBER	DESCRIPTION	REMARKS	RESULTS IN ppm Pb
6[illegible]210	#1	Soil in backyard - 15 ft. from dump - across drainage ditch	Clay	126 ppm
6[illegible]2711	#2	Soil from garden approx. 75 feet from dump	Clay	37 ppm

COMMENTS: Send report to: Charlene Wiggins
Env. Epi.

REPORTED BY: John L. Neal
Chief, Occupational Health Lab

NIOSH Analytical Method: P&CAM 173: GENERAL PROCEDURES FOR METALS. Filter collection, atomic absorption analysis. 1977.

Ref 4

29 April 1987

TO: File

FROM: Stan Atwood SA

RE: Ulah Battery Lead Reclaiming

I spoke by telephone with Mr. Jerry Dickinson, Chief - Ulah Volunteer Fire Department (919) 629-3300. Mr. Dickinson lives about 0.1 miles south of the site. He provided the following information:

1. Elbert and Daisy Caviness probably own most of the property at the site. Elbert began the battery operation.

2. Batteries were broken on site and the acid ran onto the ground.

3. There was a fire at the site about 8-10 years ago that was confined to the casing pile behind the Hoskins home.

4. Most wells in the area are about 100 feet deep. He dug his own well - 83 ft. deep, 40 ft. to bedrock, 55 ft. of water in the well, 4 in. diameter. His son, who lives across the street, recently had a well dug. He will call me back if he can get information on this well.

5. Some well drillers used in the area include W.W. Maness and Sons, 464-3633; and Asheboro Well, 625-6374.

SA/tb/0374b

Ref. 5

28-29 April 1987

TO: File

FROM: Stan Atwood SA

RE: Surface water use - Ulah Battery Lead Reclaiming.

On these dates I spoke by telephone with David Slater and Harvey Fouts, Randolph County Agricultural Extension Agents (919) 629-2131. They provided the following information:

1. The Little River in the site vicinity is not used for irrigation; however, cattle use the water. A tobacco farm in the area irrigates from a pond.

2. The Little River is not likely fished above SR 1127 which is more than three miles from the site.

3. Batteries were generally chopped open with an axe to reclaim the lead. The acid ran onto the ground.

SA/tb/0374b

Ref 6

STATE OF NORTH CAROLINA

DEPARTMENT OF NATURAL AND ECONOMIC RESOURCES

CLASSIFICATIONS AND WATER QUALITY STANDARDS ASSIGNED TO THE WATERS OF THE YADKIN-PEE DEE RIVER BASIN

DIVISION OF ENVIRONMENTAL MANAGEMENT

RALEIGH, NORTH CAROLINA

Reprint from North Carolina Administrative Code: 15 NCAC 2B .0309
Current Through: June 30, 1981

.0301 CLASSIFICATIONS; GENERAL

(a) Schedule of Classifications. The classifications assigned to the waters of the State of North Carolina are set forth in the schedules of classifications and water quality standards assigned to the waters of the river basins of North Carolina, 15 NCAC 2B .0302 to .0317. These classifications are based upon the existing or contemplated best usage of the various streams and segments of streams in the basin, as determined through studies and evaluations and the holding of public hearings for consideration of the classifications proposed.

(b) Stream Names. The names of the streams listed in the schedules of assigned classifications were taken as far as possible from United States Geological Survey topographic maps. Where topographic maps were unavailable, U.S. Corps of Engineers maps, U.S. Department of Agriculture soil maps, and North Carolina highway maps were used for the selection of stream names.

(c) Classifications. The classifications assigned to the waters of North Carolina are denoted by the letters A-I, A-II, B, C, SA, SB, and SC in the column headed "class." These class designations refer to the classifications established by the Rules, Regulations, Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina, as adopted by the North Carolina Board of Water and Air Resources on October 13, 1970, and approved by the Environmental Protection Agency on January 20, 1971. A brief explanation of the "best usage" for which the waters in each class must be protected is given as follows:

Fresh Waters

Class A-1:	source of water supply for drinking, culinary, or food processing purposes after treatment by approved disinfection only, and any other usage requiring waters of lower quality;
Class A-II:	source of water supply for drinking, culinary, or food processing purposes after approved treatment equal to coagulation, sedimentation, filtration, and disinfection, etc., and any other usage specified by the "C" classification;
Class B:	primary recreation and any other usage specified by the "C" classification;
Class C:	fish and wildlife propagation, secondary recreation, agriculture and other uses requiring waters of lower quality.

Tidal Salt Waters

Class SA:	shellfishing for market purposes and any other usage specified by the "SB" and "SC" classification;
Class SB:	primary recreation and any other usage specified by the "SC" classification;
Class SC:	fish and wildlife propagation, secondary recreation, and other uses requiring waters of lower quality.

Name of Stream	Description	Classification Class	Date	Index No.
Camp Branch	From source to Rocky River	C	9/1/74	13-17-46
Dula Thoroughfare	From source to Pee Dee River	C	9/1/74	13-18
Buffalo Creek	From source to Dula Thoroughfare	C	9/1/74	13-18-1
North Prong Buffalo Creek	From source to Buffalo Creek	C	9/1/74	13-18-1-1
South Prong Buffalo Creek	From source to Buffalo Creek	C	9/1/74	13-18-1-2
Pressely Creek	From source to Pee Dee River	A-II&B	4/6/55	13-19
Brown Creek	From N.C.-S.C. State Line to Pee Dee River	C	7/1/73	13-20
Little Brown Creek	From source to Brown Creek	C	9/1/74	13-20-1
Wallace Branch	From source to Little Brown Creek	C	9/1/74	13-20-1-1
Rushing Branch	From source to Brown Creek	C	7/1/73	13-20-2
Black Jack Branch	From source to Brown Creek	C	7/1/73	13-20-3
Big Branch	From source to Brown Creek	C	7/1/73	13-20-4
Key Branch	From source to Big Branch	C	7/1/73	13-20-4-1
Kelly Branch	From source to Big Branch	C	7/1/73	13-20-4-2
Lick Creek	From source to Brown Creek	C	9/1/74	13-20-5
Swans Branch	From source to Brown Creek	C	7/1/73	13-20-6
Ledbetter Branch	From source to Brown Creek	C	7/1/73	13-20-7
Little Brown Creek	From source to Brown Creek	C	9/1/74	13-20-8
Leggett Branch	From source to Little Brown Creek	C	9/1/74	13-20-8-1
Haileys Branch	From source to Brown Creek	C	7/1/73	13-20-9
Pinch Gut Creek	From source to Brown Creek	C	9/1/74	13-20-10
Tanyard Branch	From source to Pinch Gut Creek	C	9/1/74	13-20-10-1
Cranes Branch	From source to Brown Creek	C	7/1/73	13-20-11
Cabin Branch	From source to Brown Creek	C	9/1/74	13-20-12
Jacks Branch	From source to Brown Creek	C	7/1/73	13-20-13
Cabbage Branch	From source to Brown Creek	C	9/1/74	13-20-14
Goulds Fork	From source to Brown Creek	C	9/1/74	13-20-15
Rocky Ford Creek	From source to Goulds Fork	C	9/1/74	13-20-15-1
Culpepper Creek	From source to Goulds Fork	C	9/1/74	13-20-15-2
Grindstone Branch	From source to Goulds Fork	C	9/1/74	13-20-15-3
Palmetto Branch	From source to Brown Creek	C	9/1/74	13-20-16
Canal Branch	From source to Palmetto Branch	C	9/1/74	13-20-16-1
Ingold Pond	Entire pond and connecting stream to Canal Branch	C	9/1/74	13-20-16-1-1
Gaddys Goose Ponds	Entire ponds and connecting stream to Canal Branch	C	9/1/74	13-20-16-1-2
Hurricane Creek	From source to Brown Creek	C	9/1/74	13-20-17
Flat Fork	From source to Brown Creek	C	9/1/74	13-20-18
Cedar Creek	From source to Pee Dee River	C	9/1/74	13-21
Dry Creek (Andrews Pond)	From source to Pee Dee River	C	9/1/74	13-22
Slink Branch	From source to Pee Dee River	C	9/1/74	13-23
Turkey Top Creek	From source to Pee Dee River	C	9/1/74	13-24
Little River	From source to Randolph County Line	C	7/1/73	13-25-(1)
South Prong Little River	From source to Little River	C	9/1/74	13-25-2
Scott Branch	From source to South Prong Little R.	C	9/1/74	13-25-2-1
Bell Branch	From source to South Prong Little R.	C	9/1/74	13-25-2-2
Big Branch	From source to Little River	C	9/1/74	13-25-3
Reedy Creek	From source to Little River	C	9/1/74	13-25-4
Reed Creek	From source to Little River	C	9/1/74	13-25-5
Rocky Creek	From source to Little River	C	9/1/74	13-25-6
Kings Creek	From source to Little River	C	9/1/74	13-25-7
Wagners Branch	From source to Little River	C	9/1/74	13-25-8
Wesley Dean Branch	From source to Little River	C	9/1/74	13-25-9
Little River	From Randolph County Line to Biscoe Water Supply, two miles upstream from N.C. Hwy. 27	A-II	1/1/56	13-25-(10)
Asheworth Branch	From source to Little River	A-II	1/1/56	13-25-11
Suggs Creek	From source to Little River	A-II	1/1/56	13-25-12
Wards Creek	From source to Little River	A-II	1/1/56	13-25-13
White Oak Creek	From source to Little River	A-II	1/1/56	13-25-14
West Fork Little River	From source to Randolph County Line	C	7/1/73	13-25-15-(1)
West Fork Little River	From Randolph County Line to Little River	A-II	1/1/56	13-25-15-(2)
Betsy Creek	From source to West Fork Little River	A-II	1/1/56	13-25-15-3

Ref 7

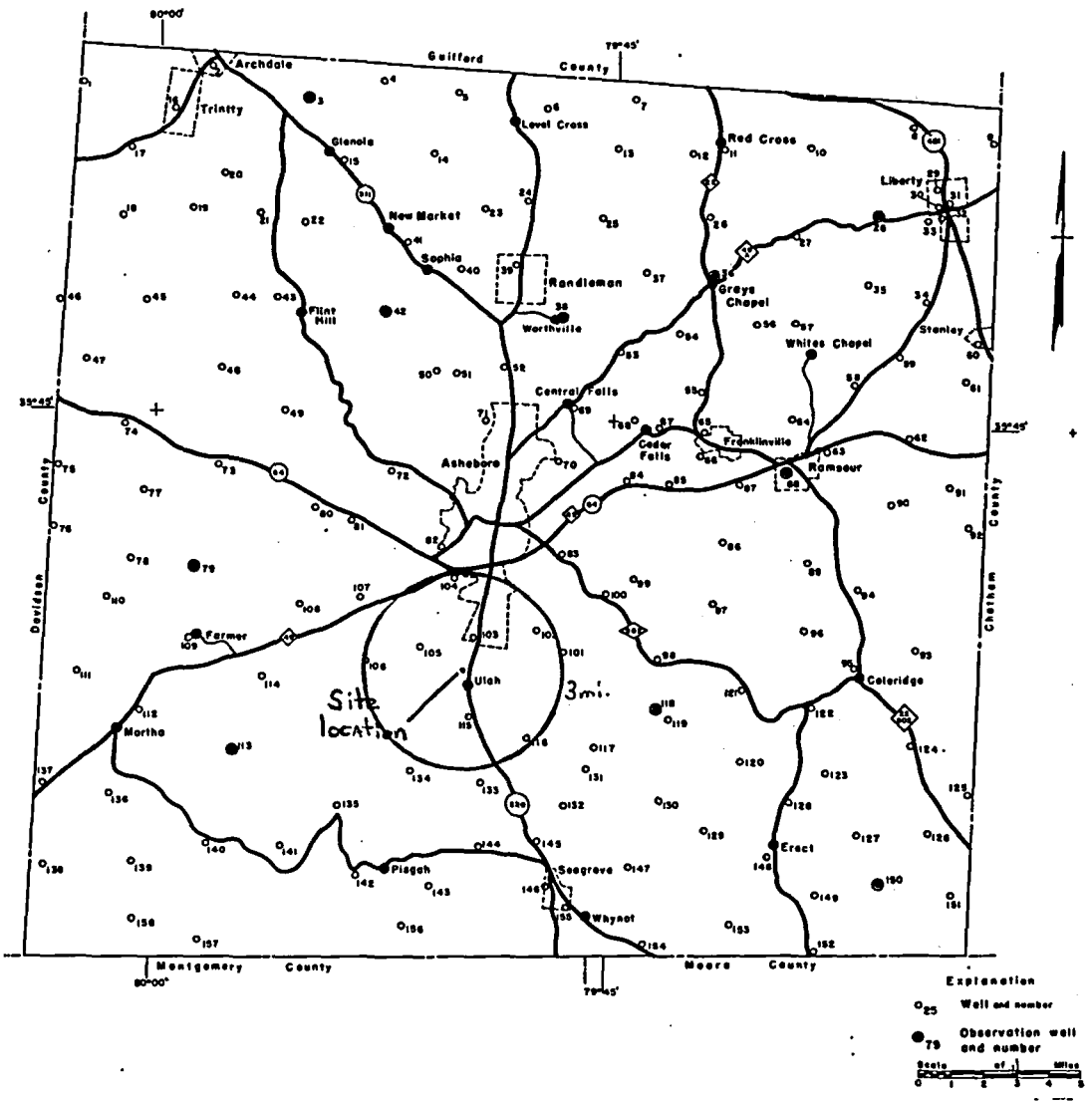

Figure 31. Map of Randolph County showing the location of wells

Ref 7

GEOLOGY AND GROUND-WATER
in the
DURHAM AREA, NORTH CAROLINA

By

GEORGE L. BAIN
Geologist, U. S. Geological Survey

Chemical Quality of Water Section

By

J. D. THOMAS, *Chemist*, U. S. Geological Survey

GROUND-WATER BULLETIN NUMBER 7

NORTH CAROLINA
DEPARTMENT OF WATER RESOURCES
GEORGE E. PICKETT, *Director*

Division of Ground Water
HARRY M. PEEK, *Chief*

Prepared Cooperatively By
the Geological Survey
United States Department of the Interior

May
1966

Randolph County

(Area 801 square miles; population 61,497)

Randolph County is the largest and westernmost county in the Durham area. It is bounded on the north by Guilford County, on the west by Davidson County, on the south by Montgomery and Moore Counties, and on the east by Chatham and Alamance Counties. Asheboro, the county seat, has a population of 9,449 and is the largest city in the county. Other population centers include Archdale, Liberty, Trinity, Randleman, Staley, Ramseur, Franklinville, Coleridge, and Seagrove.

The county is drained by the Uwharrie, Deep, and Rocky Rivers. The topography of Randolph County is rolling to mountainous. The Uwharrie Mountains are the dominant topographic feature in the central and south-central parts of the county. Streams are deeply incised except for the Uwharrie River, which has carved a fairly broad lowland on argillite that is less resistant than the surrounding metavolcanic unit. Highest elevations are in the Uwharrie Mountains and along the Davidson-Randolph County line. Lowest elevations are at the Uwharrie River in the southwest corner and at the Deep River in the southeast corner of the county.

Randolph County is largely rural but has many textile mills and furniture plants, which employ many part-time farmers. Agricultural products include small grains, hay, corn, and livestock.

Geology

Most of Randolph County is underlain by rocks of the metavolcanic unit (pl. 2). The metavolcanic unit in the county includes felsic to mafic tuffs and flows of volcanic origin interbedded with thin beds of argillaceous tuff and graywacke. The central part of the county in the south of Asheboro is underlain by the more felsic rocks of this unit.

The metavolcanic unit is overlain by the argillite-graywacke unit consisting of argillite, graywacke, graywacke conglomerate, and tuff. Graywacke and graywacke conglomerate are confined to the eastern part of the county. The argillite in the western part of the county is more deeply weathered and less deformed than elsewhere in the Durham area.

The argillite in the southwestern part of the county grades upward into the tuffaceous argillite unit. The contact between the argillite and tuffaceous argillite is drawn where the more massive tuffaceous argillite exceeds 50 percent of the total.

The argillite-graywacke unit is overlain by the mafic tuff and flow unit. This unit, consisting of coarse andesitic tuffs and flows, is present near the axial regions of the argillite-graywacke synclines. Tuffaceous argillite in the western part of the county is interbedded with the rocks of the mafic tuff and flow unit. This may indicate that the tuffaceous argillite unit is a facies of the mafic tuff and flow unit.

The metavolcanic and argillite-graywacke units have been intruded by granite, granodiorite, and gabbro. The large plutonic mass in the northwest corner is chiefly granite. The large ones east of Ramseur and west of Liberty are more mafic in composition. The argillite-graywacke unit west of Asheboro and the metavolcanic unit in the vicinity of Asheboro have been intruded by gabbro dikes and sills. Most of the high ridges in the western part of the county are capped by gabbro.

Ground Water

Most water used for domestic, public, and industrial purposes, other than in the towns of Asheboro and Ramseur, is obtained from ground water. The town of Liberty, in the eastern part of the county, uses ground water from five wells to serve about 1,500 people. Storage is in one elevated tank having a capacity of 275,000 gallons. The water is not treated. Ground water in the county comes from secondary openings in the rocks such as fractures and planes of schistosity or from the overlying porous mantle of soil and weathered rock. Because the depth of dug and bored wells in the county is limited by the depth to unweathered rock, the dug and bored wells generally go dry during periods of drought. Drilled wells are more dependable sources of water in the county, because they are more easily constructed below the water table. Drilled wells have the additional advantage of being less susceptible to contamination by surface water.

Data from 154 wells in Randolph County are summarized in table 19.

Comparison of yields indicates that the metavolcanic unit

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Table 19. Summary of well data in Randolph County according to rock type

Map unit	Number of wells	Yield (gallons per minute)		Average depth (feet) 1/
		Average	Per foot of well	
Granite and granodiorite	18	7.5	.07	108.4
Argillite-graywacke	37	8.8	.08	106.1
Metavolcanic	99	12.9	.13	98.5

1/Average water level for wells in Randolph County is 26.7 feet below land surface.

yields the most water per foot of well in Randolph County. However, this is not true of other counties in the Durham area. Figures 15 and 16 show that there is a direct relationship between depth of weathered rock and yield in the metavolcanic and argillite-graywacke units. The metavolcanic unit in the county is deeply weathered and this may account for the higher yields; however, the argillite-graywacke unit is also deeply weathered except in the southeast corner of the county. Figure 18 indicates that topography is the most important yield-controlling factor in the granite and granodiorite unit. It is apparent that rock type, depth of weathering, and topography are among the factors that control the yield in any one locality in the county.

Plate 1 shows the areas distribution of relative yields in the Durham area. Comparison of this map with plate 2 shows that most of the area underlain by the metavolcanic unit yields 0.1 gallon per minute per foot of uncased hole. In the unshaded areas in Randolph County, a well 80 feet deep that has 30 feet of casing should yield 5 gpm or more. Wells in the areas shown by a horizontal-line pattern should yield less than 5 gpm for the same well and casing depths. Areas in which yields would be expected to be less than 1 gpm under the same set of conditions are shown in a crosshatched pattern.

Figure 30 consists of two selected hydrographs which illustrate the seasonal fluctuation of the water table in Randolph County.

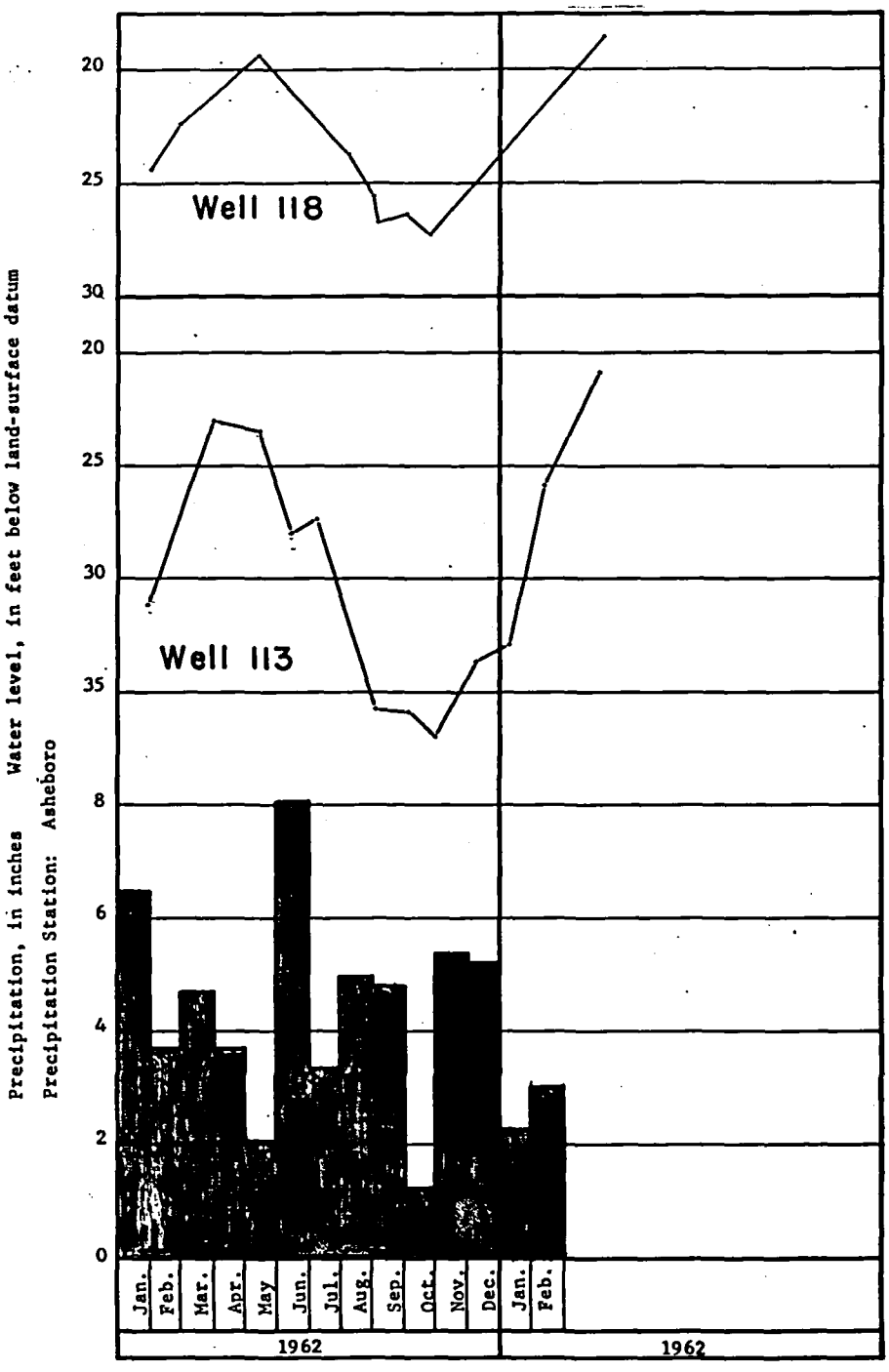

Figure 30. Selected hydrographs showing seasonal fluctuation of the water table in Randolph County.

Ref 7

Quality of Water

Ground water in Randolph County is principally a calcium bicarbonate type. Sodium and magnesium bicarbonate, and calcium chloride types also are present.

Iron concentrations were below the U. S. Public Health Service recommendations of 0.3 ppm in 10 out of 17 of the ground waters analyzed. Chloride was above 250 ppm in only one ground-water sample. Hardness ranged from 8 ppm to 1340 ppm.

Analyses of ground water from 20 selected wells is presented in table 21.

Table 20. Records of Wells in Randolph County

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
1	3.0 mi. W of Trinity	Troy Forrester	Upland flat	Dr	79	8	Mafic tuff	20	40	14	0.24	S	
2	Archdale	Randolph County Schools	do	do	92	6	Granite			9		S	
3	4.0 mi. E of Trinity	J. W. Bundy	Draw	B	25	24	do	25	11	5		S	Observation well; analysis in table.
4	5.3 mi. E of Archdale	J. R. Hill	Knoll	Dr	150	6	do	50	20	1		S	
5	2.0 mi. NW of Level Cross	Lester L. Crotts	Hill	do	150	6	do		30	8		M	
6	1.0 mi. NE of Level Cross	Vera Vickory	Slope	do	65	3	Diorite	50		4	0.27	S	
7	2.8 mi. NW of Red Cross	Tom Hockett	Flat	do	118	2	Mafic tuff		18	7		S	
8	2.5 mi. N of Liberty	Ray York	do	do	94	6	Granodiorite			35		S	
9	2.5 mi. NE of Liberty	Ervin Workman	do	B	40	24	Tuff	40	24	5		S	
10	4.4 mi. NW of Liberty	R. L. Well	Hill	Dr	182	6	Granodiorite	10	35	10+	0.06	H	
11	Red Cross	G. C. Salmon	do	B	28	24	Mafic tuff	28	13	5		S	
12	0.8 mi. SW of Red Cross	Charles Field	Draw	Dr	117	6	Granodiorite		12	2.5		S	
13	3.1 mi. W of Red Cross	J. A. Whitley	Slope	D	41	36	Mafic tuff	0	28	4		S	
14	1.6 mi. SW of Level Cross	B. E. Davis	Flat	Dr	120	6	do		30	30+			Reported corrosive, with some iron.

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
15	Glenola------	Clyde R. Spencer	Flat	--B--	44	24	Mafic tuff---	44	20	6	-------	M	Some iron reported.
16	Trinity------	Randolph County Schools------	Knoll--	-Dr--	400	6	Granite------	30	23	22	0.06	S	Analysis in table.
17	2.1 mi. SW of Trinity----	John C. Easter	--do---	-do--	75	3	------do-----	26	10	7	.14	S	
18	4.0 mi. S of Trinity----	J. M. Hill-----	Hill---	--D--	45	48	Mafic tuff---	0	38	3	-------	S	
19	3.4 mi. S of Trinity----	Mary Brunson---	Slope--	-Dr--	30	6	Granite------	9	15	1	0.05	S	
20	2.6 mi. SE of Trinity----	J. M. Elder----	Hill---	-do--	79	6	------do-----	5	40	6	.08	H	
21	2.8 mi. SW of Glenola----	Dr. McLean B. Leath-------	--do---	-do--	90	6	------do-----	15	-----	4	.05	S	
22	2.2 mi. S of Glenola----	M. J. Davis----	--do---	-do--	100	6	Mafic tuff---	------	30	5	-------	M	
23	2.5 mi. NW of Randleman--	L. V. Adams----	Low flat-	-do--	214	6	Diorite------	------	40	10	-------	S	
24	2.4 mi. N of Randleman--	Wood Smith-----	Slope--	--B--	55	24	Argillite----	------	14	4	-------	S	
25	3.0 mi. NE of Randleman--	C. W. Henley---	Hill---	-Dr--	72	3	Mafic tuff---	------	----	25	-------	S	
26	2.4 mi. S of Red Cross--	V. O. Routh----	Knoll--	--B--	35	24	Felsic tuff--	35	6	5	-------	S	
27	4.0 mi. W of Liberty----	Curtiss Dodson-	--do---	-Dr--	72	6	Granodiorite	63	6	5	0.56	S	
28	2.0 mi. W of Liberty----	George York----	Hill---	-do--	68	6	------do-----	34	22	5	.15	S	Observation well; analysis; bitter taste reported.

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
29	Liberty------	Town of Liberty	Flat---	-Dr--	299	10	Mafic tuff---	65	20	40	0.29	--------	
30	-----do------	-----do------	--do---	-do--	242	10	-----do------	135	30	75	.72	--------	
31	-----do------	-----do------	--do---	-do--	292	8	-----do------	125	15	75	.46	--------	
32	-----do------	-----do------	--do---	-do--	221	8	-----do------	150	20	75	1.00	--------	
33	-----do------	-----do------	--do---	-do--	600	6	-----do------	600	12	100	--------	--------	Cased with slotted pipe; analysis in table.
34	3.0 mi. S of Liberty----	M. M. Vickrey--	--do---	-do--	101	6	-----do------	18	10	10	0.12	S	
35	3.3 mi. SW of Liberty----	H. A. Faust----	Hill---	-do--	68	6	-----do------	-----	-----	5	--------	S	Some iron reported.
36	Grays Chapel-	Randolph County Schools------	--do---	-do--	223	6	-----do------	32	22	16	0.08	S	Observation well.
37	2.0 mi. W of Grays Chapel	J. T. Routh----	--do---	-do--	72	2	Felsic tuff--	-----	14	20	--------	S	
38	Worthville---	Leward Cotton Mills--------	--do---	-do--	105	6	Mafic tuff---	75	63	15	0.50	--------	Observation well.
39	Randleman----	Commonwealth Hosiery------	Valley-	-do--	180	6	Felsic tuff--	-----	30	20	--------	H	
40	1.7 mi. W of Randleman--	Jack Garner----	Hill---	-do--	123	6	Mafic tuff---	108	-----	5	0.33	--------	
41	1.0 mi. NW of Sophia-----	Randolph County Schools------	--do---	-do--	130	6	-----do-----	-----	-----	22	--------	--------	
42	1.7 mi. SW of Sophia-----	C. W. Sumner---	--do---	--B--	48	24	Sericite schist-----	48	30	3	--------	S	Observation well; analysis in table.
43	0.8 mi. NW of Flint Hill-	Garland-------- Hawkins------	--do---	-Dr--	130	2	Mafic tuff---	-----	-----	1	--------	S	

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
44	2.0 mi. W of Flint Hill--	George W. Spencer-----	Slope--	-Dr--	95	3½	Argillite----	20	-----	25	0.33	S	
45	4.7 mi. W of Flint Hill--	L. E. Hoover--	Hill---	-do--	96	6	-----do------	20	20	12	0.16	S	
46	7.4 mi. W of Flint Hill--	Glenn Thomas--	--do--	-do--	125	6	-----do------	46	-----	5	0.06	S	
47	6.7 mi. SW of Flint Hill--	Billy Loftin--	--do--	-do--	96	6	Felsic tuff--	20	-----	20	0.26	M	Limy taste reported.
48	3.0 mi. SW of Flint Hill--	Mt. Pleasant Church------	--do--	-do--	122	6	Andesitic tuff and argillite	6	-----	5	0.04	-------	
49	3.0 mi. S of Flint Hill--	Robert Crotts-	--do--	--B--	51	24	Argillite and tuff-------	51	37	5	-------	S	
50	4.0 mi. SW of Randleman---	Willard W. Cox	Slope--	-Dr--	91	6	Argillite----	-----	50	15	-------	S	
51	4.0 mi. SW of Randleman---	William J. Hylton------	Hill---	-do--	87	2½	-----do------	-----	50	7	-------	M	
52	3.0 mi. S of Randleman---	Hal Garner----	--do---	-do--	150	4	-----do------	125	-----	10+	0.40	S	
53	2.2 mi. SE of Worthville--	Gurney Harrelson---	Draw---	-do--	70	6	Felsic crystal tuff-------	55	4	20	1.25	S	Analysis in table.
54	1.9 mi. SW of Grays Chapel	Whites Memorial Baptist Church------	Knoll--	-do--	100	6	Mafic tuff---	7	-----	3	0.03	-------	
55	1.3 mi. N of Franklinville	E. M. Bass----	Slope--	-do--	70	4	Mafic crystal tuff-------	-----	30	6	-------	S	
56	1.9 mi. SE of Grays Chapel------	J. F. Pugh----	Hill---	-do--	61	6	Argillite----	6	18	9	0.16	S	
57	1.0 mi. N of Whites Chapel------	J. L. York----	--do---	-do--	57	6	Mafic tuff---	54	20	6	2.00	-------	Analysis in table.
58	3.0 mi. NE of Ramseur-----	James Hicks---	--do---	-do--	150	6	-----do------	30	-----	5	0.04	M	

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
59	2.5 mi. W of Staley-----	F. F. Pugh----	Upland flat	--Dr--	65	6	Mafic tuff---	-----	45	5	------	S	
60	Staley-------	Randolph County Schools-----	Hill---	--do--	80	-----	Felsic tuff--	-----	30	8	------	-------	
61	1.2 mi. S of Staley-----	F. M. Lindley-	Slope--	--do--	59	2	Argillite----	-----	-----	4	------	S	
62	3.8 mi. SW of Staley-----	W. Mike York--	Hill---	--do--	200	4	Granodiorite	32	32	3.5	0.02	S	
63	0.8 mi. NE of Ramseur----	V. C. Marley--	--do---	--do--	159	6	Argillite----	45	30	20	.17	S	Analysis in table.
64	1.5 mi. N of Ramseur----	W. H. Jones---	Low flat-	--do--	65	6	Felsic tuff--	28	15	5.5	.15	S	
65	Franklinville	Randolph Mills	Valley-	--do--	65	6	Mafic tuff---	-----	-----	9	------	S	
66	-----do------	Clarence Cheek	--do---	--do--	65	6	-----do------	40	-----	20	0.77	-------	
67	0.5 mi. E of Cedar Falls	Sapona Mfg. Co.	Slope--	--do--	300	8	Quartz veins in mafic tuff-------	-----	88	37	------	-------	
68	0.3 mi. W of Cedar Falls	Jordan Spinning Company-----	Valley-	--do--	202	6	Gabbro-------	-----	-----	11	------	S	
69	Central Falls	Klopman Mills	Slope--	--do--	160	6	Felsic crystal tuff-------	-----	-----	28	------	-------	
70	1.7 mi. S of Central Falls	Ralph Swan----	Hill---	--do--	89	6	Rhyolite-----	-----	35	6	------	S	
71	2.5 mi. W of Central Falls	Joe F. Rich---	--do---	--do--	133	6	Argillite----	80	30	12	0.23	S	
72	3.8 mi. NW of downtown Asheboro---	Bill Bollerd--	--do--	--do--	138	6	-----do------	80	80	17	.30	M	Some iron reported.
73	5.3 mi. S of Flint Hill-	Randolph County Schools-----	Slope	--do--	85	6	-----do------	-----	-----	8	------	S	
74	6.4 mi. SW of Flint Hill-	Wade Yonts----	--do--	--do--	36	6	Mafic tuff---	4	7	3	0.09	H	

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)		
75	7.0 mi. NW. of Farmer-----	Joe Ray Dunn--	Hill--	-Dr--	66	6	Felsic crystal tuff-------	-----	-----	4	--------		
76	5.5 mi. NW of Farmer-----	Brink Hunt----	--do--	--B--	34	24	Mafic tuff----	34	15	5	--------	S	
77	4.8 mi. NW of Farmer-----	J. M. Byrum---	Slope-	-Dr--	39	6	Mafic tuff breccia-----	4	9	5	0.14	M	Analysis in table.
78	3.1 mi. NW of Farmer-----	R. S. Ferrer--	Draw--	-do--	125	6	Mafic tuff and argillite---	-----	0	*3	--------	S	*Flows about 3 gpm when not pumped.
79	2.2 mi. N of Farmer-----	R. G. Yates---	Hill--	-do--	283	6	Argillite-----	-----	49	1.5	--------	--------	Observation well; analysis in table
80	5.5 mi. NE of Farmer-----	Howard Sawyer-	--do--	-do--	100	24	-----do-------	-----	85	8	--------	S	
81	4.4 mi. W of Asheboro---	S. A. Lowe, Jr.	--do--	-do--	118	6	-----do-------	-----	48	7	--------	S	Some iron reported.
82	Asheboro-----	Colen Auman---	--do--	-do--	50	4	Mafic tuff----	10	20	10	0.25	--------	Analysis in table.
83	2.0 mi. E of Asheboro---	Herbert Shepherd----	Slope-	-do--	85	6	Crystal tuff-- and argillaceous tuff-------	-----	20	5	--------	S	
84	2.8 mi. S of Cedar Falls	Blue Mist Drive Inn---	Hill--	-do--	54	6	Mafic tuff----	32	-----	22	1.00	--------	
85	2.0 mi. SW of Franklinville	Clage Pritchard	--do--	-do--	120	6	-----do-------	46	-----	3	.04	--------	
86	3.2 mi. SW of Ramseur----	John H. Williams----	--do--	-do--	80	6	-----do-------	28	22	9	.18	S	
87	1.8 mi. W of Ramseur----	Melvin's Drive Inn---------	--do--	-do--	114	4	Argillite-----	40	12	10+	.14	S	
88	Ramseur-----	Ramseur Furniture Co.----	Slope-	-do--	58	5	Argillite and graywacke---	-----	7	5	--------	--------	Observation well.

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
89	3.0 mi. S of Ramseur---	P. T. Allen---	Hill--	-Dr--	100	6	Mafic tuff---	95	60	10	2.00	M	
90	3.0 mi. SE of Ramseur---	Mrs. Allene Parks-------	--do--	--D--	51	36	Granodiorite	0	43	3	--------	S	
91	5.0 mi. E of Ramseur---	Earnest Burgess	Slope-	--B--	30	24	-----do------	30	25	1	--------	S	
92	5.5 mi. SE of Ramseur---	I. W. Parks---	--do--	-Dr--	75	6	Argillite----	25	-----	5	0.10	S	Some iron reported.
93	2.0 mi. NE of Coleridge-	H. W. Ferree--	--do--	-do--	125	6	Mafic tuff---	18	55	3	.03	S	Analysis in table.
94	2.8 mi. N of Coleridge-	J. M. Greene--	Knoll-	-do--	47	6	Granodiorite-	37	-----	12	1.25	S	Do.
95	Coleridge---	Randolph County Schools-----	Hill--	-do--	185	6	Argillite----	15	60	22	.13	--------	
96	2.3 mi. NW of Coleridge-	Francis Byrd--	--do--	-do--	74	4	Mafic tuff---	37	28	7	.18	S	
97	5.0 mi. NW of Coleridge-	Archie L. Rumley------	--do--	-do--	75	6	Phyllite-----	45	35	3	.10	S	Reported to have iron and to be corrosive.
98	6.3 mi. W of Coleridge-	T. E. Smith---	Draw--	-do--	72	4	Crystal lithic tuff-------	21	22	10	.20	S	
99	4.5 mi. SE of Asheboro--	Evelyn Smith--	Knoll-	-do--	126	4	Mafic tuff---	26	35	8	.08	S	
100	4.0 mi. E of Asheboro--	E. L. Smith---	Flat--	-do--	71	4	Crystal tuff-	42	28	12	.42	S	
101	4.0 mi. SE of Asheboro--	G. B. Beeson--	Slope-	-do--	62	4	Crystal lithic tuff-------	16	22	8	.17	S	Analysis in table.
102	3.0 mi. SE of Asheboro--	Coy J. Hamilton----	Hill--	-do--	60	4	Mafic tuff---	30	17	10	.33	S	
103	3.5 mi. S of downtown Asheboro--	Arthur Johnson	--do--	-do--	50	6	Crystal tuff-	18	-----	10	.31	S	

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
104	Asheboro-----	H. L. Frye-----	Hill--	-Dr--	75	6	Crystal tuff--	21	18	3	0.06	H	Reported to have iron and to be acid.
105	2.0 mi. NW of Ulah-------	J. E. Allred---	--do--	-do--	76	4	------do------	60	35	8	0.50	M	Reported corrosive.
106	4.4 mi. NW of Ulah-------	Walter Ganter--	--do--	-do--	100	6	------do------	------	-----	8	-------	M	
107	3.3 mi. W of Ulah-------	John J. Hill---	Draw--	-do--	110	6	------do------	22	30	2	0.02	S	
108	3.5 mi. NE of Farmer-----	James Morris---	Upland flat	--B--	80	24	Argillite-----	80	40	1	-------	S	
109	Farmer-------	Randolph County Schools------	Slope-	-Dr--	160	6	------do------	40	35	20	0.17	-------	
110	3.0 mi. W of Farmer-----	E. J. Bailey---	Knoll-	-do--	90	4	Argillite and mafic tuff--	------	6	8	-------	S	
111	3.8 mi. SW of Farmer-----	Paul Apple-----	Slope-	-do--	50	6	Gabbro and mafic tuff--	------	3	8	-------	M	Water reported to be limy.
112	2.8 mi. SW of Farmer-----	E. W. Elliot---	Hill--	-do--	135	2	Argillite-----	35	5	5	0.05	S	Some iron reported.
113	2.4 mi. SE of Farmer-----	T. V. Allman---	Slope-	-do--	99	6	------do------	55	34	25	0.59	S	
114	3.7 mi. SE of Farmer-----	Marshall Quick-	Knoll-	-do--	71	6	Crystal tuff--	------	23	1.5	-------	S	Observation well.
115	0.8 mi. S of Ulah-------	Ervin Cole-----	Hill--	-do--	83	6	Crystal lithic tuff--------	40	20	10	0.23	M	
116	2.4 mi. SE of Ulah-------	Mr. Garner-----	Slope-	-do--	49	4	------do------	36	-----	15	1.10	S	
117	4.3 mi. SE of Ulah-------	Richard E. Taylor-------	--do--	-do--	85	4	------do------	70	15	5	0.33	S	
118	6.3 mi. W of Coleridge--	Tom Brown------	Hill--	--B--	41	24	Crystal tuff--	41	24	3	-------	S	Observation

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
119	6.0 mi. W of Coleridge--	Ray Brown-----	Hill--	-Dr--	134	6	Crystal tuff-	123	17	5	0.46	S.	
120	4.5 mi. SW of Coleridge--	E. A. Bean----	--do--	-do--	91	6	Felsic tuff--	------	------	9	-------	S	Analysis in table
121	3.5 mi. W of Coleridge--	Luther Owens--	Flat--	-do--	32	4	------do-----	------	11	8	-------	S	
122	1.9 mi. SW of Coleridge--	Mrs. Van Oldham------	--do--	--B--	24	24	------do-----	34	12	3	-------	S	
123	3.1 mi. S of Coleridge--	N. L. Rumley--	Slope-	-Dr--	42	6	------do-----	15	15	7	0.26	M	
124	2.7 mi. SE of Coleridge--	D. E. Brown---	Hill--	-do--	60	6	Mafic argillite--	------	30	5	-------	M	Limy taste reported.
125	4.9 mi. SE of Coleridge--	L. B. Goins---	Slope-	-do--	36	6	Mafic tuff---	20	30	1.5	0.09	-------	
126	5.2 mi. SE of Coleridge--	Albert Brown--	Hill--	-do--	126	6	------do-----	14	46	0.1	.00	H	
127	4.8 mi. S of Coleridge--	Roy Macon-----	--do--	-do--	80	6	Mafic argillite--	53	------	20	.72	S	
128	1.2 mi. N of Erect------	M. D. Chrisco-	--do--	--B--	31	22	Felsic tuff--	31	21	5	-------	S	
129	2.2 mi. W of Erect------	Clinton Richardson--	Slope-	-Dr--	64	6	Mafic crystal tuff-------	30	------	20	0.60	S	
130	2.3 mi. NW of Erect------	E. E. Hammer--	Hill--	--D--	38	30	Welded flow	38	32	1	-------	S	
131	4.0 mi. N of Seagrove---	F. L. Allen---	--do--	-Dr--	81	4	Crystal lithic tuff-------	35	18	8	0.18	S	
132	2.7 mi. N of Seagrove---	Huldah Baptist Church------	--do--	-do--	80	4	Lithic crystal tuff-------	------	-----	8	-------	S	
133	2.9 mi. S of Ulah-------	C. C. Boling--	--do--	--B--	40	24	Crystal tuff-	40	23	4	-------	S	

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
134	3.2 mi. SW of Ulah-------	Ervin Parks---	Slope-	-Dr--	155	6	Crystal tuff-	17	20	20	0.14	M	Limy water reported; analysis in table.
135	5.5 mi. SW of Ulah-------	High Pines Church------	Flat--	-do--	64	6	Welded flow tuff-------	-----	30	10	-------	S	
136	2.0 mi. S of Martha-----	Jack Lanlier--	Knoll-	-do--	100	6	Argillite----	45	35	4	0.07	S	
137	2.9 mi. SW of Martha-----	Roscoe Miller-	Flat--	-do--	100	4	Tuffaceous argillite--	60	4	6	0.15	S	
138	4.9 mi. SW of Martha-----	J. B. Surratt-	Slope-	--D--	25	40	-----do------	0	19	1	-------	M	
139	4.2 mi. S of Martha-----	C. A. Lanier--	Knoll-	-Dr--	170	4	Argillite----	40	-----	0.5	0.00	--------	
140	4.4 mi. SE of Martha-----	R. C. Millkan-	Hill--	-do--	125	6	-----do------	40	57	12	0.14	S	Analysis in table.
141	3.3 mi. W of Pisgah-----	Arthur Hill---	--do--	-do--	129	6	Crystal tuff	70	-----	5	0.08	--------	
142	1.0 mi. W of Pisgah-----	Lacy Strider--	Flat--	-do--	100	6	-----do------	12	7	7	0.08	S	
143	1.5 mi. E of Pisgah-----	Gray Lambert--	Slope-	-do--	70	6	-----do------	15	-----	8	0.14	S	
144	2.6 mi. NW of Seagrove---	Grady Auman---	Knoll-	-do--	70	6	-----do------	60	-----	8	0.77	S	
145	1.5 mi. NW of Seagrove---	Arthur Latham-	Flat--	-do--	124	6	Crystal tuff-	28	30	3.5	0.04	S	
146	Seagrove-----	C. R. Richardson--------	Knoll-	-do--	75	6	-----do------	40	20	20	0.56	M	
147	2.4 mi. NE of Seagrove---	J. E. Spivey--	Slope-	-do--	40	6	-----do------	35	20	5	1.00	S	Reported to be corrosive to copper.

Ref 7

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
148	Erect--------	Lewis Teague---	Slope--	-Dr--	102	6	Felsic tuff--	18	40	17	0.20	S	Reported to have iron.
149	2.0 mi. SE of Erect------	Robert Garner--	Hill---	-do--	95	6	-----do------	90	25	18	3.33	S	
150	3.4 mi. SE of Erect------	Frank Kiser----	Flat---	-do--	71	5	Mafic argillite--	11	19	0.5	.01	--------	Observation well.
151	5.5 mi. SE of Erect------	Sam Caviness---	Knoll--	-do--	55	6	Mafic tuff---	-----	20	4	------	H	Some iron reported.
152	3.4 mi. S of Erect------	J. W. Culler---	Hill---	-do--	82	6	Sheared felsic tuff	70	37	20	1.66	S	Encountered quartz veins.
153	2.7 mi. SW of Erect------	Everett Stutts-	--do---	-do--	111	6	Phyllite-----	54	31	14	.24	S	Some iron reported; analysis in table.
154	3.1 mi. SE of Seagrove---	F. L. Gatlin---	Flat---	--B--	54	24	Felsic tuff--	54	20	7	------	S	
155	Seagrove-----	Lucks, Inc.-----	Slope--	-Dr--	275	6	Rhyolite-----	35	-----	25	0.10	--------	Analysis in table.
156	1.8 mi. S of Pisgah-----	Barnett Payne	Flat---	-do--	103	6	Crystal tuff-	93	30	20	2.00	S	
157	6.2 mi. SW of Pisgah-----	Everett Simmons	Slope--	-do--	95	4	Argillite----	-----	25	3	------	--------	Reported to be corrosive.
158	5.9 mi. S of Martha-----	Ratio Cranford	Knoll--	-do--	135	4	-----do------	-----	32	15	------	S	

Ref 7

Table 21. Chemical Analyses of Ground Water from Randolph County
(Numbers heading the columns correspond to well numbers in table 20)

(Parts per million)

	3	16	28	33	42	53	57	63	77	79	82	93	94	101	120	134	140	150	153[3]	155
Date of collection	12/17/62	12/17/62	12/17/62	5/13/59	12/17/62	12/17/62	12/17/62	12/18/62	1/4/63	12/17/62	10/17/62	10/17/62	12/18/62	10/17/62	10/17/62	10/17/62	10/17/62	1/15/62	10/17/62	10/17/62
Silica (SiO_2)	43	34	42	31	6.6	31	28	28	17	14	31	23	19	29	22	27	23	--	29	28
Aluminum (Al)	.0	.1	.0	.0	.0	.1	.1	.1	.0	.0	.0	.0	.0	.0	.0	.1	.0	--	.1	.0
Iron (Fe)	.07	.04	.07	.06	.69	1.4	5.0	.22	.18	.04	.10	.03	.33	2.0	--	3.2	--	--	5.4	.00
Manganese (Mn)	.01	.05	.01	.01	.00	.05	.01	.05	--	--	--	--	.03	--	--	--	--	--	--	--
Calcium (Ca)	22	67	10	23	1.9	22	37	24	13	7.0	19	44	2.6	5.0	6.5	52	6.7	388	38	9.8
Magnesium (Mg)	7.5	30	7.9	6.0	.7	6.3	28	10	14	4.6	7.0	16	2.2	1.3	2.9	6.4	4.2	89	19	3.5
Sodium (Na)	2.8	18	11	11	.2	8.7	15	11	6.1	2.2	14	18	2.3	6.8	6.2	13	7.2	--	24	8.8
Potassium (K)	.1	2.0	.2	1.1	.1	.2	.1	1.4	.1	.1	1.0	.3	.2	1.1	.6	3.8	.4	--	.8	1.7
Lithium (Li)	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.1	.0	--	.2	.0
Bicarbonate (HCO_3)	102	291	64	120	11	118	166	139	82	34	106	192	20	29	46	183	40	412	136	53
Sulfate (SO_4)	5.4	26	14	1.0	.8	7.6	3.0	2.6	22	1.0	4.4	7.8	.4	2.6	3.8	13	2.8	--	6.6	4.0
Chloride (Cl)	1.0	42	6.6	1.1	.2	.2	71	6.0	6.6	4.0	9.0	27	1.0	2.3	2.0	16	4.7	750	79	6.8
Fluoride (F)	.0	.1	.2	.0	.0	.1	.2	.1	.0	.1	.0	.1	.0	.1	.0	.1	.1	--	.1	.1
Nitrate (NO_3)	1.0	2.7	8.2	.1	.2	.2	.9	.9	5.4	13	1.5	11.	4.6	5.0	1.6	1.7	13	.1	1.8	1.7
Phosphate (PO_4)	.0	.3	.1	.1	.0	.0	.0	.0	.0	.1	.1	.1	.0	.0	.0	.0	.2	--	.0	.0
Dissolved solids	133	365	132	130	16	134	265	152	125	65	139	242	42	67	71	223	82	--	265	89
Hardness as $CaCO_3$	86	291	58	81	8	82	207	100	90	36	76	174	16	18	28	156	34	1340	174	36
Noncarbonate	2	52	6	0	0	0	71	0	23	8	0	18	0	0	0	6	1	998	63	0
Specific conductance	179	610	188	200	22	190	478	258	255	92	180	375	53	72	85	338	107	3100	458	112
pH	6.9	7.2	6.5	8.0	6.2	7.2	6.9	7.4	6.6	6.6	6.9	6.9	6.4	6.1	6.4	7.2	6.6	7.2	6.6	6.5
Color	--	--	--	5	--	--	--	--	3	3	3	3	--	3	3	3	3	--	3	3
Map unit	Granite and granodiorite	Granite and granodiorite	Granite and granodiorite	Metavolcanic	Metavolcanic	Metavolcanic	Metavolcanic	Argillite-graywacke	Metavolcanic	Argillite-graywacke	Metavolcanic	Metavolcanic	Granite and granodiorite	Metavolcanic	Metavolcanic	Metavolcanic	Argillite-graywacke	Argillite-graywacke	Metavolcanic	Metavolcanic

[3] Bromide (Br)--0.17 ppm.

Ref 7

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GEOLOGY AND GROUND-WATER
in the
DURHAM AREA, NORTH CAROLINA

Ref 7

PLATE I

MAP OF THE DURHAM AREA
SHOWING
AREAL DISTRIBUTION
OF
YIELDS PER FOOT OF DEPTH

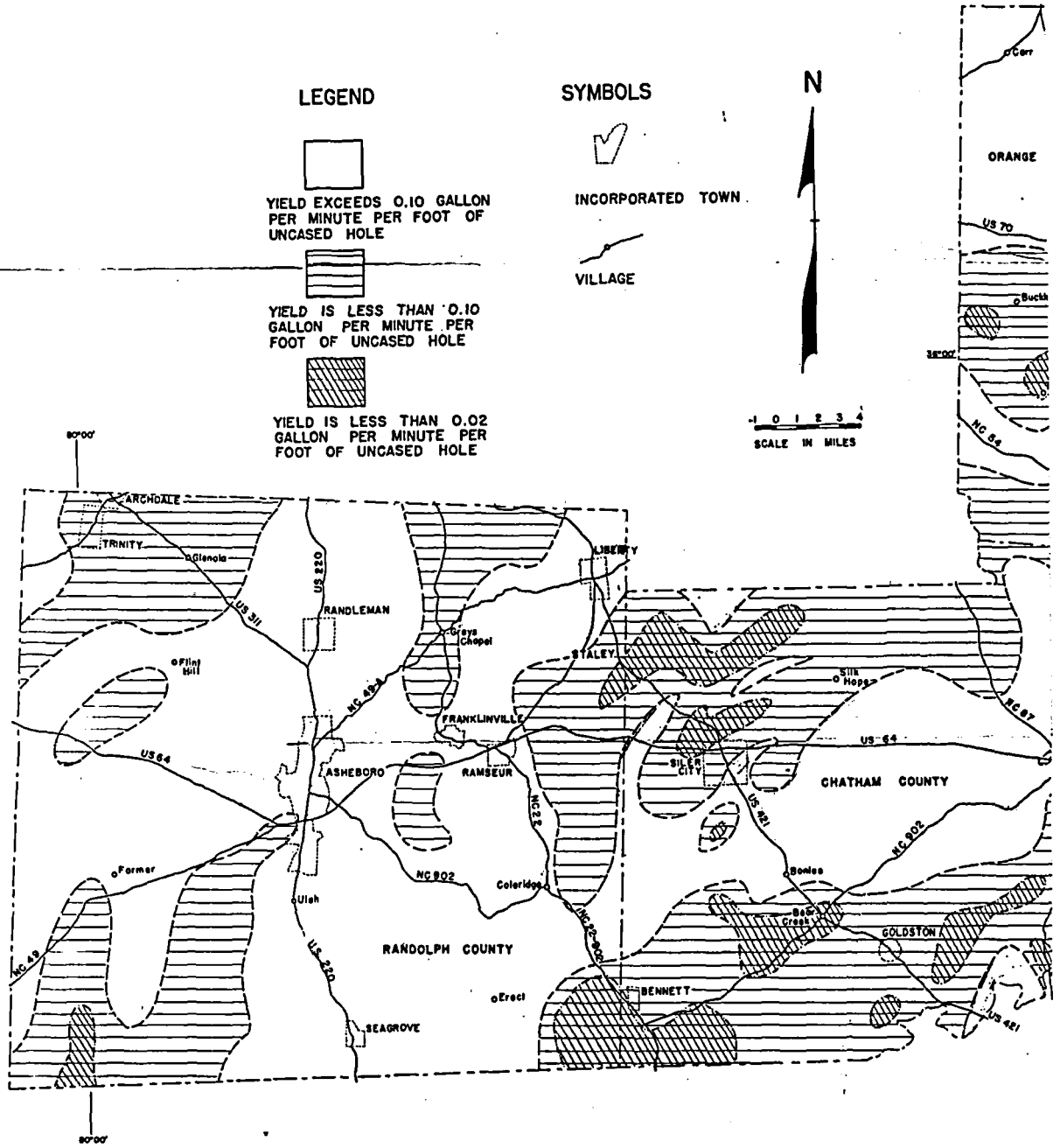


PLATE 2

Ref 7

RECONNAISSANCE GEOLOGIC MAP

OF THE

DURHAM AREA, NORTH CAROLINA

EXPLANATION

Newark Group — TRIASSIC

- Rs / Rd — Triassic unit: Rs, shale and sandstone; Rd, diabase

MISSISSIPPIAN (?)

- Mgr — Granite and granodiorite unit
- Mdg — Gabbro and diorite units

ORDOVICIAN (?)

- Mafic tuff and flow unit
- Ola — Tuffaceous argillite unit
- Od — Argillite — graywacke unit
- Omv — Metavolcanic unit

PRECAMBRIAN

- p€hg — Hornblende gneiss unit
- p€mg — Mica gneiss and schist unit

Reconnaissance Geology by George Bain

SYMBOLS

APPROXIMATE LOCATION OF CONTACT

GRADATIONAL CONTACT

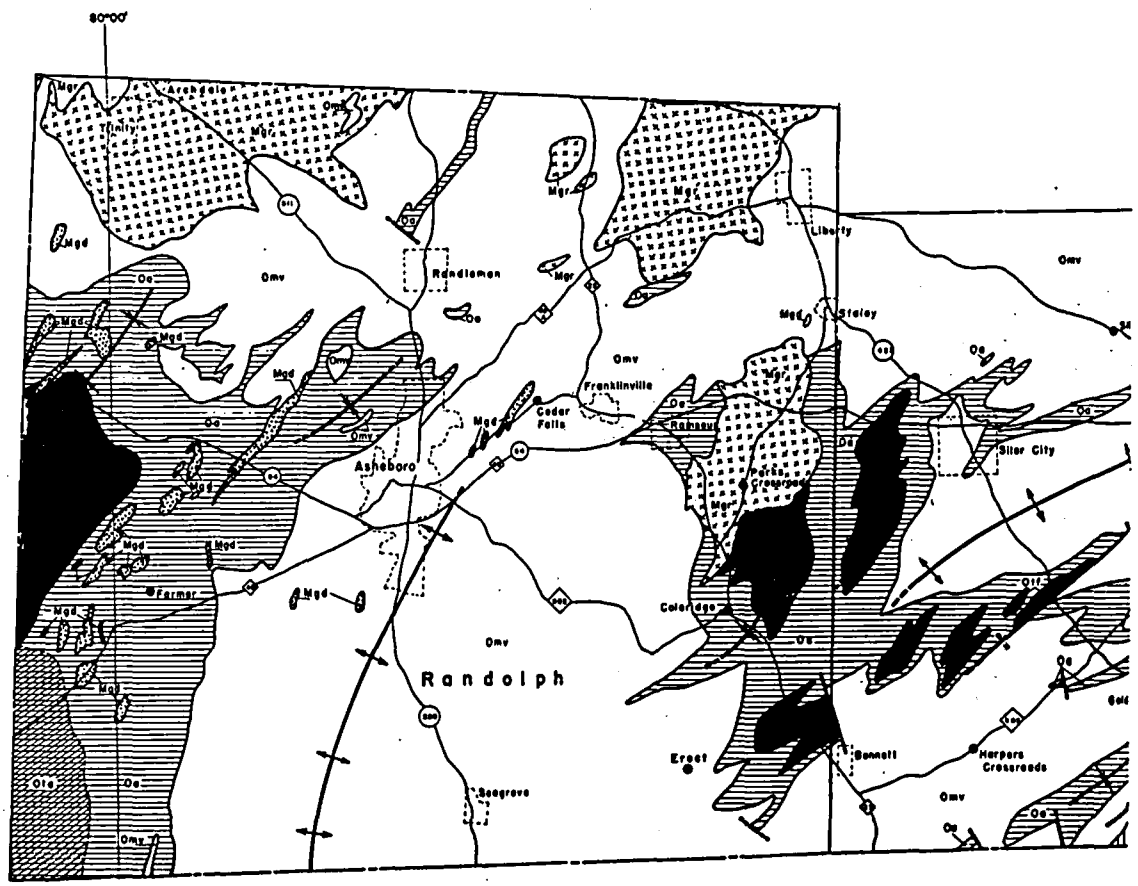
ANTICLINAL AXIS

SYNCLINAL AXIS

FAULT

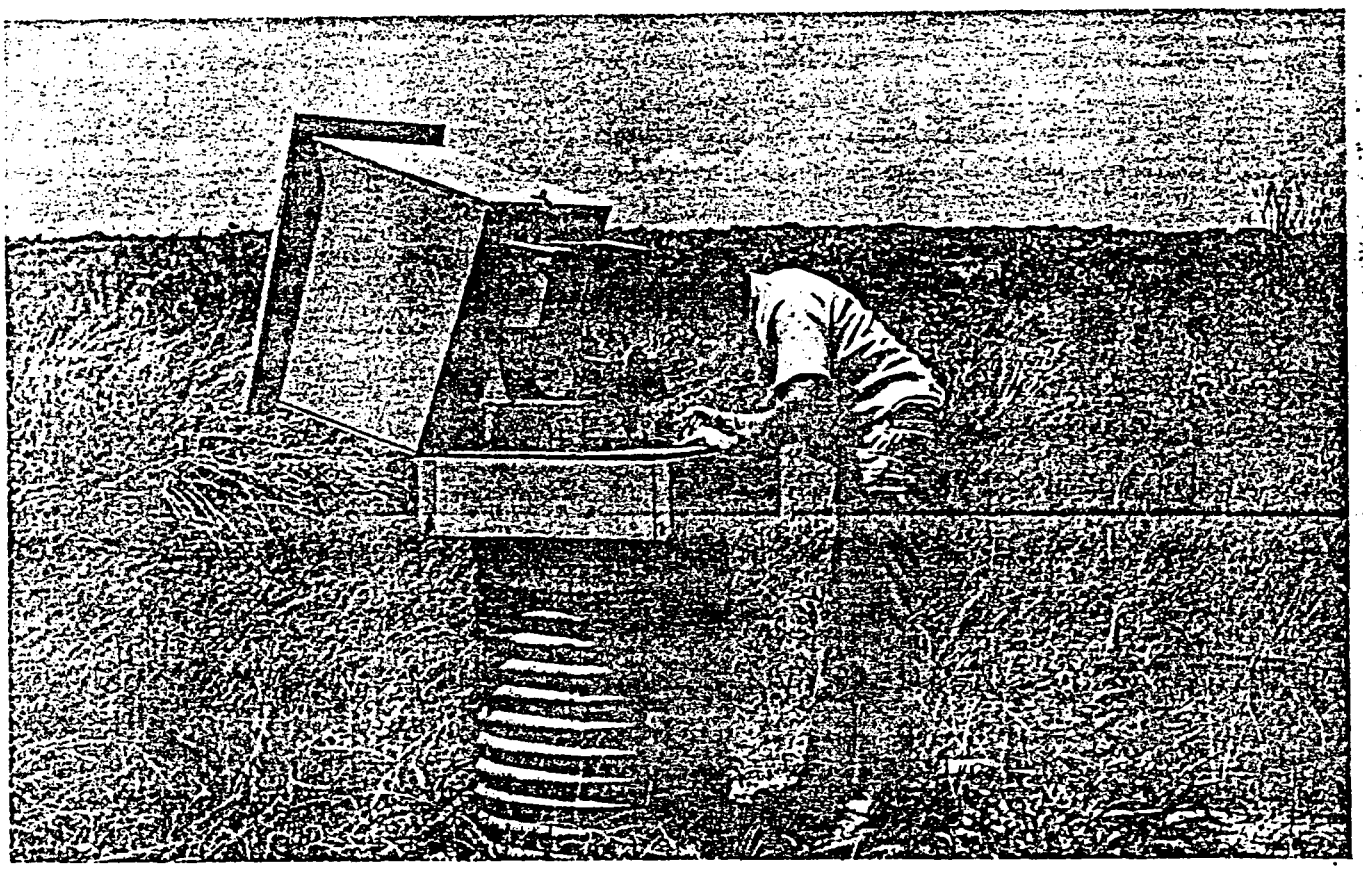
Dashed where approximate. U, upthrown block; D, downthrown block.

Geology in part after *Reinemund, 1955*



Ref 8

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

Bale

Ref 8

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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

By Ralph C. Heath

U.S. Geological Survey
Water-Resources Investigations
Open-File Report 80-44

Prepared in cooperation with the
North Carolina Department of Natural
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Raleigh, North Carolina
1980

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)

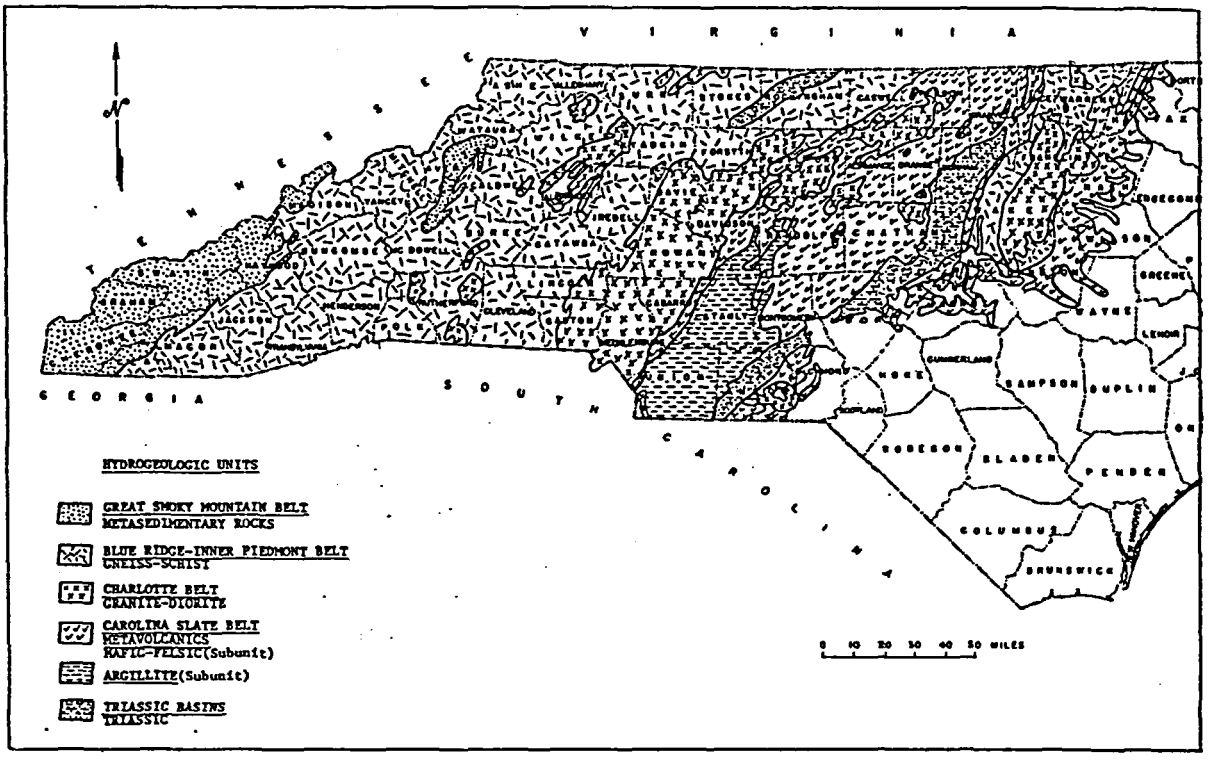
$$K = \frac{Qdl}{Adh} = \frac{150\ ft^3}{day} \times \frac{1}{ft^2} \times \frac{1\ ft}{1\ ft} = \frac{150\ ft^3}{day\ ft^2} = 150\ ft/day$$

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

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

Ref 8

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.

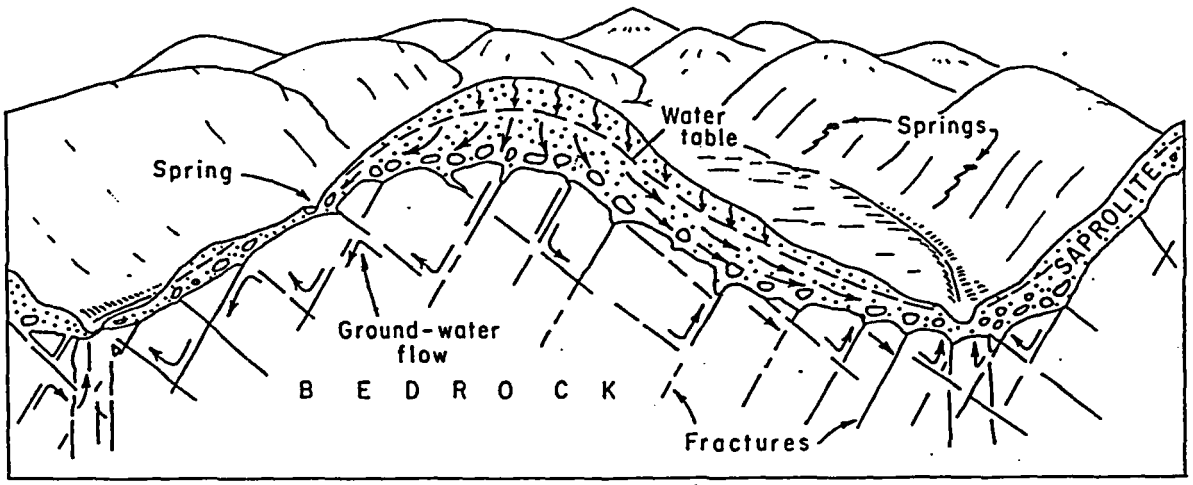
The bedrock underlying the Piedmont and mountains consists of many different types of igneous and metamorphosed igneous and sedimentary rocks. The Generalized Geological Map of North Carolina accompanying the discussion of WATER-BEARING ROCKS divides the bedrock in the Piedmont and mountains into six 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.

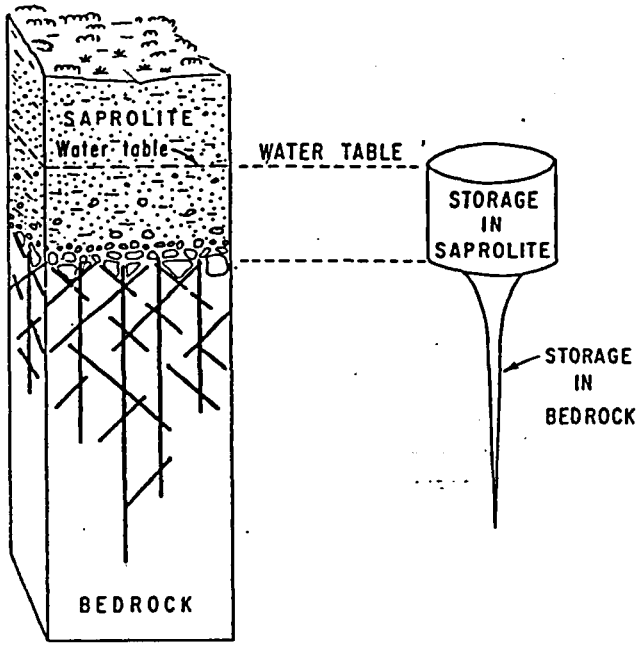
Fractures (joints and faults) are more abundant under valleys, draws, and other surface depressions than under hills. In fact, geologists assume that it is the presence of fractures that determined the position of valleys in the first place. Fractures tend to be more closely-spaced and the openings developed 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.

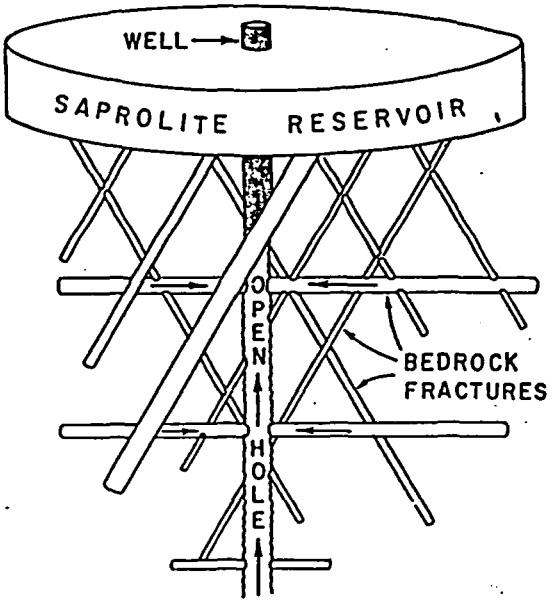
The ground-water system in the Piedmont and mountains is recharged by precipitation on the interstream areas. A part of the precipitation infiltrates through the unsaturated zone to the water table, which normally occurs in the saprolite.

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.

Ref 8

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.

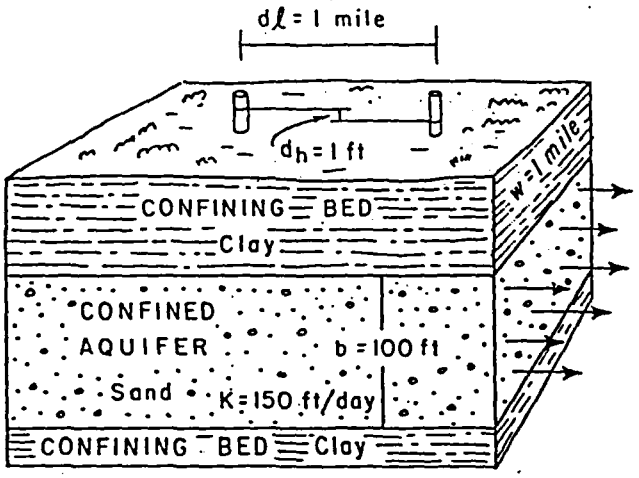
The yield of a well drawing from fractured bedrock depends on several factors. The most important of these are believed to be:

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.

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

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

NORTH CAROLINA ATLAS

PORTRAIT OF A CHANGING SOUTHERN STATE

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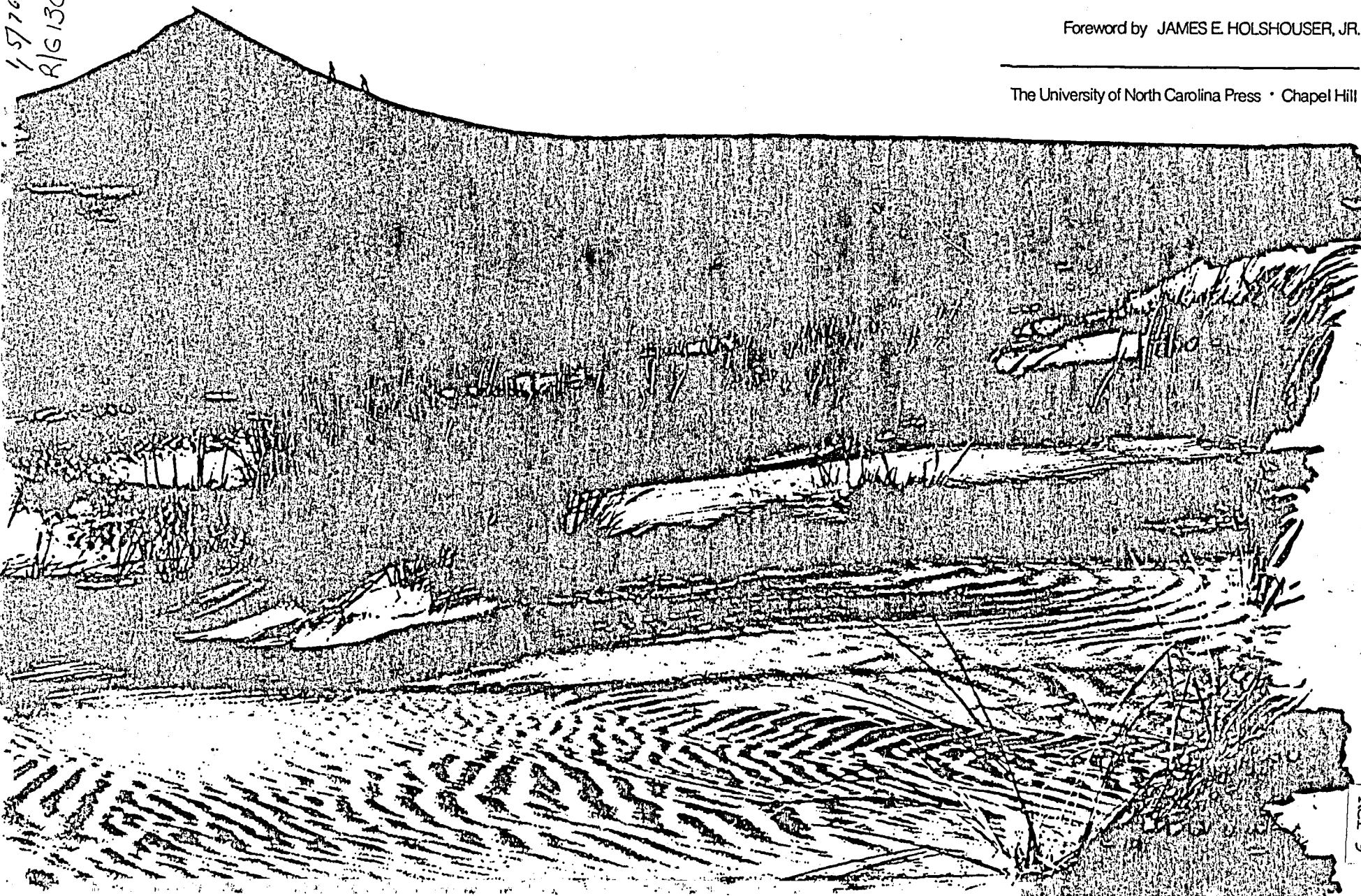

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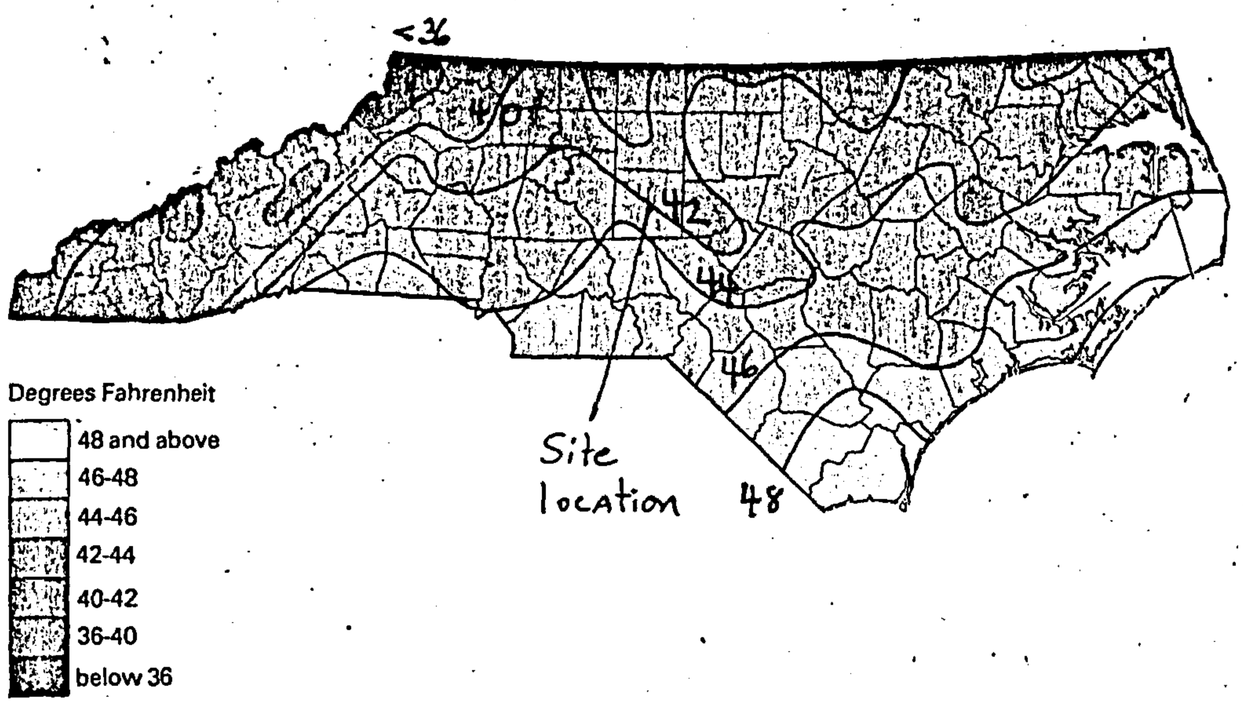
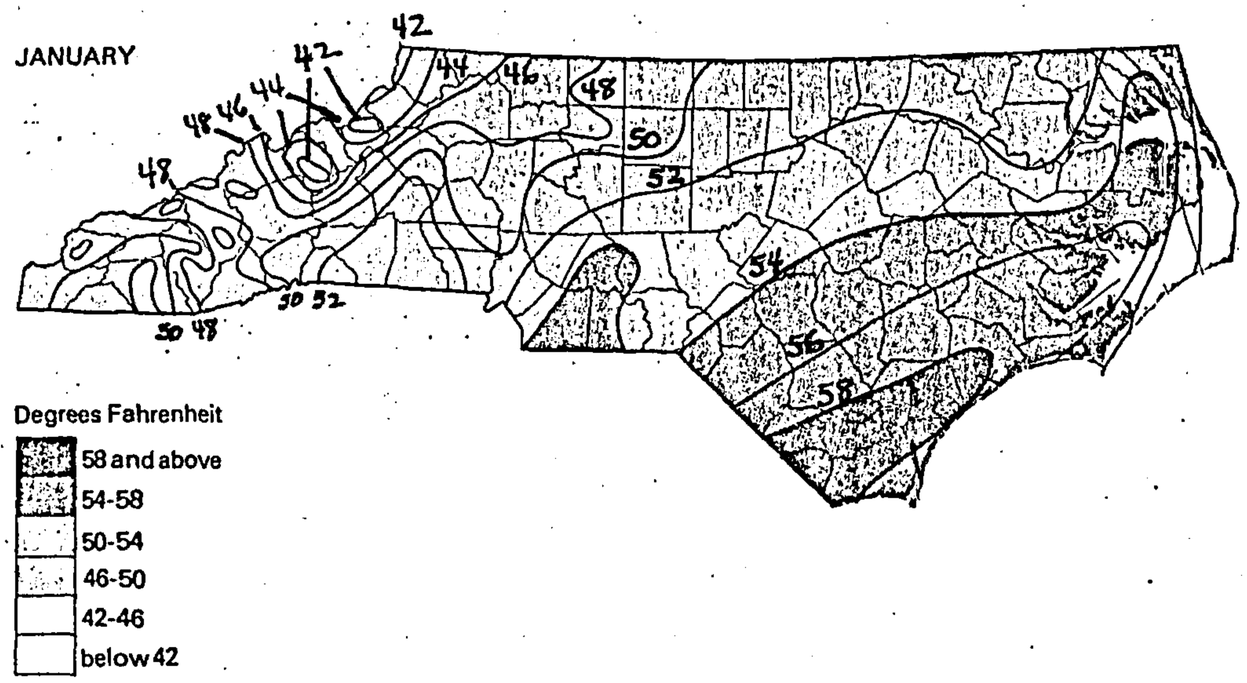
Figure 5.2. Average January Temperatures in N.C.



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.

Seasonal Changes in Climate

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.

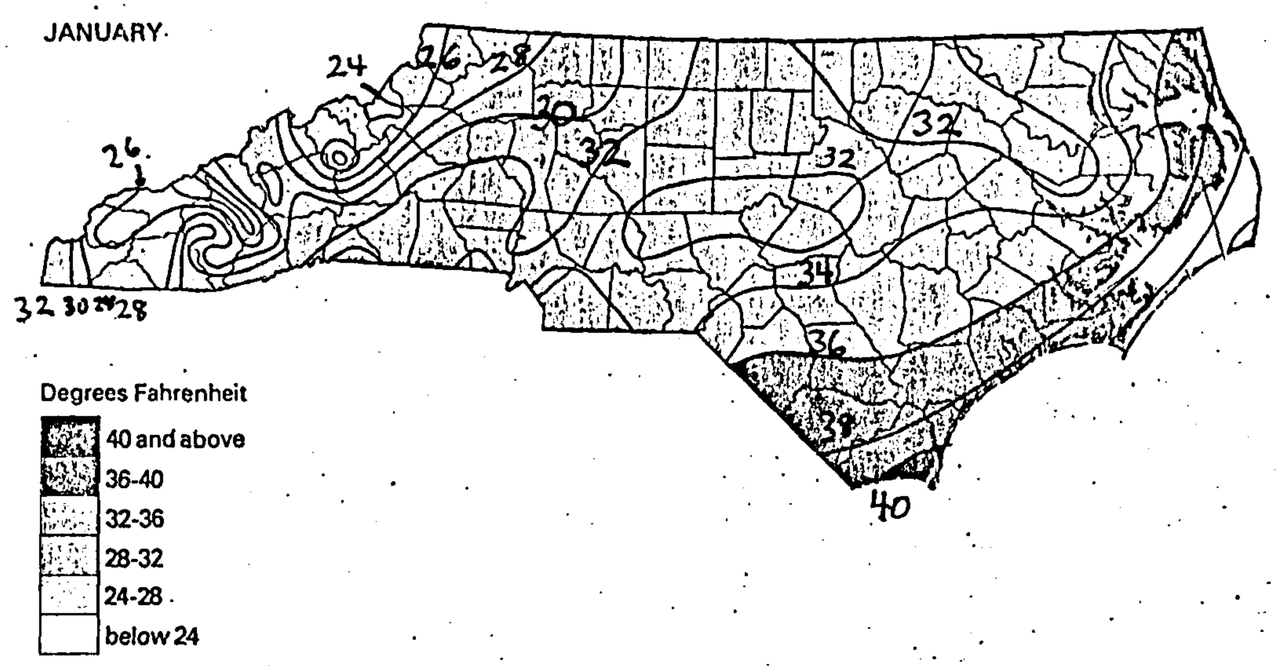
Ref 9

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.

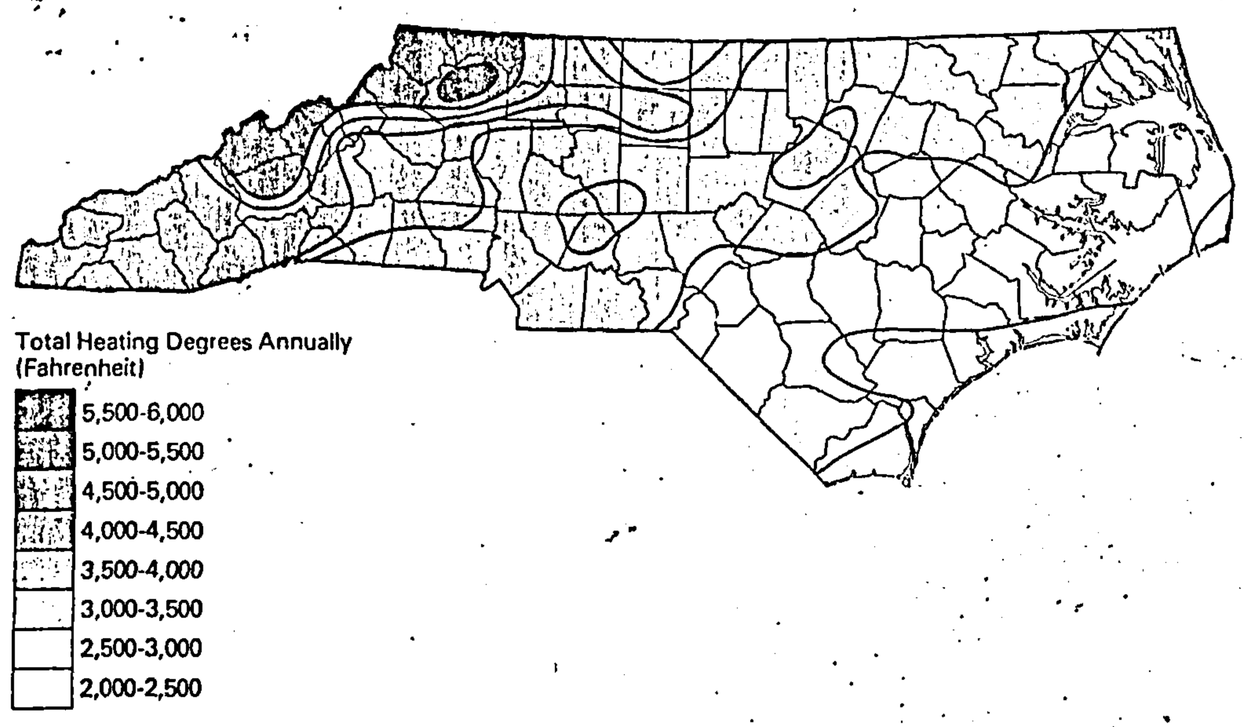
Average Annual Heating Degree Days There are climatically significant measurements of heat energy variation other than the direct determination of temperature, the cyclical occurrence of certain temperature levels, or the periodicity of temperature realms. These measurements relate to temperature efficiency 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.

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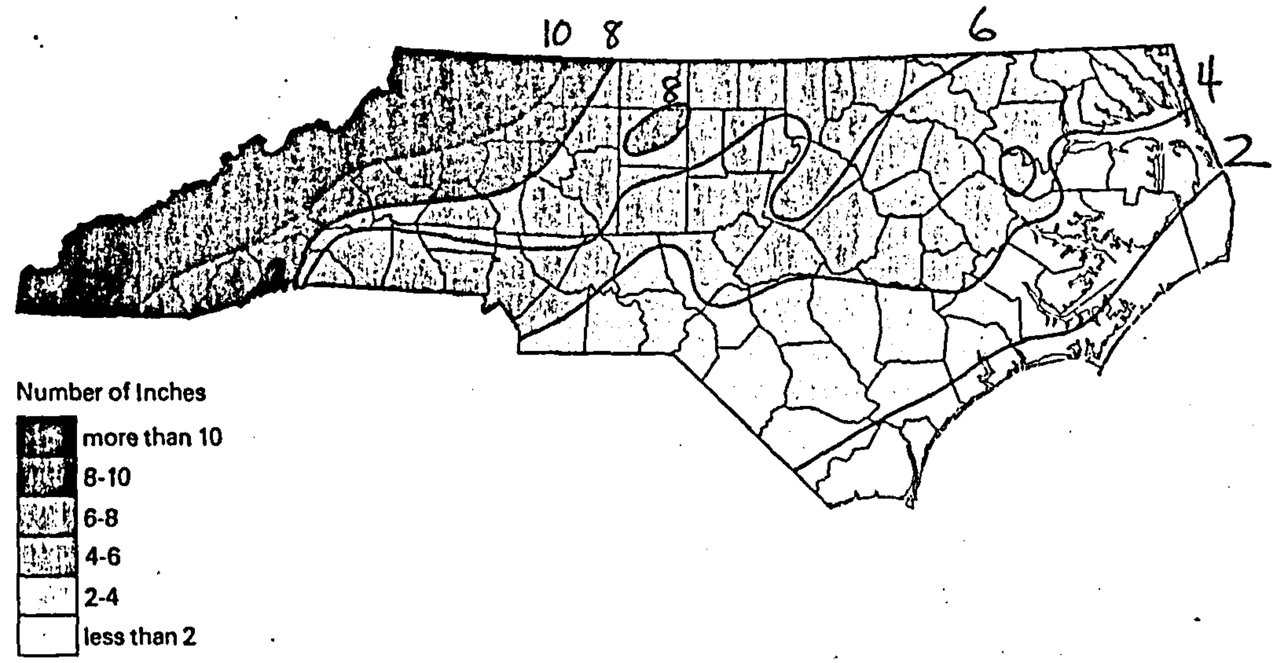
When high-pressure systems (anticyclones) dominate, clear to partly cloudy weather prevails. Receiving, on the average, 50 to 60 percent of total possible sunshine, North Carolina receives more hours of winter sunshine than do states to the north and to the immediate west. Sunshine is more prevalent 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.

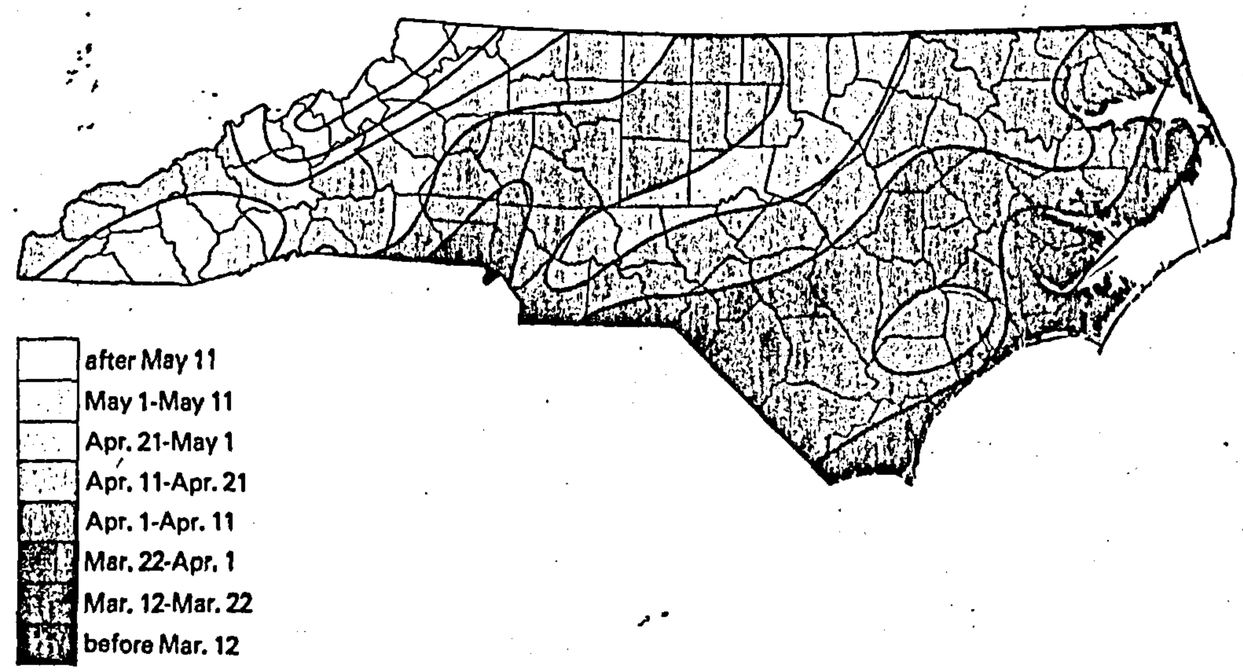
Average Date of the Last Freeze in Spring As illustrated by Figure 5.8, the beginning of the freeze-free season varies across the state from 1 March to 10 May, a difference in time of over two months. As expected, the milder climate along North Carolina's coast engenders early dates, whereas the more 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.

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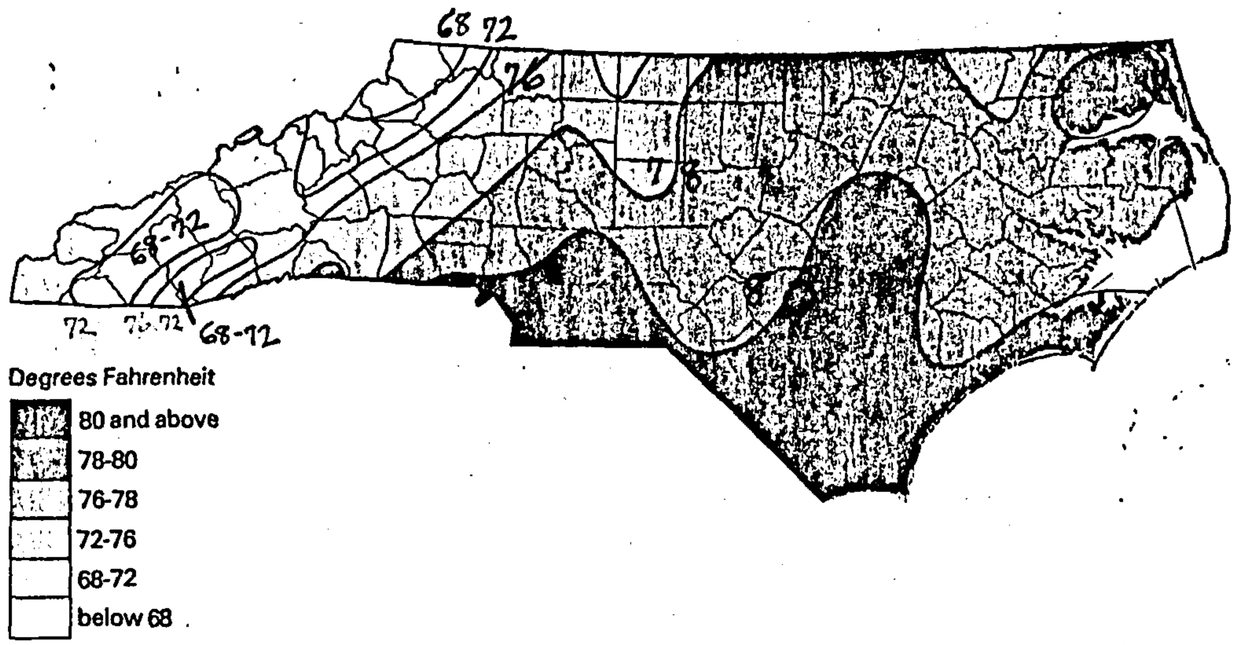
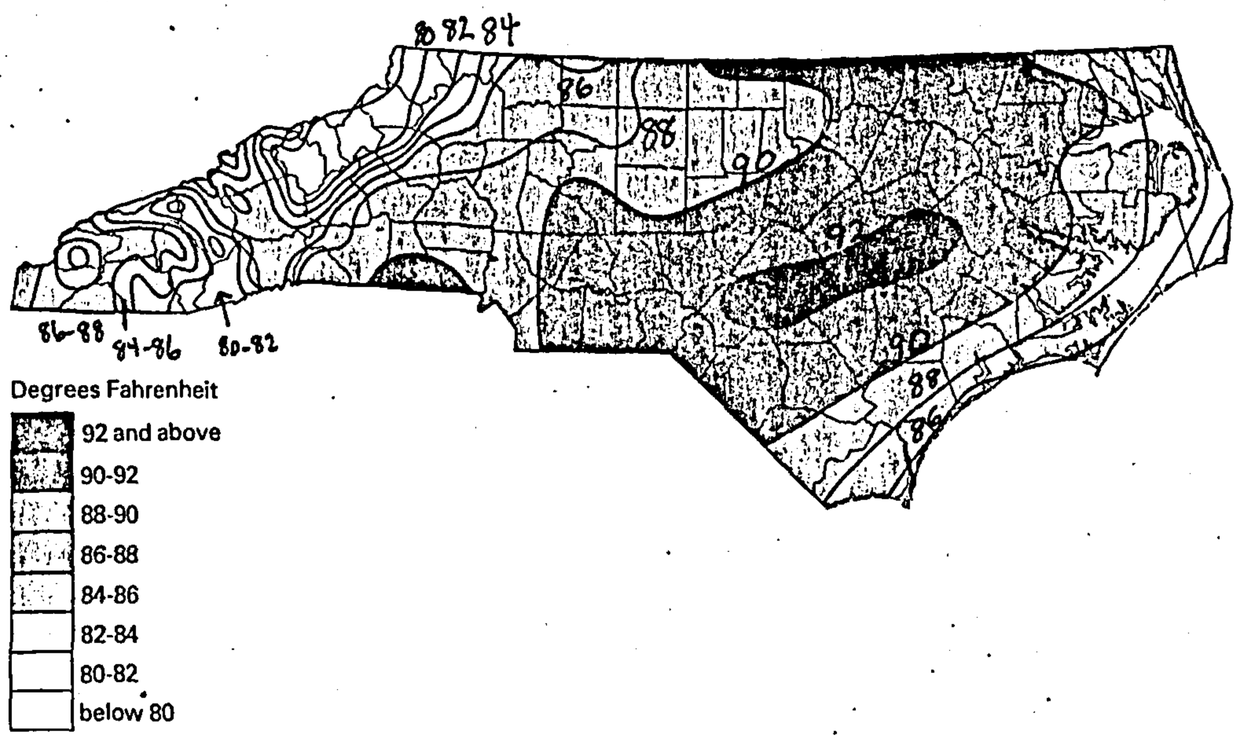
Figure 5.9. Average July Temperature in N.C.



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 strip-like regions have longer freeze-free seasons 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.

Ref 9

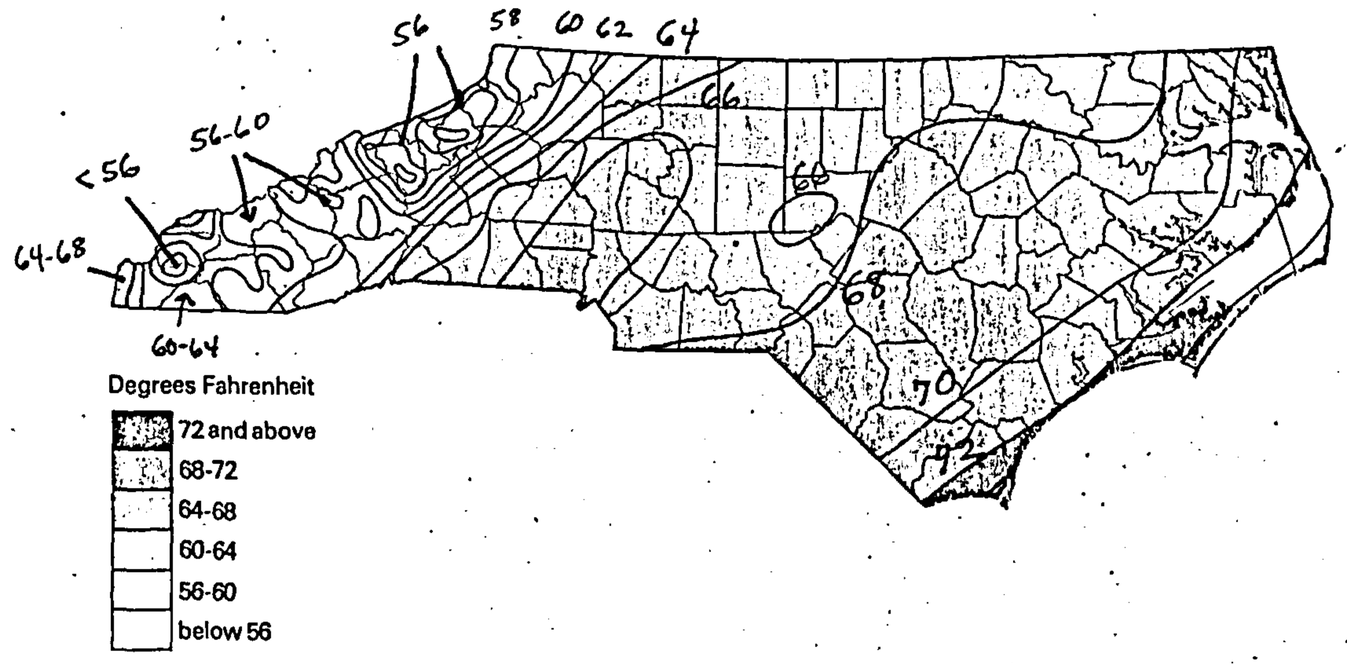
In the Mountains, the effects of altitude reduce mean temperature values sharply. The temperature gradient in July is even steeper than in January. East to west across Caldwell County, mean temperatures drop from 76° F. to 68° F. and Mount Mitchell remains the coolest site in the state with a July average 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 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.

Figure 5.11. Mean Minimum July Temperature in N.C.

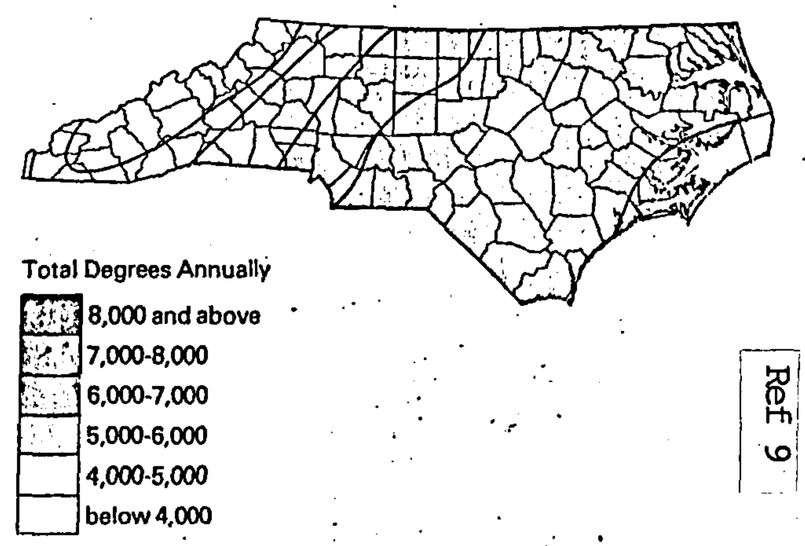


Source: U.S. Department of Commerce, *Weather and Climate in North Carolina*, 1972.

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.

Ref 9

Autumn is the driest season of the year and rainfall 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.

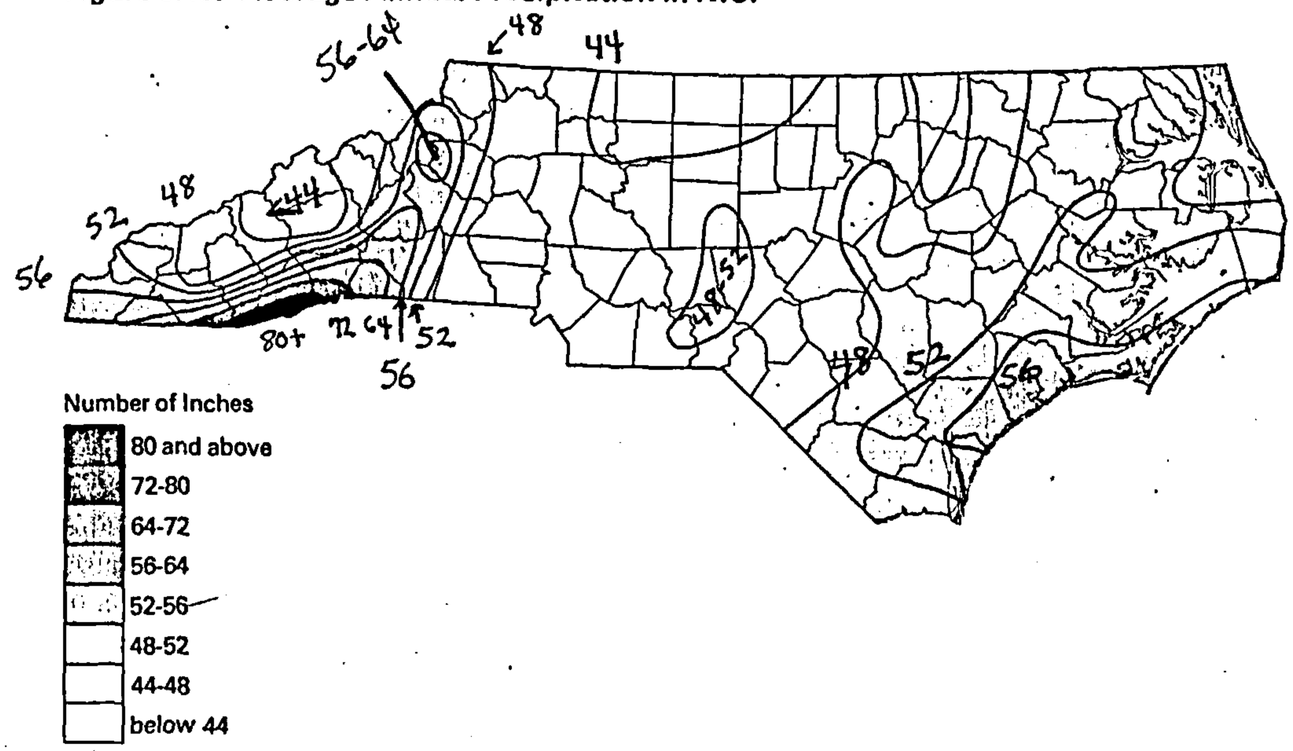
As illustrated in Figure 5.14, freezes begin early in October in the Mountains and slowly move eastward toward the coast. In early December, the freeze-free season reluctantly comes to a close in the Wilmington-Southport area. Deciduous trees begin their dormancy period and the color of the state gradually 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.

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.

Figure 5.15. Average Annual Precipitation in N.C.



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

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

Ref 9

soil 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.

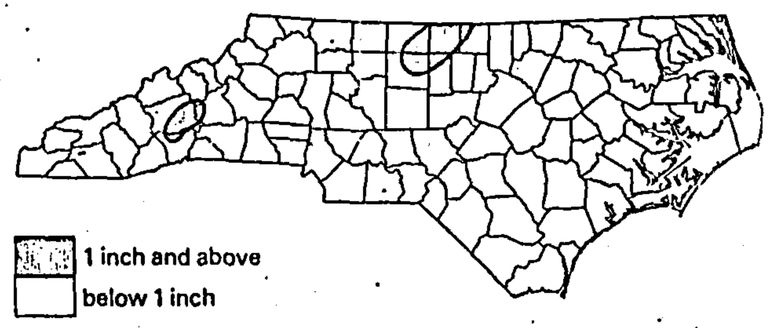
Mean annual evaporation for North Carolina is shown in Figure 5.20. Evaporation rates and totals are related to temperature, wind velocity, and relative humidity. Where temperatures are highest and humidities lowest, evaporation intensities will be greatest. Since temperatures throughout the Coastal 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.

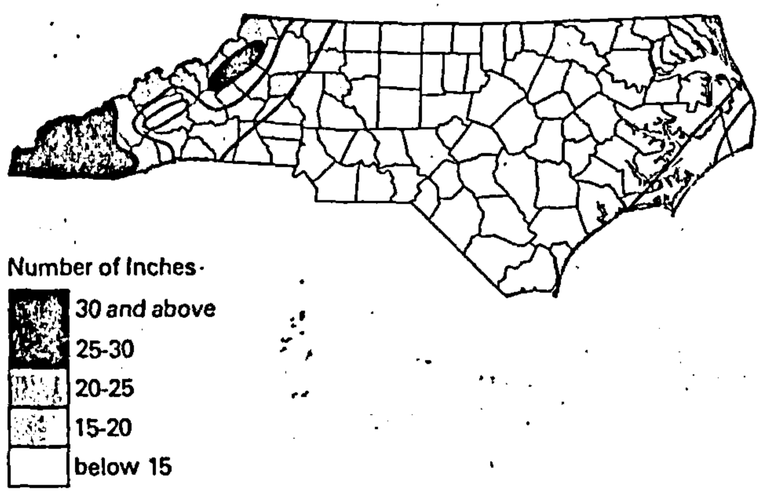
Although prevailing winds (winds that persist in blowing from one direction more so than any other) characterize given geographical areas, wind direction changes frequently. A northwesterly wind (coming from the northwest) will be, relatively speaking, a cooling and drying wind, whereas a southeasterly 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.



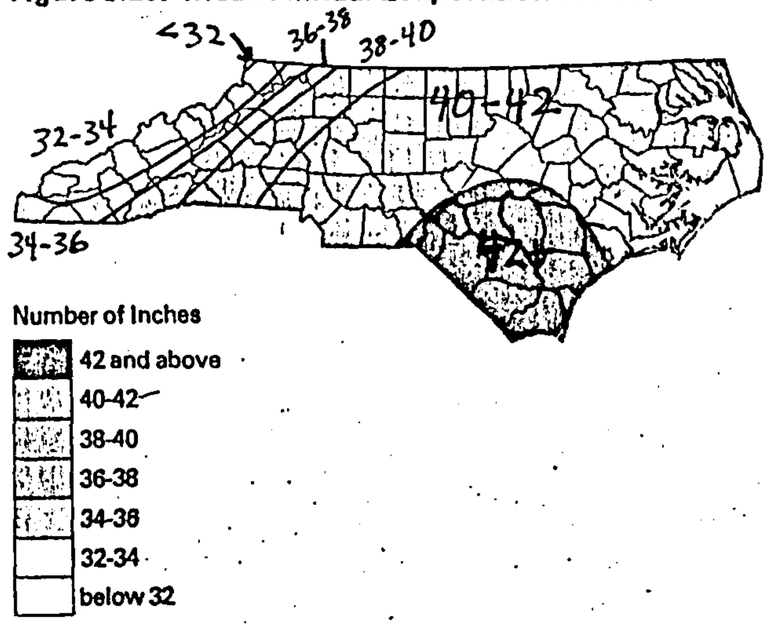
Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

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.



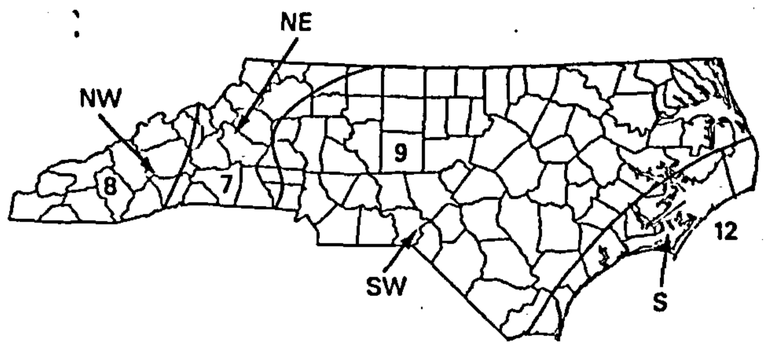
Source: U.S. Department of Commerce, *Climatic Summary of the U.S.*, 1972.

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.

Ref 9

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.

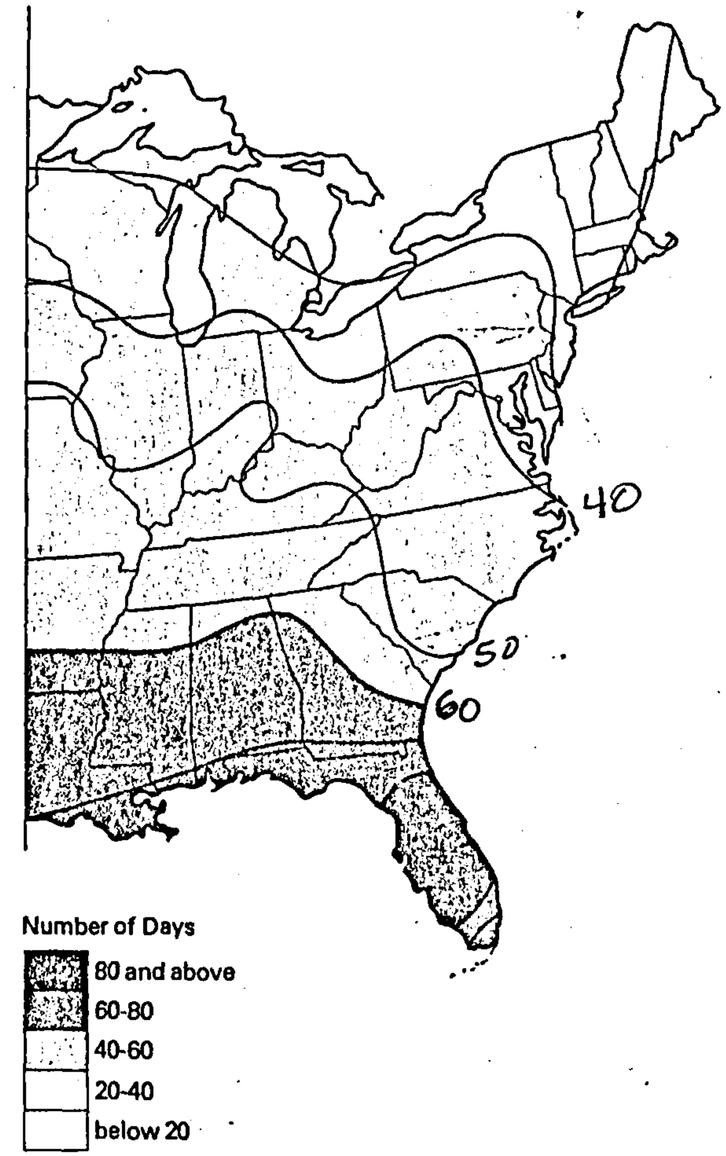
Wind speeds have been averaged for each zone of prevailing winds. Winds tend to diminish in speed westward from the coast where sea breezes and offshore storms contribute to velocities that average twelve miles per hour. Throughout the Inner Coastal Plain and the Piedmont, the mean wind speed is nine 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 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 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.

Figure 5.22. Average Number of Days with Thunderstorms

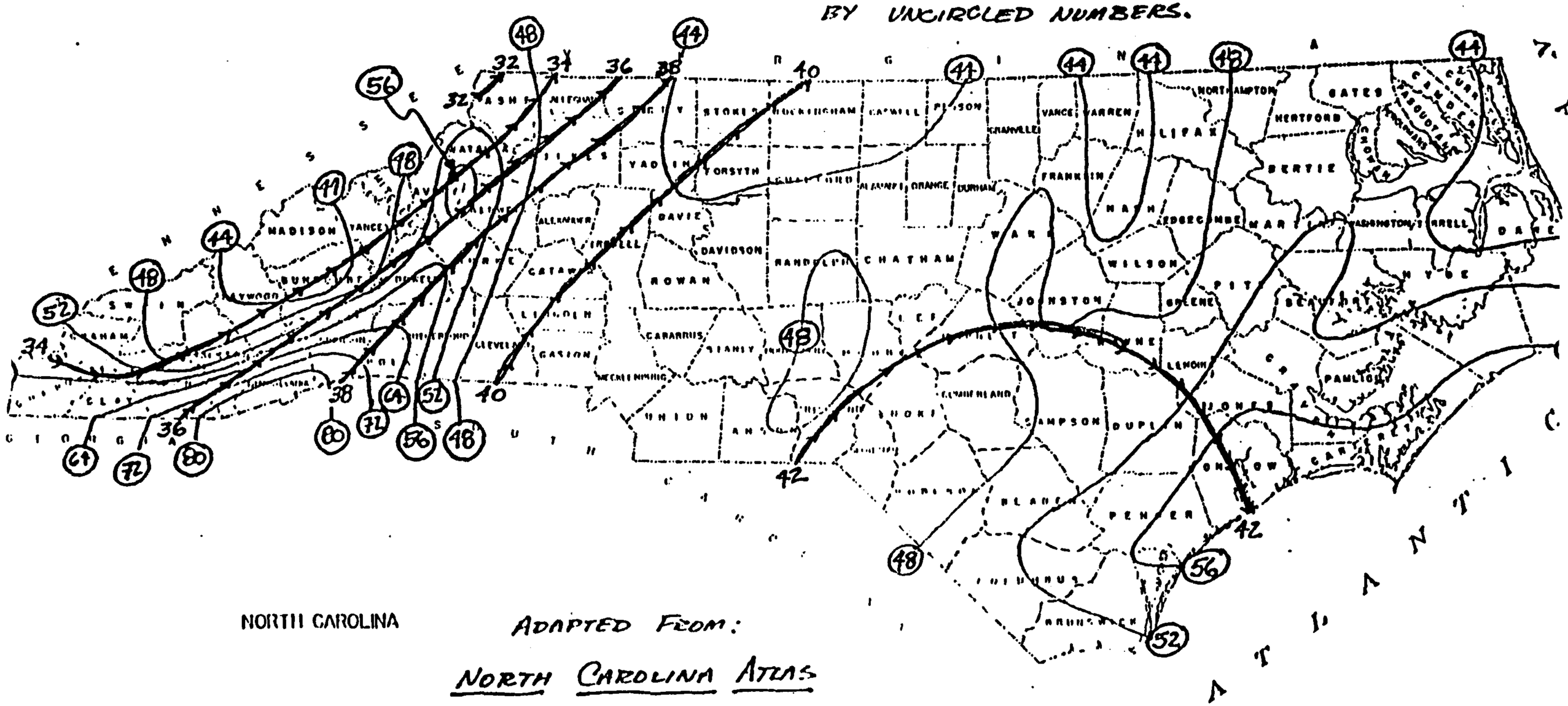


Source: Glenn T. Trewartha, Arthur H. Robinson, and Edwin H. Hammond, eds., *Elements of Geography*, 5th ed. (New York: McGraw-Hill Book Co., 1967).

Ref 9

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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RALEIGH, NORTH CAROLINA 27602

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Fifth Edition, 1984

North Carolina State Government

Statistical Abstract

North Carolina State Data Center

Research and Planning Services
Office of State Budget and Management

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Table 178

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

Ref 11

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	1,048	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	-	3,165	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	138	4,069	31	5,726	718	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	-	12,482	-
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.

Table 16

Ref 11

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 8

URBAN AND RURAL DISTRIBUTION OF THE POPULATION OF NORTH CAROLINA COUNTIES
YEARS 1950, 1960, 1970, 1980

County	1950 Percent Urban	1950 Percent Rural	1960 Percent Urban	1960 Percent Rural	1970[a] Percent Urban	1970[a] Percent Rural	1980 Percent Urban	1980 Percent Rural
State Total	33.7%	66.3%	39.5%	60.5%	45.5%	54.5%	48.0%	52.0%
Alamance	41.5	58.5	51.2	48.8	60.9	39.1	64.6	35.4
Alexander	-	100.0	-	100.0	-	100.0	3.4	96.6
Alleghany	-	100.0	-	100.0	-	100.0	-	100.0
Anson	12.7	87.3	15.0	85.0	16.9	83.1	16.4	83.6
Ashe	-	100.0	-	100.0	-	100.0	-	100.0
Avery	-	100.0	-	100.0	-	100.0	-	100.0
Beaufort	32.9	67.1	27.6	72.4	24.9	75.1	20.9	79.1
Bertie	-	100.0	-	100.0	-	100.0	-	100.0
Bladen	-	100.0	-	100.0	-	100.0	11.6	88.4
Brunswick	-	100.0	-	100.0	-	100.0	12.3	87.7
Buncombe	47.0	53.0	52.7	47.3	52.2	47.8	62.9	37.1
Burke	24.3	75.7	23.0	77.0	28.5	71.5	34.8	65.2
Cabarrus	66.0	34.0	67.7	32.3	64.0	36.0	62.6	37.4
Caldwell	18.2	81.8	26.0	74.0	30.9	69.1	28.4	71.6
Camden	-	100.0	-	100.0	-	100.0	-	100.0
Carteret	36.2	63.8	31.0	69.0	27.2	72.8	19.9	80.1
Caswell	-	100.0	-	100.0	-	100.0	-	100.0
Catawba	33.7	66.3	44.1	55.9	42.9	57.1	55.8	44.2
Chatham	9.8	90.2	16.6	83.4	15.9	84.1	13.3	86.7
Cherokee	-	100.0	-	100.0	-	100.0	-	100.0
Chowan	35.6	64.4	38.0	62.0	44.3	55.7	42.7	57.3
Clay	-	100.0	-	100.0	-	100.0	-	100.0
Cleveland	35.3	64.7	38.9	61.1	34.0	66.0	28.5	71.5
Columbus	8.4	91.6	9.6	90.4	8.9	91.1	16.2	83.8
Craven	32.4	67.6	26.7	73.3	55.2	44.8	49.6	50.4
Cumberland	39.7	60.3	47.3	52.7	76.1	23.9	86.6	13.4
Currituck	-	100.0	-	100.0	-	100.0	-	100.0
Dare	-	100.0	-	100.0	-	100.0	-	100.0
Davidson	39.7	60.3	39.4	60.6	37.1	62.9	33.4	66.6
Davie	-	100.0	-	100.0	13.4	86.6	10.7	89.3
Duplin	-	100.0	0.1	99.9	14.9	85.1	14.2	85.8
Durham	20.2	79.8	75.6	24.4	75.9	24.1	80.2	19.8
Edgecombe	40.7	59.3	42.9	57.1	47.1	52.9	45.9	54.1
Forsyth	65.8	34.2	69.2	30.8	68.8	31.2	75.2	24.8
Franklin	8.1	91.9	10.0	90.0	11.0	89.0	10.8	89.2
Gaston	55.2	44.8	61.8	38.2	71.0	29.0	69.1	30.9
Gates	-	100.0	-	100.0	-	100.0	-	100.0
Graham	-	100.0	-	100.0	-	100.0	-	100.0
Granville	21.0	79.0	21.1	78.9	32.7	67.3	34.8	65.2
Greene	-	100.0	-	100.0	-	100.0	-	100.0
Guilford	66.0	34.0	76.1	23.9	76.7	23.3	75.9	24.1
Halifax	24.1	75.9	32.7	67.3	36.5	63.5	37.1	62.9
Harnett	20.3	79.7	22.3	77.7	22.5	77.5	23.0	77.0
Haywood	27.1	72.9	28.3	71.7	27.9	72.1	24.5	75.5
Henderson	19.7	80.3	16.3	83.7	28.0	72.0	19.4	80.6
Hertford	16.7	83.3	31.8	68.2	36.6	63.4	33.8	66.2
Hoke	-	100.0	18.7	81.3	19.3	80.7	17.8	82.2
Hyde	-	100.0	-	100.0	-	100.0	-	100.0
Iredell	42.7	57.3	42.8	57.2	44.2	55.8	33.0	67.0
Jackson	-	100.0	-	100.0	-	100.0	-	100.0
Johnston	12.5	87.5	19.9	80.1	22.9	77.1	26.8	73.2
Jones	-	100.0	-	100.0	-	100.0	-	100.0
Lee	42.6	57.4	46.1	53.9	38.5	61.5	40.2	59.8
Lenoir	39.9	60.1	44.9	55.1	45.0	55.0	47.4	52.6
Lincoln	19.7	80.3	19.8	80.2	16.2	83.8	11.5	88.5
McDowell	21.9	78.1	12.5	87.5	30.6	69.4	10.5	89.5
Macon	-	100.0	-	100.0	-	100.0	13.1	86.9
Madison	-	100.0	-	100.0	-	100.0	-	100.0
Martin	17.8	82.2	25.5	74.5	26.6	73.4	23.7	76.3
Mecklenburg	71.5	28.5	78.0	22.0	79.6	20.4	87.6	12.4
Mitchell	-	100.0	18.0	82.0	-	100.0	-	100.0
Montgomery	-	100.0	-	100.0	-	100.0	12.0	88.0
Moore	12.9	87.1	14.2	85.8	15.2	84.8	23.8	76.2
Nash	24.7	75.3	28.4	71.6	32.2	67.8	40.0	60.0
New Hanover	71.2	28.8	69.0	31.0	69.5	30.5	86.7	13.3
Northampton	-	100.0	-	100.0	-	100.0	-	100.0
Onslow	18.2	81.8	20.5	79.5	57.5	42.5	64.6	35.4
Orange	26.7	73.3	29.3	70.7	50.3	49.7	57.5	42.5
Pamlico	-	100.0	-	100.0	-	100.0	-	100.0
Pasquotank	52.1	47.9	54.9	53.6	52.4	46.4	49.2	50.8
Pender	-	100.0	-	100.0	-	100.0	0.1	99.9
Perquimans	-	100.0	-	100.0	-	100.0	-	100.0
Person	17.7	82.3	19.5	80.5	20.7	79.3	25.8	74.2
Pitt	30.8	69.2	42.8	57.2	50.0	50.0	49.7	50.3
Polk	-	100.0	-	100.0	-	100.0	-	100.0
Randolph	15.2	84.8	25.3	74.7	30.2	69.8	30.3	69.7
Richmond	34.3	65.7	33.6	66.4	33.4	66.6	40.0	60.0
Robeson	10.5	89.5	20.3	79.7	27.3	72.7	29.3	70.7
Rockingham	38.5	61.5	41.1	58.9	44.7	55.3	40.3	59.7
Rowan	41.1	58.9	47.2	52.8	42.1	57.9	44.2	55.8
Rutherford	33.4	66.6	31.1	68.9	30.1	69.9	28.6	71.4
Sampson	8.9	91.1	15.5	84.5	15.9	84.1	15.2	84.8
Scotland	27.1	72.9	32.7	67.3	32.9	67.1	36.0	64.0
Stanly	31.8	68.2	30.0	70.0	26.0	74.0	31.1	68.9
Stokes	-	100.0	-	100.0	-	100.0	26.5	73.5
Surry	28.4	71.6	20.6	79.4	25.0	75.0	16.3	83.7
Swain	-	100.0	-	100.0	-	100.0	-	100.0
Transylvania	25.7	74.3	29.7	70.3	26.6	73.4	22.7	77.3
Tyrrell	-	100.0	-	100.0	-	100.0	-	100.0
Union	24.1	75.9	24.4	75.6	25.3	74.7	21.7	78.3
Vance	34.3	65.7	39.8	60.2	42.5	57.5	36.8	63.2
Wake	53.1	46.9	63.2	36.8	69.6	30.4	71.8	28.2
Warren	-	100.0	-	100.0	-	100.0	-	100.0
Washington	34.0	66.0	34.6	65.4	34.0	66.0	30.9	69.1
Watauga	16.2	83.8	21.0	79.0	37.4	62.6	32.2	67.8
Wayne	39.2	60.8	40.8	59.2	46.7	53.3	64.4	35.6
Wilkes	9.7	90.3	9.3	90.7	6.8	93.2	10.9	89.1
Wilson	42.2	57.8	49.8	50.2	51.1	48.9	54.5	45.5
Yadkin	-	100.0	-	100.0	-	100.0	-	100.0
Yancey	-	100.0	-	100.0	-	100.0	-	100.0

(a) Urban-rural percentages for 1970 were not corrected for all those counties which had population corrections after the 1970 urban-rural figures were published but were corrected in selected counties by the Bureau of the Census.

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

Ref 11

Ref 12

5 January 1987

TO: File

FROM: Stan Atwood SA

RE: Asheboro water distribution

I spoke with Randy Macon at the Asheboro water plant (919) 626-1200. The city water lines extend south on US 220 to Hawthorne Road. This is about two miles north of the Ulah Battery Site.

SA/tb/0323b

5/01/87 WO-118 COM PWS W/IN SPEC. GRID FOR STAN. PAGE 0001

PWID	PWMANAME	PWMAARCO	PWMAPNUM	PWPLSOC1	PWPLPOPL	PWPLTYPE	PWPLACTV	PWPLLAT1	PWPLLON1
0276121	HICKORY LANE MH COMMINITY	919	4983089	G	000000088	C	A	0353930	0795240
0276126	KINGSBURY MHP	919	8737429	G	000000090	C	A	0353555	0794845
0276128	LEROY'S TP	919	6291319	G	000000088	C	A	0353945	0794935
0276144	WHITE OAK MHP	919	6291319	G	000000182	C	A	0353725	0794930
0276151	PINEWOOD COUNTRY CLUB WA SYS	919	2991325	G	000000203	C	A	0353650	0794920
0276155	SOUTHWEST MHP	919	6295978	G	000000056	C	A	0353840	0795145
0276165	HERITAGE WEST	919	2991325	G	000000040	C	A	0353925	0795240
0276169	ROCKWOOD PARK WA SYS	919	6254515	G	000000147	C	A	0353920	0794850

Ref 13

Ref 14

United States Department of the Interior

FISH AND WILDLIFE SERVICE

ENDANGERED SPECIES FIELD STATION
100 OTIS STREET, ROOM 224
ASHEVILLE, NORTH CAROLINA 28801

June 21, 1985

Ms. Pat Derosa
Solid and Hazardous Waste Management Branch
Environmental Health Section
North Carolina Department of Human Resources
P. O. Box 2091
Raleigh, North Carolina 27602

Dear Ms. Derosa,

In response to your telephone conversation with John Fridell on May 30, 1985, we are enclosing the following items of information:

A. North Carolina county distribution records of Federally listed, proposed and status review species,

B. map of the critical habitat of the threatened spotfin chub (Hybopsis monacha),

C. map of the critical habitat of mountain golden heather (Hudsonia montana), and

D. copy of the U.S. Fish and Wildlife Service interagency Section 7 consultation process guidelines (included for your information)

The abbreviations following the species names on the North Carolina species distribution records (A. above) indicate Federal status, i.e., E - endangered, T - threatened, PE - proposed endangered, PT - proposed threatened and SR - under status review. Status review species are not legally protected under the Endangered Species Act. However, they are subject to being listed and agencies should be cognizant of their potential presence in a project area.

Since additions and deletions are made to the list of species on a regular basis, questions regarding updates of the list should be made to this office.

We hope this information will be of use to you. If we can be of any further assistance, please call John Fridell or Nora Murdock at (704) 259-0321.

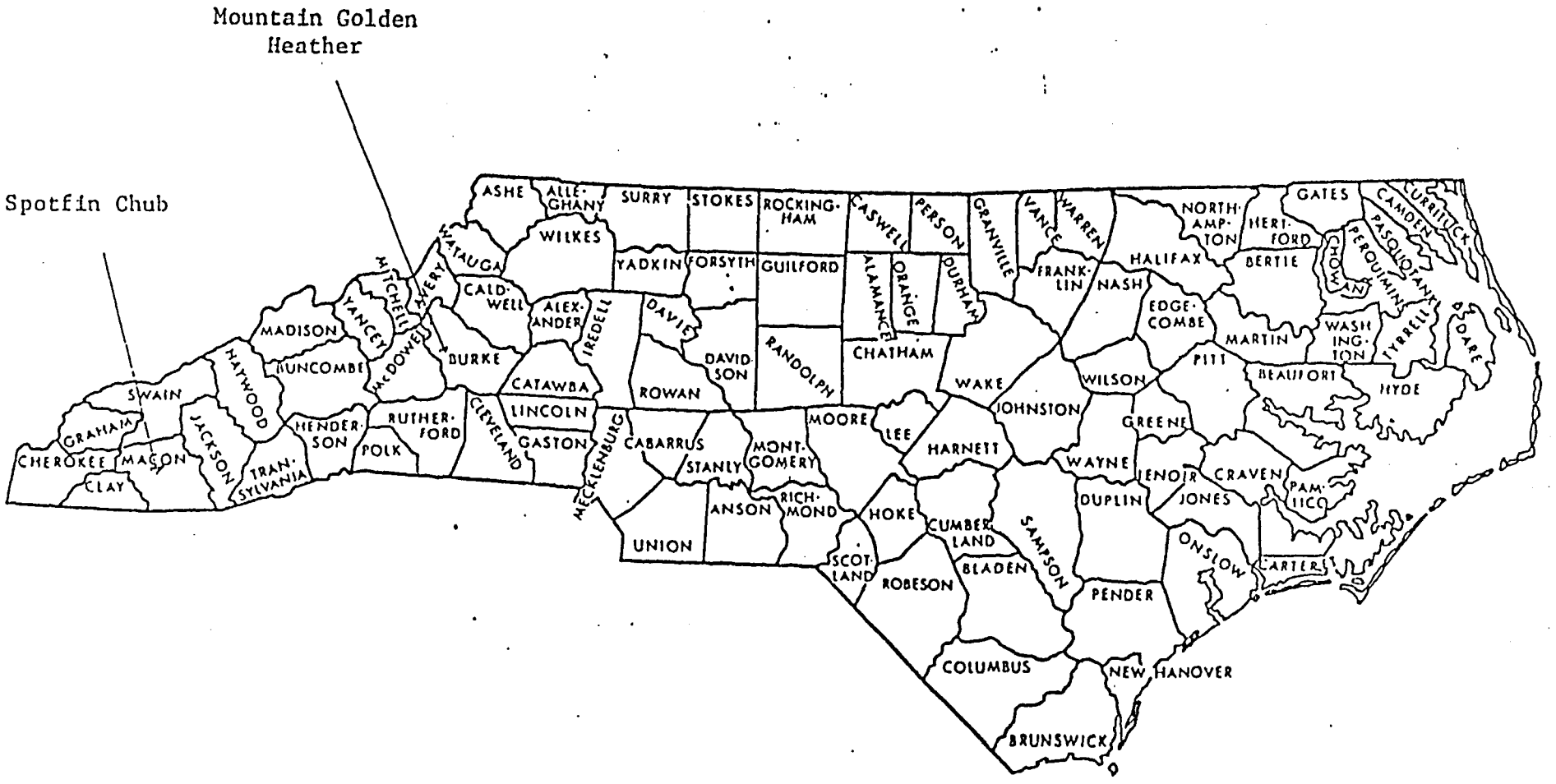
Sincerely yours,

Warren T. Parker

Warren T. Parker
Field Supervisor

CRITICAL HABITATS OF FEDERALLY LISTED

ENDANGERED SPECIES IN NC



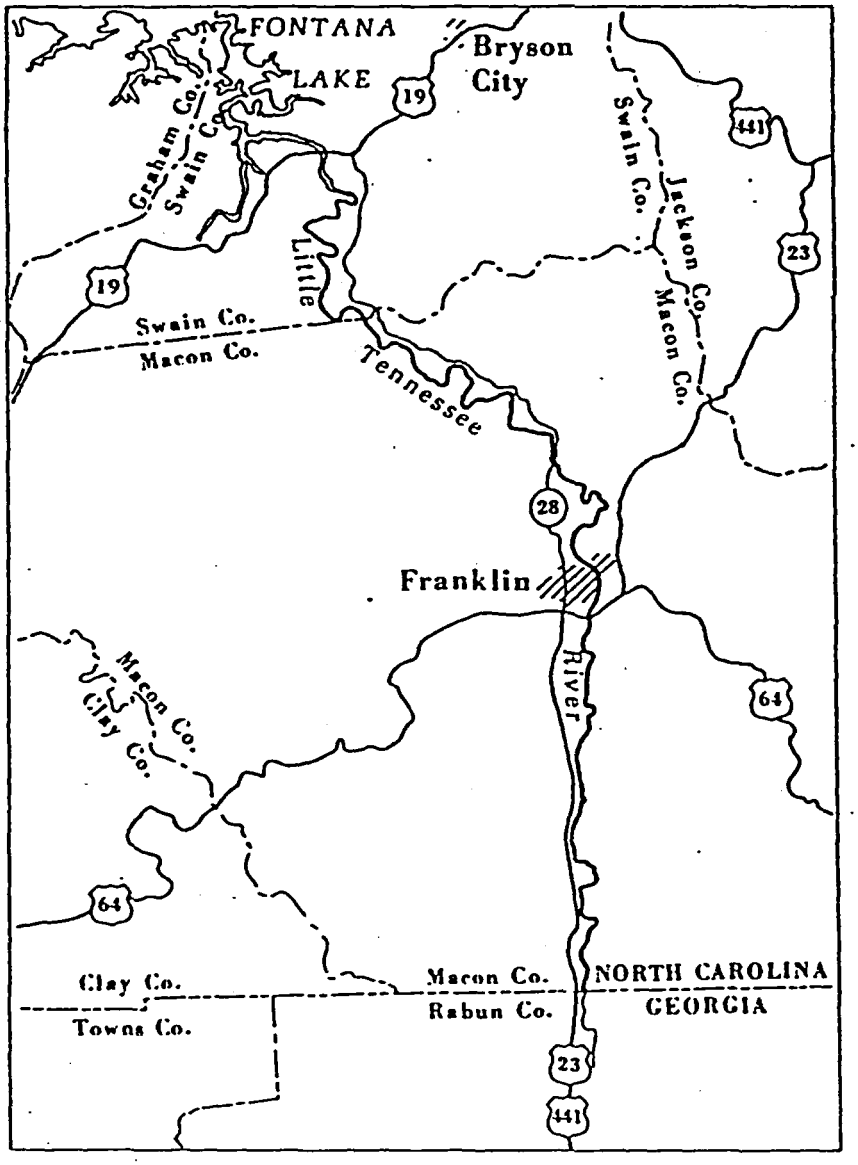
1 inch = approx. 53 miles

Ref. 14

NORTH CAROLINA - Critical Habitat

Hybopsis monacha, "spotfin chub"

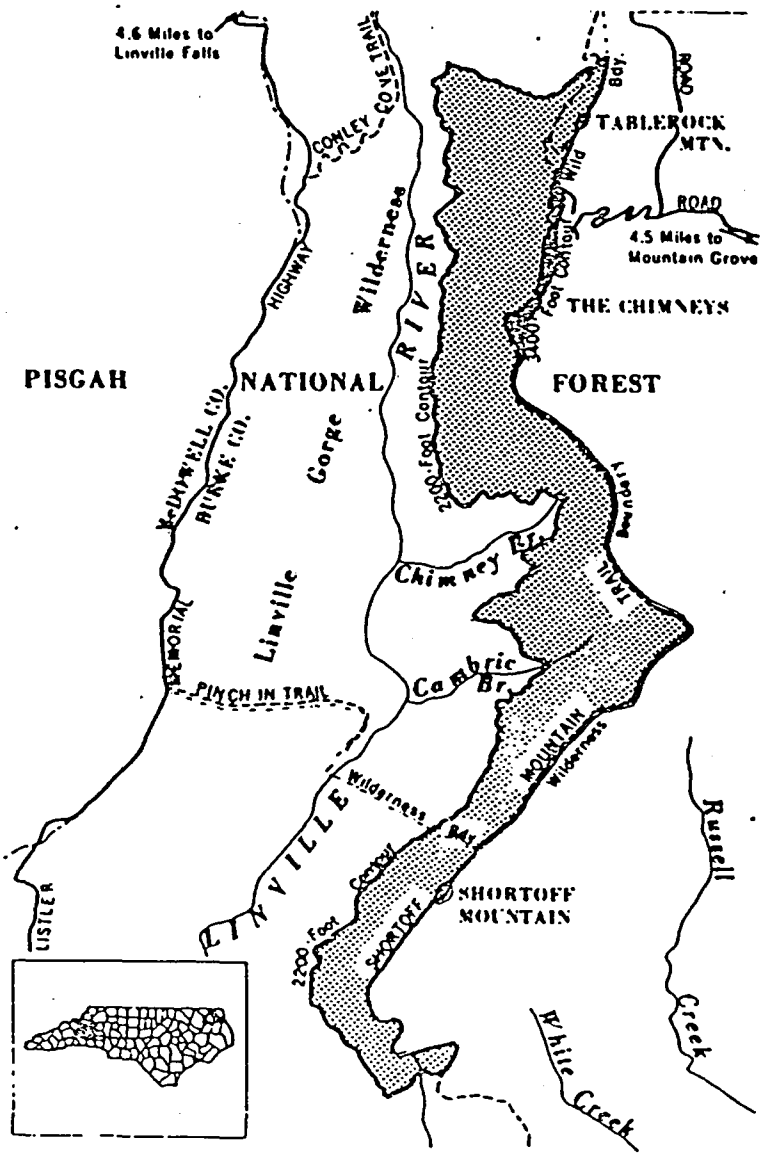
Macon and Swain Counties. Little Tennessee River, main channel from the backwaters of Fontana Lake upstream to the North Carolina-Georgia state line.



NORTH CAROLINA - Critical Habitat

Hudsonia montana, "mountain golden heather"

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



Ref. 15

12 August 1986

TO: CERCLA Unit Staff

FROM: Pat DeRosa

RE: Critical Habitats of Federally Listed Endangered Species in N.C.

I spoke by telephone today with John Fridell, US Fish and Wildlife Service (704) 259-0321 to request an update on critical habitats in NC. Mr. Fridell informed me that the only change since our previous correspondence of June 21, 1985 has been a "Proposal to List the Cape Fear Shiner as an Endangered Species with Critical Habitats" in NC. (FR Vol. 51, No. 133, July 11, 1986). A copy of the proposed rule is attached for your information.

PD/tb/0221b

Public Comments Solicited

The Service intends that any final action from this proposal will be as accurate and as effective as possible. Therefore, any comments or suggestions from the public, other concerned governmental agencies, the scientific community, industry, or any other interested party concerning any aspect of this proposal are hereby solicited. Comments particularly are sought concerning:

(1) Biological, commercial trade, or other relevant data concerning any threat (or lack thereof) to this species;

(2) The location of any additional populations of this species and the reasons why any habitat should or should not be determined to be critical habitat as provided by section 4 of the Act;

(3) Additional information concerning the range and distribution of this species;

(4) current or planned activities in the subject area and their possible impacts on this species; and

(5) Any foreseeable economic and other impacts resulting from the proposed designation of critical habitat.

Final promulgation of the regulations on this species will take into consideration the comments and any additional information received by the Service, and such communications may lead to adoption of a final regulation that differs from this proposal.

The Endangered Species Act provides for a public hearing on this proposal, if requested. Requests must be filed within 45 days of the date of the proposal. Such requests must be made in writing and addressed to the Endangered Species Field Office, 100 Otis Street, Room 224, Asheville, North Carolina 28801.

National Environmental Policy Act

The Fish and Wildlife Service has determined that an Environmental Assessment, as defined under the authority of the National Environmental Policy Act of 1969, need not be prepared in connection with regulations adopted pursuant to section 4(a) of the Endangered Species Act of 1973, as amended. A notice outlining the Service's reasons for this determination was published in the Federal Register on October 25, 1983 (48 FR 49244).

References Cited

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

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

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

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

Author

The primary author of this proposed rule is Richard G. Biggins, Endangered Species Field Office, 100 Otis Street, Room 224, Asheville, North Carolina 28801 (704/259-0321 or FTS 672-0321).

List of Subjects in 50 CFR Part 17

Endangered and threatened wildlife, Fish, Marine mammals, Plants (agriculture).

Proposed Regulations Promulgation.

PART 17—[AMENDED]

Accordingly, it is hereby proposed to amend Part 17, Subchapter B of Chapter I, Title 50 of the Code of Federal Regulations, as set forth below:

1. The authority citation for Part 17 continues to read as follows:

Authority: Pub. L. 93-205, 87 Stat. 884; Pub. L. 94-359, 90 Stat. 911; Pub. L. 95-632, 92 Stat. 3751; Pub. L. 96-159, 93 Stat. 1225; Pub. L. 97-304, 96 Stat. 1411 (16 U.S.C. 1531 *et seq.*).

2. It is proposed to amend § 17.11(h) by adding the following, in alphabetical order under "FISHES," to the List of Endangered and Threatened Wildlife:

§ 17.11 Endangered and threatened wildlife.

* * * * *

(h) * * *

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
FISHES							
Shiner, Cape Fear	*Notropis mekistocholas*	U.S.A. (NC)	Entire	E		17.95(e)	NA

3. It is further proposed to amend § 17.95(e) by adding critical habitat of the "Cape Fear shiner," in the same alphabetical order as the species occurs in § 17.11(h).

§ 17.95 Critical habitat—fish and wildlife.

(e) * * *

* * * * *

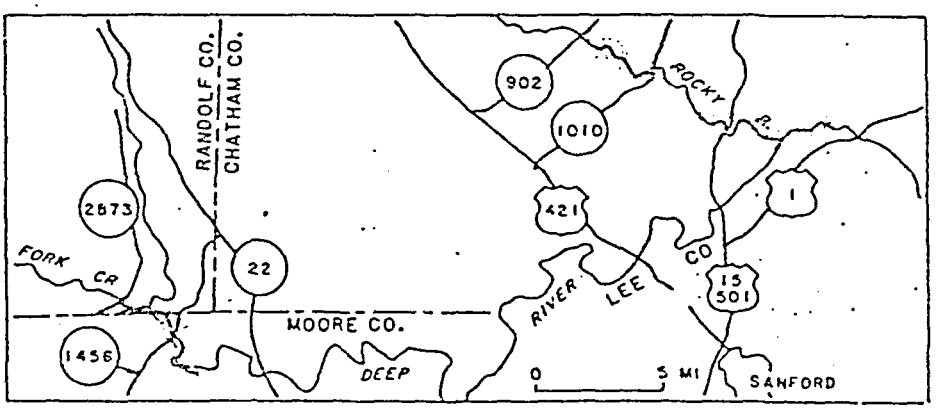
Cape Fear Shiner

(*Notropis mekistocholas*)

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

(2) *North Carolina.* Chatham and Lee Counties. Approximately 0.5 miles of Bear Creek, from Chatham County Road 2156 Bridge downstream to the Rocky River, then downstream in the Rocky River (approximately 4.2 miles) to the Deep River, then downstream in the Deep River (approximately 2.6) in Chatham and Lee Counties, to a point 0.3 river miles below the Moncure, North Carolina, U.S. Geological Survey Gaging Station; and

(3) *North Carolina.* Randolph and Moore Counties. Approximately 1.5 miles of Fork Creek, from a point 0.1 creek miles upstream of Randolph County Road 2873 Bridge downstream to the Deep River then downstream appoximately 4.1 miles to the Deep River in Randolph and Moore Counties, North Carolina, to a point 2.5 river miles below Moore County Road 1456 Bridge.



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

* * * * *

Dated: May 30, 1986.

P. Daniel Smith,

Acting Assistant Secretary for Fish and Wildlife and Parks.

[FR Doc. 86-15643 Filed 7-10-86; 8:45 am]

BILLING CODE 4310-55-M

Ref. 16

30 April 1987

TO: File

FROM: Stan Atwood SA

RE: Ulah Battery Lead Reclaiming

I called Jim Martin, Randolph County Health Department, about results for samples collected at the referenced site in 1980. Six soil samples and two samples of battery casing chips were collected. Mr. Martin said that lab sheets were never forwarded to their office. Results were received over the telephone. The soil samples averaged 3000 ppm lead and the battery casing chips averaged 2580 ppm lead. He said he would forward copies of the hand written notes in their files concerning this matter.

SA/tb/0234b

Ref 17

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

30 January 1987

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
Ulah Battery Lead Reclaiming NC D981864614
Asheboro, NC

The subject site is located in a residential area about two miles south of Asheboro, NC. Between the mid 1960's and about 1980, lead from automobile batteries was reclaimed on site. The residents all use ground water.

On 29 January 1987 a CERCLA site investigation was conducted at this site by Stan Atwood and Jack Butler. The County Health Department was contacted prior to the visit and a meeting was arranged for 10:00 a.m. on the 29th. Arrangements were also made to pick up a copy of the Asheboro water distribution map at the city water department.

The water distribution map was picked up at 9:30 a.m. We then met with Jim Martin, Sanitarian Supervisor; J.D. Smith, Sanitarian; Galenda Sandlin, County Nurse; and Yvonne Chilcoat, Director Public Health Division; at the Health Department. We briefly discussed the site history and the sampling plans before driving to the site at 10:30.

Figure 1 is a sketch of the site layout and sampling locations. A pile of battery casings (approx. 100 ft. x 30 ft. x 15 ft.) is located within 20 ft. of the nearest well. There is a small drainage ditch along the western edge of the pile. Livestock (chickens, turkeys, and goats) are kept in pens adjacent to the disposal area.

Ref. 17

Two wells were sampled during the inspection (Figure 1). Conductivity and pH readings for the Hammond well were 73.5 and 7.27. Readings for the Caviness well were 175.3 and 6.68. This well was reported to be about 150 feet deep. We were unable to sample the well nearest the disposal area, however, it will be sampled by Randolph County Health Department personnel.

We then drove to the stream draining the site. Upstream and downstream sediment samples were collected. An additional battery casing disposal area (measuring about 150 feet long, 10 to 60 feet wide, and 3 to 10 feet deep) was discovered about 200 feet above the stream.

Photographs of the sampling points and the site in general were taken, including both disposal areas. The investigation was concluded at 12:30 p.m.

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

Sincerely,

Stan Atwood

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

SA/tb/0338b

Ref. 18

6 November 1986

TO: File

FROM: Stan Atwood

RE: Randolph County Battery Site

I spoke by telephone with Charlene Wiggins, Lead Epidemiologist, Environmental Epidemiology Branch, (919) 733-3410, about the subject site.

One 4 year old child in the site vicinity was found to have elevated blood lead levels (PbB) and elevated free erythrocyte protoporphyrin levels (FEP). These levels were 40-50 ug/dl (low 20's normal) and 140-150 ug/dl (35 normal).

The site is located south of Asheboro just off US 220 near the Ulah community on SR 1219.

SA/tb/0342b

Ref 19

22 January 1986

TO: File

FROM: Mary Giguere

RE: Ulah Battery Lead Reclaiming MG
NC D981864614
Sample Preservation

Any well or ground water samples that are taken for volatile organic analyses, that have no visible sediment, will be preserved with 4 drops of hydrochloric (HCl) acid. Any well or ground water samples taken for metal analyses, that contain no visible sediment, will be preserved with 3 ml of nitric acid. If the pH of the metals samples is not less than 2, acid will be added until the pH is less than 2 and greater than 1 ($1 > pH < 2$). Samples with 3 ml of nitric acid will be marked with a check mark on the sample container cap. Any sample with more than 3 ml of nitric acid will be labeled with the amount of acid added.

Goggles and gloves will be worn while measuring acids and collecting samples. Pasteur pipets will be used for measuring the hydrochloric acid. These can been disposed of after rinsing. Graduated pipets will be used for the nitric acid. These will be rinsed and returned to the equipment room.

MG/tb/0354b

Ref 20

Casarett and Doull's
TOXICOLOGY

The Basic Science of Poisons

THIRD EDITION

Macmillan Publishing Company
New York

Collier Macmillan Canada, Inc.
Toronto

Collier Macmillan Publishers
London

skin. Allergic chromium skin reactions readily occur with exposure and are independent of dose. Trivalent chromium compounds are considerably less toxic than the hexavalent compounds and are neither irritating nor corrosive. Nevertheless, nearly all workers in industries are exposed to both forms of chromium compounds, and at present, there is no information as to whether there is a gradient of risk from predominant exposure to hexavalent or insoluble forms of chromium to exposure to soluble trivalent forms. In a recent review, Norseth (1981) suggests that if there are similar increased risks in both groups, as estimated from the death rates, trivalent chromium should be considered as an equally potent carcinogen as are the hexavalent compounds.

Whether chromium compounds cause cancer at sites other than the respiratory tract is not clear. A slight increase in cancer of the gastrointestinal tract has been reported in other studies, but each involved only small groups of workers.

Animal studies support the notion that the most potent carcinogenic chromium compounds are the slightly soluble hexavalent compounds. Studies on *in vitro* bacterial systems, however, show no difference between soluble and slightly soluble compounds. Trivalent chromium salts have little or no mutagenic activity in bacterial systems. Since there is preferred uptake of the hexavalent form by cells and it is the trivalent form that is metabolically active and binds with nucleic acids within the cell, it has been suggested that the causative agent in chromium mutagenesis is trivalent chromium bound to genetic material after reduction of the hexavalent form (Norseth, 1981).

Human Body Burden. Tissue concentrations of chromium in the general population have considerable geographic variation, as high as 7 μg/kg in lungs of persons in New York or Chicago with lower concentrations in liver and kidney (Schroeder *et al.*, 1962a). In persons without excess exposure, blood chromium concentration is between 20 and 30 μg/liter and is evenly distributed between erythrocytes and plasma. With occupational exposure, increase in blood chromium is related to increase in chromium in red blood cells. Urinary excretion is generally less than 10 μg/day in the absence of excess exposure (Underwood, 1977).

Lead

> If we were to judge of the interest excited by any medical subject by the number of writings to which it has given birth, we could not but regard the poisoning by lead as the most important to be known of all those that have been treated of, up to the present time.
>
> ORFILA, 1817

Lead, the most ubiquitous toxic metal, is detectable in practically all phases of the inert environment and in all biologic systems. Because it is toxic to most living things at high exposures and there is no demonstrated biologic need, the major issue regarding lead is at what dose does it become toxic. Specific concerns vary with the age and circumstances of the host, and the major risk is toxicity to the nervous system. Several reviews and multiauthored books on the toxicology of lead are available (NAS, 1972; Goyer and Rhyne, 1973; WHO, 1977b; Nriagu, 1978; Singhal and Thomas, 1980; Needleman, 1980; Chisolm and O'Hara, 1982; Rutter and Jones, 1983).

Sources. The principal route of exposure is food, but it is usually environmental and presumably controllable sources that produce excess exposure and toxic effects. These sources include lead-based indoor paint in old dwellings, lead in air from combustion of lead-containing auto exhausts or industrial emissions, lead-based paint, hand-to-mouth activities of young children living in polluted environments, and, less commonly, lead dust brought home by industrial workers on their clothes and shoes, and lead-glazed earthen ware.

The total daily intake of lead for an adult in the United States varies from less than 0.1 mg/day to more than 2 mg/day (Kehoe, 1961; NAS, 1972). The major source of daily intake of lead in adults and children (without excess exposure) is food and beverages. Lead content of food is extremely variable, but there are practically no lead-free food items. The average adult diet contains from 150 μg/day, 0.75 to 120 μg/day for infants and small children. Most municipal water supplies measured at the tap contain less than the WHO-recommended limit of 0.05 μg/ml, so that daily intake from water is usually about 10 μg, and unlikely to be more than 20 μg.

Air is a third source of lead exposure for persons in the general population. Concentrations of lead in air vary widely and may be lower than 1.0 $\mu g/m^3$ in rural areas to 10 $\mu g/m^3$ in certain urban environments. For the contemporary urbanite, the magnitude of respired lead is about one-half the intake from the diet.

Disposition. The gastrointestinal absorption of lead is influenced by a large number of factors of which age and nutritional factors are of particular importance. Adults absorb 5 to 15 percent of ingested lead and usually retain less than 5 percent of what is absorbed. Children are known to have a greater absorption of lead than adults; one study found an average net absorption of 41.5 percent and 31.8 percent net retention in infants on regular diets.

Lead in the atmosphere exists either in solid

forms, dust or particulates of lead dioxide, or in the form of vapors, particularly alkyl lead that has escaped by evaporation from automobile fuel systems.

Lead absorption by the lungs also depends on a number of factors in addition to concentration. These include volume of air respired per day, whether the lead is in particle or vapor form, and size distribution of lead-containing particles. Only a very minor fraction of particles over 0.5 μm in mean maximal external diameter are retained in the lung but are cleared from the respiratory track and swallowed. However, the percentage of particles less than 0.5 μm retained in the lung increases with reduction in particle size. About 90 percent of lead particles in ambient air that are deposited in the lungs are small enough to be retained. Absorption of retained lead through alveoli is relatively efficient and complete.

More than 90 percent of lead in blood is in the red blood cells. There seem to be at least two major compartments for lead in the red blood cell, one associated with the membrane and the other with hemoglobin (Barltrop and Smith, 1971). Small fractions may be related to other red blood cell components. Plasma ligands are not well defined, but it has been suggested that plasma and serum may contain diffusible fractions of lead in equilibrium with soft tissue or end-organ binding sites for lead. This fraction is difficult to measure accurately, but there is an equilibrium between red cell and plasma lead.

Blood lead levels are a good indicator of recent exposure to lead and are influenced by inhalation and ingestion. A number of recent studies suggest that inhalation of air containing 1 $\mu g/m^3$ in respirable particles will increase blood lead concentrations by about 1 μg/dl when air lead concentrations are in the range of 1 to 5 $\mu g/m^3$ (WHO, 1977b).

Lead in blood varies with age (Figure 19–3) (Mahaffey *et al.*, 1982). Children under seven years of age have significantly higher blood lead levels than older children, and there is no difference between boys and girls under age 12. Blood lead levels decline during adolescence probably related to bone growth and deposition of lead in bones with calcium. Blood lead levels are lower in adult females than adult males.

The total body burden of lead may be divided into at least two kinetic pools, which have different rates of turnover. The largest and kinetically slowest pool is the skeleton with a half-life of more than 20 years and a much more labile soft tissue pool. The total lifetime accumulation of lead may be about 200 mg and over 500 mg for an occupationally exposed worker. Kidney lead accumulates with age; lead in lung does not

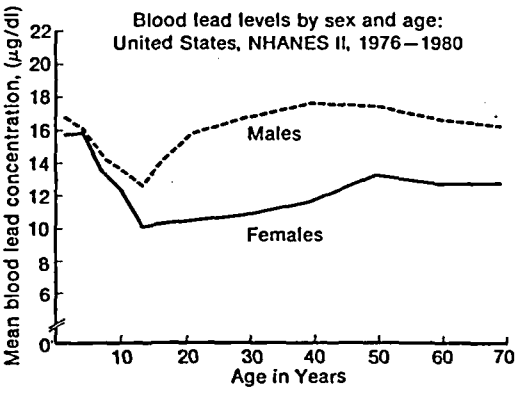


Figure 19–3. National estimates of blood lead levels in the United States. (From Mahaffey, K. R.; Annest, J. L.; Roberts, J.; and Murphy, R. S.: Estimates of blood lead levels: United States 1976–1980. Association with selected demographic and socioeconomic factors. *N. Engl. J. Med.*, 307:573–79, 1982. Reprinted by permission of *The New England Journal of Medicine.*)

change. Lead in the central nervous system tends to concentrate in gray matter and certain nuclei. The highest concentrations are in the hippocampus, followed by cerebellum, cerebral cortex, and medulla. Cortical white matter seems to contain the least amount, but these comments are based on only a few reported human and animal studies.

Renal excretion of lead is usually with glomerular filtrate with some renal tubular resorption. With elevated blood lead levels, excretion may be augmented by transtubular transport.

Placental transfer of lead occurs. Cord blood generally correlates with maternal blood lead levels but is slightly lower. It is interesting that maternal blood lead decreases during pregnancy, suggesting that maternal lead is transferred to the fetus or excreted in some way.

Toxicity. The topic of greatest interest at the present time concerns the maximal level of lead exposure in the neonatal and young child that does not produce a cognitive or motor neurologic deficit. For the adult excess occupational exposure or even accidental exposure, the concerns are peripheral neuropathy and/or chronic nephropathy. Effects on the heme system provide biochemical indicators of lead exposure in the absence of chemically detectable effects, but anemia due to lead exposure is uncommon without other detectable effects or other synergistic factors. Other target organs are the gastrointestinal and reproductive systems.

Nearly all environmental exposure to lead is to inorganic compounds, even lead in food. Organolead exposures, including tetraethyl lead,

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have unique toxicologic patterns and will be discussed later.

Neurologic Effects. The central nervous system (CNS) effects of lead are the most significant in terms of human health and performance (Needleman, 1980; Rutter and Jones, 1983). Manifestations of CNS effects are encephalopathy and/or peripheral neuropathy. Symptomatic encephalopathy is almost always a disease of childhood and varies from ataxia to stupor, coma, and convulsions. This form of lead intoxication has decreased appreciably in North America over the past 20 years with better understanding of factors that contribute to lead toxicity, particularly reduction of lead exposure in children. Morphologic effects of lead on the brain are nonspecific. Lead encephalopathy is accompanied by severe cerebral edema, increase in cerebral spinal fluid pressure, proliferation and swelling of endothelial cells in capillaries and arterioles, proliferation of glial cells, neuronal degeneration, and areas of focal cortical necrosis in fatal cases.

The pathogenesis of neuronal damage in lead encephalopathy is not well understood. In severe cases, there are obvious changes in hemodynamics (cerebral edema) and cellular hypoxia, but it is now apparent that there is a direct effect of lead on neuronal and possibly synaptic transmission at levels of lead exposure that do not produce apparent symptoms of intoxication. These effects are termed "low-level lead toxicity" because they are believed to be associated with blood lead levels of approximately 30 to 50 μg/dl or possibly even lower bloodlead levels. These effects are also termed "subclinical lead toxicity" because they can only be detected by assessment of neuropsychologic behavior, such as hyperactivity, poor classroom behavior (decreased attention span), and even small decrements (point average in group studies) of four to five in I.Q. scores (Needleman *et al.*, 1979). Studies by others confirm the subclinical detrimental effects on I.Q., but possibly occurring at somewhat higher blood lead levels than found by Needleman (Ernhardt *et al.*, 1981). However, that low-level lead exposure (blood lead, 30 to 50 μg/dl) does, indeed, affect CNS function is further supported by the finding of changes in EEG brain wave patterns and CNS evoked potential responses in children displaying neuropsychologic deficits (Burchfield *et al.*, 1980). Neurochemical studies in experimental models have shown that lead in the absence of morphologic changes does produce deficits in neurotransmission through inhibition of cholinergic function, possibly by reduction of extracellular calcium. Other noted changes in neurotransmitter function include impairment of dopamine uptake by synaptosomes and impairment of the function of the inhibitory neurotransmitter γ-aminobutyric acid.

Peripheral neuropathy is a classic manifestation of lead toxicity, particularly the footdrop and wristdrop that characterized the house painter and other workers with excessive occupational exposure to lead more than a half-century ago (Thomas, 1904). Segmental demyelination and possibly axonal degeneration follow lead-induced Schwann cell degeneration (Lampert and Schochet, 1968). Wallerian degeneration of posterior roots of sciatic and tibial nerves is possible, but sensory nerves are less sensitive to lead than motor nerve structure and function (Schlaepfer, 1969). Motor nerve dysfunction, assessed clinically by electrophysiologic measurement of nerve conduction velocities, has been shown to occur with blood lead levels in the 50 to 70 μg/dl range or lower (Seppalainen *et al.*, 1975).

Hematologic Effects. Lead has multiple hematologic effects. In lead-induced anemia, the red blood cells are microcytic and hypochronic, as in iron deficiency, and usually there are increased numbers of reticulocytes with basophilic stippling. This morphologic characteristic has long been recognized as a feature of lead-induced anemia and in the past (pre–World War II), it was employed as a method of monitoring workers in the lead industry (McCord *et al.*, 1935).

The test is no longer useful because it is now known to be nonspecific and, most important, it is an uncommon occurrence with blood lead below 80 μg/dl, which is considerably above the present-day permissible industrial standard. Basophilic stippling results from inhibition of the enzyme pyrimidine-5-nucleotidase (Paglia *et al.*, 1975), which cleaves residual nucleotide chains remaining in erythrocytes after extrusion of the nucleus. The activity of this enzyme is decreased in persons with elevated blood lead levels even when stippling is not morphologically evident.

The anemia that occurs in lead poisoning results from two basic defects: shortened erythrocyte life-span and impairment of heme synthesis. Shortened life-span of the red blood cell is thought to be due to increased mechanical fragility of the cell membrane. The biochemical basis for this effect is not known but is accompanied by inhibition of sodium- and potassium-dependent ATPase's (Hernberg *et al.*, 1967).

A schematic presentation of effects of lead on heme synthesis is shown in Figure 19–4. Probably the sensitive effect is inhibition of δ-aminolevulinic acid dehydratase (ALA-D), resulting in a negative exponential relationship

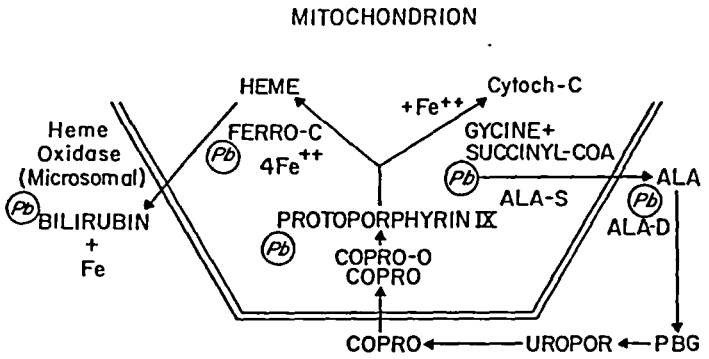

Figure 19–4. Scheme of heme synthesis showing sites where lead has an effect. *COA*, coenzyme A; *ALA-S*, aminolevulinic acid synthetase; *ALA*, *d*-aminolevulinic acid; *ALA-D*, aminoleuvulinic acid dehydratase; *PBG*, porphobilinogen; *UROPOR*, uroporphyrinogen; *COPRO*, coproporphyrinogen; *COPRO-O*, coproporphyrinogen oxidase; *FERRO-C*, Ferrochelatase; *CYTOCH-C*, cytochrome c; (Pb), site for lead effect.

between ALA-D and blood lead. There is also depression of coproporphyrinogen oxidase, resulting in increased coproporphyrin activity. Lead also decreases ferrochelatase activity. This enzyme catalyzes the incorporation of the ferrous ion into the porphyrin ring structure. Bessis and Jensen (1965) have shown that iron in the form of apoferritin and ferruginous micelles may accumulate in mitochondria of bone marrow reticulocytes from lead-poisoned rats. Failure to insert iron into protoporphyrin results in depressed heme formation. The excess protoporphyrin takes the place of heme in the hemoglobin molecule and, as the red blood cells containing protoporphyrin circulate, zinc is chelated at the center of the molecule at the site usually occupied by iron. Red blood cells containing zinc-protoporphyrin are intensely fluorescent and may be used to diagnose lead toxicity. Depressed heme synthesis is thought to be the stimulus for increasing the rate of activity of the first step in the heme synthetic pathway, δ-aminolevulinic acid synthetase, by virtue of negative feedback control as proposed by Granick and Levere (1964). As a consequence, the increased production of *d*-aminolevulinic acid and decreased activity of ALA-D result in a marked increase in circulating blood levels and urinary excretion of *d*-ALA. Prefeeding of lead to experimental animals also raises heme oxygenase activity, resulting in some increase in bilirubin formation. The change in rates of activity of these enzymes by lead produces a dose-related alteration in activity of affected enzymes, but anemia only occurs in very marked lead toxicity. The changes in enzyme activities, particularly ALA-D in peripheral blood and excretion of ALA in urine, correlate very closely with actual blood lead levels and serve as early biochemical indices of lead effect.

Renal Effects. Toxicologic effects of lead on the kidney divide into two major concerns: reversible renal tubular dysfunction that occurs mostly in children with acute exposure to lead, usually associated with overt central nervous system effects, and irreversible chronic interstitial nephropathy characterized by vascular sclerosis, tubular cell atrophy, interstitial fibrosis, and glomerular sclerosis (Goyer, 1971a). It is most often seen in workmen with years of exposure to lead. In the early stages of excess lead exposure, morphologic and functional changes in the kidney are confined to the renal tubules and are most pronounced in proximal tubular cells.

A pathognomonic feature of lead poisoning is the presence of characteristic nuclear inclusions bodies (Goyer, 1971b). By light microscopy the inclusions are dense, homogeneous eosinophilic bodies. They are acid-fast when stained with carbolfuchsin. Ultrastructurally the bodies have a dense central core and outer fibrillary region, as shown in Figure 19–5. The bodies are composed of a lead-protein complex (Moore *et al.*, 1973). The protein is acidic and contains large amounts of aspartic and glutamic acids and little cystine. It is suggested that lead binds loosely to the carboxyl groups of the acidic amino acids. Most of the lead in the tubular cell is bound to the inclusion body. The sequestering of lead in these complexes may protect more susceptible organelles like mitochondria and endoplasmic reticulum (Goyer, 1971b).

Experimental studies have shown that nuclear inclusion bodies are the earliest evidence of lead exposure and may be observed before any of the functional changes are detectable. Cells containing inclusion bodies are usually swollen and contain altered mitochondria. It has been shown that mitochondria isolated from kidneys of rats

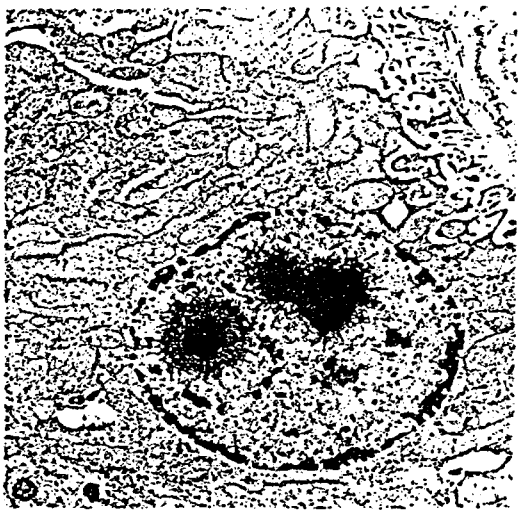

Figure 19–5. Lead-induced inclusion bodies in nucleus of renal tubular lining cell.

with lead toxicity have impaired oxidative and phosphorylative abilities. This may in part be responsible for the decrease in reabsorptive functions of proximal tubular cells. Experimental animals and people, that is, children and workmen with early exposure to lead, have a generalized amino aciduria, glycosuria, and hyperphosphaturia, and probably some impairment of sodium reabsorption. Some indirect evidence for an effect of lead on sodium transport is found in the clinical observation that the renin-aldosterone response to sodium deprivation is altered in people with lead intoxication (Sandstead *et al.*, 1970).

The pathogenesis of the inclusion bodies may be related to renal tubular cell transport and excretion of lead. Treatment of lead-exposed animals with chelating agents such as EDTA is accompanied by a sudden spike of urinary lead, which is maximum 12 to 24 hours after treatment (Goyer and Wilson, 1975). Also, no inclusion bodies can be found by morphologic study of renal tubular cells after EDTA therapy. The bodies may also be found intact in the urinary sediment of workmen with heavy exposure to lead (Schumann *et al.*, 1980). The bodies account for the major fraction of intracellular lead, and their loss in the urine may reflect a major pathway for lead excretion.

With continued exposure to lead there is a gradual change in morphology beginning with the appearance of peritubular and periglomerular fibrosis, particularly in the deep cortex of juxtamedullary zone (Goyer, 1971a). This is accompanied by atrophy of some tubules and hyperplasia of others. There are also fewer inclusion bodies present in the advanced stages of lead-induced nephrosclerosis, and it may be impossible to find any inclusion bodies in lead-induced nephrosclerosis. Recognition of interstitial fibrosis induced by lead, therefore, from any other forms of interstitial fibrosis is not possible morphologically, but must be made from history and knowledge of progression of the disease if this is available.

The most important feature of the changes associated with acute lead nephropathy is that they are reversible, either by reduction of lead exposure or by chelation therapy, but the progression into interstitial fibrosis is not reversible. It is very important, therefore, to diagnose this disorder as early as possible so that exposure to lead can be discontinued and decrease in function halted. At the present time there is no single definitive diagnostic test that will recognize lead-induced interstitial nephropathy except possibly renal biopsy, but this is not a practical measure. There have been several clinical studies in recent years of renal function in workmen with long-term occupational exposure to lead (Wedeen *et al.*, 1979; Lilis *et al.*, 1979; Hong *et al.*, 1980). If looked at together, the conclusion is reached that an early functional accompaniment of interstitial fibrosis is a reduction in glomerular filtration rate.

The relationship between chronic lead exposure and gouty nephropathy, suggested more than a hundred years ago by the English physician Garrod, has received recent support from studies showing that gout patients with renal disease have a greater chelate-provoked lead excretion than do renal patients without gout (Batuman *et al.*, 1981). Lead reduces uric acid excretion (Emerson, 1963). Elevated blood uric acid has been demonstrated in rats with chronic lead nephropathy (Goyer, 1971a).

The relationship between lead and hypertension is uncertain; it has been associated with lead poisoning in a number of studies but not in others. The second National Health and Nutrition Examination Survey (1976–1980) found a statistically significant relationship between blood pressure and blood lead levels in white males age 40–59 years (Pirkle *et al.* 1985). Hypertension may follow the vascular changes associated with lead-induced chronic renal disease, or changes in renin-angiotensin-aldosterone metabolism (Sandstead, 1970; Victery *et al.*, 1982).

Carcinogenesis. The possible carcinogenic effects of lead have been receiving increasing attention (IARC, 1980). It is clear that lead can induce cancer in kidneys of rodents fed high doses of lead (Moore and Meredith, 1979). On the other hand, the evidence that lead is carcino-

genic to humans is very limited. A study of workmen in England many years ago with occupational exposure to lead did not show an increased incidence of cancer (Dingwall-Fordyce and Lane, 1963). A more recent study of causes of mortality in 7000 lead workers in the United States showed a slight excess of deaths from cancer (Cooper and Gaffey, 1975), but the statistical significance of these findings has been debated (Kang *et al.*, 1980; Cooper, 1980). The most common tumors found were of the respiratory and digestive systems, not the kidney. However, case reports of renal adenocarcinoma in workmen with prolonged occupational exposure to lead have appeared (Baker *et al.*, 1980; Lilis, 1981).

Other Effects. Severe lead toxicity has long been known to cause sterility, abortion, and neonatal mortality and morbidity. Studies have demonstrated gametotoxic effects in both male and female animals. However, the impact of levels of lead exposure occurring in today's society on reproductive effects is uncertain. The greatest concern is for intrauterine effects on the unborn fetus. Umbilical cord blood levels are the same as those of mother's blood, and because of the greater sensitivity of the fetus, pregnancy must be regarded as a period of increased susceptibility to lead.

A few clinical studies have found increased chromosomal defects in workers with blood lead levels above 60 μg/dl (Deknudt *et al.*, 1977). Experimental studies suggest that lead alters the humoral immune system and lead-induced immunosuppression occurs at low dosages in experimental animals in which there is no apparent evidence of toxicity (Koller *et al.*, 1983.) Also, children with asymptomatic increase in blood lead levels appear to have more frequent febrile illness (Perlstein and Attala, 1966).

Lead lines (Burton's lines) or purple-blue discoloration of gingiva is a classical feature of severe lead toxicity in children with lead encephalopathy. However, this feature of lead toxicity as well as the presence of lead lines at the epiphyseal margins of long bones seen on x-rays of children with severe lead exposure are uncommon today.

Interaction with Other Minerals. Lead toxicity is enhanced by dietary deficiencies in calcium and iron and possibly zinc (Mahaffey and Michaelson, 1980). The increased lead susceptibility found in animals on low calcium regimes is not a direct effect of calcium intake but of increased lead retention associated with decreased renal excretion of lead. In children, elevated blood lead is associated with decreased levels of 25-hydroxyvitamin D (synthesized in liver) and 1-to-25-dihydroxyvitamin D (synthesized in kidney). Iron deficiency is thought to increase gastrointestinal absorption of lead but does not otherwise affect lead metabolism. Relationships between lead and zinc have been studies in experimental animals and veterinary practice. Animals fed diets low in zinc accumulate greater amounts of lead in bones. Extra zinc in the diet has been found to protect horses grazing on lead-contaminated pastures from clinical manifestations of lead toxicity.

Organolead Compounds. Alkyl lead compounds used as gasoline additives, tetraethyl and tetramethyl lead, are rapidly absorbed into the nervous system and are much more severe neurotoxins on an equivalent dose basis than inorganic lead. Although these compounds may be emitted in small amounts from automobile exhaust, they degrade rapidly in the atmosphere. However, the practice of young people sniffing gasoline for psychodelic effects is particularly hazardous. Experimental studies have shown that tetraethyl lead is converted to triethyl lead and inorganic lead. Triethyl lead is relatively stable and becomes rapidly distributed between brain, liver, kidney, and blood (Cremer, 1959).

Biologic Indicators of Lead Toxicity. The most serious effects of lead are related to the central nervous system, although other effects such as chronic nephropathy may be important in some individuals with chronic exposure to high lead levels. Effects on heme synthesis are less evident from a clinical viewpoint, but these are the effects that in biochemical terms are best understood. With continual improvement in industrial hygiene and consciousness and control of potential environmental exposures to lead, concern for recognition of lead poisoning, in terms of traditional clinical signs and symptoms, is less relevant now than the matter of interpretation of more subtle neurologic and biochemical effects. Table 19–5 shows blood lead levels below which various parameters of lead toxicity are not detected. Blood lead level greater than 80 μg/dl is usually associated with clinical symptoms. Persons with blood lead levels above 60 μg/dl may also have clinical manifestations of lead poisoning, particularly in terms of minimal brain dysfunction. For these reasons children with blood levels in this range are sometimes treated with chelating agents. However, effects of lead on heme synthesis, along with increased urinary excretion of δ-ALA, are associated with blood lead levels of 40 μg/dl.

Heme Metabolism. The ALA-D activity of peripheral red blood cells may currently be the most sensitive biochemical parameter affected by lead. Samples collected from both children and adults have shown a negative correlation

Table 19-5. BLOOD LEAD LEVELS BELOW WHICH THE LISTED EFFECTS HAVE NOT BEEN DETECTED*

BLOOD LEVELS (μg pb/dl)	EFFECT	POPULATION
>10	Erythrocyte ALA-D inhibition	Adults, children
20–25	FEP†	Children
20–30	FEP	Adult, female
25–35	FEP	Adult, male
30–40	Erythrocyte ATPase inhibition	General
40	ALA excretion in urine	Adults, children
40	CP excretion in urine	Adults
40	Anemia	Children
40–50	Peripheral neuropathy	Adults
50	Anemia	Adults
50–60	Minimal brain dysfunction	Children
60–70	Minimal brain dysfunction	Adults
60–70	Encephalopathy	Children
>80	Encephalopathy	Adults

* From WHO Environmental Health Criteria 3. *Lead*. World Health Organization, Geneva, 1977.
† FEP, free erythrocyte protoporphyrin (see Figure 19–4).

between the log of ALA-D activity and the blood lead concentration over a range to below 20 μg/dl. At present they are considered chemical effects of lead rather than adverse health effects. However, children with blood lead levels less than 40 μg/dl exhibit behavioral and fine-motor changes. Therefore, the maximum blood lead level that is not associated with harmful effects is not known. It may, indeed, differ for different segments of the population. Furthermore, blood lead levels and alterations in heme metabolism are indicative of recent exposure but do not reflect past exposure or body burden and may not correlate with the appearance and persistence of chronic effects of lead that are due to tissue levels. This is particularly true of irreversible effects on the central nervous system and kidney.

Chelatable Lead. Urinary excretion of lead after chelation with EDTA or penicillamine reflects the mobilizable pool of lead located in soft tissue. Urinary excretion of lead in the 24-hour period after administration of the chelating agent correlates with blood lead levels for persons in the steady state, without unusual past or recent exposure to lead. However, for persons exposed to excess lead for one year or more, urinary excretion of lead is considerably greater. It has been estimated that nearly 20 percent of the body burden of lead is mobilized into the urine during the 24-hour period after an injection of 40 mg of $CaNa_2$ EDTA per kilogram body weight (Araki and Ushig, 1982).

Lead in Teeth. Lead concentration in circumpulpal dentine of deciduous teeth has been proposed as a method for estimating exposure to lead during childhood. It has been shown that dentine lead content is dose dependent and not reduced by chelation. The distribution of lead in various components of the tooth including enamel, root dentine, and coronal dentine is similar. However, lead content in secondary or circumpulpal dentine, the area of dentine adjacent to pulp and in immediate contact with blood, is higher than in other areas of the tooth and seems to reflect actual exposure to lead throughout the life of the tooth. Several studies now have found substantially higher dentine levels in teeth from urban children living in deteriorated housing or attending school in proximity to a major manufacturer of paint and lead products than in teeth from children considered to be at low risk for lead exposure (Shapiro *et al.*, 1975).

Treatment. Treatment of lead toxicity must go beyond medical care for specific tissue and organ effects and chelation of lead. For both asymptomatic excess exposure to lead as well as the symptomatic child or worker with occupational exposure the sources of lead must be identified and controlled. For the child, this might involve a review of life-style including diet, particularly iron deficiency, type of dwelling, play habits, and pica. Treatment might involve social services, modification of dwelling, and parent education. For the workman, industrial hygiene practices must be reviewed including appropriate environmental and biologic monitoring and deficiencies corrected. One must always be aware of the relationship between occupation and the home. Practices of changing or washing contaminated workclothes must be reviewed, and potential sources of transfer of metal and contamination need to be corrected.

Chelation usually has a role in the treatment of the symptomatic worker or child. Institution of

chelation therapy is probably warranted in workmen with blood lead levels over 60 μg/100 ml, but this determination must be made after assessment of exposure factors including biologic estimates of clinical and biochemical parameters of toxicity.

For children, criteria have been established that may serve as guidelines to assist in evaluating the individual case (Chisolm and O'Hara, 1982). These include blood lead levels from 30 μg/dl up to 60 μg/dl depending on FEP levels, and results of a lead mobilization test.

Also, cautionary measures for the safe use of chelating agents have been expressed particularly for Ca EDTA (Lilis and Fischbein, 1976). Serum blood urea nitrogen and creatinine are followed as indicators of renal function, and serum calcium is measured to monitor untoward effects of EDTA. In children with severe lead poisoning including encephalopathy, the mortality rate may be 25 to 38 percent when EDTA or BAL is used singly; combination therapy of EDTA and BAL has been shown to be effective in reducing mortality.

Mercury

No other metal better illustrates the diversity of effects caused by different biochemical forms than does mercury. On the basis of toxicologic characteristics, there are three forms of mercury: elemental, inorganic, and organic compounds. The major source of mercury is the natural degassing of the earth's crust, including land areas, rivers, and the ocean, and is estimated to be in the order of 25,000 to 150,000 tons per year (WHO, 1976; Goldwater and Stopford, 1977; NRCC, 1979). Metallic mercury in the atmosphere represents the major pathway of global transport of mercury. Although anthropogenic sources of mercury have reached about 8000 to 10,000 tons per year since 1973, nonanthropogenic sources are the predominating factors. Nevertheless, mining, smelting, and industrial discharge have been factors in environmental contamination in the past. For instance, it is estimated that loss in water effluent from chloralkali plants, one of the largest users of mercury, has been reduced by 99 percent in recent years. Also, the use of mercury in the paper pulp industries has been reduced dramatically and has been banned in Sweden since 1966. Industrial activities not directly employing mercury or mercury products give rise to substantial quantities of this metal. Fossil fuel may contain as much as 1 ppm of mercury, and it is estimated that about 5000 tons of mercury per year may be emitted from burning coal, natural gas, and the refining of petroleum products. Calculations based on mercury content of the Greenland ice-cap show an increase from the year 1900 to the present day and suggest that the increment is related to increase in background levels in rainwater and is related to man-made release. As much as one-third of atmospheric mercury may be due to industrial release of organic or inorganic forms. Regardless of source, both organic and inorganic forms of mercury may undergo environmental transformation. Metallic mercury may be oxidized to inorganic divalent mercury, particularly in the presence of organic material such as in the aquatic environment. Divalent inorganic mercury may, in turn, be reduced to metallic mercury when conditions are appropriate for reducing reactions to occur. This is an important conversion in terms of the global cycle of mercury and a potential source of mercury vapor that may be released to the earth's atmosphere. A second potential conversion of divalent mercury is methylation to dimethyl mercury by anaerobic bacteria This may diffuse into the atmosphere and return to earth crust or bodies of water as methyl mercury in rainfall. If taken up by fish in the food chain, it may eventually cycle through humans.

Disposition. Toxicity of various forms or salts of mercury is related to cationic mercury *per se* whereas solubility, biotransformation, and tissue distribution are influenced by valence state and anionic component (Suzuki, 1977; Berlin, 1983; and Clarkson, 1983). Metallic or elemental mercury volatilizes to mercury vapor at ambient air temperatures, and most human exposure is by inhalation. Mercury vapor readily diffuses across the alveolar membrane and is lipid soluble so that it has an affinity for red blood cells and central nervous system. Metallic mercury, such as may be swallowed from a broken thermometer, is only slowly absorbed by the gastrointestinal tract (0.01 percent) at a rate related to the vaporization of the elemental mercury and is generally thought to be of no toxicologic consequence.

Inorganic mercury salts may be divalent (mercuric) or monovalent (mercurous). Gastrointestinal absorption of inorganic salts of mercury from food is less than 15 percent in mice and about 7 percent in a study of human volunteers, whereas absorption of methyl mercury is in the order of 90 to 95 percent. Distribution between red blood cells and plasma also differs. For inorganic mercury salts cell-plasma ratio ranges from a high of two with high exposure to less than one, but for methyl mercury it is about ten. The distribution ratio of the two forms of mercury between hair and blood also differs; for organic mercury it is about 250.

Kidneys contain the greatest concentrations of mercury following exposure to inorganic salts

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NORTH CAROLINA

OSHA STANDARDS FOR GENERAL INDUSTRY

OFFICE OF THE NATIONAL SAFETY AND STATE
COMPLIANCE, U.S. DEPARTMENT OF LABOR

WITH AMENDMENTS AS OF JUNE 1, 1984

NORTH CAROLINA DEPARTMENT OF LABOR

JOHN C. BROOKS

Commissioner

NORTH CAROLINA
OCCUPATIONAL SAFETY AND HEALTH STANDARDS
FOR GENERAL INDUSTRY

The State of North Carolina has an approved State Plan for Occupational Safety and Health which vests the administrative and enforcement authority for all matters relating to occupational safety and health in the North Carolina Department of Labor, Occupational Safety and Health Division, as opposed to the U. S. Department of Labor, Occupational Safety and Health Administration (OSHA).

The Commissioner of Labor, pursuant to North Carolina General Statute 95-131, has the responsibility for the adoption and promulgation of occupational safety and health rules, regulations and standards for the protection of employees in North Carolina. All adopted standards are included in 13 NCAC Subchapter 7C of the North Carolina Administrative Code.

Under the conditions for state plan approval, a state's standards must be as effective as the counterpart federal standards. In order to meet this obligation, North Carolina has adopted by reference, as provided by law, the federal OSHA Standards for General Industry (29 CFR Part 1910). This publication includes all revisions and amendments to 29 CFR Part 1910 through June 1, 1984.

The Commissioner of Labor also has the statutory authority to promulgate standards different from, or in addition to, the federal OSHA standards. This has been done on a limited basis. For copies of these standards, or for additional standards information including interpretations, contact the Division of Occupational Safety and Health, North Carolina Department of Labor, 4 West Edenton Street, Raleigh, North Carolina 27601. Phone: (919) 733-4880.

(Occupational Safety and Health Standards for Construction and Agriculture are printed under separate cover.)

OCCUPATIONAL SAFETY AND HEALTH STANDARDS FOR GENERAL INDUSTRY

(29 CFR Part 1910)

With amendments as of June 1, 1984

Including 29 CFR Part 1990 Carcinogen Policy and Model Standards

Promulgated by the
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
UNITED STATES DEPARTMENT OF LABOR

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fingernails and toenails are commonly seen in chronic arsenical poisoning and are considered to be a diagnostic accompaniment of arsenical polyneuritis.

Inhalation of inorganic arsenic compounds is the most common cause of chronic poisoning in the industrial situation. This condition is divided into three phases based on signs and symptoms.

First Phase: The worker complains of weakness, loss of appetite, some nausea, occasional vomiting, a sense of heaviness in the stomach, and some diarrhea.

Second Phase: The worker complains of conjunctivitis, a catarrhal state of the mucous membranes of the nose, larynx, and respiratory passage. Coryza, hoarseness, and mild tracheobronchitis may occur. Perforation of the nasal septum is common, and is probably the most typical lesion of the upper respiratory tract in occupational exposure to arsenical dust. Skin lesions, eczematoid and allergic in type, are common.

Third Phase: The worker complains of symptoms of peripheral neuritis, initially of hands and feet, which is essentially sensory. In more severe cases, motor paralyses occur; the first muscles affected are usually the toe extensors and the peroneal. In only the most severe cases will paralysis of flexor muscles of the feet or of the extensor muscles of hands occur.

Liver damage from chronic arsenical poisoning is still debated, and as yet the question is unanswered. In cases of chronic and acute arsenical poisoning, toxic effects to the myocardium have been reported based on EKG changes. These findings, however, are now largely discounted and the EKG changes are ascribed to electrolyte disturbances concomitant with arsenicalism. Inhalation of arsenic trioxide and other inorganic arsenical dusts does not give rise to radiological evidence or pneumoconiosis. Arsenic does have a depressant effect upon the bone marrow, with disturbances of both erythropoiesis and myelopoiesis.

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III. SPUTUM CYTOLOGY

Sputum can be collected by aerosol inhalation during the medical exam or by spontaneous early morning cough at home. Sputum is induced by transoral inhalation of an aerosolized solution of eight per cent (8 percent) sodium chloride in water. After inhaling as few as three to five breaths the subject usually yields an adequate sputum. All sputum should be collected directly into sixty percent (60 percent) alcohol.

Scientific evidence suggests that chest X-rays and sputum cytology should be used together as screening tests for lung tests for lung cancer in high risk populations such as workers exposed to inorganic arsenic. The tests are to be performed every six months on workers who are 45 years of age or older or have worked in the regulated area for 10 or more years. Since the tests seem to be complementary, it may be advantageous to alternate the test procedures. For instance, chest X-rays could be obtained in June and December and sputum cytologies could be obtained in March and September. Facilities for providing necessary diagnostic investigation should be readily available as well as chest physicians, surgeons, radiologists, pathologists and immunotherapists to provide any necessary treatment services.

[FR Doc. 78-12170 Filed 5-3-78; 11:00 am]

[§1910.1018 added at 43 F.R. 19624, May 5, 1978; generally effective August 1, 1978.]

§ 1910.1025 Lead.

Caution: parts of standard stayed—see foreword.

(a) *Scope and application.* (1) This section applies to all occupational exposure to lead, except as provided in paragraph (a)(2).

(2) This section does not apply to the construction industry or to agricultural operations covered by 29 CFR Part 1928.

[§ 1910.1025(a)(2) amended at 44 F.R. 50338, August 28, 1979.]

(b) *Definitions.* "Action level" means employee exposure, without regard to the use of respirators, to an airborne concentration of lead of 30 micrograms per cubic meter of air (30 $\mu g/m^3$) averaged over an 8-hour period.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Director" means the Director, National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health, Education, and Welfare, or designee.

"Lead" means metallic lead, all inorganic lead compounds, and organic lead soaps. Excluded from this definition are all other organic lead compounds.

(c) *Permissible exposure limit (PEL).* (1) The employer shall assure that no employee is exposed to lead at concentrations greater than fifty micrograms per cubic meter of air (50 $\mu g/m^3$) averaged over an 8-hour period.

(2) If an employee is exposed to lead for more than 8 hours in any work day, the permissible exposure limit, as a time weighted average (TWA) for that day, shall be reduced according to the following formula:

$$\text{Maximum permissible limit (in } \mu g/m^3) = 400 \div \text{hours worked in the day.}$$

(3) When respirators are used to supplement engineering and work practice controls to comply with the PEL and all the requirements of paragraph (f) have been met, employee exposure, for the purpose of determining whether the employer has complied with the PEL, may be considered to be at the level provided by the protection factor of the respirator for those periods the respirator is worn. Those periods may be averaged with exposure levels during periods when respirators are not worn to determine the employee's daily TWA exposure.

(d) *Exposure monitoring.* (1) *General.* (i) For the purposes of paragraph (d), employee exposure is that exposure which would occur if the employee were not using a respirator.

(ii) With the exception of monitoring under paragraph (d)(3), the employer shall collect full shift (for at least 7 continuous hours) personal samples including at least one sample for each shift for each job classification in each work area.

(iii) Full shift personal samples shall be representative of the monitored employee's regular, daily exposure to lead.

(2) *Initial determination.* Each employer who has a workplace or work operation covered by this standard shall determine if any employee may be exposed to lead at or above the action level.

(3) *Basis of initial determination.* (i) The employer shall monitor employee exposures and shall base initial determinations on the employee exposure monitoring results and any of the following, relevant considerations:

(A) Any information, observations, or calculations which would indicate employee exposure to lead;

(B) Any previous measurements of airborne lead; and measurements of airborne lead made in the preceding year if the sampling and analytical methods used meet the accuracy and confidence levels of paragraph (d)(9) of this section; and

(C) Any employee complaints of symptoms which may be attributable to exposure to lead.

(ii) Monitoring for the initial determination may be limited to a representative sample of the exposed employees who the employer reasonably believes are exposed to the greatest airborne concentrations of lead in the workplace.

(iii) Measurement of airborne lead made in the preceding 12 months may be used to satisfy the requirement to monitor under paragraph (d)(3)(i) if the sampling and analytical methods used meet the accuracy and confidence levels of paragraph (d)(9) of this section.

(4) *Positive initial determination and initial monitoring.* (i) Where a determination conducted under paragraphs (d)(2) and (d)(3) of this section shows the possibility of any employee exposure at or above the action level, the employer shall conduct monitoring which is

makes contact with the skin, unacceptable stress to breathing in some workers with underlying cardiopulmonary impairment, difficulty in providing adequate fit, the tendency for respirators to create additional hazards by interfering with vision, hearing, and mobility, and the difficulties of assuring the maximum effectiveness of a complicated work practice program involving respirators. Respirators do, however, serve a useful function where engineering and work practice controls are inadequate by providing supplementary, interim, or short-term protection, provided they are properly selected for the environment in which the employee will be working, properly fitted to the employee, maintained and cleaned periodically, and worn by the employee when required.

In its final standard on occupational exposure to inorganic lead, OSHA has prohibited prophylactic chelation. Diagnostic and therapeutic chelation are permitted only under the supervision of a licensed physician with appropriate medical monitoring in an acceptable clinical setting. The decision to initiate chelation therapy must be made on an individual basis and take into account the severity of symptoms felt to be a result of lead toxicity along with blood lead levels, ZPP levels, and other laboratory tests as appropriate. EDTA and penicillamine which are the primary chelating agents used in the therapy of occupational lead poisoning have significant potential side effects and their use must be justified on the basis of expected benefits to the worker.

Unless frank and severe symptoms are present, therapeutic chelation is not recommended given the opportunity to remove a worker from exposure and allow the body to naturally excrete accumulated lead. As a diagnostic aid, the chelation mobilization test using CA-EDTA has limited applicability. According to some investigators, the test can differentiate between lead-induced and other nephropathies. The test may also provide an estimation of the mobile fraction of the total body lead burden.

Employers are required to assure that accurate records are maintained on exposure monitoring, medical surveillance, and medical removal for each employee. Exposure monitoring and medical surveillance records must be kept for 40 years or the duration of employment plus 20 years, whichever is longer, while medical removal records must be maintained for the duration of employment. All records required under the standard must be made available upon request to the Assistant Secretary of Labor for Occupational Safety and Health and the Director of the National Institute for Occupational Safety and Health. Employers must also make environmental and biological monitoring and medical removal records available to affected employees and to former employees or their authorized employee representatives. Employees or their specifically designated representatives have access to their entire medical surveillance records.

In addition, the standard requires that the employer inform all workers exposed to lead at or above the action level of the provisions of the standard and all its appendices, the purpose and description of medical surveillance and provisions for medical removal protection if temporary removal is required. An understanding of the potential health effects of lead exposure by all exposed employees along with full understanding of their rights under the lead standard is essential for an effective monitoring program.

II Adverse health effects of inorganic lead

Although the toxicity of lead has been known for 2,000 years, the knowledge of the complex relationship between lead exposure and human response is still being refined. Significant research into the toxic properties of lead continues throughout the world, and it should be anticipated that our understanding of thresholds of effects and margins of safety will be improved in future years. The provisions of the lead standard are founded on two prime medical judgments: first, the prevention of adverse health effects from exposure to lead throughout a working lifetime requires that worker blood lead levels be maintained at or below 40 μg/100 g and second, the blood lead levels of workers, male or female, who intend to parent in the near future should be maintained below 30 μg/100 g to minimize adverse reproductive health effects to the parents and developing fetus. The adverse effects of lead on reproduction are being actively researched and OSHA encourages the physician to remain abreast of recent developments in the area to best advise pregnant workers or workers planning to conceive children.

The spectrum of health effects caused by lead exposure can be subdivided into five developmental stages: normal, physiological changes of uncertain significance, pathophysiological changes, overt symptoms (morbidity), and mortality. Within this process there are no sharp distinctions, but rather a continuum of effects. Boundaries between categories overlap due to the wide variation of individual responses and exposures in the working population. OSHA's development of the lead standard focused on pathophysiological changes as well as later stages of disease.

1. *Heme Synthesis Inhibition.* The earliest demonstrated effect of lead involves its ability to inhibit at least two enzymes of the heme synthesis pathway at very low blood levels. Inhibition of delta aminolevulinic acid dehydrase (ALA-D) which catalyzes the conversion of delta-aminolevulinic acid (ALA) to protoporphyrin is observed at a blood lead level below 20 μg/100 g whole blood. At a blood lead level of 40 μg/100 g, more than 20% of the population would have 70% inhibition of ALA-D. There is an exponential increase in ALA excretion at blood lead levels greater than 40 μg/100 g.

Another enzyme, ferrochelatase, is also inhibited at low blood lead levels. Inhibition of ferrochelatase leads to increased free erythrocyte protoporphyrin (FEP) in the blood which can then bind to zinc to yield zinc protoporphyrin. At a blood lead level of 50 μg/100 g or greater, nearly 100% of the population will have an increase in FEP. There is also an exponential relationship between blood lead levels greater than 40 μg/100 g and the associated ZPP level, which has led to

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the development of the ZPP screening test for lead exposure.

While the significance of these effects is subject to debate, it is OSHA's position that these enzyme disturbances are early stages of a disease process which may eventually result in the clinical symptoms of lead poisoning. Whether or not the effects do progress to the later stages of clinical disease, disruption of these enzyme processes over a working lifetime is considered to be a material impairment of health.

One of the eventual results of lead-induced inhibition of enzymes in the heme synthesis pathway is anemia which can be asymptomatic if mild but associated with a wide array of symptoms including dizziness, fatigue, and tachycardia when more severe. Studies have indicated that lead levels as low as 50 μg/100 g can be associated with a definite decreased hemoglobin, although most cases of lead-induced anemia, as well as shortened red-cell survival times, occur at lead levels exceeding 80 μg/100 g. Inhibited hemoglobin synthesis is more common in chronic cases whereas shortened erythrocyte life span is more common in acute cases.

In lead-induced anemias, there is usually a reticulocytosis along with the presence of basophilic stippling, and ringed sideroblasts, although none of the above are pathognomonic for lead-induced anemia.

2. *Neurological Effects.* Inorganic lead has been found to have toxic effects on both the central and peripheral nervous systems. The earliest stages of lead-induced central nervous system effects first manifest themselves in the form of behavioral disturbances and central nervous system symptoms including irritability, restlessness, insomnia and other sleep disturbances, fatigue, vertigo, headache, poor memory, tremor, depression, and apathy. With more severe exposure, symptoms can progress to drowsiness, stupor, hallucinations, delerium, convulsions and coma.

The most severe and acute form of lead poisoning which usually follows ingestion or inhalation of large amounts of lead is acute encephalopathy which may arise precipitously with the onset of intractable seizures, coma, cardiorespiratory arrest, and death within 48 hours.

While there is disagreement about what exposure levels are needed to produce the earliest symptoms, most experts agree that symptoms definitely can occur at blood lead levels of 60 μg/100 g whole blood and therefore recommend a 40 μg/100 g maximum. The central nervous system effects frequently are not reversible following discontinued exposure or chelation therapy and when improvement does occur, it is almost always only partial.

The peripheral neuropathy resulting from lead exposure characteristically involves only motor function with minimal sensory damage and has a marked predilection for the extensor muscles of the most active extremity. The peripheral neuropathy can occur with varying degrees of severity. The earliest and mildest form which can be detected in workers with blood lead levels as low as 50 μg/100 g is manifested by slowing of motor nerve conduction velocity often without clinical symptoms. With progression of the neuropathy there is development of painless extensor muscle weakness usually involving the extensor muscles of the fingers and hand in the most active upper extremity, followed in severe cases by wrist drop or, much less commonly, foot drop.

In addition to slowing of nerve conduction, electromyographical studies in patients with blood lead levels greater than 50 μg/100 g have demonstrated a decrease in the number of acting motor unit potentials, an increase in the duration of motor unit potentials, and spontaneous pathological activity including fibrillations and fasciculations. Whether these effects occur at levels of 40 μg/100 g is undetermined.

While the peripheral neuropathies can occasionally be reversed with therapy, again such recovery is not assured particularly in the more severe neuropathies and often improvement is only partial. The lack of reversibility is felt to be due in part to segmental demyelination.

3. *Gastrointestinal.* Lead may also affect the gastrointestinal system producing abdominal colic or diffuse abdominal pain, constipation, obstipation, diarrhea, anorexia, nausea and vomiting. Lead colic rarely develops at blood lead levels below 80 μg/100 g.

4. *Renal.* Renal toxicity represents one of the most serious health effects of lead poisoning. In the early stages of disease nuclear inclusion bodies can frequently be identified in proximal renal tubular cells. Renal function remains normal and the changes in this stage are probably reversible. With more advanced disease there is progressive interstitial fibrosis and impaired renal function. Eventually extensive interstitial fibrosis ensues with sclerotic glomeruli and dilated and atrophied proximal tubules; all represent end stage kidney disease. Azotemia can be progressive, eventually resulting in frank uremia necessitating dialysis. There is occasionally associated hypertension and hyperuricemia with or without gout.

Early kidney disease is difficult to detect. The urinalysis is normal in early lead nephropathy and the blood urea nitrogen and serum creatinine increase only when two-thirds of kidney function is lost. Measurement of creatinine clearance can often detect earlier disease as can other methods of measurement of glomerular filtration rate. An abnormal Ca-EDTA mobilization test has been used to differentiate between lead-induced and other nephropathies, but this procedure is not widely accepted. A form of Fanconi syndrome with aminoaciduria, glycosuria, and hyperphosphaturia indicating severe injury to the proximal renal tubules is occasionally seen in children.

5. *Reproductive effects.* Exposure to lead can have serious effects on reproductive function in both males and females. In male workers exposed to lead there can be a decrease in sexual drive, impotence, decreased ability to produce healthy sperm, and sterility. Malformed sperm (teratospermia), decreased number of sperm (hypospermia), and sperm with decreased motility (asthenospermia) can all occur. Teratospermia has been noted at mean blood lead levels of 53 μg/100 g and hypospermia and asthenospermia at 41 μg/100 g. Furthermore, there appears to be a dose-response relationship for teratospermia in lead exposed workers.

Women exposed to lead may experience menstrual disturbances including dysmenorrhea, menorrhagia and amenorrhea. Following exposure to lead, women have a higher frequency of sterility, premature births, spontaneous miscarriages, and stillbirths.

Germ cells can be affected by lead and cause genetic damage in the egg or sperm cells before conception and result in failure to implant, miscarriage, stillbirth, or birth defects.

Infants of mothers with lead poisoning have a higher mortality during the first year and suffer from lowered birth weights, slower growth, and nervous system disorders.

Lead can pass through the placental barrier and lead levels in the mother's blood are comparable to concentrations of lead in the umbilical cord at birth. Transplacental passage becomes detectable at 12–14 weeks of gestation and increases until birth.

There is little direct data on damage to the fetus from exposure to lead but it is generally assumed that the fetus and newborn would be at least as susceptible to neurological damage as young children. Blood lead levels of 50–60 μg/100 g in children can cause significant neurobehavioral impairments and there is evidence of hyperactivity at blood levels as low as 25 μg/100 g. Given the overall body of literature concerning the adverse health effects of lead in children, OSHA feels that the blood lead level in children should be maintained below 30 μg/100 g with a population mean of 15 μg/100 g. Blood lead levels in the fetus and newborn likewise should not exceed 30 μg/100 g.

Because of lead's ability to pass through the placental barrier and also because of the demonstrated adverse effects of lead on reproductive function in both the male and female as well as the risk of genetic damage of lead on both the ovum and sperm, OSHA recommends a 30 μg/100 g maximum permissible blood lead level in both males and females who wish to bear children.

6. *Other toxic effects.* Debate and research continue on the effects of lead on the human body. Hypertension has frequently been noted in occupationally exposed individuals although it is difficult to assess whether this is due to lead's adverse effects on the kidney or if some other mechanism is involved. Vascular and electrocardiogarphic changes have been detected but have not been well characterized. Lead is thought to impair thyroid function and interfere with the pituitary-adrenal axis but again these effects have not been well defined.

III. Medical Evaluation

The most important principle in evaluating a worker for any occupational disease including lead poisoning is a high index of suspicion on the part of the examining physician. As discussed in Section 2, lead can affect numerous organ systems and produce a wide array of signs and symptoms, most of which are non-specific and subtle in nature at least in the early stages of disease. Unless serious concern for lead toxicity is present, many of the early clues to diagnosis may easily be overlooked.

The crucial initial step in the medical evaluation is recognizing that a worker's employment can result in exposure to lead. The worker will frequently be able to define exposures to lead and lead containing materials but often will not volunteer this information unless specifically asked. In other situations the worker may not know of any exposures to lead but the suspicion might be raised on the part of the physician because of the industry or occupation of the worker. Potential occupational exposure to lead and its compounds occur in at least 120 occupations, including lead smelting, the manufacture of lead storage batteries, the manufacture of lead pigments and products containing pigments, solder manufacture, shipbuilding and ship repair, auto manufacturing, construction, and painting.

Once the possibility for lead exposure is raised, the focus can then be directed toward eliciting information from the medical history, physical exam, and finally from laboratory data to evaluate the worker for potential lead toxicity.

A complete and detailed work history is important in the initial evaluation. A listing of all previous employment with information on work processes, exposure to fumes or dust, known exposures to lead or other toxic substances, respiratory protection used, and previous medical surveillance should all be included in the worker's record. Where exposure to lead is suspected, information concerning on-the-job personal hygiene, smoking or eating habits in work areas, laundry procedures, and use of any protective clothing or respiratory protection equipment should be noted. A complete work history is essential in the medical evaluation of a worker with suspected lead toxicity, especially when long term effects such as neurotoxicity and nephrotoxicity are considered.

The medical history is also of fundamental importance and should include a listing of all past and current medical conditions, current medications including proprietary drug intake, previous surgeries and hospitalizations, allergies, smoking history, alcohol consumption, and also non-occupational lead exposures such as hobbies (hunting, riflery). Also known childhood exposures should be elicited. Any previous history of hematological, neurological, gastrointestinal, renal, psychological, gynecological, genetic, or reproductive problems should be specifically noted.

A careful and complete review of systems must be performed to assess both recognized complaints and subtle or slowly acquired symptoms which the worker might not appreciate as being significant. The review of symptoms should include the following:

General—weight loss, fatigue, decreased appetite.

Head, Eyes, Ears, Nose, Throat (HEENT)—headaches, visual disturbances or decreased visual acuity, hearing deficits or tinnitus, pigmentation of the oral mucosa, or metallic taste in mouth.

Cardio-pulmonary—shortness of breath, cough, chest pains, palpitations, or orthopnea.

Gastrointestinal—nausea, vomiting, heartburn, abdominal pain, constipation or diarrhea.

Neurologic—irritability, insomnia, weakness (fatigue), dizziness, loss of

memory, confusion, hallucinations, incoordination, ataxia, decreased strength in hands or feet, disturbances in gait, difficulty in climbing stairs, or seizures.

Hematologic—pallor, easy fatigability, abnormal blood loss, melena.

Reproductive (male and female and spouse where relevant)—history of infertility, impotence, loss of libido, abnormal menstrual periods, history of miscarriages, stillbirths, or children with birth defects.

Musculo-skeletal—muscle and joint pains.

The physical examination should emphasize the neurolcgical, gastrointestinal, and cardiovascular systems. The worker's weight and blood pressure should be recorded and the oral mucosa checked for pigmentation characteristic of a possible Burtonian or lead line on the gingiva. It should be noted, however, that the lead line may not be present even in severe lead poisoning if good oral hygiene is practiced.

The presence of pallor on skin examination may indicate an anemia, which if severe might also be associated with a tachycardia. If an anemia is suspected, an active search for blood loss should be undertaken including potential blood loss through the gastrointestinal tract.

A complete neurological examination should include an adequate mental status evaluation including a search for behavioral and psychological disturbances, memory testing, evaluation for irritability, insomnia, hallucinations, and mental clouding. Gait and coordination should be examined along with close observation for tremor. A detailed evaluation of peripheral nerve function including careful sensory and motor function testing is warranted. Strength testing particularly of extensor muscle groups of all extremities is of fundamental importance.

Cranial nerve evaluation should also be included in the routine examination.

The abdominal examination should include auscultation for bowel sounds and abdominal bruits and palpation for organomegaly, masses, and diffuse abdominal tenderness.

Cardiovascular examination should evaluate possible early signs of congestive heart failure. Pulmonary status should be addressed particularly if respirator protection is contemplated.

As part of the medical evaluation, the lead standard requires the following laboratory studies:

1. Blood lead level
2. Hemoglobin and hematocrit determinations, red cell indices, and examination of the peripheral blood smear to evaluate red blood cell morphology
3. Blood urea nitrogen
4. Serum creatinine
5. Routine urinalysis with microscopic examination.
6. A zinc protoporphyrin level (This requirement is currently not in effect due to the pending litigation, but is recommended nonetheless).

In addition to the above, the physician is authorized to order any further laboratory or other tests which he or she deems necessary in accordance with sound medical practice. The evaluation must also include pregnancy testing or laboratory evaluation of male fertility if requested by the employee.

Additional tests which are probably not warranted on a routine basis but may be appropriate when blood lead and ZPP levels are equivocal include delta aminolevulinic acid and coproporphyrin concentrations in the urine, and dark-field illumination for detection of basophilic stippling in red blood cells.

If an anemia is detected further studies including a careful examination of the peripheral smear, reticulocyte count, stool for occult blood, serum iron, total iron binding capacity, bilirubin, and, if appropriate, vitamin B12 and folate may be of value in attempting to identify the cause of the anemia.

If a peripheral neuropathy is suspected, nerve conduction studies are warranted both for diagnosis and as a basis to monitor any therapy.

If renal disease is questioned, a 24 hour urine collection for creatinine clearance, protein, and electrolytes may be indicated. Elevated uric acid levels may result from lead-induced renal disease and a serum uric acid level might be performed.

An electrocardiogram and chest x-ray may be obtained as deemed appropriate.

Sophisticated and highly specialized testing should not be done routinely and where indicated should be under the direction of a specialist.

IV. Laboratory Evaluation

The blood lead level at present remains the single most important test to monitor lead exposure and is the test used in the medical surveillance program under the lead standard to guide employee medical removal. The ZPP which has several advantages over the blood lead level is, due to the pending litigation, not required under the standard. Because of its relatively recent development and the lack of extensive data concerning its interpretation, the ZPP currently remains an ancillary test.

This section will discuss the blood lead level and ZPP in detail and will outline their relative advantages and disadvantages. Other blood tests currently available to evaluate lead exposure will also be reviewed.

The blood lead level is a good index of current or recent lead absorption when there is no anemia present and when the worker has not taken any chelating agents. However, blood lead levels along with urinary lead levels do not necessarily indicate the total body burden of lead and are not adequate measures of past exposure. One reason for this is that lead has a high affinity for bone and up to 90% of the body's total lead is deposited there. A very important component of the total lead body burden is lead in soft tissue (liver, kidney, and brain). This fraction of the lead body burden, the biologically active lead, is not entirely reflected by blood lead levels since it is a function of the dynamics of lead absorption, distribution, deposition in bone and excretion. Following discontinuation of exposure to lead, the excess body burden is only slowly mobilized from bone and other relatively stable body stores and excreted. Consequently, a high blood lead level may only represent recent heavy exposure to lead without a significant total body excess and likewise a low blood lead level does not

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Lead, alloys and inorganic compounds

Lead (Pb)
a.w. 207.2
sp.gr. 11.3
m.p. 327 °C
b.p. 1 525 °C

slightly soluble in water in the presence of nitrates, ammonium salts and carbon dioxide; the calcium carbonates in hard water form a deposit on exposed lead thus preventing solution

a blue-grey metal which tarnishes in moist air; it is very soft and malleable, and is easily cast, moulded and extruded.

TWA OSHA 0.05 mg/m³
TLV ACGIH 0.15 mg/m³
STEL ACGIH 0.45 mg/m³
MAC USSR 0.01 mg/m³

Further information is provided in LEAD CONTROL IN THE WORKING ENVIRONMENT.

Sources. Lead ores are found in many parts of the world. The richest ore is galena (lead sulphide) and this is the main commercial source of lead. Other lead ores include cerussite (carbonate), anglesite (sulphate), corcoite (chromate), wulfenite (molybdate), pyromorphite (phosphate), mutlockite (chloride), vanadinite (vanadate). In many cases the lead ores may also contain other toxic metals.

Production. Lead minerals are separated from gangue and other materials in the ore by dry crushing, wet grinding (to produce a slurry), gravity classification and flotation. The liberated lead minerals are smelted by a three-stage process of charge preparation (blending, conditioning, etc.), blast sintering and blast furnace reduction. The blast-furnace bullion is then refined by the removal of copper, tin, arsenic, antimony, zinc, silver and bismuth.

Uses. Metallic lead is used in the form of sheeting or pipes where pliability and resistance to corrosion are required such as in chemical plant and the building industry; it is used also for cable sheathing, as an ingredient in solder, and as a filler in the automobile industry. It is a valuable shielding material for ionising radiations. It is used for metallising to provide protective coatings, in the manufacture of storage batteries and as a heat treatment bath in wire drawing. Lead is present in a variety of alloys and its compounds are prepared and used in large quantities in many industries.

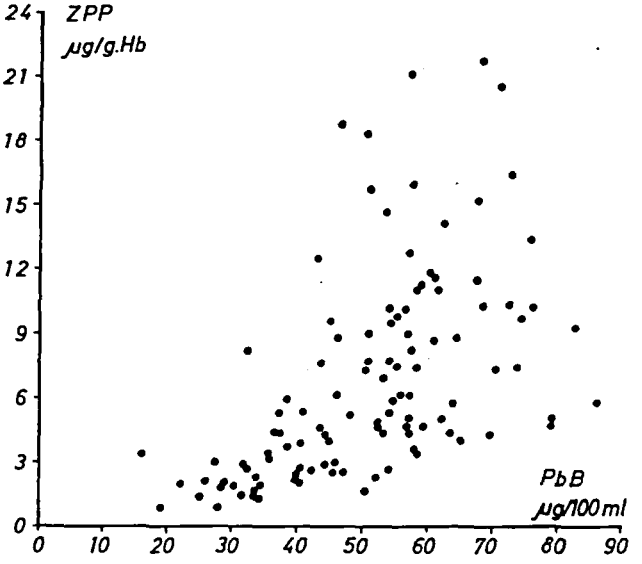

Figure 1. Exposure-response relationship in a secondary lead smelter.

Lead alloys

Other metals such as antimony, arsenic, tin and bismuth may be added to lead to improve its mechanical or chemical properties, and lead itself may be added to alloys such as brass, bronze and steel, to obtain certain desirable characteristics.

Lead compounds

Space is not available to describe the very large number of organic and inorganic lead compounds encountered in industry. However, the common inorganic compounds include lead monoxide (PbO), lead dioxide (PbO_2), lead tetroxide (Pb_3O_4), lead sesquioxide (Pb_2O_3), lead carbonate, lead sulphate, lead chromates, lead arsenate, lead chloride, lead silicate and lead azide. The organic compounds of industrial importance include tetramethyllead, tetraethyllead, lead acetate, lead phthalate, lead salicylate, lead stearate, lead palmitate, lead oleate, and lead naphthenate.

For certain lead compounds of particular importance see the separate articles: LEAD ARSENATE; LEAD, ALKYL COMPOUNDS; EXPLOSIVES INDUSTRY (lead azide).

Uses. About 40% of lead is used as a metal, 25% in alloys and 35% in chemical compounds. Lead oxides are used in the plates of electric batteries and accumulators (PbO and Pb_3O_4), as compounding agents in rubber manufacture (PbO), as paint ingredients (Pb_3O_4) and as constituents of glazes, enamels and glass.

Lead salts form the basis of many paints and pigments: lead carbonate and lead sulphate are used as white pigments and the lead chromates provide chrome yellow, chrome orange, chrome red and chrome green. Lead arsenate is an insecticide, lead sulphate is used in rubber compounding, lead acetate has important uses in the chemical industry, lead naphthenate is an extensively used dryer and tetraethyllead is an antiknock additive for gasoline.

HAZARDS

The prime hazard of lead is its toxicity. Clinical lead poisoning has always been one of the most important occupational diseases. Medico-technical prevention has resulted in a considerable decrease in notified cases and also in less serious clinical manifestations. However, in the past decade it has become evident that adverse neurophysiological effects on the nervous system, resulting in minor brain dysfunction and in impaired motor conduction velocity in peripheral nerves, already occur at exposure levels hitherto regarded as acceptable. Moreover, the potential adverse effects on offspring of pregnant workers has led to separate recommendations for acceptability of exposure of female workers of fertile age.

Occupational exposure. Industrial consumption of lead is increasing and traditional consumers are being supplemented by new users such as the plastics industry. Hazardous exposure to lead, therefore, occurs in many occupations.

In lead mining a considerable proportion of lead absorption occurs through the alimentary tract and consequently the extent of the hazard in this industry depends, to some extent, on the solubility of ores being worked. The lead sulphide (PbS) in galena is insoluble and absorption from the lung is limited; however, in the

stomach, some lead sulphide may be converted to slightly soluble lead chloride which may then be absorbed in moderate quantities.

In lead smelting the main hazards are the lead dust produced during crushing and dry grinding operations, and lead fume and lead oxide encountered in sintering, blast-furnace reduction and refining.

Lead sheet and pipe are used principally for the construction of equipment for storing and handling sulphuric acid. The use of lead for water and town gas pipes is limited nowadays. If lead is worked at temperatures below 500 °C, as in soldering, the risk of fume exposure is minimal; however, in lead welding, higher flame temperatures are used and the danger is higher. The spray coating of metals with molten lead is dangerous since it gives rise to dust and fume at high temperatures. Cable sheathing is believed to involve little or no risk.

The demolition of steel structures such as bridges and ships that have been painted with lead-based paints frequently gives rise to cases of lead poisoning.

Other activities in which lead exposure may occur are dealt with in the articles: AUTOMOBILE INDUSTRY; BATTERIES AND ACCUMULATORS; GLASS INDUSTRY; PAINTS, LACQUERS AND VARNISHES; PAINTING AND VARNISHING; POTTERY INDUSTRY; PRINTING, PUBLISHING AND ALLIED INDUSTRIES; WIREWORKS.

Absorption. Inorganic lead compounds enter into the body primarily by inhalation and ingestion; penetration of the skin is a factor only in the case of organic compounds.

Gastric hydrochloric acid may promote intestinal absorption but most ingested lead is excreted in the faeces. Secondary ingestion may occur if lead trapped in the upper respiratory tract is subsequently swallowed; this is particularly the case with larger particles.

The main route of entry in industry is the respiratory tract. A certain amount may be absorbed in the air passages, but the main portion is taken up by the pulmonary bloodstream. The degree of absorption depends on the proportion of the dust accounted for by particles less than 5 μm in size and the exposed worker's respiratory minute volume. Increased workload therefore results in higher lead absorption. Although the respiratory tract is the main route of entry, poor work hygiene, smoking during work (pollution of tobacco; polluted fingers while smoking), poor personal hygiene may considerably increase total exposure mainly by the oral route. This is one of the reasons why the correlation between the concentration of lead in workroom air and lead in blood levels often is very poor, certainly on an individual basis.

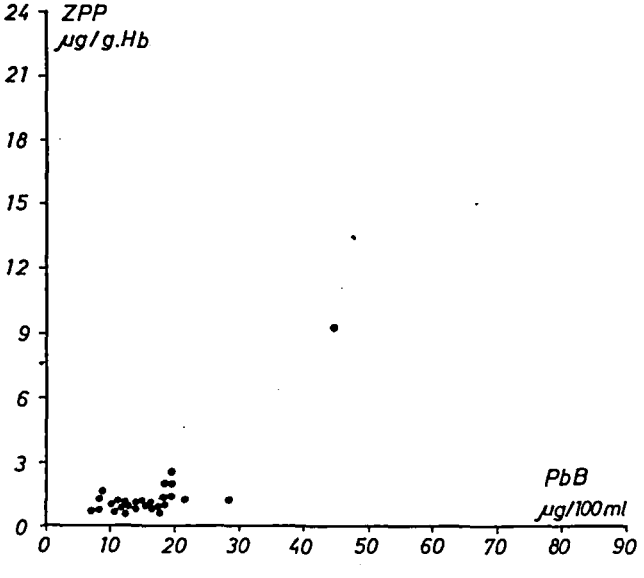

Figure 2. Exposure-response relationship in a cable factory.

Lead absorbed by the pulmonary bloodstream is transported to various organs and tissues. More than 90% of the lead in the blood will be held by the erythrocytes but lead has a preference for the bone and accumulates in bone tissue. Regular ingestion of about 0.6 mg of lead per day constituted the borderline of lead exposure that may be experienced without apparent increase in the body burden of lead. Excretion takes place both in urine and faeces. Lead in faeces is derived mainly from non-absorbed lead; lead in urine therefore provides a much better measure of absorption. The lead content in faeces may be used as a criterion for malingering since a faeces lead concentration of 4 mg/100 g, 4 weeks after hazardous lead exposure, may be regarded as proof of wilful ingestion. Blood-lead and urine-lead values provide a direct and reliable quantitative indication of lead exposure but only indirect evidence of lead effect. Lead passes the placenta and is also excreted by breast milk. This may lead to exposure of the fetus *in utero* and of the suckling infant.

Pharmacotoxic effects. Inorganic lead causes contraction of the peripheral vascular system and affects the blood and blood-forming tissues (bone marrow). The "normal" cases of lead poisoning in industry always include haemopoietic effects; these occur very early, before the appearance of symptoms or signs and, therefore, are important for diagnosis. Lead shortens the life of erythrocytes and impairs haemoglobin synthesis.

The activity of the enzyme δ-aminolaevulinic acid (δ-ALA dehydratase is reduced, resulting in increased δ-ALA in blood and urine; in addition there is a further disturbance in porphyrin metabolism, particularly in the uptake of Fe^{++} in protoporphyrin IX. As a consequence, increased lead absorption results in:

(a) decreased activity of δ-ALA dehydratase;

(b) increased δ-ALA in serum and urine;

(c) increased protoporphyrin (PP) in erythrocytes;

(d) increased coproporphyrin (mainly ether-extractable coproporphyrin III in urine);

(e) decreased content of haemoglobin;

(f) decreased number of erythrocytes and shortened life span;

(g) increased number of reticulocytes (young erythrocytes);

(h) increased number of basophil punctated erythrocytes (manifestation of degenerated regeneration);

(i) increase of Fe in serum.

Occupational history, and haemopoietic changes are the prime elements in diagnosis. In particular, the haemopoietic changes are apparent before the signs and symptoms and they also provide quantitative information on exposure intensity. Removal from exposure results in the disappearance of haemopoietic effects. However, the disappearance is relatively slow and haemopoietic examination will still be of a diagnostic value even several weeks after termination of exposure.

Signs and symptoms. Lead poisoning displays a great variety of signs and symptoms, almost none of them

typical. Full-blown poisoning has become relatively unusual. Most of the signs and symptoms range between impaired physiological functioning of organ systems, impaired subjective health, and definite diseases of moderate, and sometimes serious, rarely fatal character.

The chief early symptoms are a fall-off in physical fitness, fatigue, sleep disturbance, headache, aching bones and muscles, digestive symptoms, particularly obstipation (not diarrhoea), stomach pains and decreased appetite. If the level of sickness absence due to gastrointestinal disorders in a lead processing industry is higher than that due to respiratory disease, the possibility of excessive lead absorption amongst workers should be suspected.

The above-mentioned early symptoms are non-specific, and can be considered only as signs of poisoning if working conditions and laboratory investigations also point to increased lead absorption. These symptoms are reversible and a complete recovery is possible. By means of interviews of exposed groups of workers in recent years an increased prevalence of a variety of non-specific symptoms have been observed: fatigue, disturbed sleep, forgetfulness, alienation and restlessness.

The subjective symptoms may be accompanied and even preceded by non-specific objective signs, either observed in medical examination, or only to be measured on a group basis by sophisticated psychophysiological and neurophysiological tests. As objective signs, observed in medical examination, can be mentioned: pallor of the skin (vasoconstriction); Burton or "blue" line which consists of a deposit of dark blue-grey PbS in the gums about 1 mm from the margin (not in edentulous gums); in marked prolonged exposure a decrease in the strength of the hand-grip. The lead line only indicates increased absorption, and should not be regarded as an effect as such; it usually occurs when dental hygiene is poor. Increased gum pigmentation in non-White subjects should not be mistaken for a lead line. With sophisticated tests non-specific impairment of, for example, visual-motor function (eye-hand co-ordination, visual reaction time), impaired intellectual functions, and decreased motor conduction velocity have been demonstrated.

If a worker with the above-mentioned symptoms remains exposed to undue amounts of lead, the disease may progress to greater severity, manifesting itself in the gastrointestinal tract and in the peripheral and central nervous system. Most important is lead colic, very intense periodical abdominal cramps, associated with severe obstipation, and possibly with sickness and vomiting. If further lead intake is prevented, symptoms regress and prognosis is favourable. Many cases are wrongly diagnosed as surgical disease, particularly appendicitis. Colic occurs particularly in the first 2 years of exposure; drinking bouts and sports activities during weekends may precipitate an attack due to mobilisation of lead from accumulations.

A typical disease of the peripheral nervous system is lead paralysis, especially in the most active muscles, including paralysis of the radial nerve with "wrist drop". The afferent nerves are not affected; there is no loss of sensation and no pain. Paralysis usually occurs after many years of increased lead absorption, often preceded by one or more colics. Recovery is slow, and not always complete. The disease is now rather unusual due to improved standards of industrial hygiene.

A very serious manifestation is encephalopathy—severe headache, convulsions as in epilepsy, coma, delirium, possibly death. Fortunately it has become very rare. Workers who recover from lead-induced disorders of the peripheral or central nervous system should not be re-exposed to lead.

A slight hypertension due to vascular contractions is frequently found in cases of acute lead poisoning such as colic. This is a completely reversible change in blood pressure. A permanent hypertension associated with arteriosclerosis of blood vessels and renal sclerosis may ultimately occur after long-term, intense exposure accompanied by various acute poisonings. Recently a few studies indicated impairment of renal function, evidenced by increased levels of uric acid in the blood.

Exposure-effect/response relationships

One should distinguish between biological *indicators of exposure* and *health effects*.

Lead absorbed through the lungs and the gastrointestinal tract is at first taken up into the blood, and from this it is distributed to various organs, and partly excreted. It is deposited to a large extent in the bone compacta, from which it is hardly released. The *lead in blood level* (PbB in µg/100 ml) is the best indicator of *total* exposure. In non-occupationally exposed adults the individual PbB levels usually do not exceed 25-30 µg/100 ml, and are normally 15-25 µg/100 ml. Pb in urine levels (PbU) normally do not exceed 65 µg/l. Increased occupational exposure increases the PbB (and PbU) levels, but PbB does not continue to increase with continuing exposure: after 3-6 months the PbB levels can be used as an indicator of *total* exposure over the last 2-3 months (work, food, beverages, etc.). With increasing intensity of exposure the equilibrium level of PbB increases, and health effects may occur: more effects and more serious effects at higher PbB levels. The PbB level as such does not indicate the health status, but it predicts the health *risk*, i.e. the probability that certain effects will exist or will occur in the future if exposure goes on. The PbB level provides a better indicator of exposure (and of health risk) than the PbU level, because the concentration in urine depends upon diuresis and specific gravity; moreover, samples of urine easily become contaminated. In the last decade *measurement of the PbB level has become the indicator of choice to assess exposure and health risk*. However, it should be emphasised that the analysis requires high-level analytical techniques; it can only be carried out in well equipped laboratories and by well trained personnel.

The *no-adverse-response levels* (i.e. the effect mentioned will very probably not occur if exposure does not exceed the given PbB levels) in adults can be summarised as follows (adapted from WHO, 1977 and WHO, 1980) (the figures refer to exposure level: PbB in µg/100 ml):

decrease of β-ALA-D in erythrocytes 5-10
increase of protoporphyrin in erythrocytes 25-30 (males); 20-25 (females)
increase of ALA or coproporphyrin in urine 35-45 (males); 30-40 (females)
decrease of Hb 60-80

peripheral nervous system
- decreased motor conduction velocity 40-50
- paralysis > 80

central nervous system
- minor brain dysfunction > 50
- encephalopathia > 80
- non-specific symptoms > 50
- brain dysfunction in fetus and infant > 30

kidney
- impaired function > 60

chromosomal anomalies > 30-40

A more detailed panorama of lead effects at various PbB

levels will be found in LEAD CONTROL IN THE WORKING ENVIRONMENT. Adult females (and also fetus and infant) respond with disturbed haemsynthesis (evidenced by increased protoporphyrin (PP) for free erythrocyteporphyrin (FEP) or zincprotoporphyrin (ZPP)) at lower PbB levels than adult males. Disregarding the early effect on ALA-D as not significant for health, it can be concluded that effects on organ functions will not occur if PP (FEP, ZPP) levels in erythrocytes (or whole blood) do not increase or only slightly increase.

At an individual PbB of 70 µg/100 ml in *males* there is an increased risk of: marked increase of PP (FEP, ZPP); in some individuals maybe slight decrease of Hb; functional impairment of central and peripheral nervous system; non-specific symptoms; impaired kidney function; maybe chromosomal anomalies; but hardly any risk of clinically manifest disease.

The PbB levels given should not be regarded as an absolute yardstick: the sequence over time (increase, decrease, stable) is more important than a single value. The evaluation of the health status requires a full medical examination, and measurement of at least PbB, Hb and FEP or ZPP.

Increase of PP (FEP) occurs in overexposure to lead, in iron-deficiency and in some rare diseases of the porphyrogenic system; increased ZPP occurs in Pb overexposure and in Fe deficiency. Because increase of FEP (ZPP) is the first early health-relevant effect of lead, and because prevention of marked increase of FEP/ZPP also prevents the development of serious effects, the evaluation of the health risk of lead-exposed workers should make full use of these parameters. In recent years an automated ZPP-haematofluorimeter has been developed, which presents the ZPP level within 5 seconds; this measurement can be carried out by technicians after a simple training; moreover, only a few drops of blood are needed.

Figure 1 presents an example of an exposure (PbB)-response (ZPP) relationship in a group of workers from a secondary smelter; figure 2 presents an example from a group of subjects in a cable factory. The second figure shows that only one worker with PbB of 45 µg/100 ml had an increased ZPP; figure 1, with PbB levels up to about 90 µg/100 ml shows that ZPP is increased in the large majority of workers; however, at PbB < 40 µg/100 ml, ZPP > 3 µg/g Hb hardly occurs. If in subjects who have not been previously exposed to lead, and with a *pre*-employment level of ZPP $\leqslant 2$ µg/g Hb, ZPP during employment does not exceed 3 µg/g Hb, then there is hardly any risk of increase of PbB > 40 µg/100 ml. Therefore, frequent monitoring of total exposure by means of ZPP-measurement can greatly contribute to prevention of overexposure in previously non-exposed workers. In a cross-sectional study in already long-term exposed subjects, PbB has to be measured, except when ZPP does not exceed or hardly exceeds 3 µg/g Hb in *all* subjects.

The introduction of ZPP-measurement in the medical surveillance of workers has made evaluation of health risk much easier than in previous years when one relied on the much more sophisticated measurement of ALA-U, FEP or PP. However, in the case of markedly increased ZPP levels, measurement of PbB has still to take place. The old-time periodical measurement of basophilpunctated erythrocytes has become obsolete.

Personal factors. Lead poisoning arises from the body's incapacity to cope with an increased absorption of lead and many conditions influence both the biological capacity and the rate of absorption.

In young subjects (already *in utero*) the health risk is higher than in adults. At term the PbB level in the blood of the mother and in cord blood is about the same, but the fetus has a higher health risk than the mother. In the older literature an increased abortion risk has been reported. Nowadays the risk of impaired development of the central nervous system is decisive for the acceptable exposure of the mother (see LEAD CONTROL IN THE WORKING ENVIRONMENT).

Pre-existent disease is a factor which increases susceptibility. Infectious diseases, such as influenza, may mobilise deposited lead. Nervous system disorders, gastrointestinal affections and anaemia probably increase the risk of poisoning. Chronic bronchitis may increase local resorption in the respiratory tract and disturb the normal clearing mechanism of the ciliated epithelium. Mental attitude and intelligence determine personal hygiene. For this reason alcoholics provide a high-risk group. Respiration by mouth instead of by nose, and nail-biting, increase lead uptake.

In addition to the above-mentioned predispositions, mainly determining the capacity to deal with lead, one should take into account certain personal influences on lead uptake: personal hygiene, use of respirators, smoking in the working quarters, eating habits, and the wearing of dirty clothes outside working hours.

Another important factor is the level of energy expenditure: the product of concentration in air and of respiratory minute volume determines lead uptake. The effect of working overtime is to increase exposure time and reduce recovery time.

The above-mentioned examples give some indication of the possibilities of increased lead burden, many of which are associated with the individual characteristics of the worker. For this reason the evaluation of these possibilities involves the personal examination of each worker and the operations he has to perform.

Industrial lead exposure in former jobs may considerably increase the risk of poisoning; pre-employment examination should always take this into account.

Exposure time. This is much more complicated than official personnel records indicate. Only time analysis in the workplace can yield relevant data. The worker may move around the department or the factory; a job with frequent changes in posture (turning, bending) results in exposure to a great range of concentrations. A representative measure of lead intake is almost impossible to obtain without the use of a personal sampler applied for many hours and for many days.

Haber's Law ($E = KCT$), in which K (Haber's constant) is an index of toxicity, is not valid for lead poisoning: the effect (E) is not directly dependent on the product of concentration in air (C) and exposure time (T). In workers exposed for more than about 6 months the biological parameters are much more dependent on C than on T, because lead is a cumulative poison, i.e. the body burden reaches a certain level mainly determined by daily uptake.

Particle size. Since the most important route of lead absorption is by the lungs, the particle size of industrial lead dust is of considerable significance and this depends on the nature of the operation giving rise to the dust. Fine dust of respirable particle size is produced by processes such as the pulverising and blending of lead colours, the abrasive working of lead-based fillers in automobile bodies and the dry rubbing-down of lead paint. The exhaust gases of gasoline engines yield lead chloride and lead bromide particles of 1 µm diameter. The larger particles, however, may be ingested and be absorbed via the stomach. A more informative picture of the hazard associated with a sample of lead dust might be given by including a size distribution as well as a total lead determination. But this information is probably

more important for the research investigator than for the field hygienist.

Solubility. Some authors attach great importance to the type of lead compound, since the solubility of different compounds in water and biological fluids varies considerably. This is a consideration that has to be applied with caution, however. Hydrochloric acid in the stomach and carbonic acid in the lungs may convert insoluble compounds into soluble products. Nevertheless, the introduction of insoluble, fritted lead polysilicates as glazes in the pottery industry has greatly reduced the risk of lead poisoning.

In general, except where favourable properties have been clearly established, as in the case of polysilicates, all lead compounds should be regarded as potentially hazardous.

Metallic lead. Unless it is in the form of fine dust, contact with metallic lead at normal temperatures does not give rise to a considerable health hazard. If metallic lead is heated to 550 °C, however, lead vapour will be evolved and will become oxidised. This is a condition that is liable to be present in metal refining, the melting of bronze and brass, the spraying of metallic lead, lead burning, chemical plant plumbing, ship breaking, and the burning, cutting and welding of steel structures coated with paints containing lead tetroxide.

SAFETY AND HEALTH MEASURES

The object of precautions is first to prevent the inhalation of lead and secondly to prevent its ingestion.

These objects are most effectively achieved by the substitution of a less toxic substance for the lead compound. The use of lead polysilicates in the potteries has already been mentioned. The avoidance of lead carbonate paints for the painting of the interiors of buildings has proved very effective in reducing painters' colic; effective substitutes for lead for this purpose have become so readily available that it has been considered reasonable in some countries to prohibit the use of lead paint for the interiors of buildings.

Even if it is not possible to avoid the use of lead itself, it may still be possible to avoid dust. Water sprays may be used in large quantities to prevent the formation of dust and to prevent it from becoming airborne. In lead smelting, the ore and the scrap may be treated in this way and the floors on which it has been lying may be kept wet. Unfortunately, there is always a potential source of dust in these circumstances if ever the treated material or floors are allowed to become dry. In some few instances, arrangements are made to ensure that the dust will be coarse rather than fine. Instead of smoothing off the leaded parts of automobile bodies by discing, a much coarser dust which drops immediately to the ground is produced by hand filing. In spite of the slow, onerous nature of this operation it is sometimes adopted in the interest of avoiding unhealthy conditions.

Conditions were improved when the constituents of lead paint were supplied in the form of paste instead of dry powder so that dust would not be formed in the course of mixing. In preparation for repainting, old lead-painted surfaces are rubbed down by a wet process and not by a dry one to prevent dust from becoming airborne.

There are still, however, a very large number of processes in which lead material is necessarily present in a dry dusty condition. This dust must be prevented from entering the air of an occupied workroom. This is achieved by conducting the dusty operations in conditions of enclosure and exhaust ventilation. Efficient exhaust draught should be provided at hoppers, chutes, mixers, crushers, sieves, grinding mills (even when grinding in oil) where lead colours including lead chromates are being made and manipulated. This requirement applies to other lead compounds as well as those used for pigments. Proper enclosure and exhaust should be provided for every lead melting pot where the temperature of the lead is raised above 550 °C, whether the process is that of smelting or use of the lead. Further, no skimmings of dross from the molten lead should be removed from the exhaust except in suitable covered receptacles.

Workers who are exposed to lead in any of its forms should wear personal protective equipment, which should be washed or renewed at least once a week. Protective clothing made of certain man-made fibres retains much less dust than cotton overalls and should be used where the conditions of work render it possible; turn-ups, pleats and pockets in which lead dust may collect should be avoided.

Cloakroom accommodation should be provided for this personal protective equipment with separate accommodation for clothing taken off during working hours. Washing accommodation, including bathing accommodation with warm water, should be provided and used. Time should be allowed for washing before eating. Arrangements should be made to prohibit eating and smoking in the vicinity of lead processes and suitable messrooms should be provided.

It is essential that the rooms and the plant associated with lead processes should be kept clean by continuous cleaning either by a wet process or by vacuum cleaners. Where, in spite of these precautions, workers may still be exposed to lead, respiratory protective equipment should be provided and properly maintained. Supervision should ensure that this equipment is maintained in a clean and efficient condition and that it is used when necessary (see LEAD CONTROL IN THE WORKING ENVIRONMENT).

Medical prevention. Periodic medical examination should involve measurement of health risk (PbB), and of health effects (ZPP, Hb, physical examination). Pre-employment examination should include measurement of PbB, ZPP, Hb. Individual data should be grouped according to (sub-) department, processes, etc. Moreover, individual data should be followed up over time and for each worker exposure/effect-time diagrams should be drawn. The periodic examination also provides an opportunity to keep check on individual workers who require special attention: poor work or personal hygiene, occurrence of non-lead related diseases, recovery after overexposure.

Although prevention should be primarily based upon technical preventive measures, the *primary yardstick for overexposure* is the *lead in blood level* (if adequately measured). WHO (1980) recommended that in adult male workers a PbB of 40 µg/100 ml should not be exceeded, and in female workers of fertile age a PbB of 30 µg/100 ml. If PbB exceeds these levels, technical and personal preventive measures should be undertaken. The PbB limits recommended by WHO (1980) were health-based, and did not take into account economic or technical feasibility. Because there usually is a poor correlation between the lead in air and in blood levels, one cannot rely on the lead in air levels alone, although it is true that with decreasing lead in air levels the PbB levels on a group basis, but not necessarily in all individual workers, will also decrease.

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Recommended health-based limits in occupational exposure to heavy metals. Technical report series 647 (Geneva, World Health Organisation, 1980), 116 p. Ref.

Lead arsenate

There are three kinds of lead arsenate: neutral type–$Pb_3(AsO_4)_2$; acid type–$PbHAsO_4$; basic type–$Pb_5OH(AsO_4)_3$. The acid type is the most stable and most widely used. Its physical and chemical properties are:

Lead arsenate ($PbHAsO_4$)
m.w. 327
sp.gr. 5.79
m.p. 270 °C (decomposes)
insoluble in water; soluble in dilute nitric acid and in caustic alkalis
a heavy, white powder, containing about 60% lead and 21.5% arsenic; on heating it emits toxic fumes.
TWA OSHA 0.01 mg/m³
TLV ACGIH 0.15 mg/m³
STEL ACGIH 0.45 mg/m³
IDLH 300 mg/m³
MAC USSR 0.01 mg/m³ (the same figure for all inorganic lead compounds)

Production. Lead arsenate is produced by the reaction of arsenic acid with lead oxide. An arsenic acid solution is added to lead oxide in water, in a reaction vessel and stirred in the presence of nitric acid at a temperature of 45 °C. The reaction

$$PbO + 2NHO_3 = Pb(NO_3)_2 + H_2O$$
$$Pb(NO_3)_2 + H_3AsO_4 = PbHAsO_4 + 2HNO_3$$

is exothermic, with a temperature rise to 60 °C at the endpoint of the reaction. Precipitated $PbHAsO_4$ is filtered, dried at a temperature of 100-110 °C and powdered to a size of 300 mesh. This acid lead arsenate contains 0.2-0.4% soluble arsenic (As_2O_5), 31-32.5% total arsenic and 62% lead. A flow chart of the manufacturing process of lead arsenate is given in figure 1.

Uses. Lead arsenate has been used as a pesticide for mandibulate-types of insects since 1892. It is, however, prone to produce residues of soluble arsenic which become phytotoxic to plant bodies and, since the Second World War, it has been replaced with the organosynthetic pesticides, especially organophosphorous compounds. The toxic effect is particularly pronounced in insects with alkali digestive juices.

For agricultural application, a solution of 25-38 g of lead arsenate in 10 l of water is made up. To reduce the phytotoxic action, lime-bordeau liquid or up to twice the quantity of lime is added.

HAZARDS

In industry, inhalation and in agriculture, accidental ingestion seem to be the most common modes of entry. Poisoning may occur during both the manufacture and application of lead arsenate insecticide. In the body, the compound is broken down, absorbed and excreted or accumulated in body tissues. Lead and arsenic excretion is mainly via the kidney, with arsenic disappearing from the urine more quickly than lead.

Symptoms and signs. Both lead and arsenic are toxic to humans but there is a divergence of opinion as to whether the lead or the arsenic plays a more important role in the symptoms of lead arsenate poisoning. However, both lead and/or arsenic poisoning may occur and it is reported that in acute poisoning the arsenic symptoms predominate whereas prolonged inhalation of lead arsenate may induce the clinical picture of lead poisoning.

Acute symptoms, which occur rapidly after exposure to toxic doses, include nausea, vomiting, abdominal pain, watery diarrhoea or on the contrary constipation, muscular cramps, excitation and disorientation. Chronic poisoning is manifested by anorexia, weakness, weight loss, pallor, diarrhoea or constipation, colic, peripheral neuritis, hepatitis and nephritis. Skin disorders are characteristic of arsenic exposure, particularly in the chronic stage. In the acute stage, contact dermatitis may sometimes be observed. Chronic cutaneous manifestations are diffuse pigmentation appearing in 1 to 2 years after arsenic exposure, then corn-like punctate hyperkeratotic lesions appearing mainly on the palms and soles, and Bowen's lesions occurring after several years or more. Lead arsenate dust may cause ulceration and perforation of the nasal septum. Epidemiological and case studies have suggested the carcinogenic hazard of chronic exposure to arsenic among workers manufacturing lead arsenate or orchard workers spraying lead arsenate. As the latency period is prolonged until the occurrence of cancers of skin and internal organs, follow-up medical examination should be continued.

Examination of punctate basophilia, coproporphyrinuria, lead and arsenic content of blood and urine and of arsenic content of hair are valuable aids to diagnosis.

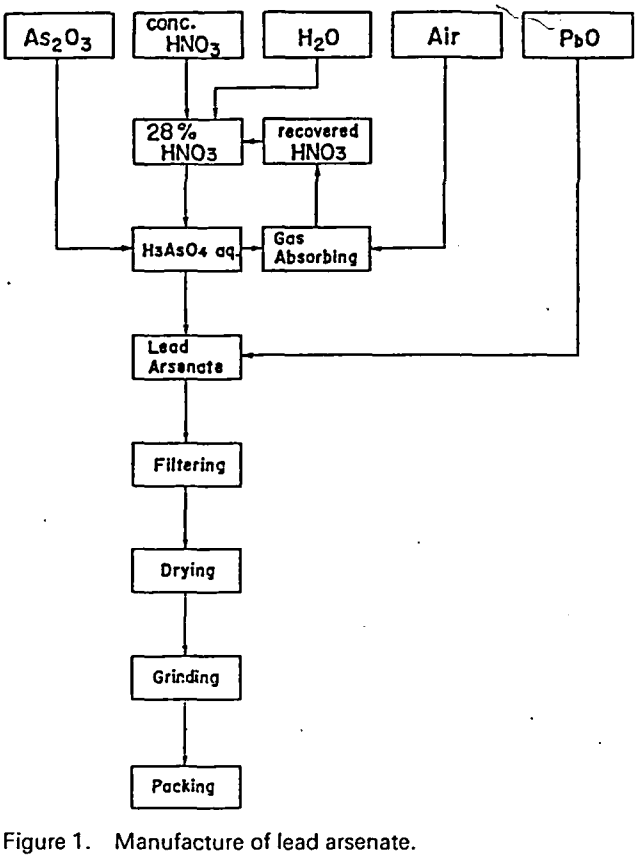

Figure 1. Manufacture of lead arsenate.

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The Condensed Chemical Dictionary

TENTH EDITION

Revised by

GESSNER G. HAWLEY

VNR VAN NOSTRAND REINHOLD COMPANY

C74
1981
c.3

line, and ethyl acetate. Flash point 210° F (99° C). Combustible.
Grades: 95% min.
Containers: Steel drums; carboys; tank cars.
Hazard: May be injurious to eyes.
Use: Manufacture of synthetic rubber and plastics, also in the synthesis of pharmaceuticals, and in insecticides and fungicides; nonionic detergent.
See also thiol.

lauryl methacrylate $CH_2{:}C(CH_3)COO(CH_2)_{11}CH_3$. The commercial material is a mixture, containing also lower and higher fatty derivatives. Boiling range 272–344° C; density 0.868 g/ml; flash point 270° F (132° C) (COC). Combustible. Probably low toxicity.
Containers: Drums.
Uses: Polymerizable monomer for plastics, molding powders, solvent coatings, adhesives, oil additives; emulsions for textile, leather, and paper finishing. See also acrylic resin.

lauryl pyridinium chloride $C_5H_5NClC_{12}H_{25}$.
Properties: Mottled tan semisolid. Soluble in water and organic solvents. Flashpoint 347° F (175° C); combustible.
Grade: Technical, contains higher and lower fatty acid derivatives.
Uses: Cationic detergent; dispersing and wetting agent; ingredient of fungicides and bactericides.

lauryl pyridinium 5-chloro-2-benzothiazyl sulfide. See "Vancide 26EC."

lautal. A hard aluminum alloy containing 4–5% copper, 1.5–2% silicon and fractional percentages of other metals such as iron, manganese, or magnesium.

"Lauxein."[58] Trademark for casein and soybean adhesives, dry powders good for low-temperature applications and glue bonding where water-resistance is desired.
Containers: Multiwall bags and fiber drums.
Uses: Bonding and cold-setting glues used in the manufacture of plywood furniture.

"Lauxite."[58] Trademark for a series of urea, phenolic, melamine and resorcinol resins. Available as dry powders or liquids. Used for bonding, cold-setting and impregnating adhesives and glues for furniture, plywood and aircraft; hot and cold pressing; radio frequency equipment; molding of diversified components from granulated wood.

lavandin oil. See lavender oil.

lavender oil. An essential oil used in perfumery. 35% ester content as linalyl acetate required. Terpeneless grade has about twice the concentration of the natural oil.

"Lavenol."[188] Trademark for a series of synthetic lavender oil substitutes of various types.

Lavoisier, Antoine Laurent (1743–1794). French chemist generally regarded as the "father" of chemistry. His "Traité Elementaire de Chimie" (1789) listed 30 elements, clarified the nomenclature of acids, bases and salts, and described the composition of numerous organic substances. He erroneously believed that oxygen is the characteristic element of acids. However, his fundamental work on combustion, as a result of which he identified and named nitrogen (azote), and on the separation of hydrogen from water by a unique reduction experiment carried out in a heated gun barrel, earned him a leading position among early chemists. (See also Mendeleéf).

lawrencium Lr A synthetic radioactive element with atomic number 103, discovered in 1961. Atomic weight 257. Only one other isotope is known (256). the 257 isotope has a half-life of 8 seconds. It has been made by bombarding californium with boron ions. It exhibits alpha radiation. See actinide series.

lay-up. In the reinforced plastics industry, a term used to refer to placement of the reinforcing material in the mold.

LC_{50} (lethal concentration, 50%). That quantity of a substance administered by inhalation that is necessary to kill 50% of test animals exposed to it within a specified time. This test applies not only to gases and vapors but to fume, dusts and other particulates suspended in air.

LCL. Abbreviation for "less than carload lot"; used by shippers, traffic managers, railroads, etc.

LD_{50} (lethal dose, 50%). That quantity of a substance administered either orally or by skin contact necessary to kill 50% of exposed animals in laboratory tests within a specified time. A substance having an LD_{50} of less than 50 mg per kg of body weight is rated highly toxic by toxicologists.

leaching. See solvent extraction.

lead Pb (from Latin plumbum). Metallic element of atomic number 82, Group IVA of the periodic table. Atomic weight 207.2; valences 2, 4; 4 stable isotopes. The isotopes are the end products of the three series of natural radioactive elements uranium (206), thorium (208), and actinium (207).
Properties: Heavy, ductile, soft gray solid. Sp. gr. 11.35; m.p. 327.4° C; b.p. 1755° C; soluble in dilute nitric acid; insoluble in water but dissolves slowly in water containing a weak acid; resists corrosion; relatively impenetrable to radiation. Poor electrical conductor; good sound and vibration absorber. Non-combustible.
Occurrence: U.S., Mexico, Canada, S. America, Australia, Africa, Europe.
Derivation: Roasting and reduction of galena (lead sulfide), anglesite (lead sulfate), and cerussite (lead carbonate). Also from scrap.
Purification method: Desilvering (Parkes process); electrolytic refining (Betts process); pyrometallurgy

gical refining (Harris process). Bismuth is removed by Betterton-Kroll process.
Grades: High purity (less than 10 ppm impurity); pure (99.9+); powdered (99% pure); pig lead; paste.
Forms available: Ingots, sheet, pipe, shot, buckles or straps, grids, rod, wire, etc.; paste; powder; single crystals.
Hazard: Toxic by ingestion and inhalation of dust or fume. Tolerance (as Pb), (fumes and dusts, and inorganic compounds) 0.15 mg per cubic meter of air. For ambient air the EPA standard is 1.5 micrograms per cubic meter. A cumulative poison. FDA regulations require zero lead content in foods and 0.05% in house paints.
Uses: Storage batteries; tetraethyllead (gasoline additive); radiation shielding; cable covering; ammunition; chemical reaction equipment (piping, tank linings, etc.); solder and fusible alloys; type metal; vibration damping in heavy construction; foil; babbit and other bearing alloys.
For further information refer to Lead Industries Association, 292 Madison Ave., New York.

lead acetate (sugar of lead) $Pb(C_2H_3O_2)_2 \cdot 3H_2O$.
Properties: White crystals or flakes (commercial grades are frequently brown or gray lumps). Sweetish taste. Absorbs carbon dioxide when exposed to air, becoming insoluble in water. Soluble in water; slightly soluble in alcohol; freely soluble in glycerol. Sp. gr. 2.50; m.p. loses H_2O at 75° C; at 200° C decomposes; b.p. (anhydrous) 280° C. Combustible.
Derivation: By the action of acetic acid on litharge or thin lead plates.
Grades: Powdered; granular; crystals; flakes; C.P.
Containers: Multiwall paper sacks; drums; carloads.
Hazard: Highly toxic by ingestion, inhalation, skin absorption. Use may be restricted.
Uses: Dyeing of textiles; waterproofing; varnishes; lead driers; chrome pigments; gold cyanidation process; insecticide; antifouling paints; analytical reagent; hair dye.
Shipping regulations: (Air) Poison label.

lead alkyl, mixed. A mixture containing various methyl and ethyl derivatives of tetraethyl lead and tetramethyl lead. Thus methyl triethyl lead, dimethyl diethyl lead and ethyl trimethyl lead may all be present with or without tetraethyl and tetramethyl lead.
Hazard: Toxic by ingestion and skin absorption.
Uses: Antiknock agents in aviation gasoline.

lead antimonate (Naples yellow; antimony yellow) $Pb_3(SbO_4)_2$.
Properties: Orange-yellow powder. Insoluble in water. Sp. gr. 6.58 (20° C). Noncombustible.
Derivation: Interaction of solutions of lead nitrate and potassium antimonate, concentration and crystallization.
Hazard: Toxic by inhalation. Tolerance (as Pb), 0.15 mg per cubic meter of air.
Use: Staining glass, crockery and porcelain.

lead arsenate (lead orthoarsenate) $Pb_3(AsO_4)_2$.
Properties: White crystals. Soluble in nitric acid; insoluble in water; sp. gr. 5.8; m.p. 1042° C (decomposes).
Derivation: By the action of a soluble lead salt on a solution of sodium arsenate, concentration and crystallization.
Uses: Insecticide; herbicide.
Hazard: Highly toxic. Tolerance (as Pb), 0.15 mg per cubic meter of air. A carcinogen.
Shipping regulations: (Rail, Air) Poison label.

lead arsenite $Pb(AsO_2)_2$.
Properties: White powder; soluble in nitric acid; insoluble in water. Sp. gr. 5.85.
Hazard: Highly toxic.
Use: Insecticide.
Shipping regulations: (Rail, Air) Poison label.

lead azide $Pb(N_3)_2$.
Properties: Colorless needles; an initiating explosive. Should always be handled submerged in water.
Derivation: Reaction of sodium azide with a lead salt.
Hazard: Severe explosion risk; detonates at 350° C (660° F). Highly toxic. Tolerance (as Pb), 0.15 mg per cubic meter of air.
Use: Primary detonating compound for high explosives.
Shipping regulations: (Rail) Explosive A label. Not Not acceptable passenger. (Air) Not accepted.
Note: Explosions have occurred in cases where azide compounds have reacted with the lead in plumbing after being washed down sinks.

lead-base Babbitt. See Babbitt metal.

lead biorthophosphate. See lead phosphate, dibasic.

lead, blue. A term applied to galena to distinguish it from white lead ore. It is also applied to blue basic lead sulfate.

lead borate $Pb(BO_2)_2 \cdot H_2O$.
Properties: White powder. Soluble in dilute nitric acid; insoluble in water. Sp. gr. 5.598; m.p. 160° C (loses water). Noncombustible.
Derivation: Interaction of solutions of lead hydroxide and boric acid, with subsequent crystallization.
Hazard: Highly toxic by inhalation. Tolerance, 0.15 mg per cubic meter of air.
Uses: Varnish and paint drier; waterproofing paints; lead glass; electrically conductive ceramic coatings.

lead borosilicate. A constituent of optical glass, composed of a mixture of the borate and silicate of lead.

lead bromate $Pb(BrO_3)_2 \cdot H_2O$.
Properties: Colorless crystals. Soluble in hot water; sp. gr. 5.53; decomposes at about 180° C.
Hazard: Highly toxic by inhalation or ingestion.

lead bromide $PbBr_2$.
Properties: White powder. Slightly soluble in hot

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	D981864614

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site)	02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER
Ulah Battery Lead Reclaiming	Rt. 7

03 CITY	04 STATE	05 ZIP CODE	06 COUNTY	07 COUNTY CODE	08 CONG DIST
Asheboro	NC	27203	Randolph	76	04

09 COORDINATES LATITUDE	LONGITUDE	10 TYPE OF OWNERSHIP (Check one)
35 38 20	079 49 45	☒ A. PRIVATE ☐ B. FEDERAL ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL ☐ F. OTHER ☐ G. UNKNOWN

III. INSPECTION INFORMATION

01 DATE OF INSPECTION (MONTH DAY YEAR)	02 SITE STATUS	03 YEARS OF OPERATION (BEGINNING YEAR / ENDING YEAR)
1 29 87	☐ ACTIVE ☒ INACTIVE	1965 / 1981 ___ 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.
Stan Atwood	Toxicologist	S&HW	(919) 733-2801
09 OTHER INSPECTORS	**10 TITLE**	**11 ORGANIZATION**	**12 TELEPHONE NO.**
Jack Butler	Environmental Engineer	S&HW	(919) 733-2801
Jim Martin	Sanitarian Supervisor	Health Dept.	(919) 629-2131
J.D. Smith	Sanitarian	Health Dept.	(919) 629-2131
Galenda Sandlin	Nurse	County	( )
Yvonne Chilcoat	Director	Public Health	( )

13 SITE REPRESENTATIVES INTERVIEWED	14 TITLE	15 ADDRESS	16 TELEPHONE NO
Lash Hammond		Rt. 7, Box 280 Asheboro	( )
Daisy Caviness		Rt. 7, Box 381 Asheboro	(919) 625-2330
			( )
			( )
			( )
			( )

17 ACCESS GAINED BY (Check one)	18 TIME OF INSPECTION	19 WEATHER CONDITIONS
☒ PERMISSION ☐ WARRANT	1000-1230	Sunny and cold

IV. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF (Agency/Organization)	03 TELEPHONE NO.
Jim Martin	Randolph Co. Health Dept.	(919) 629-2131

04 PERSON RESPONSIBLE FOR SITE INSPECTION FORM	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NO.	08 DATE (MONTH DAY YEAR)
Stan Atwood	NC DHR/DHS	S&HW	(919) 733-2801	5 06 87

EPA FORM 2070-13 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 2 - WASTE INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981864614

II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS

01 PHYSICAL STATES *(Check all that apply)*

- [x] A. SOLID
- [ ] B. POWDER, FINES
- [ ] C. SLUDGE
- [ ] D. OTHER _____ *(Specify)*
- [ ] E. SLURRY
- [x] F. LIQUID
- [ ] G. GAS

02 WASTE QUANTITY AT SITE *(Measures of waste quantities must be independent)*

TONS _____
CUBIC YARDS ~ 1400
NO. OF DRUMS _____

03 WASTE CHARACTERISTICS *(Check all that apply)*

- [x] A. TOXIC
- [x] B. CORROSIVE
- [ ] C. RADIOACTIVE
- [x] D. PERSISTENT
- [ ] E. SOLUBLE
- [ ] F. INFECTIOUS
- [ ] G. FLAMMABLE
- [x] 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			
SOL	SOLVENTS			
PSD	PESTICIDES			
OCC	OTHER ORGANIC CHEMICALS			
IOC	INORGANIC CHEMICALS			
ACD	ACIDS	Unknown		Battery Acid
BAS	BASES			
MES	HEAVY METALS	Unknown		Lead melted, battery casings, burned or stored in waste piles

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
ACD	Sulfuric Acid	7664-93-9	Unknown		
MES	Lead	7439-92-1		Soil to 14%	

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 Management Branch, Raleigh, NC
2. Jim Martin, Sanitarian Supervisor, Randolph County Health Dept.
3. USGS Topo map, Asheboro Quadrangle, 1970.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981864614

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 ☒ A. GROUNDWATER CONTAMINATION — 02 ☐ OBSERVED (DATE: _____) — ☒ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ — 04 NARRATIVE DESCRIPTION

Leaching of soil contamination

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

Runoff to Little River

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

People living at the site, particularly children, can easily contact the contaminated soil.

01 ☒ F. CONTAMINATION OF SOIL — 02 ☒ OBSERVED (DATE: 7-23-86) — ☐ POTENTIAL — ☐ ALLEGED
03 AREA POTENTIALLY AFFECTED: _____ (Acres) — 04 NARRATIVE DESCRIPTION

Lead content in soil as high as 14.4%

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

All residents near the site rely on wells for drinking water

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

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

One four-year old girl living at the site was found to have elevated blood lead.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981864614

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

V. SOURCES OF INFORMATION *(Cite specific references, e. g., state files, sample analysis, reports)*

As previously cited.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION
PART 4 - PERMIT AND DESCRIPTIVE INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981864614

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	~ 1400	yd^3
☐ 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

20 (Acres)

07 COMMENTS

Lead reclaimed from automobile batteries. Battery casings burned, used to pave driveways, or piled up on site. There are two large piles of battery casings on site.

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

One waste pile is just behind a home, heavy soil contamination near several homes.

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	D981864614

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 (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 > 3000

03 DISTANCE TO NEAREST DRINKING WATER WELL 0 (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
25 (ft)	west	25 (ft)	(gpd)	☒ YES ☐ NO

09 DESCRIPTION OF WELLS *(Including useage, depth, and location relative to population and buildings)*

10 RECHARGE AREA		11 DISCHARGE AREA	
☒ YES ☐ NO	COMMENTS	☐ 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
Little River	☐	1 (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. 820 NO. OF PERSONS	B. 2580 NO. OF PERSONS	C. 5280 NO. OF PERSONS

02 DISTANCE TO NEAREST POPULATION 0 (mi)

03 NUMBER OF BUILDINGS WITHIN TWO (2) MILES OF SITE 700

04 DISTANCE TO NEAREST OFF-SITE BUILDING 0 (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 rural, the town of Asheboro is located about 2 miles north of the site.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981864614

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)	(ft)	

06 NET PRECIPITATION	07 ONE YEAR 24 HOUR RAINFALL	08 SLOPE: SITE SLOPE	DIRECTION OF SITE SLOPE	TERRAIN AVERAGE SLOPE
(in)	(in)	5 %	West	8 %

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: _____

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. 1.5 (mi)	B. 0 (mi)	C. _____ (mi)	D. 0.5 (mi)

14 DESCRIPTION OF SITE IN RELATION TO SURROUNDING TOPOGRAPHY

The site is located on a 5% slope. The lower end of the site is about 20 feet higher than the nearest stream bed.

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. Heath, R.C. 1980. Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 6 - SAMPLE AND FIELD INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981864614

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	2/87
SURFACE WATER	2	"	2/87
WASTE			
AIR			
RUNOFF			
SPILL			
SOIL			
VEGETATION			
OTHER			

III. FIELD MEASUREMENTS TAKEN

01 TYPE	02 COMMENTS
	pH, conductivity, and temperature readings were taken for
	water samples.

IV. PHOTOGRAPHS AND MAPS

01 TYPE ☒ GROUND ☐ AERIAL

02 IN CUSTODY OF NC CERCLA Unit (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)*

As previously cited.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 7 - OWNER INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981864614

II. CURRENT OWNER(S) / **PARENT COMPANY** (If applicable)

01 NAME	02 D+B NUMBER	08 NAME	09 D+B NUMBER
Elbert Caviness			

03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	10 STREET ADDRESS (P.O. Box, RFD #, etc.)	11 SIC CODE
Rt. 7, Box 381			

05 CITY	06 STATE	07 ZIP CODE	12 CITY	13 STATE	14 ZIP CODE
Asheboro	NC	27203			

01 NAME	02 D+B NUMBER	08 NAME	09 D+B NUMBER
Glen Hoskins			

03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	10 STREET ADDRESS (P.O. Box, RFD #, etc.)	11 SIC CODE
Rt. 7, Box 376			

05 CITY	06 STATE	07 ZIP CODE	12 CITY	13 STATE	14 ZIP CODE
Asheboro	NC	27203			

01 NAME	02 D+B NUMBER	08 NAME	09 D+B NUMBER

03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	10 STREET ADDRESS (P.O. Box, RFD #, etc.)	11 SIC CODE

05 CITY	06 STATE	07 ZIP CODE	12 CITY	13 STATE	14 ZIP CODE

01 NAME	02 D+B NUMBER	08 NAME	09 D+B NUMBER

03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	10 STREET ADDRESS (P.O. Box, RFD #, etc.)	11 SIC CODE

05 CITY	06 STATE	07 ZIP CODE	12 CITY	13 STATE	14 ZIP CODE

III. PREVIOUS OWNER(S) (List most recent first) / **IV. REALTY OWNER(S)** (If applicable; list most recent first)

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

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)

1. As previously cited.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 8 - OPERATOR INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D981864614

II. CURRENT OPERATOR *(Provide if different from owner)*

01 NAME	02 D+B NUMBER
None	

03 STREET ADDRESS *(P.O. Box, RFD #, etc.)*	04 SIC CODE

05 CITY	06 STATE	07 ZIP CODE

08 YEARS OF OPERATION	09 NAME OF OWNER

OPERATOR'S PARENT COMPANY *(If applicable)*

10 NAME	11 D+B NUMBER

12 STREET ADDRESS *(P.O. Box, RFD #, etc.)*	13 SIC CODE

14 CITY	15 STATE	16 ZIP CODE

III. PREVIOUS OPERATOR(S) *(List most recent first; provide only if different from owner)*

01 NAME	02 D+B NUMBER

03 STREET ADDRESS *(P.O. Box, RFD #, etc.)*	04 SIC CODE

05 CITY	06 STATE	07 ZIP CODE

08 YEARS OF OPERATION	09 NAME OF OWNER DURING THIS PERIOD

PREVIOUS OPERATORS' PARENT COMPANIES *(If applicable)*

10 NAME	11 D+B NUMBER

12 STREET ADDRESS *(P.O. Box, RFD #, etc.)*	13 SIC CODE

14 CITY	15 STATE	16 ZIP CODE

01 NAME	02 D+B NUMBER
Same as owner	

03 STREET ADDRESS *(P.O. Box, RFD #, etc.)*	04 SIC CODE

05 CITY	06 STATE	07 ZIP CODE

08 YEARS OF OPERATION	09 NAME OF OWNER DURING THIS PERIOD

10 NAME	11 D+B NUMBER

12 STREET ADDRESS *(P.O. Box, RFD #, etc.)*	13 SIC CODE

14 CITY	15 STATE	16 ZIP CODE

01 NAME	02 D+B NUMBER

03 STREET ADDRESS *(P.O. Box, RFD #, etc.)*	04 SIC CODE

05 CITY	06 STATE	07 ZIP CODE

08 YEARS OF OPERATION	09 NAME OF OWNER DURING THIS PERIOD

10 NAME	11 D+B NUMBER

12 STREET ADDRESS *(P.O. Box, RFD #, etc.)*	13 SIC CODE

14 CITY	15 STATE	16 ZIP CODE

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	D981864614

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	D981864614

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	D981864614

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	D981864614

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 Ulah Battery Lead Reclaiming Site Number NC D981864614
Location SR 1219 Date 1/16/87
Asheboro, NC 27203

Purpose of Visit ____ PA __X__ SI ____ Other

Proposed Date of Inspection 1/27/87
Date of Briefing 1/23/87

Priority Ranking ____ Low ____ Medium __X__ High

Site Investigation Team

Personnel	Responsibilities
Stan Atwood	Sampling
Jack Butler	Sampling

PLAN PREPARATION:
Prepared By Mary Giguere Mary Giguere
Approved By Lee Crosby

B. SITE/WASTE CHARACTERISTICS

Waste Type(s) ____ Liquid __X__ 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)
Lead, metallic lead	lassitude, pallor, abdominal pain
lead oxide - inhalation	GI, CNS, kidneys, blood, and gums are affected.
and ingestion	

Facility Description: Size approx. 5 acres Buildings 10 homes

Disposal Methods Being Investigated surface disposal of battery cases and spillage of lead from a lead reclaiming operation.

Unusual Features on Site (dike integrity, power lines, terrain etc.):
Two large piles of battery casings on site - one is 25' high and 75' x 100' in diameter, the other 40' in diameter.

History of the Site: Site was used from 1965 to 1981 as a lead reclaiming operation. Batteries were broken on site and lead plates melted in a 55 gallon drum. The battery casings were burned, used as road fill or just piled up. Previous samples have shown lead levels in the soil from 0.6 to 14.4%.

C. HAZARD EVALUATION

This site has a high Pb contamination. The Pb can be ingested or inhaled. Ingestion can be easily prevented and inhalation should not pose a hazard because the sampling to take place on site is drinking water wells and stream stream sediment samples. This site can be sampled in Level D. When preserving samples be sure to wear goggles and P.E. gloves. Efforts should be made to keep clothes free of lead contamination.

D. WORK PLAN INSTRUCTION

Map or Sketch Attached? Yes
Perimeter Identified? No
Command Post Identified? No
Zones of Contamination Identified? No

Personal Protective Equipment

Level of Protection ____A ____B ____C X D

Modifications goggles, P.E. gloves, rubber boots, and tyveks (tyvek is optional).

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 Boot rinse. Gloves and tyveks should be bagged and disposed of.

Modifications _____

_____

Work Schedule/ Limitations Sampling to take place: private drinking water wells and stream sediment.

EMERGENCY PRECAUTIONS

Acute Exposure Symptoms	First Aid
Eyes	flush immediately
Skin	soap and water wash
Ingestion	medical attention
Inhalation	medical attention

Hospital (Address and Phone Number)

Randolph Hospital

Fayetteville Road, Asheboro, NC

Emergency Transportation Systems (Phone Numbers)

Fire use 911

Ambulance use 911

Rescue Squad use 911

Emergency Route to Hospital Take SR 1219 to Bus. Rd. 220 take a left and take BR 220 into Asheboro past US 64 and past Salisbury St (Highway 42). Hospital will be on the left in 2 to 3 blocks.

PREVAILING WEATHER CONDITIONS AND FORECAST _____

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	X	Boots or Boot Covers
	Detector Tube & Pump	X	Coveralls (tyvek)
	Eye Wash Unit	X	Eye Protection
	H Nu		Hard Hat
X	pH Meter	X	Decontamination Materials.(soap & water)
	Explosimeter		
	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 919-379-4105	Moses Cone Hospital 1200 N. Elm St, 27420	WILMINGTON 919-343-7046	New Hanover Mem. Hospital 2131 S. 17th St, 28401

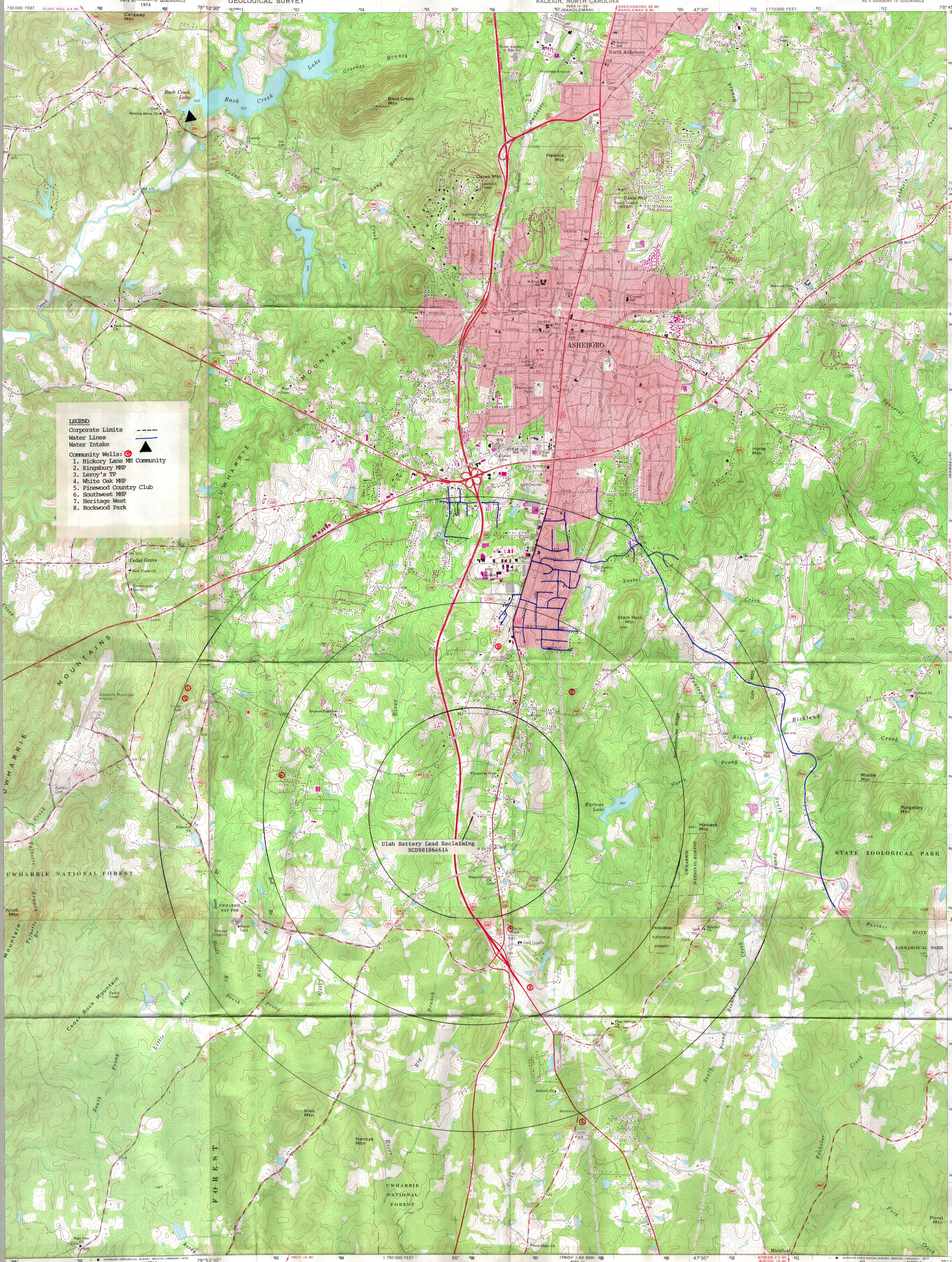
1-800-722-2222

FARMER QUADRANGLE
NORTH CAROLINA—RANDOLPH CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NW/4 ASHEBORO 15' QUADRANGLE
1974

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NORTH CAROLINA
DEPARTMENT OF NATURAL AND ECONOMIC RESOURCES
RALEIGH, NORTH CAROLINA

1970
PHOTOREVISED 1981
ASHEBORO QUADRANGLE
NORTH CAROLINA—RANDOLPH CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 ASHEBORO 15' QUADRANGLE



INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1976

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road
Interstate Route — U. S. Route — State Route

N.C. LOCATION

ELEAZER, N.C.
SW/4 ASHEBORO 15' QUADRANGLE
N3530—W7952.5/7.5

1973

AMS 5055 III SW—SERIES V842

Mapped, edited, and published by the Geological Survey

Control by USGS, NOS/NOAA, and North Carolina Geodetic Survey

Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1973

Projection and 10,000-foot grid ticks: North Carolina coordinate system (Lambert conformal conic)
1000-metre Universal Transverse Mercator grid ticks, zone 17, shown in blue. 1927 North American datum

MN GN
4½° 80 MILS
0°41' 12 MILS
UTM GRID AND 1973 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

(TROY 1:62 500)
5054 IV

SCALE 1:24 000

1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETRE

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1977

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road
Interstate Route — U. S. Route — State Route

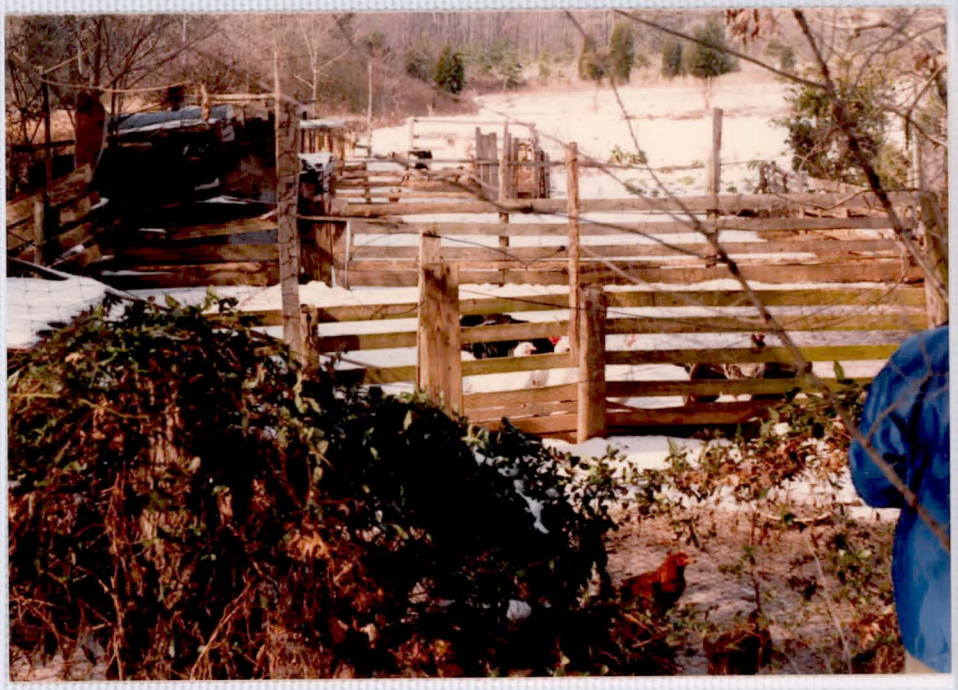
SEAGROVE, N.C.
SE/4 ASHEBORO 15' QUADRANGLE
N3530—W7945/7.5

1973

AMS 5055 III SE—SERIES V842

ASHEBORO CITY WATER SYSTEM

1986



ADDITIONAL PHOTOS
NCD 981864614 RANDOLPH
ULAH BATTERY LEAD RECLAIMING
ASHEBORO, NC JANUARY 29, 1987

Second casing pile