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Site Name (Subject):	UNION CARBIDE CORP/EVEREADY BATTERY
Site ID (Document ID):	NCD003216462
Document Name (DocType):	Preliminary Assessment/Site Inspection (PA/SI)
Report Segment:	2
Description:	Phase I Screening Site Investigation, Volume II
Date of Document:	7/1/1990
Date Received:	
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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**

STATE OF NORTH CAROLINA

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

Union Carbide Corporation
NCD 003216462

Phase I
Screening Site Investigation

July 1990

Volume II

By:

Greenhorne & O'Mara, Inc.

CERCLA

PHASE I

SCREENING SITE INVESTIGATION

FOR THE

UNION CARBIDE CORP.

NCD 003216462

Submitted to:

State of North Carolina
Department of Environment, Health, and Natural Resources
Division of Solid Waste Management
Raleigh, North Carolina 27611-7687

Prepared by:

Greenhorne & O'Mara, Inc.

July, 1990

UNION CARBIDE CORPORATION, INC. REFERENCE LIST
SITE #NCD 003216462

1. Field Notes, Greenhorne & O'Mara, Inc., Mr. Hunter Loftin, site investigation, May 25, 1990.

2. Print Out. Randolf County, North Carolina Tax Assessor's Office.

3. Potential Hazardous Waste Site Preliminary Assessment and field notes, December 1984. Joseph H. Deakins and O. W. Strickland.

4. City of Asheboro, North Carolina; Permit to Discharge Wastewater Under the Industrial Pretreatment Program, July 1, 1987.

5. Letter and attachment to O. W. Strickland, Head, Solid and Waste Management Branch, from G. B. McClanahan, Plant Manager, Union Carbide Corporation, Asheboro, N.C., October 6, 1982.

6. Letter and attachments to G. B. McClanahan, Union Carbide Corporation from O. W. Strickland, Head, Solid and Hazardous Waste Management Branch, Raleigh, NC, September 19, 1983.

7. Letter and attachments to G. B. McClanahan, Union Carbide Corporation from O. W. Strickland, Head, Solid and Hazardous Waste Management Branch, Raleigh, NC, October 13, 1982.

8. Letter and attachments to G. B. McClanahan, Union Carbide Corporation from O. W. Strickland, Head, Solid and Hazardous Waste Management Branch, Raleigh, NC, September 19, 1983.

9. Letter and attachment to O. W. Strickland, Head, Solid and Waste Management Branch, from G. B. McClanahan, Plant Manager, Union Carbide Corporation, Asheboro, N.C., October 6, 1982.

10. EPA General Information Form OMB No. 158-R0175 and EPA Hazardous Waste Permit Application OMB No. 158-S80004. Signed by P. J. Kennedy, Vice President, Union Carbide Corporation.

11. Pollution Incident Report #3155 by W. Douglas Dixon, Division of Environmental Management in response to Report of Spill by Union Carbide Corporation, January 8, 1986.

12. Letter and attachments by G. B. McClanahan, Plant Manager, Union Carbide Corporation to W. Douglas Dixon, Division of Environmental Management, Raleigh, NC, January 3, 1986.

13. Letter and Permit by Brenda J. Smith, Supervisor, Division of Environmental Management to Dario A. Sena, Union Carbide Corporation, Asheboro, NC, March 5, 1986.

14. Letter Report by Dave A. Horna, Branch Manager, Soil and Material Engineers, Inc. to Buster Hill, Eveready Battery Company, Asheboro, NC, November 18, 1986.

15. Letter by M. Steven Mauney, Water Quality Supervisor, Division of Environmental Management to T. Wayne Hodges, Quality Control Manager, Eveready Battery Company, Asheboro, NC, March 16, 1982.

16. Letter by T. Wayne Hodges, Eveready Battery Company, to M. Steven Mauney, Water Quality Supervisor, Winston-Salem, NC, April 8, 1987.

17. Letter by M. Steven Mauney, Water Quality Supervisor, Division of Environmental Management to T. Wayne Hodges, Quality Control Manager, Eveready Battery Company, Asheboro, NC, April 10, 1987.

18. Letter by W. E. Banker, Eveready Battery Company, to Steve Mooney (Mauney), Division of Environmental Management, Winston-Salem, NC, February 3, 1987.

19. Letter by M. Steven Mauney, Water Quality Section to W. E. Banker, Eveready Battery Company, Asheboro, NC, February 9, 1987.

20. Letter and attachments by Dario A. Sena, Eveready Battery Company, to Hugh W. Jernigan, Air Quality Section, Winston-Salem, NC, July 31, 1987.

21. Letter and Permit by R. Paul Wilms, North Carolina Environmental Management Commission, to G. B. McClanahan, Eveready Battery Company, Asheboro, NC, October 23, 1987.

22. Report. Contaminant Migration Study Underground Storage Tank, Eveready Battery Company, Asheboro, NC, by Soil and Material Engineers, Inc., August 14, 1986.

23. Air Quality Action Request by Hugh W. Jernigan, August 21, 1987.

24. Letter and attachments by O. W. Strickland, Head, Solid and Hazardous Waste Management Branch to Vincent Godette, Union Carbide Corporation, July 8, 1982.

25. Bain, G. L. and Thomas, J. D., Geology and Groundwater in the Durham Area, North Carolina. North Carolina Department of Water Resources, Groundwater Bulletin Number 7, May 1966.

26. Memo to file from JAB, Greenhorne & O'Mara, Inc., telephone conversation with Randy Macon, City of Asheboro, June 21, 1990.

27. Printout. Water supply locations near Asheboro, North Carolina Division of Environmental Management, May 1990.

28. Memo to file from Cairole Bernstein, Greenhorne & O'Mara, Inc., telephone conversation with Don Bostick, City of Asheboro, NC, June 27, 1990.

29. Memo to file from Cairole Bernstein, Greenhorne & O'Mara, Inc., telephone conversation with Ernie P. Cain, Water Supply Regional Engineer, North Carolina, June 27, 1990.

30. North Carolina Administrative Code Section 15A NCAC 23.0100-Procedures for Assignment of Water Quality Standards and 15A NCAC 2B.0200 Classification and Water Quality Standards Applicable to Surface Waters of North Carolina, December 14, 1989.

31. North Carolina Administrative Code Section 15A NCAC 2B.0309 Classification and Water Quality Standards assigned to the Waters of the Yadken-Pee Dee River Basin.

32. Memo to file from Cairole Bernstein, Greenhorne & O'Mara, Inc., telephone conversation with Dumont Bunker, City of Asheboro, NC, June 27, 1990.

33. North Carolina Soil Conservation Service excerpt Georgeville Series, January 1979.

34. Asheboro-Randolf Chamber of Commerce Market Data, Randolf County, 1990.

35. Memo to file, Greenhorne & O'Mara, Inc., North Carolina Superfund Sites, Property Ownership History with Attachments.

36. Figure 5 Climatic Atlas of the United States, U.S. Department of Commerce, National Climatic Center, Asheville, NC, 1979.

37. IBID. Figure 4.

38. IBID. Figure 8.

39. Figure 2, Appendix A.

40. Figure 3, Appendix B.

41. Figure 4, Appendix A.

42. Memo to Superfund Branch Staff from Pat DeRosa, Critical Habitats of Federally Listed Endangered Species in North Carolina with Attachments, May 18, 1989.

43. Figure 1, Appendix A.

44. The Merck Index, 11th Edition, edited by S. Budavari et al. Merck & Company, Inc., Rahway, NJ. 1989.

45. Hawley's Condensed Chemical Dictionary, 11th Edition, revised by Sax, N. I. and Lewis, R. N. Sr. Van Nostrand Reinhold Company, New York, NY. 1987.

46. Callahan et. al. Water-Related Environmental Fate of 129 Priority Pollutants. U.S. Environmental Protection Agency, Office of Water Planning and Standards, Washington, DC. EPA-440/4-79-02b. 1979.

47. Sax, N. I. and Lewis, R. N., Sr. Dangerous Properties of Industrial Materials, 7th ed. Van Nostrand Reinhold Company. 1989.

48. Hine, J. and Mookerjee, P. K. J. Organic Chemistry 40:292-8. 1975.

49. IRIS. Integrated Risk Information System. National Library of Medicine Database. Retrieved May 29, 1990, June 18 or June 25, 1990.

50. Toxicological Profile for Selected PCBs, U. S. Public Health Service and U.S. Environmental Protection Agency, November 1987.

51. Memo to File from Larry Ramsey and Hunter Loftin, Greenhorne & O'Mara, Inc., telephone conversation with Dario Sena, Eveready Battery Company, Asheboro, NC. July 5, 1990.

Appendix B

REFERENCE 19

Reference 19

State of North Carolina
Department of Natural Resources and Community Development
Winston-Salem Regional Office

James G. Martin, Governor

S. Thomas Rhodes, Secretary

DIVISION OF ENVIRONMENTAL MANAGEMENT
Februay 9, 1987

Mr. W. E. Banker
Eveready Battery Co.
P.O. Box 849
Asheboro, North Carolina 27204

Subject: Eveready Battery Pretreatment Unit Start-Up, Randolph County

Dear Mr. Hodge:

This letter is to acknowledge your correspondence below as received 2-6-87.

Thank you for the notification dated 2-3-87 that the pretreatment unit has been installed. An inspection of the facility has not been arranged but if our schedule allows us to visit, you will be notified in advance.

If you have any questions on the status of this project please call Ms. Sherri Vaden or me.

Sincerely,

M. Steven Mauney
Water Quality Section

cc: WSRO
Central Files
Melvin Allen
Doug Finan

8025 North Point Boulevard, Suite 100, Winston-Salem, N.C. 27106-3295 • Telephone 919-761-2351

An Equal Opportunity Affirmative Action Employer

REFERENCE 20

EVEREADY BATTERY COMPANY, INC.
P.O. BOX 849
ASHEBORO, NC 27204-0849

July 31, 1987

RECEIVED
N.C. Dept. NRCD
AUG 6 1987
Environmental Management
Winston-Salem Reg. Office

North Carolina Department of Natural
Resources and Community Development
Air Quality Section
Suite 100, 8025 North Pt. Blvd.
Winston-Salem, North Carolina 27106

ATTN: Mr. Hugh W. Jernigan

Gentlemen:

Attached are triplicate copies for new permit applications to install and/or operate air pollution abatement facilities and/or emission sources at Eveready Battery Company, Inc., Plant No. 1, Asheboro, North Carolina.

These new applications are being submitted for the following:

(1) Installation and operation of the Dust Filtering System for our moisturizing room.

(2) Operation of our existing uncontrolled emission sources such as (a) Zinc Casting Tank Repair Bench; (b) Zinc Can Extrusions; (c) Zinc Casting Furnaces.

(3) Operation of our existing controlled emission sources as follows: (a) Zinc Drossing; (b) Zinc Calot Lubrication; (c) Electrolyte Paste Manufacture.

(4) Permit renewal for our existing Dust Collector/Paper Scrap Cyclone Collector Permit No. 5035R2.

If there are questions, please call me at (919) 672-3500.

Very truly yours,

Dario A. Sena

DAS:jh

Attachments

cc: G. B. McClanahan
G. W. Beck/T. R. Voyles
A. M. Nash/J. T. Houser
P. R. Brown
R. G. Behr

North Carolina Department of Natural Resources and Community Development

Environmental Management Commission

AIR PERMIT APPLICATION*

GENERAL INFORMATION

INSTRUCTIONS ON BACK

A

To construct and operate Air Emission Sources and Control Devices in accordance with N. C. General Statutes Chapter 143, Article 21.

PLEASE TYPE OR PRINT. ATTACH APPROPRIATE EMISSION SOURCE AND CONTROL DEVICE FORMS FOR EACH SOURCE LISTED IN ITEM 6 BELOW.

1. Facility Name (Company, Establishment, Town, Etc.): Eveready Battery Company, Inc., Plant I — Date

2. Site Location (St./Rd./Hwy.): 800 Albemarle Road — City: Asheboro — Zip Code: 27203 — County: Randolph

Latitude: 39° - 50' — Longitude: 74° - 49' — SIC Code: 3692

Mailing Address (P. O. Box/St./Rd./Hwy.): P. O. Box 849

City: Asheboro — State: N. C. — Zip Code: 27204-0849 — Phone with Area Code: (919) 672-3500

Applicant Technical Contact: Dario A. Sena — Title: Environmental Coordinator — Phone with Area Code: (919) 672-3524

FOR DEM USE ONLY

DATE RECEIVED:

RECEIVED
N.C. Dept. NRCD
AUG 6 1987
Environmental Management
Winston-Salem Reg. Office

PERMIT NUMBER:

DATE ISSUED:

5. Description of operation conducted at above facility:
Manufacture of primary dry cell battery

6. List each EMISSION SOURCE and CONTROL DEVICE for which application is made. Assign an ID NUMBER to each emission source and control device which uniquely identifies that source. Attach appropriate emission source and control device forms for each.

EMISSION SOURCE	ID NO.	CONTROL DEVICE	ID NO.
Paper Moisturizing Room	RPC 368317	Filter - 4 ft²	RPC 368346
Zinc Casting Tank Repair Bench	-	None	-
Zinc Can Extrusion	See attached	None	-
Zinc Calot Lubrication	RPC 368244/242	Filter - 1150 ft²	RPC 368332
Zinc Drossing -	RPC 368219	Filter - 150 ft²	RPC 368219
Zinc Casting Furnaces	RPC 368251	None	-
Electrolyte Paste Mfg.	-	Filter - 300 ft²	RPC 359691

USE SEPARATE SHEET(S) IF NEEDED

7. Maximum facility operation: 16 Hours/Day — 5 Days/Week — 49 Weeks/Year

8. Name and address of engineering firm that prepared application or plans:
Eveready Battery Co., Inc., Engineering Dept., Asheboro Plant No. 1

9. Signature of responsible person or company official: [signature] — Date 5/4/87

Signer's Name (TYPE OR PRINT): G. B. McClanahan — Title: Manager Plant I — Phone with Area Code: (919) 672-3501

FORM AQ-22

-15 00 520 8 $ 35

20. Stack or En
Height Abo

Volumetric
(ACFM)
1000

Is scaffoldi
(X) No (

21. Indicate m
( ) Opacit

22. Attach or
BACK OF

23. Comm

GENERAL DATA FOR PROCESSES OR FUEL BURNING SOURCES

NOTE: DO NOT USE THIS FORM FOR INCINERATORS, USE FORM "F".

PLEASE TYPE OR PRINT. ATTACH TO THE GENERAL INFORMATION FORM "A". IF APPLICABLE, ATTACH AIR PC CONTROL DEVICE FORM "C". USE SEPARATE FORM FOR EACH SOURCE.

1. Emission Source and ID NO. (FROM GENERAL INFORMATION FORM "A", ITEM 6):
Electrolyte Paste Manufacture

2. Description of Process or Fuel Burning Source Including Air Control Device:
Mercuric chloride is added in the manufacture of the electrolyte paste. Merci chloride is weighed and any dust generated passes through a Torit filter befor discharge to the atmosphere.

3. Permit Application is made for (CHECK ONE ONLY):
( ) New Source (X) Existing Source ( ) Modification – Last Permit No. _____
Commence Construction Date _____, 19____ Operation Date July, 19

4. Maximum Source Operation: 1 Hours/Day 5 Days/Week 49 W

5. Air Contaminants Emitted:

	Maximum Actual Emissions Before Control (lb/hr)	After Control (lb/hr)	Emission Estimate Method*	Control Device**	C. Effi
Particulates					
Sulfur Dioxide					
Nitrogen Dioxide					
Carbon Monoxide					
Hydrocarbons (VOC)					
Lead					
Other (Mercuric Chloride)	No Data	0	1	Torit Bag Filter	
Other ( )					

*REFER TO BACK OF GENERAL INFORMATION FORM "A" FOR EMISSION ESTIMATION CODE
**ATTACH AIR CONTROL DEVICE FORM "C"

6. Type of Source:
CHECK ONE
(X) A GENERAL PROCESS – Source not covered by B and C below. (Complete items 7, 8, 18 through 22)
( ) B GENERAL PROCESS WITH IN-PROCESS FUEL – Source where products of combustion contact materials hea (Complete items 7, 8, 9, 13, 14, 18 through 22)
( ) C FUEL BURNING SOURCE (boilers, etc.) – Source where products of combustion are for the primary purpo ducing heat or power by indirect heat transfer. (Complete items 9 th

7. Process Operation: ( ) Continuous (X) Batch – Normal Batch Time 15 No. Batches per Day 3

8. Process Name Paste Manufacture

Materials Entering Process*: (Include In-process Solid Fuels)	Input Rates (lb/hr) Design	Actual	Max. Re Permit Rates
A. Zinc Chloride Solution, Ammonium Chloride		750	150
B. Flour, Starch, Mercuric Chloride & Water			
C.			
D.			
E.			
F.			
G.			
TOTAL WEIGHT ENTERING PROCESS			

*DO NOT LIST ANY VOLATILE HYDROCARBONS, USE HYDROCARBON EMISSION SOURCES FORM "E"

DATA FOR PROCESSES OR FUEL BURNING SOURCES – *continued*

9. Type of Fuel Burning Source: Not Applicable
( ) Industrial Boiler ( ) Institutional/Residential Boiler ( ) Electric Utility Boiler ( ) Process Burner(s)
( ) Other _____ Make and Model No. _____

10. Type of Solid Fuel Burning Equipment Used: Not Applicable
( ) Hand Fired ( ) Overfeed Stoker ( ) Pulverized
( ) Spreader Stoker ( ) Traveling Grate ( ) Wet Bed
( ) Underfeed Stoker ( ) Shaking Grate ( ) Dry Bed
( ) Other (specifiy) _____

11. Is collected flyash reinjected? ( ) NO ( ) YES Percent Reinjected _____%
Combustion Air: Percent Excess Air _____% ( ) Natural ( ) Induced
Specify method and schedule of tube cleaning: Not Applicable
( ) Lancing ( ) Tube Blowing ( ) Other _____ Schedule _____

12. Boiler Horsepower Rating _____ Boiler Steam Flow (lb/hr) Not Applicable

13. Fuel Burning Source Heat Input: Maximum Not Applicable Million BTU/hr Average _____ Million BTU/hr

14. Fuel Data: Primary Fuel Type(s) (specify) _____
Standby Fuel Type(s) (specify) Not Applicable

FUEL TYPE	FUEL USAGE Max. Design	Max. Actual	Annual	Max. % Sulfur	Max. % Ash	BTU Value
#6 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
#5 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
#4 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
Coal	(lb/hr)	(lb/hr)	(ton/yr)			(BTU/lb)
Wood	(lb/hr dry)	(lb/hr dry)	(ton/yr dry)			(BTU/lb) 8,000
Other						

15. If a combination of fuels is used, specify the maximum BTU/hr heat input for each: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

16. Total maximum heat input in million BTU/hr of all indirect fired fuel burning sources within property boundaries excluding that indicated above:
Fuel Oil _____ Coal _____ Wood _____ Other _____

17. Total No. of indirect fired fuel burning sources within property boundaries:
Fuel Oil _____ Coal _____ Wood _____ Other _____

18. Are there any fugitive emissions (storage piles, product handling, haul roads, etc.)? No (X) Yes ( ). If yes, please describe in comments below, the type, size, estimated emissions and control measures.

19. Describe any liquid or solid wastes generated and method of disposal:

Dust collected from filter is recycled back into the process.

DATA FOR PROCESSES OR FUEL BURNING SOURCES – *continued*

20. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Gas Temperature (Deg. F)	Direction of Exit (up, down or horizontal)
44	0.79	Ambient	Up
Volumetric Flow Rate (ACFM)	**Velocity (ft./sec.)**	**Are sampling ports available?**	**Is rain cap or other obstruction over stack?**
1000	21	(χ) No ( ) Yes	( ) No (χ) Yes, (specify) Rain Cap

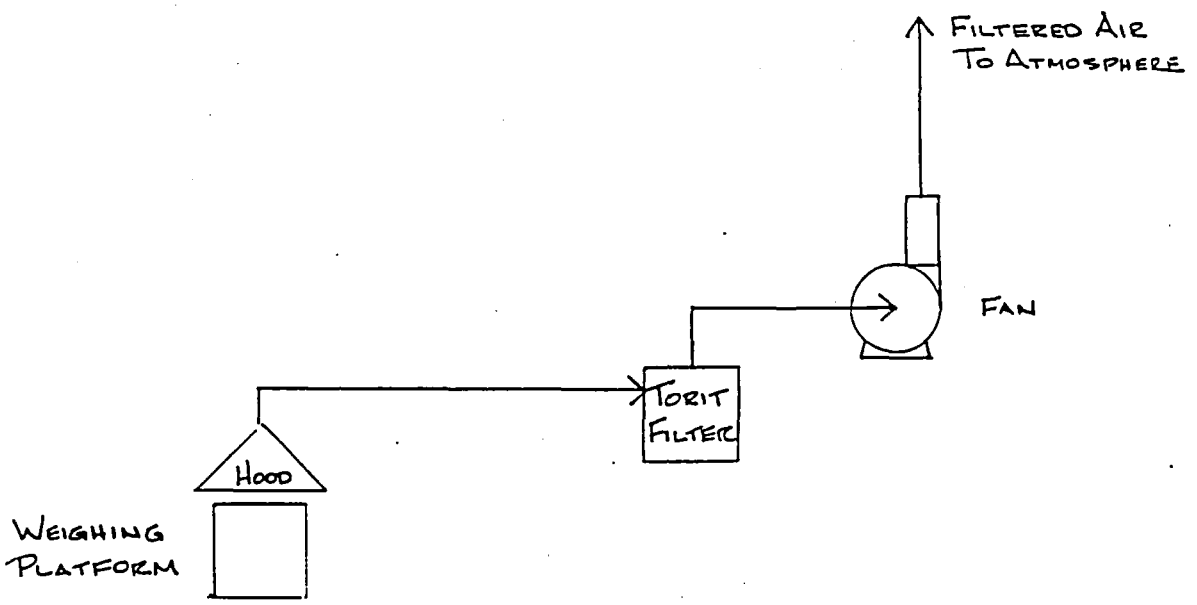
Is scaffolding available for source testing? (χ) No ( ) Yes

Stack ID No. D-5 – Sources with a common stack will have the same stack number.

21. Indicate monitoring and recording instruments installed on stack:

( ) Opacity Monitor ( ) SO2 Monitor ( ) NOx Monitor ( ) Other _____

22. Attach or sketch a flow diagram of the process or fuel burning source. Include air control device(s). (SEE INSTRUCTIONS ON BACK OF THIS PAGE):



23. Comments:

AIR POLLUTION CONTROL DEVICE

C

PLEASE TYPE OR PRINT. ATTACH TO GENERAL INFORMATION FORM "A". SUPPLY DESIGN DATA, SPECIFICATIONS, AND AVAILABLE ENGINEERING DRAWINGS.

1. Air Control Device and ID No. (FROM GENERAL INFORMATION FORM "A", ITEM 6)
   Filter RPC 359691

2. If there are several devices in series, list each unit in series starting at the emission source. Not Applicable
   (1) _____ (2) _____ (3) _____ TOTAL UNITS _____

3. Indicate Emission Source and ID No. that Control Device(s) is installed on:
   Paste Room Weighing Platform

4. Narrative Description of Control Device(s):
   Dust generated from paste manufacture passes through a Torit bag filter before discharge to the atmosphere. The filter has 30 cotten sateen bags. Average life of bags is 5 years.

Manufacturer	Model Name	Model Number
Torit	Torit	123-5H

5. Estimated Cost of Control Device
   $ 5,000

   Period of Time Control Device is Estimated to be Adequate:
   15 Years

6. Permit Application is made for (CHECK ONE ONLY):
   ( ) New Source (X) Existing Source ( ) Modification – Last Permit No. _____
   Commence Construction Date _____, 19____ Operation Date _____, 19____

7. Emission Parameters:

Pollutant(s) Controlled	PART. ( )	SO_2 ( )	NO_x ( )	CO ( )	VOC ( )	LEAD ( )	OTHER Mercuric Chloride	OTHER
Emission Rate Before Control (lb/hr) =							No Data	
Emission Rate After Control (lb/hr) =							0	
Removal Efficiency Percent (%) =							99.0	

   Particle Size Distribution of Particulates Entering Control Device (% Micron):
   _____ 0-1 _____ 1-10 _____ 10-25 _____ 25-50 _____ 50-100 _____ Over 100

8. Gas Conditions at Control Device:

		INLET	INTERMEDIATE LOCATIONS	OUTLET
Flow Rate (ACFM)	=	1000		1000
Temperature (Deg. F)	=	Ambient		Ambient
Velocity (ft./sec.)	=	No Data		21
Pressure Drop (in. H_2O)	=	0.70		
Moisture (%)	=	No Data		No Data

9. Describe Ultimate Disposal of Collected Materials:
   Collected dust is recycled back into the process.

10. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Direction of Exit (up, down, or horizontal)	Are there obstructions over the stack? ( ) No (X) Yes, (specify)
44	.79	Up	Rain Cap

   Is scaffolding available for sources testing? (X) No ( ) Yes
   Are sampling ports available? (X) No ( ) Yes

11. Comments:

C

SUPPLEMENTAL DATA FOR AIR CONTROL DEVICES

12 *** "CYCLONE" (MECHANICAL SEPARATORS) *** Not Applicable

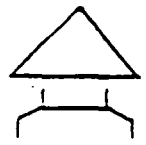
Efficiency (%)	Volumetric Flow Rate (ACFM)	Pressure Drop (in. H_2O)	Baffles or Louvers (specify)	Position in Series #____ of ____ Units
Cyclone Dimensions (inches) Inlet / Outlet		Cyclone Body Diameter (inches)	Cyclone Body Height (ft.)	Cyclone Cone Height (ft.)

Wet Spray ( ) No ( ) Yes	No. of Nozzles	Liquid Used (specify)	Flow Rate (GPM)	Makeup Rate (GPM)	% Recirculated

A process flow diagram must be attached If cyclone is routed to another cyclone or other equipment, show sketch of entire system.

CYCLONE DIAGRAM

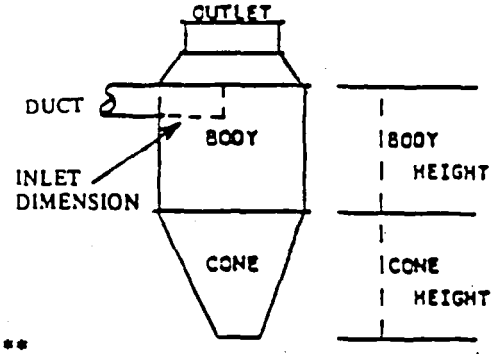
CHECK APPROPRIATE OUTLET CONFIGURATION BELOW



( )

( )

SKETCH OTHER CONFIGURATION ON DIAGRAM Below



13 Not Applicable *** "MULTICYCLONE" ***

Efficiency (%)	Volumetric Flow Rate (ACFM)	No. of Cones	Pressure Drop (In. H_2O)	Position in Series # ____ of ____ Units
Louvers ( ) No ( ) Yes	Inlet Dimension of Individual Cyclone (inches)	Outlet Dimension of Individual Cyclone (inches)	Individual Cyclone Diameter (inches)	Inlet Temperature (Deg. F)

14 *** "FILTRATION" (BAGHOUSE) ***

Efficiency (%)	Volumetric Flow Rate (ACFM)	Filter Surface Area (sq. ft.)	Air-to-Filter Area Ratio (ft./min.)	Pressure Drop (in. H_2O)
99.0	1000	300	3.33	0.70

TYPE OF FILTER
(X) Fabric Filter (BAGHOUSE)
( ) Packed Bed ( ) Mat Filter
( ) Panel Filter
( ) Other ____

FILTER MATERIAL
( ) Fiberglass ( ) Nylon
( ) Nomex ( ) Teflon
( ) Wool ( ) Dacron
( ) Cotton ( ) Orlon
(X) Other Cotten Sateen

BAG CLEANING
(X) Mechanical ( ) Sonic
( ) Reverse Flow ( ) Air Pulse
( ) Simple Bag Collapse ( ) Ringed Bag Collapse
( ) Other ____

No. of Compartments	Time Between Cleaning (mins./hr.)	Inlet Temperature (Deg. F)	Position in Series
30	Weekly PM	Ambient	# NA of ____ Units

15 *** "AFTERBURNER" (FUME INCINERATOR) *** Not Applicable

Type of Afterburner: ( ) Direct Flame ( ) Catalytic ( ) Other ____	Efficiency (%)	Volumetric Flow Rate (CFM)	Position in Series # ____ of ____ Units

Maximum Burner Rating (Million BTU/hr)	Combustion Chamber Temp. (Deg. F)	Retention Time (sec.)	Fuel Type ____ Usage ____

Combustion Chamber Dimensions (ft.): ____ Length ____ Diameter

GENERAL DATA FOR PROCESSES OR FUEL BURNING SOURCES

B

NOTE: DO NOT USE THIS FORM FOR INCINERATORS, USE FORM "F".

PLEASE TYPE OR PRINT. ATTACH TO THE GENERAL INFORMATION FORM "A". IF APPLICABLE, ATTACH AIR POLLUTION CONTROL DEVICE FORM "C". USE SEPARATE FORM FOR EACH SOURCE.

Emission Source and ID NO. (FROM GENERAL INFORMATION FORM "A", ITEM 6):
Zinc Calot Lubrication (3 Lubricators) RPC 368244/368242

Description of Process or Fuel Burning Source Including Air Control Device:
Zinc Calots (pellet) are tumbled with graphite and silicone or Antilowa.

Permit Application is made for (CHECK ONE ONLY):
( ) New Source (X) Existing Source ( ) Modification – Last Permit No. _____

Commence Construction Date _____, 19____ Operation Date March, 19 77

Maximum Source Operation: 16 Hours/Day 5 Days/Week 49 Weeks/Year

All Contaminants Emitted:	Maximum Actual Emissions Before Control (lb/hr)	After Control (lb/hr)	Emission Estimate Method*	Control Device**	Control Efficiency %
Particulates					
Sulfur Dioxide					
Nitrogen Dioxide					
Carbon Monoxide					
Hydrocarbons (VOC)					
Lead					
Other (Zinc Particles)	0.01	.00001		Torit Bag Filter	99.9
Other (Graphite)					

*REFER TO BACK OF GENERAL INFORMATION FORM "A" FOR EMISSION ESTIMATION CODE
**ATTACH AIR CONTROL DEVICE FORM "C"

Type of Source:
CHECK ONE
(X) A GENERAL PROCESS – Source not covered by B and C below. (Complete items 7, 8, 18 through 22)
( ) B GENERAL PROCESS WITH IN-PROCESS FUEL – Source where products of combustion contact materials heated. (Complete items 7, 8, 9, 13, 14, 18 through 22)
( ) C FUEL BURNING SOURCE (boilers, etc.) – Source where products of combustion are for the primary purpose of producing heat or power by indirect heat transfer. (Complete items 9 through 22)

Process Operation: ( ) Continuous (X) Batch – Normal Batch Time 30 No. Batches per Day 40

Process Name Calot Lubricator Materials Entering Process*: (Include In-process Solid Fuels)	Input Rates (lb/hr) Design	Actual	Max. Requested Permit Input Rates (lb/hr)
A. Zinc, Graphite, Lubricant for 3 Lubricators	-	3000	5000
B.			
C.			
D.			
E.			
F.			
G.			
TOTAL WEIGHT ENTERING PROCESS			

*DO NOT LIST ANY VOLATILE HYDROCARBONS, USE HYDROCARBON EMISSION SOURCES FORM "E"

DATA FOR PROCESSES OR FUEL BURNING SOURCES – *continued*

Type of Fuel Burning Source: Not Applicable
( ) Industrial Boiler ( ) Institutional/Residential Boiler ( ) Electric Utility Boiler ( ) Process Burner(s)
( ) Other _____ Make and Model No. _____

Type of Solid Fuel Burning Equipment Used: Not Applicable
( ) Hand Fired ( ) Overfeed Stoker ( ) Pulverized
( ) Spreader Stoker ( ) Traveling Grate ( ) Wet Bed
( ) Underfeed Stoker ( ) Shaking Grate ( ) Dry Bed
( ) Other (specifiy) _____

Is collected flyash reinjected? ( ) NO ( ) YES Percent Reinjected _____%
Combustion Air: Percent Excess Air _____% ( ) Natural ( ) Induced Not Applicable
Specify method and schedule of tube cleaning:
( ) Lancing ( ) Tube Blowing ( ) Other _____ Schedule _____

12. Boiler Horsepower Rating _____ Boiler Steam Flow (lb/hr) Not Applicable

13. Fuel Burning Source Heat Input: Maximum Not Applicable Million BTU/hr Average _____ Million BTU/hr

14. Fuel Data: Primary Fuel Type(s) (specify) _____
Standby Fuel Type(s) (specify) Not Applicable

FUEL TYPE	FUEL USAGE Max. Design	Max. Actual	Annual	Max. % Sulfur	Max. % Ash	BTU Value
#6 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
#5 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
#4 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
Coal	(lb/hr)	(lb/hr)	(ton/yr)			(BTU/lb)
Wood	(lb/hr dry)	(lb/hr dry)	(ton/yr dry)			(BTU/lb) 8,000
Other						

15. If a combination of fuels is used, specify the maximum BTU/hr heat input for each: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

16. Total maximum heat input in million BTU/hr of all indirect fired fuel burning sources within property boundaries excluding that indicated above: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

17. Total No. of indirect fired fuel burning sources within property boundaries: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

18. Are there any fugitive emissions (storage piles, product handling, haul roads, etc.)? No (X) Yes ( ) If yes, please describe in comments below, the type, size, estimated emissions and control measures.

19. Describe any liquid or solid wastes generated and method of disposal:
Zinc particles and graphite collected in bags are disposed in county landfill.

DATA FOR PROCESSES OR FUEL BURNING SOURCES — *continued*

20. Stack or Emission Point Data:

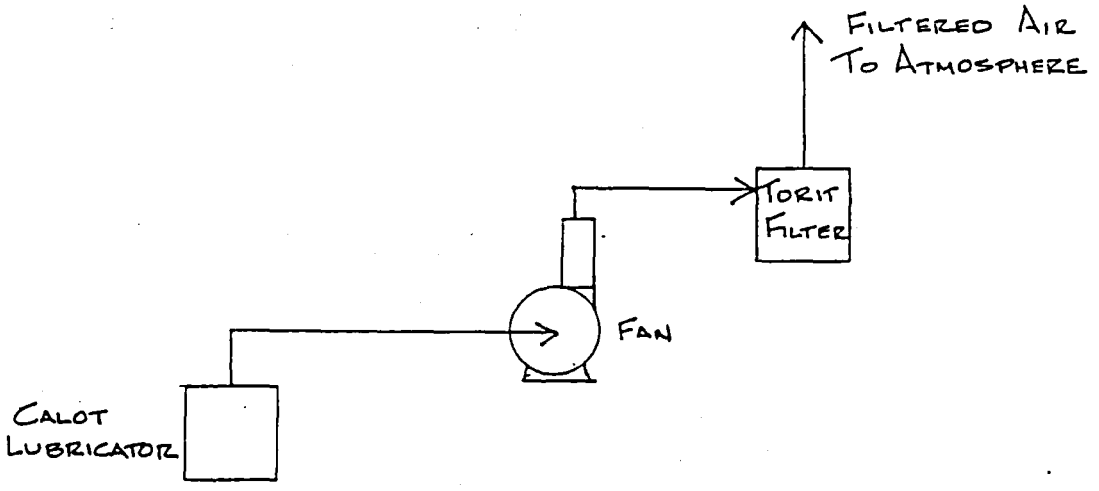
Height Above Ground (ft.)	Inside Area (sq. ft.)	Gas Temperature (Deg. F)	Direction of Exit (up, down or horizontal)
53	1.8	70 - 80	Up
Volumetric Flow Rate (ACFM)	**Velocity (ft./sec.)**	**Are sampling ports available?**	**Is rain cap or other obstruction over stack?**
3000	27.7	( ) No (X) Yes	(X) No ( ) Yes, (specify)

Is scaffolding available for source testing? (X) No ( ) Yes

Stack ID No. D-1 — Sources with a common stack will have the same stack number.

21. Indicate monitoring and recording instruments installed on stack:
( ) Opacity Monitor ( ) SO2 Monitor ( ) NOx Monitor ( ) Other None

22. Attach or sketch a flow diagram of the process or fuel burning source. Include air control device(s). (SEE INSTRUCTIONS ON BACK OF THIS PAGE):



23. Comments:

AIR POLLUTION CONTROL DEVICE

C

PLEASE TYPE OR PRINT. ATTACH TO GENERAL INFORMATION FORM "A". SUPPLY DESIGN DATA, SPECIFICATIONS, AND AVAILABLE ENGINEERING DRAWINGS.

1. Air Control Device and ID No. (FROM GENERAL INFORMATION FORM "A", ITEM 6)
   Torit Bag Filter RPC 368332

2. If there are several devices in series, list each unit in series starting at the emission source. Not Applicable
   (1) _____ (2) _____ (3) _____ TOTAL UNITS _____

3. Indicate Emission Source and ID No. that Control Device(s) is installed on:
   Calot Lubricator RPC 368244/368242

4. Narrative Description of Control Device(s):
   Zinc Particles/Graphite from calot lubricators are passed through bag filter before discharging to the atmosphere. Filter has 6 cellulose polyester bags.

Manufacturer	Model Name	Model Number
Torit	Torit	TD 1150

5. Estimated Cost of Control Device
   $ 5,000

   Period of Time Control Device is Estimated to be Adequate:
   15 Years

6. Permit Application is made for (CHECK ONE ONLY):
   ( ) New Source (X) Existing Source ( ) Modification – Last Permit No. _____
   Commence Construction Date _____, 19____ Operation Date _____, 19____

7. Emission Parameters:

Pollutant(s) Controlled	PART. ( )	SO_2 ( )	NO_x ( )	CO ( )	VOC ( )	LEAD ( )	OTHER Zinc	OTHER Graphite
Emission Rate Before Control (lb/hr) =							.01	No Data
Emission Rate After Control (lb/hr) =							.00001	No Data
Removal Efficiency Percent (%) =							99.9	No Data

Particle Size Distribution of Particulates Entering Control Device (% Micron): No Data
_____ 0-1 _____ 1-10 _____ 10-25 _____ 25-50 _____ 50-100 _____ Over 100

8. Gas Conditions at Control Device:

	INLET	INTERMEDIATE LOCATIONS	OUTLET
Flow Rate (ACFM) =	3000		3000
Temperature (Deg. F) =	70 - 80		70 - 80
Velocity (ft./sec.) =	27.7		27.7
Pressure Drop (in. H_2O) =	No Data		No Data
Moisture (%) =	No Data		No Data

9. Describe Ultimate Disposal of Collected Materials:
   Zinc particles and graphite collected are disposed in the county landfill with trash.

10. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Direction of Exit (up, down, or horizontal)	Are there obstructions over the stack? (X) No ( ) Yes, (specify)
53	1.8	Up	

Is scaffolding available for sources testing? (X) No ( ) Yes

Are sampling ports available? ( ) No (X) Yes

11. Comments:

SUPPLEMENTAL DATA FOR AIR CONTROL DEVICES

2. *** "CYCLONE" (MECHANICAL SEPARATORS) *** Not Applicable

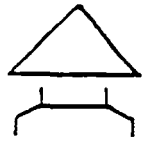
fficiency (%)	Volumetric Flow Rate (ACFM)	Pressure Drop (in. H_2O)	Baffles or Louvers (specify)	Position in Series #_____ of _____ Units
yclone Dimensions (inches) Inlet Outlet		Cyclone Body Diameter (inches)	Cyclone Body Height (ft.)	Cyclone Cone Height (ft.)

e Spray) No ( ) Yes	No. of Nozzles	Liquid Used (specify)	Flow Rate (GPM)	Makeup Rate (GPM)	% Recirculated

ocess flow diagram must be attached If cyclone is routed to another cyclone or other equipment, show sketch of entire system.

CYCLONE DIAGRAM

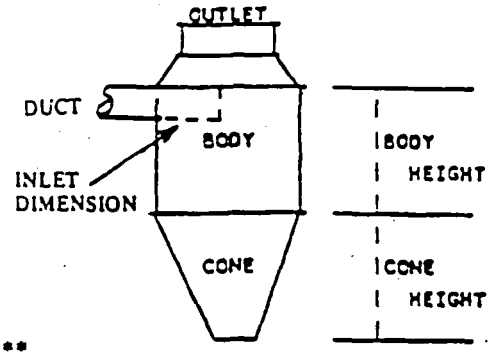
CHECK APPROPRIATE OUTLET CONFIGURATION BELOW



( )

( )

SKETCH OTHER CONFIGURATION ON DIAGRAM Below



3. Not Applicable *** "MULTICYCLONE" ***

fficiency (%)	Volumetric Flow Rate (ACFM)	No. of Cones	Pressure Drop (In. H_2O)	Position in Series # _____ of _____ Units

ouvers o ( ) Yes	Inlet Dimension of Individual Cyclone (inches)	Outlet Dimension of Individual Cyclone (inches)	Individual Cyclone Diameter (inches)	Inlet Temperature (Deg. F)

*** "FILTRATION" (BAGHOUSE) ***

iency (%)	Volumetric Flow Rate (ACFM)	Filter Surface Area (sq. ft.)	Air-to-Filter Area Ratio (ft./min.)	Pressure Drop (in. H_2O)
99.9	3000	1150	2.61	3 - 4

TYPE OF FILTER

( ) Fabric Filter (BAGHOUSE)
( ) Packed Bed ( ) Mat Filter
( ) Panel Filter
( ) Other _____

FILTER MATERIAL

( ) Fiberglass ( ) Nylon
( ) Nomex ( ) Teflon
( ) Wool ( ) Dacron
( ) Cotton ( ) Orlon
(X) Other Cellulose Polyester

BAG CLEANING

( ) Mechanical ( ) Sonic
( ) Reverse Flow (X) Air Pulse
( ) Simple Bag Collapse ( ) Ringed Bag Collapse
( ) Other _____

of Compartments	Time Between Cleaning (mins./hr.)	Inlet Temperature (Deg. F)	Position in Series # NA of _____ Units
6	Continuous	80	

*** "AFTERBURNER" (FUME INCINERATOR) *** Not Applicable

ype of Afterburner:) Direct Flame) Catalytic ( ) Other _____	Efficiency (%)	Volumetric Flow Rate (CFM)	Position in Series # _____ of _____ Units

kimum Burner Rating lion BTU/hr)	Combustion Chamber Temp. (Deg. F)	Retention Time (sec.)	Fuel Type _____ Usage _____

mbustion Chamber Dimensions (ft.): _____ Length _____ Diameter

GENERAL DATA FOR PROCESSES OR FUEL BURNING SOURCES

B

NOTE: DO NOT USE THIS FORM FOR INCINERATORS, USE FORM "F".

PLEASE TYPE OR PRINT. ATTACH TO THE GENERAL INFORMATION FORM "A". IF APPLICABLE, ATTACH AIR POLLUTION CONTROL DEVICE FORM "C". USE SEPARATE FORM FOR EACH SOURCE.

. Emission Source and ID NO. (FROM GENERAL INFORMATION FORM "A", ITEM 6):
Zinc Drossing (2 Drossing Stations) RPC 368219

. Description of Process or Fuel Burning Source Including Air Control Device:
Molten zinc alloy is "drossed" with zinc chloride. The "dross" (Approx. 60 - 70% zinc oxide) is put in 55-gal. drum under a hood. Air passes through a filter before discharging to the atmosphere.

. Permit Application is made for (CHECK ONE ONLY):
( ) New Source (X) Existing Source ( ) Modification – Last Permit No. _____
Commence Construction Date _____, 19____ Operation Date March, 19 77

. Maximum Source Operation: 3 Hours/Day 5 Days/Week 49 Weeks/Year

Air Contaminants Emitted:	Maximum Actual Emissions Before Control (lb/hr)	After Control (lb/hr)	Emission Estimate Method*	Control Device**	Control Efficiency %
Particulates					
Sulfur Dioxide					
Nitrogen Dioxide					
Carbon Monoxide					
Hydrocarbons (VOC)					
Lead					
Other (Zinc Oxide)	0.05	.00005	1	Torit Bag Filter	99.9
Other ( )					

*REFER TO BACK OF GENERAL INFORMATION FORM "A" FOR EMISSION ESTIMATION CODE
**ATTACH AIR CONTROL DEVICE FORM "C" Approx. 75# dust generated in 3 mos. for approx. 3 hrs./day

5. Type of Source:
CHECK ONE
(X) A GENERAL PROCESS – Source not covered by B and C below. (Complete items 7, 8, 18 through 22)
( ) B GENERAL PROCESS WITH IN-PROCESS FUEL – Source where products of combustion contact materials heated. (Complete items 7, 8, 9, 13, 14, 18 through 22)
( ) C FUEL BURNING SOURCE (boilers, etc.) – Source where products of combustion are for the primary purpose of producing heat or power by indirect heat transfer. (Complete items 9 through 22)

7. Process Operation: ( ) Continuous (X) Batch – Normal Batch Time 60 min. No. Batches per Day 3

8. Process Name Drossing

Materials Entering Process*: (Include In-process Solid Fuels)	Input Rates (lb/hr) Design	Actual	Max. Requested Permit Input Rates (lb/hr)
A. Zinc/Zinc Oxide (2 Drossing Stations)		300	500
B.			
C.			
D.			
E.			
F.			
G.			
TOTAL WEIGHT ENTERING PROCESS			

*DO NOT LIST ANY VOLATILE HYDROCARBONS, USE HYDROCARBON EMISSION SOURCES FORM "E".

DATA FOR PROCESSES OR FUEL BURNING SOURCES – *continued*

9. Type of Fuel Burning Source: Not Applicable
( ) Industrial Boiler ( ) Institutional/Residential Boiler ( ) Electric Utility Boiler ( ) Process Burner(s)
( ) Other _____ Make and Model No. _____

10. Type of Solid Fuel Burning Equipment Used: Not Applicable
( ) Hand Fired ( ) Overfeed Stoker ( ) Pulverized
( ) Spreader Stoker ( ) Traveling Grate ( ) Wet Bed
( ) Underfeed Stoker ( ) Shaking Grate ( ) Dry Bed
( ) Other (specifiy) _____

11. Is collected flyash reinjected? ( ) NO ( ) YES Percent Reinjected _____%
Combustion Air: Percent Excess Air _____% ( ) Natural ( ) Induced
Specify method and schedule of tube cleaning: Not Applicable
( ) Lancing ( ) Tube Blowing ( ) Other _____ Schedule _____

12. Boiler Horsepower Rating _____ Boiler Steam Flow (lb/hr) Not Applicable

13. Fuel Burning Source Heat Input: Maximum Not Applicable Million BTU/hr Average _____ Million BTU/hr

14. Fuel Data: Primary Fuel Type(s) (specify) Not Applicable
Standby Fuel Type(s) (specify) _____

FUEL TYPE	FUEL USAGE Max. Design	Max. Actual	Annual	Max. % Sulfur	Max. % Ash	BTU Value
#6 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
#5 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
#4 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
Coal	(lb/hr)	(lb/hr)	(ton/yr)			(BTU/lb)
Wood	(lb/hr dry)	(lb/hr dry)	(ton/yr dry)			(BTU/lb) 8,000
Other						

15. If a combination of fuels is used, specify the maximum BTU/hr heat input for each: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

16. Total maximum heat input in million BTU/hr of all indirect fired fuel burning sources within property boundaries excluding that indicated above: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

17. Total No. of indirect fired fuel burning sources within property boundaries: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

18. Are there any fugitive emissions (storage piles, product handling, haul roads, etc.)? No (X) Yes ( ) If yes, please describe in comments below, the type, size, estimated emissions and control measures.

19. Describe any liquid or solid wastes generated and method of disposal:
None. Dust collected is included in the dross which is sold for reclaiming.

DATA FOR PROCESSES OR FUEL BURNING SOURCES — *continued*

20. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Gas Temperature (Deg. F)	Direction of Exit (up, down or horizontal)
41	0.79	300	Up
Volumetric Flow Rate (ACFM)	**Velocity (ft./sec.)**	**Are sampling ports available?**	**Is rain cap or other obstruction over stack?**
1000	21	( ) No (X) Yes	(X) No ( ) Yes, (specify)

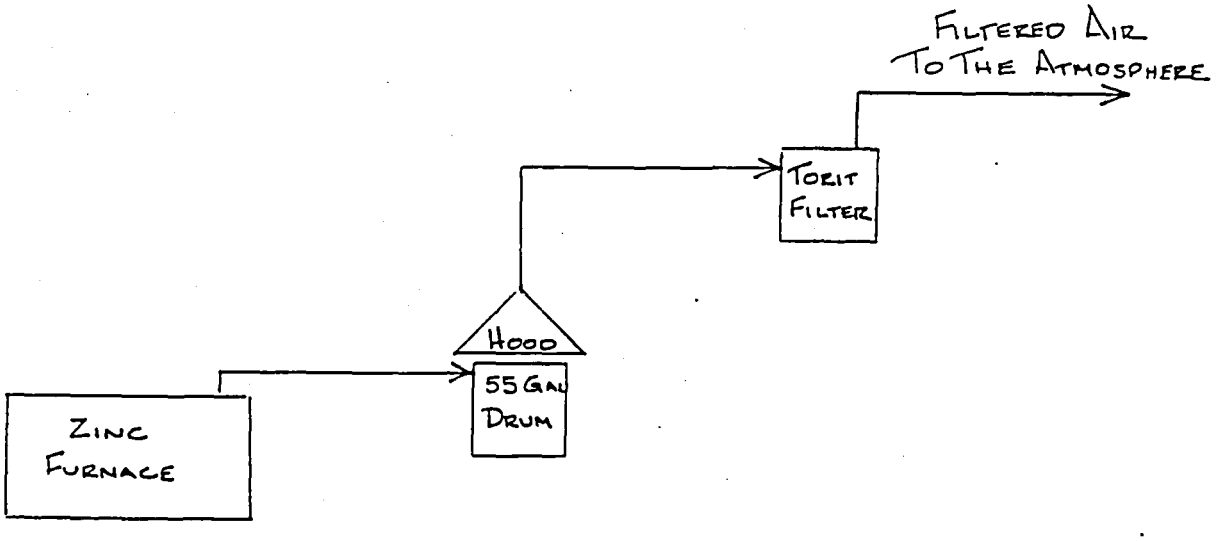
Is scaffolding available for source testing? (X) No ( ) Yes

Stack ID No. D-8 — Sources with a common stack will have the same stack number.

21. Indicate monitoring and recording instruments installed on stack:

( ) Opacity Monitor ( ) SO2 Monitor ( ) NOx Monitor ( ) Other None

22. Attach or sketch a flow diagram of the process or fuel burning source. Include air control device(s). (SEE INSTRUCTIONS ON BACK OF THIS PAGE):



23. Comments:

AIR POLLUTION CONTROL DEVICE

C

PLEASE TYPE OR PRINT. ATTACH TO GENERAL INFORMATION FORM "A". SUPPLY DESIGN DATA, SPECIFICATIONS, AND AVAILABLE ENGINEERING DRAWINGS.

1. Air Control Device and ID No. (FROM GENERAL INFORMATION FORM "A", ITEM 6)
   Torit Bag Filter RPC 368219

2. If there are several devices in series, list each unit in series starting at the emission source. Not Applicable
   (1) _____ (2) _____ (3) _____ TOTAL UNITS _____

3. Indicate Emission Source and ID No. that Control Device(s) is installed on:
   Drossing Hood RPC 368219

4. Narrative Description of Control Device(s):
   Torit filter has 30 cotten sateen bags which have an average bag life of 5 years. Contaminated air passes through the filter bags.

Manufacturer	Model Name	Model Number
Torit	Torit	84

5. Estimated Cost of Control Device
   $ 5,000

   Period of Time Control Device is Estimated to be Adequate:
   15 Years

6. Permit Application is made for (CHECK ONE ONLY):
   ( ) New Source (X) Existing Source ( ) Modification – Last Permit No. _____
   Commence Construction Date _____, 19____ Operation Date _____, 19____

7. Emission Parameters:

Pollutant(s) Controlled	PART. ( )	SO_2 ( )	NO_x ( )	CO ( )	VOC ( )	LEAD ( )	OTHER Zinc Oxide	OTHER
Emission Rate Before Control (lb/hr) =							0.05	
Emission Rate After Control (lb/hr) =							0.00005	
Removal Efficiency Percent (%) =							99.9	

Particle Size Distribution of Particulates Entering Control Device (% Micron): No Data
_____ 0-1 _____ 1-10 _____ 10-25 _____ 25-50 _____ 50-100 _____ Over 100

8. Gas Conditions at Control Device:

	INLET	INTERMEDIATE LOCATIONS	OUTLET
Flow Rate (ACFM) =			
Temperature (Deg. F) =	500		300
Velocity (ft./sec.) =	21		
Pressure Drop (in. H_2O) =	-		1.78
Moisture (%) =	Nil		Nil

9. Describe Ultimate Disposal of Collected Materials:
   Dust from the filter is put back into the dross container for selling to reclaimer.

10. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Direction of Exit (up, down, or horizontal)	Are there obstructions over the stack? (X) No ( ) Yes, (specify)
41	.79	Up	

Is scaffolding available for sources testing? (X) No ( ) Yes

Are sampling ports available? ( ) No (X) Yes

11. Comments:

SUPPLEMENTAL DATA FOR AIR CONTROL DEVICES

2. *** "CYCLONE" (MECHANICAL SEPARATORS) *** Not Applicable

Efficiency (%)	Volumetric Flow Rate (ACFM)	Pressure Drop (in. H_2O)	Baffles or Louvers (specify)	Position in Series #____ of ____ Units

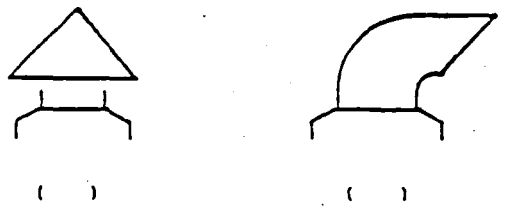
Cyclone Dimensions (inches) Inlet	Outlet	Cyclone Body Diameter (inches)	Cyclone Body Height (ft.)	Cyclone Cone Height (ft.)

Wet Spray ( ) No ( ) Yes	No. of Nozzles	Liquid Used (specify)	Flow Rate (GPM)	Makeup Rate (GPM)	% Recirculated

A process flow diagram must be attached If cyclone is routed to another cyclone or other equipment, show sketch of entire system.

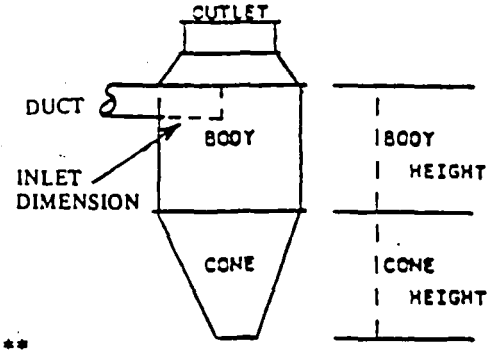
CYCLONE DIAGRAM

CHECK APPROPRIATE OUTLET CONFIGURATION BELOW



( ) ( )

SKETCH OTHER CONFIGURATION ON DIAGRAM Below



3. Not Applicable *** "MULTICYCLONE" ***

Efficiency (%)	Volumetric Flow Rate (ACFM)	No. of Cones	Pressure Drop (In. H_2O)	Position in Series # ____ of ____ Units

Louvers ( ) No ( ) Yes	Inlet Dimension of Individual Cyclone (inches)	Outlet Dimension of Individual Cyclone (inches)	Individual Cyclone Diameter (inches)	Inlet Temperature (Deg. F)

4. *** "FILTRATION" (BAGHOUSE) ***

Efficiency (%)	Volumetric Flow Rate (ACFM)	Filter Surface Area (sq. ft.)	Air-to-Filter Area Ratio (ft./min.)	Pressure Drop (in. H_2O)
99.9	1000	150	6.67	1.78

TYPE OF FILTER
(X) Fabric Filter (BAGHOUSE)
( ) Packed Bed ( ) Mat Filter
( ) Panel Filter
( ) Other ____

FILTER MATERIAL
( ) Fiberglass ( ) Nylon
( ) Nomex ( ) Teflon
( ) Wool ( ) Dacron
( ) Cotton ( ) Orlon
(X) Other Cotten Sateen

BAG CLEANING
(X) Mechanical ( ) Sonic
( ) Reverse Flow ( ) Air Pulse
( ) Simple Bag Collapse ( ) Ringed Bag Collapse
( ) Other ____

No. of Compartments	Time Between Cleaning (mins./hr.)	Inlet Temperature (Deg. F)	Position in Series # ____ of ____ Units
30	Weekly PM	400	#NA of ____ Units

5. *** "AFTERBURNER" (FUME INCINERATOR) *** Not Applicable

Type of Afterburner: ( ) Direct Flame ( ) Catalytic ( ) Other ____	Efficiency (%)	Volumetric Flow Rate (CFM)	Position in Series # ____ of ____ Units

Maximum Burner Rating (Million BTU/hr)	Combustion Chamber Temp. (Deg. F)	Retention Time (sec.)	Fuel Type ____ Usage ____

Combustion Chamber Dimensions (ft.): ____ Length ____ Diameter

GENERAL DATA FOR PROCESSES OR FUEL BURNING SOURCES

B

NOTE: DO NOT USE THIS FORM FOR INCINERATORS, USE FORM "F".

PLEASE TYPE OR PRINT. ATTACH TO THE GENERAL INFORMATION FORM "A". IF APPLICABLE, ATTACH AIR POLLUTION CONTROL DEVICE FORM "C". USE SEPARATE FORM FOR EACH SOURCE.

1. Emission Source and ID NO. (FROM GENERAL INFORMATION FORM "A", ITEM 6):
Zinc Casting Furnaces (3 Furnaces) RPC 368251

2. Description of Process or Fuel Burning Source Including Air Control Device:
Zinc Slab is melted and alloyed with 0.2% (by wt.) lead and 0.07% (by weight) cadmium. Alloying is at approximately 900°F in induction furnace.

3. Permit Application is made for (CHECK ONE ONLY):
( ) New Source (X) Existing Source ( ) Modification – Last Permit No. _____
Commence Construction Date _____, 19____ Operation Date March, 19 77

4. Maximum Source Operation: 16 Hours/Day 5 Days/Week 49 Weeks/Year

5.

Air Contaminants Emitted:	Maximum Actual Emissions Before Control (lb/hr)	After Control (lb/hr)	Emission Estimate Method*	Control Device**	Control Efficiency %
Particulates					
Sulfur Dioxide					
Nitrogen Dioxide					
Carbon Monoxide					
Hydrocarbons (VOC)					
Lead Compounds	No Data	No Data		None	NA
Other (Zinc Oxide)	.0004	NA	1	None	NA
Other (Cadmium Compds)	No Data	Nil	2	None	NA

*REFER TO BACK OF GENERAL INFORMATION FORM "A" FOR EMISSION ESTIMATION CODE
**ATTACH AIR CONTROL DEVICE FORM "C"

Type of Source:
CHECK ONE
(X) A GENERAL PROCESS – Source not covered by B and C below. (Complete items 7, 8, 18 through 22)
( ) B GENERAL PROCESS WITH IN-PROCESS FUEL – Source where products of combustion contact materials heated. (Complete items 7, 8, 9, 13, 14, 18 through 22)
( ) C FUEL BURNING SOURCE (boilers, etc.) – Source where products of combustion are for the primary purpose of producing heat or power by indirect heat transfer. (Complete items 9 through 22)

7. Process Operation: ( ) Continuous (X) Batch – Normal Batch Time 30 Mins. No. Batches per Day 240

Process Name Zinc Alloying

Materials Entering Process*: (Include In-process Solid Fuels)	Input Rates (lb/hr) Design	Actual	Max. Requested Permit Input Rates (lb/hr)
A. Zinc, Cadmium & Lead for 3 furnaces		4500	9000
B.			
C.			
D.			
E.			
F.			
G.			
TOTAL WEIGHT ENTERING PROCESS			

*DO NOT LIST ANY VOLATILE HYDROCARBONS, USE HYDROCARBON EMISSION SOURCES FORM "E"

DATA FOR PROCESSES OR FUEL BURNING SOURCES – *continued*

20. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Gas Temperature (Deg. F)	Direction of Exit (up, down or horizontal)
52	1.8	200	Up
Volumetric Flow Rate (ACFM)	**Velocity (ft./sec.)**	**Are sampling ports available?**	**Is rain cap or other obstruction over stack?**
4000	37	( ) No (X) Yes	(X) No ( ) Yes, (specify)

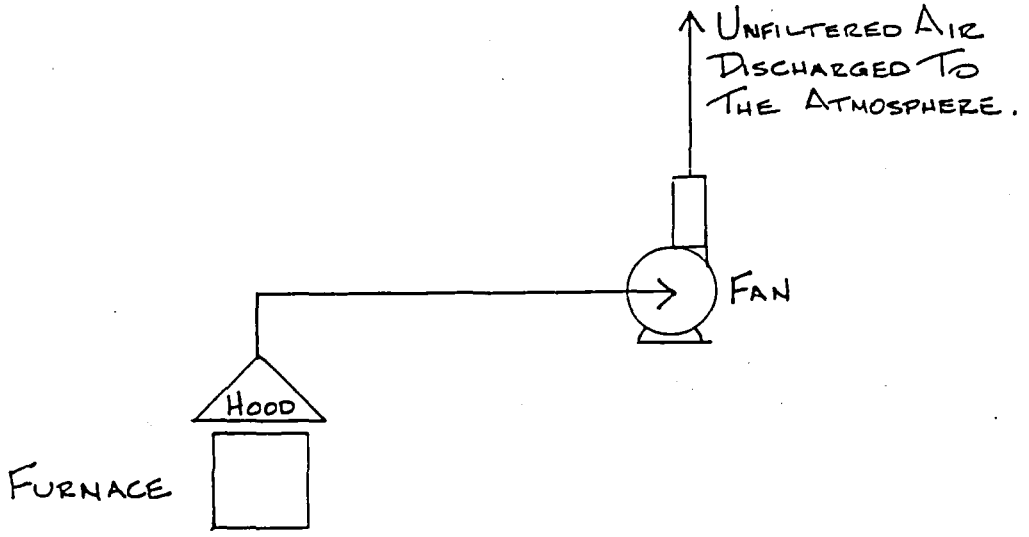
Is scaffolding available for source testing? (X) No ( ) Yes

Stack ID No. F-16/F-17 – Sources with a common stack will have the same stack number.

21. Indicate monitoring and recording instruments installed on stack:

( ) Opacity Monitor ( ) SO2 Monitor ( ) NOx Monitor ( ) Other None

22. Attach or sketch a flow diagram of the process or fuel burning source. Include air control device(s). (SEE INSTRUCTIONS ON BACK OF THIS PAGE):



23. Comments:

GENERAL DATA FOR PROCESSES OR FUEL BURNING SOURCES

B

NOTE: DO NOT USE THIS FORM FOR INCINERATORS, USE FORM "F".

PLEASE TYPE OR PRINT. ATTACH TO THE GENERAL INFORMATION FORM "A". IF APPLICABLE, ATTACH AIR POLLUTION CONTROL DEVICE FORM "C". USE SEPARATE FORM FOR EACH SOURCE.

1. Emission Source and ID NO. (FROM GENERAL INFORMATION FORM "A", ITEM 6): 368298, 368254, 368240, 368253, 368215, 368313, 368217, 368255, 368256, 368315, 368216, 368337
   Zinc Can Extrusion (14 Extruders) RPC

2. Description of Process or Fuel Burning Source Including Air Control Device:
   Zinc pellets (calots) are fed into the extruder punch and die assembly. Cans are extruded by the impact of the punch.

3. Permit Application is made for (CHECK ONE ONLY):
   ( ) New Source (X) Existing Source ( ) Modification – Last Permit No. _____
   Commence Construction Date _____, 19____ Operation Date March, 19 77

4. Maximum Source Operation: _____ Hours/Day _____ Days/Week _____ Weeks/Year

5.

Air Contaminants Emitted:	Maximum Actual Emissions Before Control (lb/hr)	Maximum Actual Emissions After Control (lb/hr)	Emission Estimate Method*	Control Device**	Control Efficiency %
Particulates					
Sulfur Dioxide	0	NA	1	None	NA
Nitrogen Dioxide					
Carbon Monoxide					
Hydrocarbons (VOC)					
Lead					
Other (_____)					
Other (_____)					

*REFER TO BACK OF GENERAL INFORMATION FORM "A" FOR EMISSION ESTIMATION CODE
**ATTACH AIR CONTROL DEVICE FORM "C"

Type of Source:
CHECK ONE
(X) A GENERAL PROCESS – Source not covered by B and C below. (Complete items 7, 8, 18 through 22)
( ) B GENERAL PROCESS WITH IN-PROCESS FUEL – Source where products of combustion contact materials heated. (Complete items 7, 8, 9, 13, 14, 18 through 22)
( ) C FUEL BURNING SOURCE (boilers, etc.) – Source where products of combustion are for the primary purpose of producing heat or power by indirect heat transfer. (Complete items 9 through 22)

Process Operation: (X) Continuous ( ) Batch – Normal Batch Time _____ No. Batches per Day _____

Process Name Zinc Can Extrusion

Materials Entering Process*: (Include In-process Solid Fuels)	Input Rates (lb/hr) Design	Input Rates (lb/hr) Actual	Max. Requested Permit Input Rates (lb/hr)
A. Lubricated Zinc Calots per Extruder		3000	5000
B.			
C.			
D.			
E.			
F.			
G.			
TOTAL WEIGHT ENTERING PROCESS			

*DO NOT LIST ANY VOLATILE HYDROCARBONS, USE HYDROCARBON EMISSION SOURCES FORM "E"

DATA FOR PROCESSES OR FUEL BURNING SOURCES – *continued*

20. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Gas Temperature (Deg. F)	Direction of Exit (up, down or horizontal)
53	1.8	70 - 80	UP
Volumetric Flow Rate (ACFM)	**Velocity (ft./sec.)**	**Are sampling ports available?**	**Is rain cap or other obstruction over stack?**
7500	69.4	( ) No (X) Yes	(X) No ( ) Yes, (specify)

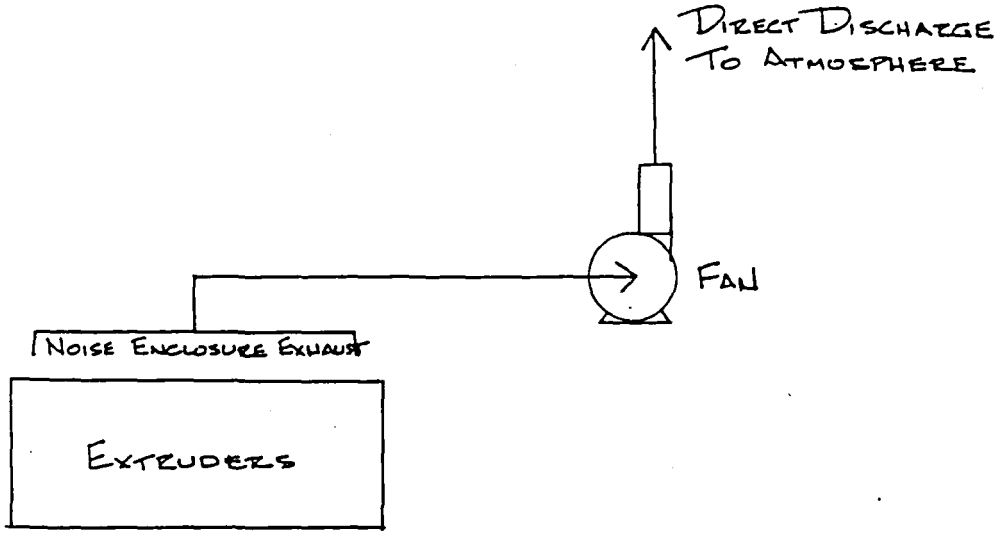
Is scaffolding available for source testing? (X) No ( ) Yes

Stack ID No. F-11/F-13/F-14 – Sources with a common stack will have the same stack number.

21. Indicate monitoring and recording instruments installed on stack:

( ) Opacity Monitor ( ) SO2 Monitor ( ) NOx Monitor ( ) Other None

22. Attach or sketch a flow diagram of the process or fuel burning source. Include air control device(s). (SEE INSTRUCTIONS ON BACK OF THIS PAGE):



23. Comments:

GENERAL DATA FOR PROCESSES OR FUEL BURNING SOURCES

B

NOTE: DO NOT USE THIS FORM FOR INCINERATORS, USE FORM "F".

PLEASE TYPE OR PRINT. ATTACH TO THE GENERAL INFORMATION FORM "A". IF APPLICABLE, ATTACH AIR POLLUTION CONTROL DEVICE FORM "C". USE SEPARATE FORM FOR EACH SOURCE.

1. Emission Source and ID NO. (FROM GENERAL INFORMATION FORM "A", ITEM 6):
Zinc Casting Tank Repair Bench

2. Description of Process or Fuel Burning Source Including Air Control Device:
Molten zinc alloy dispensing tanks are repaired by replacing liners. Any dust generated is pulled into the hood to the atmosphere.

3. Permit Application is made for (CHECK ONE ONLY):
( ) New Source (X) Existing Source ( ) Modification – Last Permit No. _____
Commence Construction Date _____, 19____ Operation Date April, 19 87

4. Maximum Source Operation: _____ Hours/Day _____ Days/Week _____ Weeks/Year

5.

Air Contaminants Emitted:	Maximum Actual Emissions Before Control (lb/hr)	After Control (lb/hr)	Emission Estimate Method*	Control Device**	Control Efficiency %
Particulates					
Sulfur Dioxide					
Nitrogen Dioxide					
Carbon Monoxide					
Hydrocarbons (VOC)					
Lead					
Other (Zinc Oxide)	No Data		NA	None	NA
Other ( )					

*REFER TO BACK OF GENERAL INFORMATION FORM "A" FOR EMISSION ESTIMATION CODE
**ATTACH AIR CONTROL DEVICE FORM "C"

6. Type of Source:
CHECK ONE
(X) A GENERAL PROCESS – Source not covered by B and C below. (Complete items 7, 8, 18 through 22)
( ) B GENERAL PROCESS WITH IN-PROCESS FUEL – Source where products of combustion contact materials heated. (Complete items 7, 8, 9, 13, 14, 18 through 22)
( ) C FUEL BURNING SOURCE (boilers, etc.) – Source where products of combustion are for the primary purpose of producing heat or power by indirect heat transfer. (Complete items 9 through 22)

7. Process Operation: ( ) Continuous (X) Batch – Normal Batch Time 2 Hrs. No. Batches per Day 1 every 2 weeks

8.

Process Name: Tank Repair Materials Entering Process*: (Include In-process Solid Fuels)	Input Rates (lb/hr) Design	Actual	Max. Requested Permit Input Rates (lb/hr)
A. Zinc Oxides		No Data	
B.			
C.			
D.			
E.			
F.			
G.			
TOTAL WEIGHT ENTERING PROCESS			

*DO NOT LIST ANY VOLATILE HYDROCARBONS, USE HYDROCARBON EMISSION SOURCES FORM "E"

DATA FOR PROCESSES OR FUEL BURNING SOURCES — *continued*

20. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Gas Temperature (Deg. F)	Direction of Exit (up, down or horizontal)
45	1.0	Ambient	Up
Volumetric Flow Rate (ACFM)	**Velocity (ft./sec.)**	**Are sampling ports available?**	**Is rain cap or other obstruction over stack?**
1600	27	( ) No (X) Yes	( ) No (X) Yes, (specify) Rain Cap

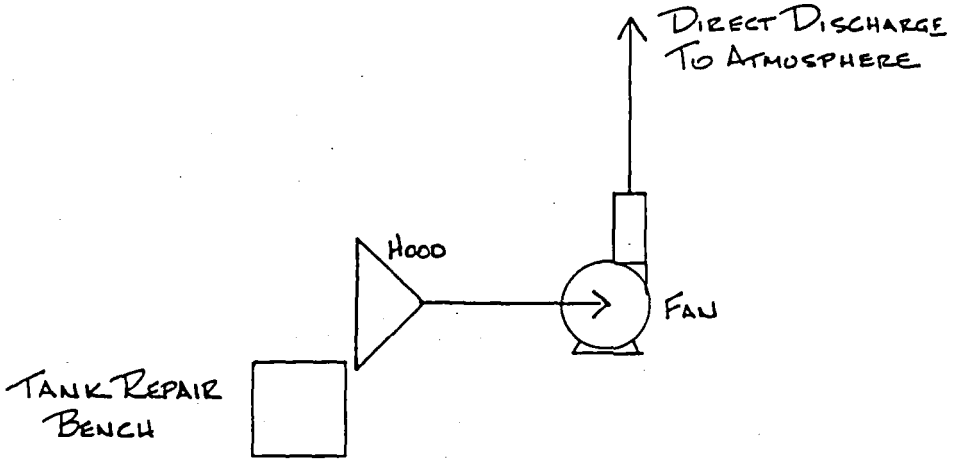
Is scaffolding available for source testing? (X) No ( ) Yes

Stack ID No. D-11 — Sources with a common stack will have the same stack number.

21. Indicate monitoring and recording instruments installed on stack:

( ) Opacity Monitor ( ) SO2 Monitor ( ) NOx Monitor ( ) Other None

22. Attach or sketch a flow diagram of the process or fuel burning source. Include air control device(s). (SEE INSTRUCTIONS ON BACK OF THIS PAGE):



23. Comments:

GENERAL DATA FOR PROCESSES OR FUEL BURNING SOURCES

B

NOTE: DO NOT USE THIS FORM FOR INCINERATORS, USE FORM "F".

PLEASE TYPE OR PRINT. ATTACH TO THE GENERAL INFORMATION FORM "A". IF APPLICABLE, ATTACH AIR POLLUTION CONTROL DEVICE FORM "C". USE SEPARATE FORM FOR EACH SOURCE.

1. Emission Source and ID NO. (FROM GENERAL INFORMATION FORM "A", ITEM 6):
Paper Moisturizing Room RPC 368317

2. Description of Process or Fuel Burning Source Including Air Control Device:
Mercurous chloride coated paper is moisturized in a humidity room. A fan is run for 8 minutes before the operator goes inside the room. The fan exhaust goes through a carbon filter before exhausting into the atmosphere. The operator stays inside the room for 5. - 7 minutes.

3. Permit Application is made for (CHECK ONE ONLY):
(X) New Source ( ) Existing Source ( ) Modification – Last Permit No. _____
Commence Construction Date _____, 19____ Operation Date August, 19 87

4. Maximum Source Operation: 2 Hours/Day 5 Days/Week 49 Weeks/Year

5.

Air Contaminants Emitted:	Maximum Actual Emissions Before Control (lb/hr)	After Control (lb/hr)	Emission Estimate Method*	Control Device**	Control Efficiency %
Particulates					
Sulfur Dioxide					
Nitrogen Dioxide					
Carbon Monoxide					
Hydrocarbons (VOC)					
Lead					
Other (Mercurous Chloride)	.00008	.00001	1	Carbon Filter	90
Other ( )					

*REFER TO BACK OF GENERAL INFORMATION FORM "A" FOR EMISSION ESTIMATION CODE
**ATTACH AIR CONTROL DEVICE FORM "C"

6. Type of Source:
CHECK ONE
(X) A GENERAL PROCESS – Source not covered by B and C below. (Complete items 7, 8, 18 through 22)
( ) B GENERAL PROCESS WITH IN-PROCESS FUEL – Source where products of combustion contact materials heated. (Complete items 7, 8, 9, 13, 14, 18 through 22)
( ) C FUEL BURNING SOURCE (boilers, etc.) – Source where products of combustion are for the primary purpose of producing heat or power by indirect heat transfer. (Complete items 9 through 22)

7. Process Operation: ( ) Continuous (X) Batch – Normal Batch Time 45 Min. No. Batches per Day 3

8. Process Name Paper Moisturizing

Materials Entering Process*: (Include In-process Solid Fuels)	Input Rates (lb/hr) Design	Actual	Max. Requested Permit Input Rates (lb/hr)
A. Mercury Coated Paper Liner		30	50
B.			
C.			
D.			
E.			
F.			
G.			
TOTAL WEIGHT ENTERING PROCESS			

*DO NOT LIST ANY VOLATILE HYDROCARBONS, USE HYDROCARBON EMISSION SOURCES FORM "E"

DATA FOR PROCESSES OR FUEL BURNING SOURCES – *continued*

9. Type of Fuel Burning Source: Not Applicable
( ) Industrial Boiler ( ) Institutional/Residential Boiler ( ) Electric Utility Boiler ( ) Process Burner(s)
( ) Other _____ Make and Model No. _____

10. Type of Solid Fuel Burning Equipment Used: Not Applicable
( ) Hand Fired ( ) Overfeed Stoker ( ) Pulverized
( ) Spreader Stoker ( ) Traveling Grate ( ) Wet Bed
( ) Underfeed Stoker ( ) Shaking Grate ( ) Dry Bed
( ) Other (specifiy) _____

11. Is collected flyash reinjected? ( ) NO ( ) YES Percent Reinjected _____%
Combustion Air: Percent Excess Air _____% ( ) Natural ( ) Induced Not Applicable
Specify method and schedule of tube cleaning:
( ) Lancing ( ) Tube Blowing ( ) Other _____ Schedule _____

12. Boiler Horsepower Rating _____ Boiler Steam Flow (lb/hr) Not applicable

13. Fuel Burning Source Heat Input: Maximum Not Applicable Million BTU/hr Average _____ Million BTU/hr

14. Fuel Data: Primary Fuel Type(s) (specify) _____
Standby Fuel Type(s) (specify) Not Applicable

FUEL TYPE	FUEL USAGE Max. Design	Max. Actual	Annual	Max. % Sulfur	Max. % Ash	BTU Value
#6 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
#5 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
#4 Fuel Oil	(gal/hr)	(gal/hr)	(gal/yr)			(BTU/gal)
Coal	(lb/hr)	(lb/hr)	(ton/yr)			(BTU/lb)
Wood	(lb/hr dry)	(lb/hr dry)	(ton/yr dry)			(BTU/lb) 8,000
Other						

15. If a combination of fuels is used, specify the maximum BTU/hr heat input for each: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

16. Total maximum heat input in million BTU/hr of all indirect fired fuel burning sources within property boundaries excluding that indicated above: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

17. Total No. of indirect fired fuel burning sources within property boundaries: Not Applicable
Fuel Oil _____ Coal _____ Wood _____ Other _____

18. Are there any fugitive emissions (storage piles, product handling, haul roads, etc.)? No (X) Yes ( ) If yes, please describe in comments below, the type, size, estimated emissions and control measures.

19. Describe any liquid or solid wastes generated and method of disposal:
Waste carbon filter media contaminated with mercurous chloride dust. Disposal on EPA approved landfill.

DATA FOR PROCESSES OR FUEL BURNING SOURCES — *continued*

20. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Gas Temperature (Deg. F)	Direction of Exit (up, down or horizontal)
44	0.2	70 - 80	Horizontal
Volumetric Flow Rate (ACFM)	**Velocity (ft./sec.)**	**Are sampling ports available?**	**Is rain cap or other obstruction over stack?**
500	45	(X) No ( ) Yes	( ) No (X) Yes, (specify)

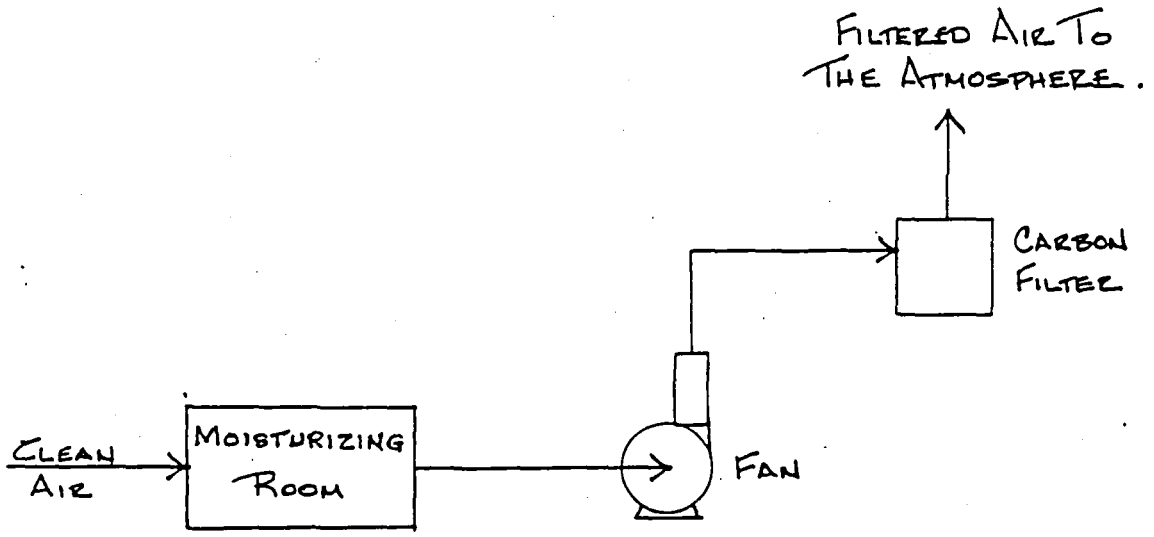
Is scaffolding available for source testing? (X) No ( ) Yes

Stack ID No. D-10 — Sources with a common stack will have the same stack number.

21. Indicate monitoring and recording instruments installed on stack:

( ) Opacity Monitor ( ) SO2 Monitor ( ) NOx Monitor ( ) Other None

22. Attach or sketch a flow-diagram of the process or fuel burning source. Include air control device(s). (SEE INSTRUCTIONS ON BACK OF THIS PAGE):



23. Comments:

C

AIR POLLUTION CONTROL DEVICE

PLEASE TYPE OR PRINT. ATTACH TO GENERAL INFORMATION FORM "A". SUPPLY DESIGN DATA, SPECIFICATIONS, AND AVAILABLE ENGINEERING DRAWINGS.

1. Air Control Device and ID No. (FROM GENERAL INFORMATION FORM "A", ITEM 6)
   Carbon Filter RPC 368346

2. If there are several devices in series, list each unit in series starting at the emission source. NA
   (1) _____ (2) _____ (3) _____ TOTAL UNITS _____

3. Indicate Emission Source and ID No. that Control Device(s) is installed on:
   Moisturizing Room RPC 368317

4. Narrative Description of Control Device(s):
   2' x 2' x 2' Two-panel type filter. The first panel is a pleated paper pre-filter which removes particulates. The second panel has 60 lbs. carbon which will remove any mercury vapor.

Manufacturer	Model Name	Model Number
Endustra	Exhaust Filter	2RI-01-111-196-093

5. Estimated Cost of Control Device
   $ 1,500

   Period of Time Control Device is Estimated to be Adequate:
   12 Years

6. Permit Application is made for (CHECK ONE ONLY):
   (X) New Source ( ) Existing Source ( ) Modification – Last Permit No. _____
   Commence Construction Date _____, 19____ Operation Date August, 19 87

7. Emission Parameters:

Pollutant(s) Controlled	PART. ( )	SO_2 ( )	NO_x ( )	CO ( )	VOC ( )	LEAD ( )	OTHER Merc Chloride	OTHER
Emission Rate Before Control (lb/hr) =							.00008	
Emission Rate After Control (lb/hr) =							.00001	
Removal Efficiency Percent (%) =							90	

Particle Size Distribution of Particulates Entering Control Device (% Micron): No information
0-1 ____ 1-10 ____ 10-25 ____ 25-50 ____ 50-100 ____ Over 100

8. Gas Conditions at Control Device:

	INLET	INTERMEDIATE LOCATIONS	OUTLET
Flow Rate (ACFM) =	500		500
Temperature (Deg. F) =	70 - 80		70 - 80
Velocity (ft./sec.) =	45		No Data
Pressure Drop (in. H_2O) =	No Data		No Data
Moisture (%) =	No Data		No Data

9. Describe Ultimate Disposal of Collected Materials:
   Mercury contaminated filter media will be put in DOT approved 55-gal. drums and disposed in an EPA approved landfill.

10. Stack or Emission Point Data:

Height Above Ground (ft.)	Inside Area (sq. ft.)	Direction of Exit (up, down, or horizontal)	Are there obstructions over the stack? ( ) No (X) Yes, (specify)
44	0.2	Horizontal	Rain Cap

Is scaffolding available for sources testing? (X) No ( ) Yes

Are sampling ports available? ( ) No ( ) Yes Not required

11. Comments:

SUPPLEMENTAL DATA FOR AIR CONTROL DEVICES

2. *** "CYCLONE" (MECHANICAL SEPARATORS) ***

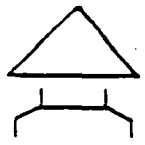
fficiency (%)	Volumetric Flow Rate (ACFM)	Pressure Drop (in. H_2O)	Baffles or Louvers (specify)	Position in Series #_____ of _____ Units
yclone Dimensions (inches) Inlet Outlet		Cyclone Body Diameter (inches)	Cyclone Body Height (ft.)	Cyclone Cone Height (ft.)

e Spray) No ( ) Yes	No. of Nozzles	Liquid Used (specify)	Flow Rate (GPM)	Makeup Rate (GPM)	% Recirculated

ocess flow diagram must be attached If cyclone is routed to another cyclone or other equipment, show sketch of entire system.

CYCLONE DIAGRAM

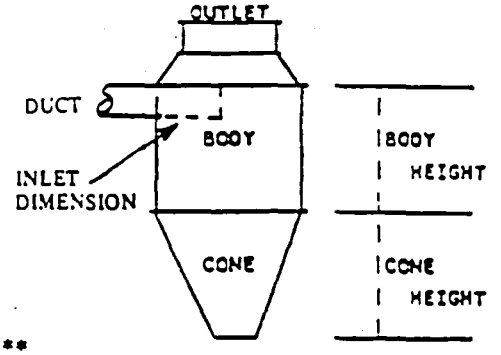
CHECK APPROPRIATE OUTLET CONFIGURATION BELOW



( )

( )

SKETCH OTHER CONFIGURATION ON DIAGRAM Below



3. *** "MULTICYCLONE" ***

ffiiency (%)	Volumetric Flow Rate (ACFM)	No. of Cones	Pressure Drop (In. H_2O)	Position in Series # _____ of _____ Units

ouvers No ( ) Yes	Inlet Dimension of Individual Cyclone (inches)	Outlet Dimension of Individual Cyclone (inches)	Individual Cyclone Diameter (inches)	Inlet Temperature (Deg. F)

*** "FILTRATION" (BAGHOUSE) ***

ciency (%)	Volumetric Flow Rate (ACFM)	Filter Surface Area (sq. ft.)	Air-to-Filter Area Ratio (ft./min.)	Pressure Drop (in. H_2O)
99	500	4	125	1½"

TYPE OF FILTER	FILTER MATERIAL		BAG CLEANING	
) Fabric Filter (BAGHOUSE)	( ) Fiberglass	( ) Nylon	(X) Mechanical	( ) Sonic
) Packed Bed ( ) Mat Filter	( ) Nomex	( ) Teflon	( ) Reverse Flow	( ) Air Pulse
Panel Filter	( ) Wool	( ) Dacron	( ) Simple Bag Collapse	( ) Ringed Bag Collapse
Other _____	( ) Cotton	( ) Orlon		
	( ) Other Pleated Paper/Carbon		( ) Other _____	

of Compartments	Time Between Cleaning (mins./hr.)	Inlet Temperature (Deg. F)	Position in Series # NA of _____ Units
1	Once/year	70-80	

*** "AFTERBURNER" (FUME INCINERATOR) ***

ype of Afterburner:) Direct Flame) Catalytic ( ) Other _____	Efficiency (%)	Volumetric Flow Rate (CFM)	Position in Series # _____ of _____ Units

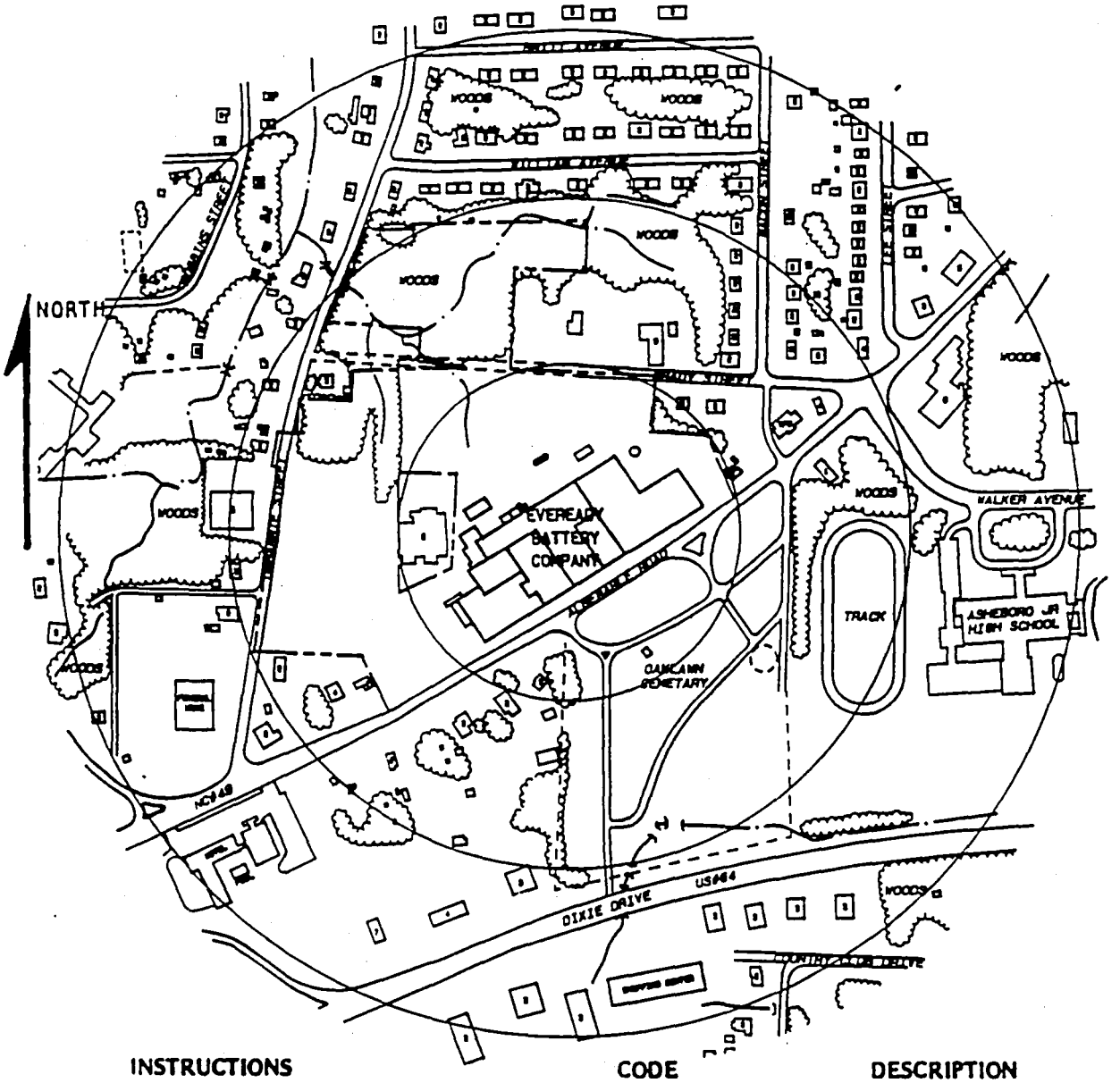
ximum Burner Rating illion BTU/hr)	Combustion Chamber Temp. (Deg. F)	Retention Time (sec.)	Fuel Type _____ Usage _____

mbustion Chamber Dimensions (ft.): _____ Length _____ Diameter

AREA DIAGRAM

D

Show all surrounding buildings and roads within 1500 feet of the equipment covered by this application. Attach a site diagram identifying each emission source location(s), property boundaries and building (structure) dimensions (height, width, and length).



INSTRUCTIONS	CODE	DESCRIPTION
1. Indicate location and type of building by the use of small numbered circles with the decription below.	(1)	CHURCH
2. Show roads as lines representing the road edges. Indicate street names and highway numbers.	(2)	RESIDENCES
3. Show wooded or cleared area by approximate boundary lines and the words "woods", "cleared", "cornfield", etc.	(3)	FOOD SERVICES
	(4)	SERVICE CENTERS (BARBER, LAUNDRY, ETC.)
	(5)	APPAREL MFG.
	(6)	PLUMBING SUPPLY CENTER
	(7)	MOBILE HOME DISTRIBUTER
	(8)	
	(9)	
	(10)	

Example:

(1) Church
(2) Residence

EVEREADY BATTERY COMPANY, INC.
P.O. BOX 849
ASHEBORO, NC 27204-0849

Plant No. 1

August 21, 1987

RECEIVED
N.C. Dept. NRCD
AUG 23 1987
Division of
Environmental Management
Winston-Salem Reg. Office

North Carolina Department of Natural
Resources and Community Development
Air Quality Section
Suite 100, 8025 North Pt. Blvd.
Winston-Salem, North Carolina 27106

ATTN: Mr. Hugh W. Jernigan

Gentlemen:

Attached is the additional information which you and Mr. Clayton requested on our Air Permit Application dated July 31, 1987.

Very truly yours,

Dario A. Sena

DAS:jh

Attachments

FILE COPY

REFERENCE 21

Reference 21

October 23, 1987

Mr. G. B. McClanahan
Eveready Battery Company, Inc.
Post Office Box 849
Asheboro, North Carolina 27204-0849

Dear Mr. McClanahan:

Subject: Air Permit No. 5035R3
Eveready Battery Company, Inc.
Asheboro, North Carolina
Randolph County

In accordance with your application received August 6, 1987, we are forwarding herewith Permit No. 5035R3 to Eveready Battery Company, Inc., Asheboro, North Carolina for the construction and operation of air pollution abatement facilities and emission sources.

If any parts, requirements, or limitations contained in this permit are unacceptable to you, you have the right to request an adjudicatory hearing within thirty (30) days following receipt of this permit, identifying the specific issues to be contended. This request must be in the form of a written petition, conforming to Chapter 150B of the North Carolina General Statutes, and filed with the Office of Administrative Hearings, Post Office Drawer 11666, Raleigh, North Carolina 27604. Unless such demand is made, this permit shall be final and binding.

This Permit supersedes Permit No. 5035R2. This permit shall be effective from October 23, 1987, until October 1, 1992, is nontransferable to future owners and operators, and shall be subject to the conditions and limitations as specified therein.

Sincerely yours,

R. Paul Wilms

NOV 1987
FILE COPY

Enclosures

cc: Mr. Larry Coble

NORTH CAROLINA ENVIRONMENTAL MANAGEMENT COMMISSION

DEPARTMENT OF NATURAL RESOURCES AND COMMUNITY DEVELOPMENT

A I R P E R M I T

To Construct and Operate, and For the Discharge of Air Contaminants Into the Atmosphere

---

In accordance with the provisions of Article 21B of Chapter 143, General Statutes of North Carolina as amended, and other applicable Laws, Rules and Regulations,

PERMISSION IS HEREBY GRANTED TO

Eveready Battery Company, Inc.
Plant No. 1
Asheboro, North Carolina

FOR THE

operation of:

a. one zinc casting tank repair operation,

b. fourteen zinc can extrusion units,

c. two zine drossing stations, and

air cleaning devices and appurtenances consisting of:

d. one bagfilter (3405 square feet of filter area, ID No. 1) installed on dry cell battery cathode mixing operations,

e. one bagfilter (3392 square feet of filter area, ID No. 2) installed on dry cell battery cathode mixing operations,

f. one simple cyclone (120 inches in diameter) installed on a scrap paper collection system,

g. one bagfilter (4 square feet of filter area) and one carbon filter (60 pounds of carbon) installed in series on a paper moisturizing operation,

h. one bagfilter (1150 square feet of filter area) installed on three zinc calot (pellet) lubricating units,

i. one bagfilter (150 square feet of filter area) installed on two zinc drossing stations using zinc chloride flux, and

j. one bagfilter (300 square feet of filter area) installed on the electrolyte paste manufacturing process,

FILE COPY

to remove particulate and visible emissions, and for the discharge of the treated air and vent gases into the outdoor atmosphere at its facility located at 800 Albemarle Road, Asheboro, North Carolina, Randolph County,

in accordance with the application received August 6, 1987, and in conformity with the plans, specifications, and other supporting data, all of which are filed with the Department of Natural Resources and Community Development and are incorporated as part of this Permit.

This permit supersedes Permit No. 5035R2. This Permit shall be effective from October 23, 1987, until October 1, 1992, is nontransferable to future owners and operators, and shall be subject to the following specified conditions and limitations:

1. The Permittee shall comply with applicable Environmental Management Regulations, including 15 NCAC 2D .0515, .0521, .0535, and .0537.

2. Reports on the operation and maintenance of the facility shall be submitted by the Permittee to the Division of Environmental Management at such intervals and in such form and detail as may be required by the Division. Information required in such reports may include, but is not limited to, process weight rates, firing rates, hours of operation, and preventive maintenance schedules.

3. As required by 15 NCAC 2D .0535, when particulate or visible emissions exceed Environmental Management Regulations for more than four hours the Regional Supervisor, Winston-Salem Region, (919)761-2351, of the Division of Environmental Management shall be notified as promptly as possible but in no case later than 24 hours of becoming aware of the occurrence. Such notice shall specify the facility name and location, the nature and cause of the excess emissions, the time when first observed, the expected duration, and the estimated rate of emissions. This reporting requirement does not allow the operation of the facility in excess of Environmental Management Regulations.

4. The Division of Environmental Management shall be notified in writing prior to the relocation of the facility, process, or air cleaning equipment.

5. This Permit does not relieve the Permittee of the responsibility of complying with any Federal, State, or local requirements governing the handling, disposal, or incineration of hazardous wastes, including the Resource Conservation and Recovery Act (RCRA) administered by the North Carolina Department of Human Resources.

NOV 1987
CEN:
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6. Any change in the information submitted in the application regarding facility emissions or changes in the quantity or quality of materials processed that will result in new or increased emissions must be reported to the Division of Environmental Management. If appropriate, modifications to the permit may then be made by the Division of Environmental Management to reflect any necessary changes in the permit conditions. In no case are any new or increased emissions allowed that will cause violation of the emission limitations specified herein.

7. The Permittee at least ninety (90) days prior to the expiration of this Permit shall request its extension by letter. The letter should include the permit number and a description of modifications, if any, that have been made.

8. This Permit is subject to revocation or modification upon a determination that information contained in the application or presented in support thereof is incorrect, conditions under which this Permit was granted have changed, or violations of conditions contained in this Permit have occurred. The facility shall be properly operated and maintained at all times in such a manner to effect an overall reduction in air pollution.

9. A violation of any term or condition of this Permit shall subject the Permittee to enforcement procedures contained in North Carolina General Statutes 143-215.114, including assessment of civil penalties.

Permit issued this the 23rd day of October, 1987.

NORTH CAROLINA ENVIRONMENTAL MANAGEMENT COMMISSION

R. Paul Wilms, Director
Division of Environmental Management
By Authority of the Environmental Management Commission

Air Permit No. 5035R3

NOV 1987
CENTRAL
FILE COPY

DISTRIBUTION: Permits_____
Region_____
Central Files___

Air Permit Review

Applicant	Site Location	County
Eveready Battery Co., Plant No. 1	Asheboro	Randolph

Applicant Contact	Phone	Applicability
R.B. Deza	(919)672-4543	NSPS____ NESHAPS____ TAX CERT____ Other_____

Permit No.	Reviewer:	Signature:	Date
5035R3	Jerry Clayton		10/6/87

Recommendations and Comments:
Issue P/N 5035R3

1. Application is made for:

	Emission Source	ID No.	Control Device	ID No.
a.	Paper Moisturizing Room	RPC 368317	Filter - 4 ft^2, 60 lb/carbon filter	RPC 36834
b.	Zince Casting Tank Repair Bench	--	None	--
c.	Zince Can Extrusion 14 units	see attached	None	--
d.	Zinc Calot Lubrication 3 units	RPC 368244/242	Filter - 1150 ft^2	RPC 36833
e.	Zinc Drossing 2 stations	RPC 368219	Filter - 150 ft^2	RPC 36821
f.	Zinc Casting Furnaces	RPC 368251	None	--
g.	Electrolyte Paste Mfg.	--	Filter - 300 ft^2	RPC 35969

2. Emissions Calculations and Regulation Applicability Analysis is attached.

3. New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP) do not apply. All applicable DEM air regulations should be met Recommend issuance of the air permit. Regional Office concurs. Ref: Hugh Jernigan, 10/6/87.

4. Prevention of Significant Deterioration (PSD) does not apply because this is a minor sour with no major source increases. The baseline date has not been triggered: therefore, increments are not affected.

/la

NOV 1987
CENTRAL
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a. The moisturizing room has a dual type filter using a plastic paper filter for particulate (mercurous chloride) and a carbon filter (60 lbs/activated carbon) for absorbing mercury vapors.

Emissions of mercurous chloride are stated to be 0.0000[illegible] lbs/hr to the filters and 0.00001 lb/hr in after control. Annual emission would be 0.0000438 TPY. Applicable reg is .053.

f. Zinc casting has 3 furnaces, totalling 900 lbs/hr (4.5 T/hr) maximum process weight. These units are not controlled. Zinc is melted and alloyed with lead (0.5% by wt) and cadmium (0.07% by weight.

EPA-450/3-77-010, Ind. Process Fugitive Particulate Emissions, Table 3-34 states TSP to be 0.055 lb/Ton for melting and alloying and casting to be 0.03 lb/Ton for uncontrolled sources. Total emission rate is 0.025 lb/Ton, since

NOV 1981
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TSP emissions would be:
4.5 Tons × 0.025 lb/Ton = 0.1125 lb/hr and 0.49 TPY

Assuming the ~~same~~ emissions to contain the same percentage of the alloyed metals, lead and cadmium emissions would be:

Pb – 0.1125 lb/hr × 0.002% Pb = 0.00023 lb/hr and 0.001 TPY

Cadmium – 0.1125 lb/hr × 0.0007 Cd = 0.00008 lb/hr and 0.00034 TPY

Allowable per .0515 is 11.2 lb/hr and 49.056 TPY.

c. Extruder emissions are negligible. Process wt is 2.5 T/hr.

b. Zinc coating tank emissions are negligible.

d. Three lubrication units use graphite and silicone, or antiblocking agent. 1.150 ft³ used with non-toxic coating for the three tumblers. 3000 CFM is the air to dilution is 2.6:1.

Reg. Ill. 07 1987 FILED

The silicone and antifoam serve to "wet" and adhere the graphite to the zinc pellets. Dust loading to the filter is stated to be 0.0 lb/hr. With 99.9% collection efficiency TSP emissions are negligible.

e. The two drossing units use zinc chloride as the fluxing agent. This does not "gas" as much as the ammonium chloride flux. Zinc oxide loading to the baghouse (1000 cfm : 50 ft² = 6.7:1 A/C ratio) is 0.05 lb/hr. TSP emissions are negligible. Mr Sena stated in a telcon on 10/7/87 that drossing is conducted on third shift only. Allowable per .055 is 1.62 lb/hr.

f. The paste manufacturing [illegible] a 300 ft² filter and 1000 cfm [illegible] to cloth ratio is 3.3:1. Materials are mixed into a wet paste. Dry magnesium chloride added to the process does

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To the atmosphere. Filter efficiency is stated to be 99%. The negligible allowable rate .055 is 3.38 lb/hr.

All sources will comply with applicable regulations.

Vestiges of mercury does not apply as this is not a named process

Permit is renewed for 5 yr as the existing permit expired on Oct 1, 1995.

REFERENCE 22

Reference 22

20

MAR 3 1 1987
GROUND WATER SECTION
RALEIGH, N. C.

RECEIVED
N.C. Dept. NRCD
AUG 21 1986
Division of
Environmental Management
Winston-Salem Reg. Office

CONTAMINANT MIGRATION STUDY
UNDERGROUND STORAGE TANK
EVEREADY BATTERY COMPANY (Union Carbide)
ASHEBORO, NORTH CAROLINA

S&ME PROJECT NO. 1381-86-008A

SOIL & MATERIAL ENGINEERS, INC.

SOIL & MATERIAL ENGINEERS, INC. ENGINEERING-TESTING-INSPECTION

135-C Montlieu Avenue, Box 18169, Greensboro, NC 27419, Phone (919) 855-7547

August 14, 1986

Eveready Battery Company
P.O. Box 849
Asheboro, North Carolina 27203

Attention: Mr. Buster Hill

Reference: Report
Contaminant Migration Study
Underground Storage Tank
Eveready Battery Company
Asheboro, North Carolina
S&ME Project No. 1381-86-008A

Gentlemen:

Soil & Material Engineers, Inc. (S&ME) has completed the soil and groundwater testing and evaluation as outlined in S&ME's proposal of April 30, 1986. This report presents data and conclusions relative to soil contamination, groundwater quality, as well as estimated groundwater flow direction and flow rate. Prior to this report, S&ME prepared a report on behalf of Black & Veatch which presented results of the test borings and monitor wells completed in March, 1986.

BACKGROUND

The presumed source of subsurface contamination was a storage tank which contained gasoline, diesel fuel, a degreaser solvent or some combination of those materials. The tank has been removed and the excavation backfilled. Eveready Battery Company records do indicate that the tank integrity was questionable in that it would not hold pressure during testing. Upon excavation, holes were noted and a chemical smell was evident. Some soil discoloration was observed.

A soil sample was obtained from the tank excavation and analyzed for volatile organics, acid-neutral extractables and base-neutral extractables. This analysis detected significant quantities of several volatiles including 1,1-dichloroethane, 1,1,1-trichloroethane and toluene. There were no acid-extractable compounds quantified

and only naphthalene was quantified among the base-neutral extractables. The semi-quantitative scan of both acid- and base-neutral extractables identified the possible presence of several other compounds.

In December 1985, five test borings and one monitor well were drilled by others. A total of 19 soil samples from these test borings were analyzed for 1,1-dichloroethane and benzene. The absence of these constituents in all but one sample may, however, be attributable to the two-month holding time (unrefrigerated) between sampling and analysis. The single well installed on December 6, 1985 (currently identified as W-2) was sampled on December 20 and again on February 20, 1986. On both occasions the samples were analyzed for a selected group of six volatiles. Of these analyses only 1,1-dichloroethane was detected at levels of 265 and 50 ppb, respectively, for the two dates.

In March, 1986 S&ME drilled two additional monitoring wells and five additional test borings. A total of 48 jar samples and two steel tube samples were collected. The jar samples were stored under refrigeration at the Black & Veatch laboratory until May 29, 1986. At that time, five samples were selected for testing and 15 samples were transported to Eveready Battery for long-term storage. The remaining 28 samples were discarded. As of the time work on the project was suspended in April, no groundwater sampling or well permeability testing had been performed. During drilling and soil sampling of these wells and borings, chemical odors were noted in several samples taken from locations near the former tank excavation. No odors were detected in any samples from the three boring/well holes located at distances of approximately 50 to 160 feet from the excavation. Further, no floating product was detected in either of the two S&ME installed wells.

HYDROGEOLOGIC CONDITIONS

As evidenced by the two wells and five soil test borings drilled by S&ME in March, the general subsurface conditions consist of fill overlying residuum. The fill was noted to consist of soft to very stiff clayey and/or sandy silts with variable amounts of rock fragments and organic debris. The fill was encountered to depths ranging from 5 to

13 feet below the present pavement surface. The residuum which underlies the fill in each boring is made up of those soils formed from the in-situ weathering of bedrock and includes some bedrock described on the Test boring Records as "partially weathered rock". The residual soils generally consisted of soft to hard clayey silt grading to stiff to hard sandy silt with rock fragments. The hard soils often exhibited the fissile structure of the metavolcanic slates from which they were derived. More detailed descriptions of the materials encountered at each drilling location are presented on the "Test Boring Records" which have been reproduced in this report.

The locations and ground surface elevations at each of the seven S&ME borings and wells and Well W-2 (drilled by others) were measured by a registered land surveyor. The locations are indicated on the enclosed Drwg. 008A-1. The elevations were based on a temporary bench mark (a sanitary sewer manhole cover in Brady Avenue) identified as elevation 838.24 feet.

Each of the five test borings (B-101 through B-105) had caved some time after the completion of drilling in March. Thus, reliable groundwater levels could not be obtained. We, therefore, removed some of the caved material by hand-auger and installed temporary standpipes in Borings B-104 and B-105. Boring B-103 was judged to provide an accurate reading without a standpipe while Boring B-101 and B-102 were abandoned. A final set of groundwater level measurements was made on June 24, 1986. These data are presented as follows:

Location	Groundwater Depth (feet)	Groundwater Elevation (feet)
W-1	13.2	822.6
W-2	7.0	818.0
W-3	7.5	814.9
B-103	13.3	822.8
B-104	14.0	822.0
B-105	14.1	817.4

Based on these data, groundwater contours (lines of equal potential) were estimated. These contours are presented in conjunction with groundwater elevations at the

boring/well locations on Drwg. 008A-1. In the vicinity of the former storage tank site, the implied groundwater flow direction is to the northwest. The estimated gradient is 0.07.

In addition to the groundwater level measurements presented above, S&ME performed rising head permeability (hydraulic conductivity) tests in each of the three monitor wells. The following hydraulic conductivities were computed:

Well No.	Hydraulic Conductivity (ft/day)
W-1	0.004
W-2	0.028
W-3	0.005

Based on these hydraulic conductivities, a gradient of 0.07, and an assumed soil porosity of 0.3, we compute the groundwater particle velocity to be in the range of 0.34 to 2.4 feet per year.

LABORATORY ANALYSES

Groundwater samples from each of the three monitor wells as well as five test boring soil samples were analyzed for volatile organics, ethylene dibromide (EDB), and lead. In addition one background soil sample was analyzed for total lead. The results of these analyses are presented in Table I.

The groundwater data indicates that Wells W-2 and W-3 are relatively free of contaminants. The EDB that was identified in W-2 in the May 29, 1986 sampling was not confirmed by testing of samples obtained on June 24, 1986. Conversely, Well W-1, which is located nearest the former tank excavation, identified significant concentrations of benzene, toluene and xylene but no other volatiles. Based on the estimated range in groundwater flow velocity, we would not expect contaminants to

have reached either Well W-2 or W-3 as yet. Given the location of Well W-1 within the Eveready Battery property, it does not appear that this contamination will threaten any offsite water body in the near future, if ever.

A review of the soil analyses indicates the results to be quite variable with a number of volatiles identified. Among the most significant constituents were chloroform (less than 1.0 to 171 ug/kg), 1,4-dichlorobenzene (284 ug/kg), 1,1-dichloroethane (less than 1.0 to 68.4 ug/kg), 1,1,2,2-tetrachloroethane (49.7 ug/kg), 1,1,1-trichloroethane (less than 1.0 to 67.9 ug/kg), and 1,1,2-trichloroethane (less than 1.0 to 48.7 ug/kg). Benzene, toluene and xylene, which had been detected in the groundwater from Well W-1, were not found in any of the soil samples. Thus, while the contaminant levels in the soil may be judged significant, it does not appear that this soil contamination has contributed to any degradation of site groundwater.

If you have any questions concerning information presented in this report, please contact us.

Very truly yours,

SOIL & MATERIAL ENGINEERS, INC.

Dane A. Horna, P.E.
Branch Manager

DAH/vl

Enclosures

APPENDIX

KEY TO
TEST BORING RECORDS

ABBREVIATIONS

Soil/Groundwater

Alluv.	Alluvium
Res.	Residuum
PWR	Partially Weathered Rock
Mica.	Micaceous
C	Coarse
M	Medium
F	Fine
Sli	Slightly
w/	With
V.	Very
g/w	Groundwater

Drilling

TOB	Termination of boring
TOD	Termination of drilling

SYMBOLS

TOB/TOD Groundwater Level

24-Hour Groundwater Level

Undisturbed Sample

NOTES

1. Boring and sampling satisfy ASTM D-1586. Core Drilling satisfies D-2113.

2. "Blows per six inches" (N-value) refers to the number of impacts required of a 140-lb. hammer falling 30 inches to drive a 1.4-inch inner diameter split-spoon sampler six inches. Three consecutive six-inch "drives" are executed at each sampling depth, except when material requiring 50 or more blows per six inches (e.g., 50/3") is encountered. In this case, the sampling at that particular depth is terminated in the drive where the "50+" material occurs.

3. "Penetration" (blows per foot) is a numerical quantity calculated at each sampling depth by summing the last two six-inch blows. In the case of a partial drive (e.g. 50/3"), a value of 100 is assumed. A graphical representation of penetration values is plotted to the left of "blows per six inches" on the Test Boring Records.

4. Recovery (REC), is a term used to describe the retrieved quantities of both soil and rock samples. When associated with soil sampling, it is the retrieved length, in inches, of the split-spoon sample. The maximum is 18 inches. With respect to rock coring, recovery is the ratio of the retrieved length of rock core to the length of the core run times 100%.

5. The Rock Quality Designation (RQD) is the ratio of the cumulative length of those core segments 4 inches or longer to the total length of the core run times 100%. When calculating RQD, mechanical fractures caused by drilling and/or core retrieval are discounted.

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.	REC. (IN.)
0.0			0 10 20 30 50		
0.6	Asphalt & Crusher Run			6-7-8	18
3.0	Stiff Tan & Grey Fine Sandy Silt-Fill;Trace Odor			8-5-6	18
	Stiff to Med. Stiff Red & Yellow to Tan & Grey Sli. Fine Sandy Clayey Silt; Trace Odor			3-2-3	18
8.0				3-4-5	18
9.5	Stiff Tan & Blue-Grey Sli. Fine Sandy Clayey Silt w/ Organics;Trace Odor			7-20-21	18
				13-18-23	18
	Hard Tan & Blue-Grey Sli. Fine Sandy Silt-Res.; Trace to Moderate Odor			9-14-13	18
17.8				50/5"	5
	PWR sampled as Tan & Brown Sli. Fine Sandy Silt w/ Rock Fragments. Soil Seam from approx. 25.0-28.0 ; Sli. Odor to 23.5 then None			50/5"	4
				50/4"	4
				8-14-19	18
				20-47-50/2"	14
33.5	Boring Terminated Auger Bored from 28.5 to 33.5 w/ no samples taken				

REFER TO ATTACHED SHEET FOR EXPLANATIONS AND SYMBOLS

JOB NUMBER 1381-86-008
BORING NUMBER W-1
DATE 3-4-86

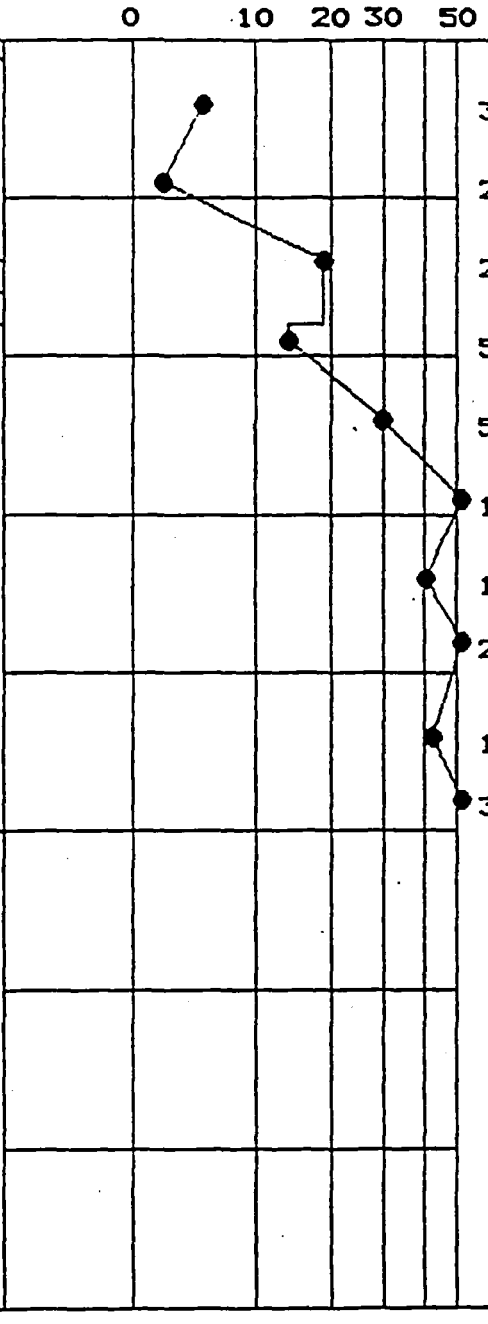
PAGE 1 OF 1

SOIL & MATERIAL ENGINEERS, INC.

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	BLOWS PER SIX IN.	REC. (IN.)
0.0			
0.6	Asphalt & Crusher Run		
	M. Stiff to Soft Orange & Grey Sli. Clayey Silt w/ Wood Debris at Bottom of Strata-Fill	3-2-3	18
		2-1-1	18
7.0		2-1-18	10
8.0			
9.0	Stiff Orange & Grey Sli. Clayey Silt w/ Trace of Organics & Rock Fragments-Poss. Fill/Poss. Res.	5-6-8	18
		5-7-23	18
	Stiff Orange & Yellow Clayey Silt-Res.	11-23-35	18
		10-22-19	18
	Hard Grey & Tan to Tan & Brown Sli. Clayey Silt w/ PWR Lenses & Clayey Seams	24-50/5"	11
		19-24-19	18
		36-50/6"	12
25.0	Boring Terminated No Hydrocarbon Odor Detected in Boring		

ELEVATION (FT.) — PENETRATION (BLOWS/FT.): 0, 10, 20, 30, 50



REFER TO ATTACHED SHEET FOR EXPLANATIONS AND SYMBOLS

JOB NUMBER 1381-86-008
BORING NUMBER W-3
DATE 3-5-86

SOIL & MATERIAL ENGINEERS, INC.

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.	REC. (IN.)
0.0			0 10 20 30 50		
0.6	Asphalt & Crusher Run			5-9-7	18
	V./ Stiff & Stiff Orange & Black FSli. C-F Sandy Silt & Red Sli. Clayey Silt-Fill Soft zone,5.5' - 6.5';No Odor in stratum			13-5-3	18
				1-2-1	18
8.0	Stiff Tan & Grey Sli. M-F Sandy Silt w/ Clayey Seams-Res.; Trace Odor			4-5-8	18
12.0	Hard Tan Sli. M-F Sandy Silt w/ Clayey Seams & Rock Fragments; Trace Odor			19-25-32	18
19.0				22-29-50/5"	17
19.4	PWR sampled as Tan Sli. M-F Sandy Silt w/ Rock Fragments; No Odor				
	Boring Terminated				
	UD REC = 100%(12' - 13')				
	Boring Caved @ 14.2',24 Hr.				

REFER TO ATTACHED SHEET FOR EXPLANATIONS AND SYMBOLS

JOB NUMBER 1381-86-008
BORING NUMBER B-101
DATE 3-6-86

SOIL & MATERIAL ENGINEERS, INC.

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 30 50	BLOWS PER SIX IN.	REC. (IN.)
0.0	Gravel/Soil Backfill in Tank Excavation; Moderate Odor				
11.0	Hard Tan & Blue-Grey Sli. Fine Sandy Silt-Res.; Moderate to No Odor from 11.0'- 20.0'			13-14-16	18
				12-12-22	18
				16-16-21	18
				20-24-30	18
22.5	Boring Terminated No Groundwater Encountered at TOB				

REFER TO ATTACHED SHEET FOR EXPLANATIONS AND SYMBOLS

JOB NUMBER 1381-86-008
BORING NUMBER B-102
DATE 3-10-86

SOIL & MATERIAL ENGINEERS, INC.

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 30 50	BLOWS PER SIX IN.	REC. (IN.)
0.0					
0.6	Asphalt & Crusher Run				
	Stiff Grey & Red and Red-Orange Sli. M-F Sandy Clayey Silt w/ Rock Fragments-Res.; No Odor			8-6-8	18
				6-4-5	18
9.5					
	Soft, Saturated Zone of Red,Grey,& Tan Sli. Clayey Silt w/ Rock Fragments-Poss. Fill/Poss. Res.; Moderate to Strong Odor			0-0-2	18
12.5				6-9-21	18
16.5	Hard Tan Silt w/ Rock Fragments; Moderate Odor			29-50/5"	11
	PWR Sampled as Tan...(same as previous); Moderate to Trace Odor			50/4"	3
				50/1"	1
31.1	Auger Refusal			50/2"	2
	UD REC=100%(9' - 11')				

REFER TO ATTACHED SHEET FOR EXPLANATIONS AND SYMBOLS

JOB NUMBER 1381-86-008
BORING NUMBER B-103
DATE 3-6-86

SOIL & MATERIAL ENGINEERS, INC.

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.	REC. (IN.)
0.0			0 10 20 30 50		
1.2	Asphalt & Crusher Run				
	M. Stiff Grey, Brown, & Orange Clayey Silt-Fill			4-2-3	18
6.0	Stiff Grey & Tan Sli. Clayey Sli. M-F Sandy Silt w/ Organic Debris-Fill			2-2-8	18
13.0	Hard to V. Hard Green-Grey to Blue-Grey & Tan Silt-Res.			12-16-21	18
				24-44-48	18
20.0	-Boring Terminated -No Hydrocarbon Odor Detected in Boring -Boring Caved at 15.5',24 Hrs.				

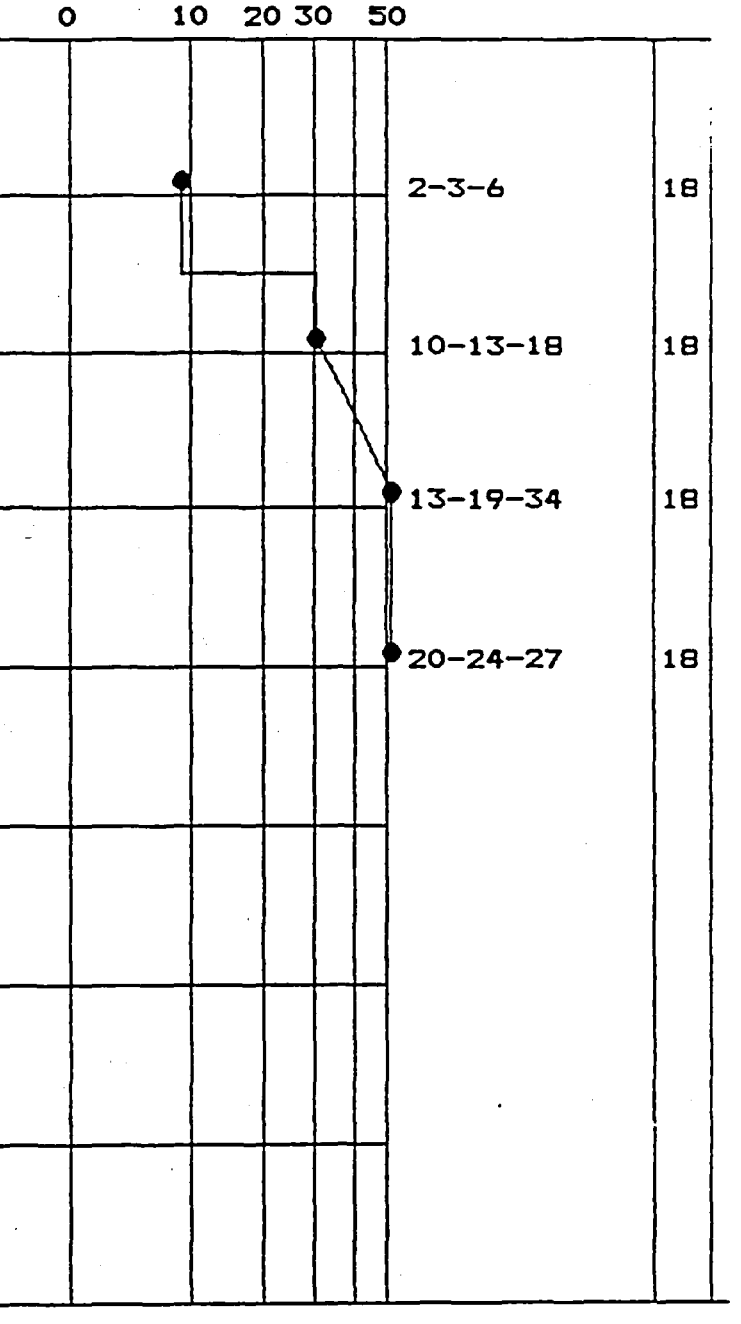
REFER TO ATTACHED SHEET FOR EXPLANATIONS AND SYMBOLS

JOB NUMBER 1381-86-008
BORING NUMBER B-104
DATE 3-10-86

SOIL & MATERIAL ENGINEERS, INC.

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.	REC. (IN.)
0.0	Stiff Orange-Brown & Grey C-F Sandy Clayey Silt w/ Rock Fragments-Fill				
5.0	Stiff Orange-Tan Clayey Silt-Res.			2-3-6	18
7.5	Hard Grey-Orange & Tan Sli. M-F Sandy Silt			10-13-18	18
				13-19-34	18
				20-24-27	18
20.0	-Boring Terminated -No Groundwater Encountered at TOB -No Hydrocarbon Odor Detected in Boring				



REFER TO ATTACHED SHEET FOR EXPLANATIONS AND SYMBOLS

JOB NUMBER 1381-86-008
BORING NUMBER B-105
DATE 3-11-86

SOIL & MATERIAL ENGINEERS, INC.

SOIL & MATERIAL ENGINEERS, INC.
P.O. Box 18169
GREENSBORO, NC 27419
(919) 855-7547

1381-86-008

JOB UNION CARBIDE PLANT #1

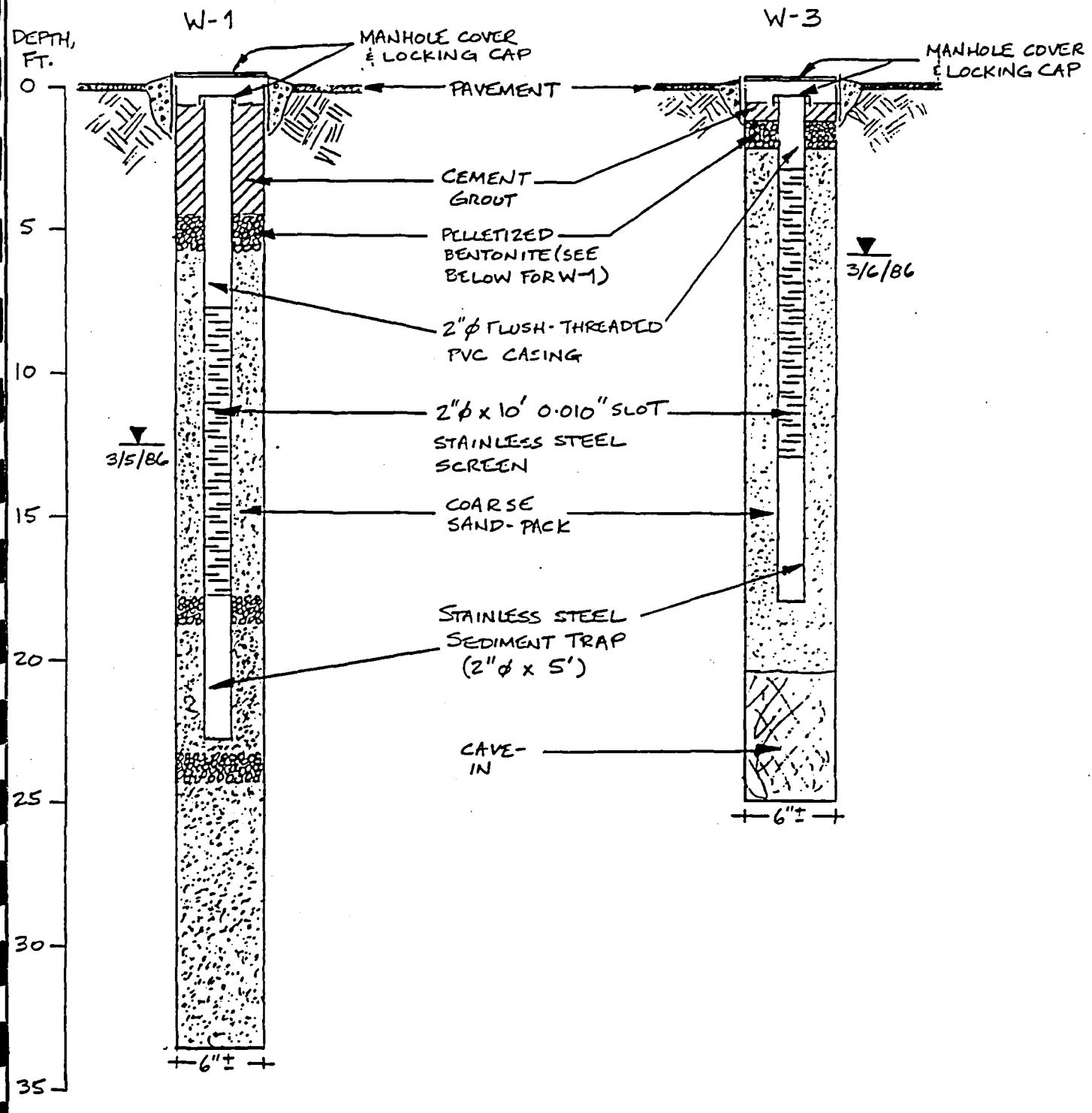
SHEET NO. 1 OF 1

CALCULATED BY C. MIMS DATE 4/18/86

CHECKED BY _____ DATE _____

SCALE (VERTICAL): 1" =

MONITOR WELL SCHEMATICS



E I

TIFICATION

SOIL

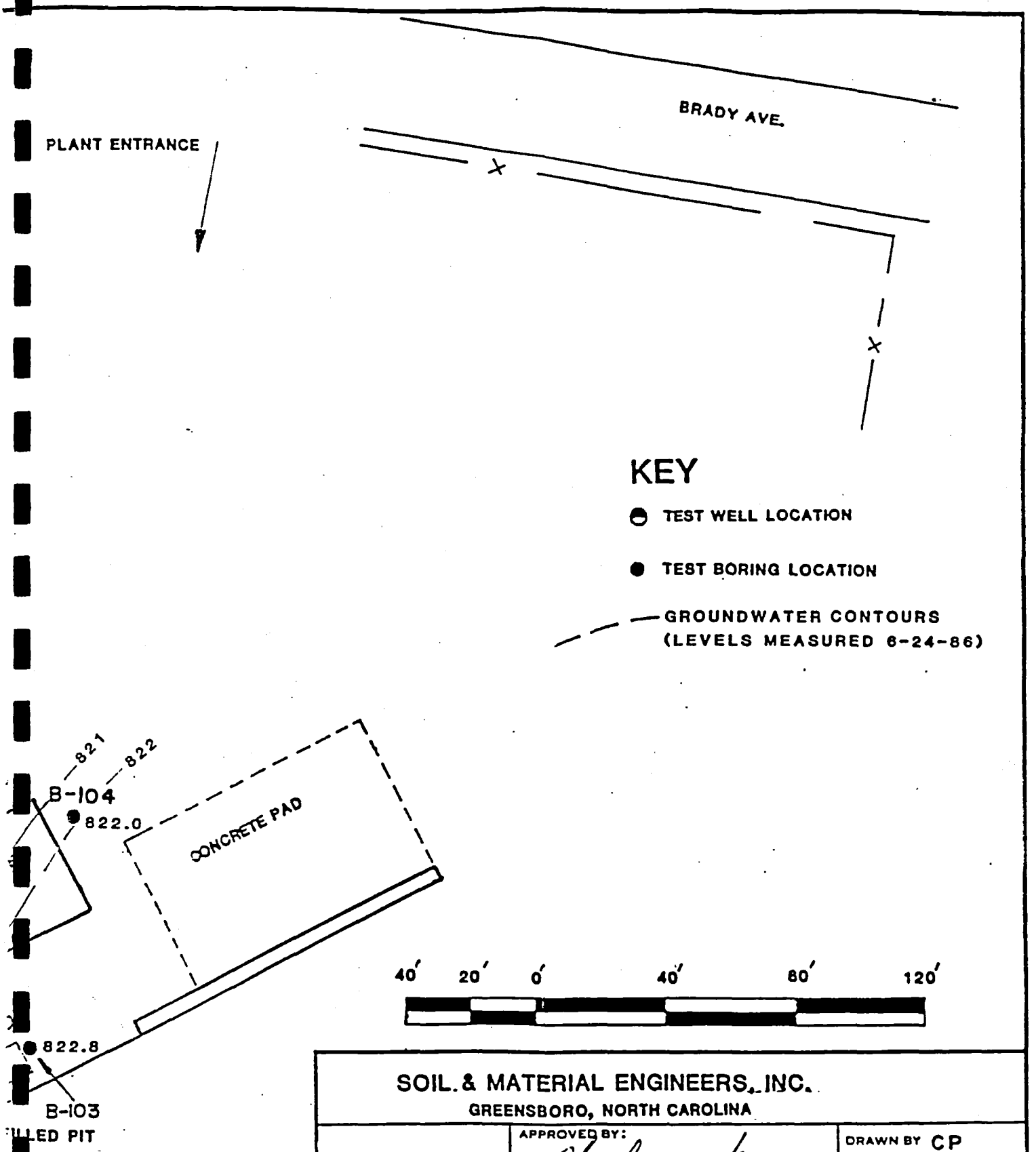
		W-1 12 ft.	W-1 17 ft.	B102 19 ft.	B103 12 ft.	B103 21 ft.	BKGD. 1 ft.
2							
24/86		3/4/86	3/4/86	3/10/86	3/6/86	3/6/86	6/24/86
	UNITS						
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	27.5	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	171	59.0	4.7	<1.0	14.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	284	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	68.4	2.1	<1.0	<1.0	2.5	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	5.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	8.4	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	30.4	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	49.7	-
	ug/kg	<1.0	12.9	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	5.4	67.9	<1.0	5.4	42.3	-
	ug/kg	<1.0	41.2	<1.0	<1.0	48.7	-
	ug/kg	5.1	2.4	<1.0	<1.0	2.3	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-
	mg/kg	4.96	6.22	7.47	9.22	15.5	12.8
0.010	ug/kg	<1.0	<1.0	<1.0	<1.0	<1.0	-

TA

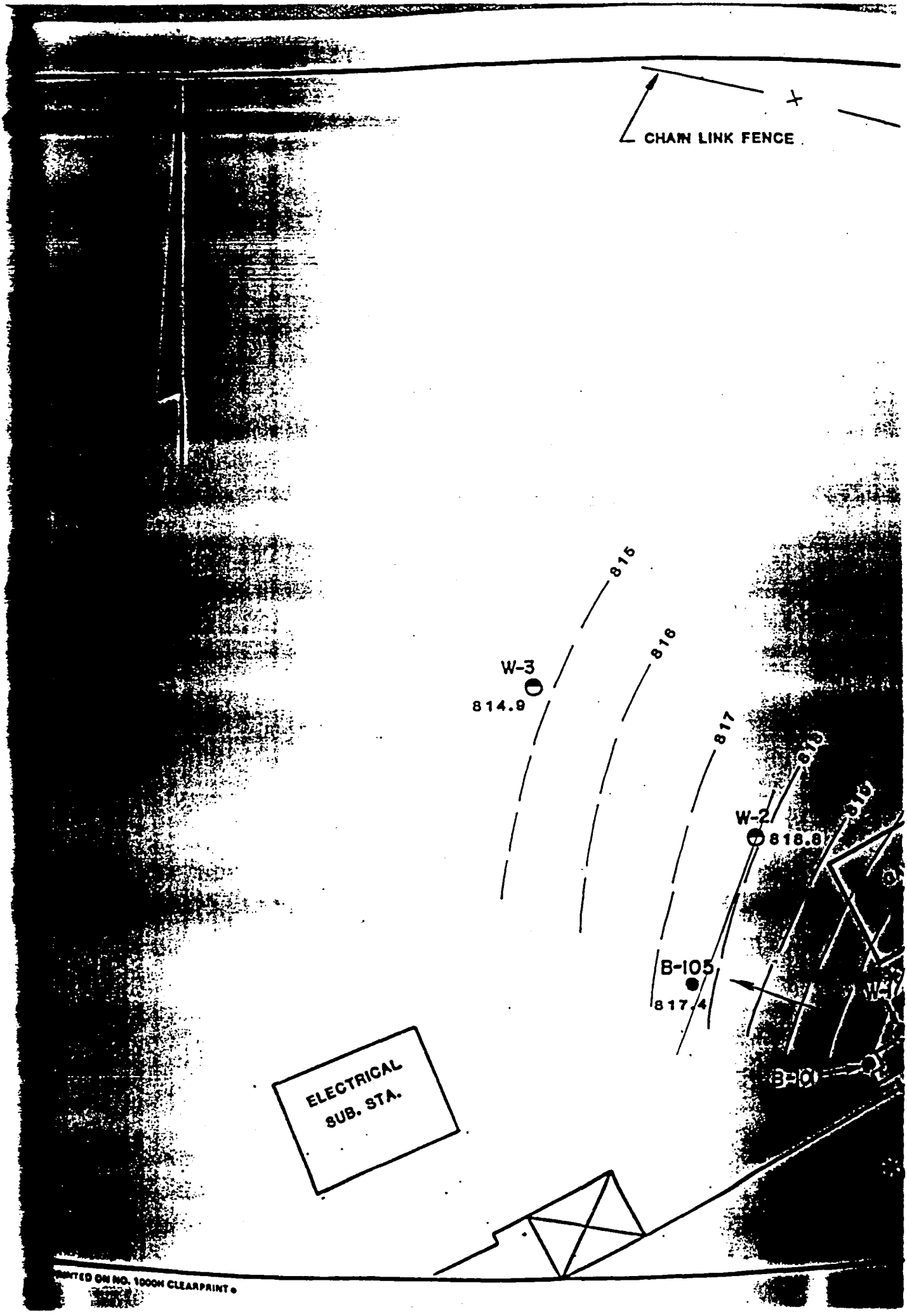
SAMPLE ID

WATER

PARAMETER	UNITS	W-1	W-2	W-3	W-1
Sample I.D.:		W-1	W-2	W-3	W-1
Sample Date:		5/29/86	5/29/86	5/29/86	6/24/86
Benzene	ug/L	72.2	<1.0	<1.0	-
Bromodichloromethane	ug/L	<1.0	<1.0	<1.0	-
Bromoform	ug/L	<1.0	<1.0	<1.0	-
Bromomethane	ug/L	<1.0	<1.0	<1.0	-
Carbon Tetrachloride	ug/L	<1.0	<1.0	<1.0	-
Chlorobenzene	ug/L	<1.0	<1.0	<1.0	-
Chloroethane	ug/L	<1.0	<1.0	<1.0	-
2-Chloroethylvinyl Ether	ug/L	<1.0	<1.0	<1.0	-
Chloroform	ug/L	<1.0	<1.0	<1.0	-
Chloromethane	ug/L	<1.0	<1.0	<1.0	-
Dibromochloromethane	ug/L	<1.0	<1.0	<1.0	-
1,2-Dichlorobenzene	ug/L	<1.0	<1.0	<1.0	-
1,3-Dichlorobenzene	ug/L	<1.0	<1.0	<1.0	-
1,4-Dichlorobenzene	ug/L	<1.0	<1.0	<1.0	-
Dichlorodifluormethane	ug/L	<1.0	<1.0	<1.0	-
1,1-Dichloroethane	ug/L	<1.0	<1.0	<1.0	-
1,2-Dichloroethane	ug/L	<1.0	<1.0	<1.0	-
1,1-Dichloroethene	ug/L	<1.0	<1.0	<1.0	-
trans-1,2-Dichloroethene	ug/L	<1.0	<1.0	<1.0	-
1,2-Dichloropropane	ug/L	<1.0	<1.0	<1.0	-
cis-1,3-Dichloropropane	ug/L	<1.0	<1.0	<1.0	-
Ethyl Benzene	ug/L	<1.0	<1.0	<1.0	-
Methylene Chloride	ug/L	<1.0	<1.0	<1.0	-
1,1,2,2-Tetrachloroethane	ug/L	<1.0	<1.0	<1.0	-
Tetrachloroethene	ug/L	<1.0	<1.0	<1.0	-
Toluene	ug/L	42.6	<1.0	<1.0	-
1,1,1-Trichloroethane	ug/L	<1.0	<1.0	<1.0	-
1,1,2-Trichloroethane	ug/L	<1.0	<1.0	<1.0	-
Trichloroethene	ug/L	<1.0	<1.0	<1.0	-
Trichlorofluoromethane	ug/L	<1.0	<1.0	<1.0	-
Vinyl Chloride	ug/L	<1.0	<1.0	<1.0	-
Xylenes	ug/L	1300	<1.0	<1.0	-
Lead	mg/L	0.021	0.001	0.020	-
Ethylene Dibromide	ug/L	48.9	3.08	< 0.010	< 0.010



SOIL & MATERIAL ENGINEERS, INC. GREENSBORO, NORTH CAROLINA		
DATE: 7/21/86	APPROVED BY:	DRAWN BY CP REVISED
EVEREADY BATTERY COMPANY ASHEBORO, NORTH CAROLINA		
GROUNDWATER CONTOUR MAP		DRAWING NUMBER 008A-1



PRINTED ON NO. 1000H CLEARPRINT

REFERENCE 23

AQ-10 Revised 3/1/84

NORTH CAROLINA DIVISION OF ENVIRONMENTAL MANAGEMENT

Reference 23

Air Quality Action Request

Computer _____

Name	Location	Reg/Co./Prem. No.
Everready Battery Company, Plt. 1	Asheboro, Randolph County	4/76/10111

Contact: Dario Sena, Plant Engineer

Telephone:

Type Action: CI ___ EE X SR ___ PC ___ VE ___ PI ___ Other _____

Air Program Status 03 ___ ___ ___ ___ Class B Chg. _____

Action Requested By: WSRO

Address/Phone

Rec'd Date

Last Insp. Date _____ Action Date 7/24/87 Next Insp. Date 7/1/91

Permit # 5035R2 Issued 6/30/86 Expires 10/1/87 Stip. # _____ Met Y/N _____

Recommendations:

Signature: Hugh W. Jernigan

Date: 8/21/87

Dist: Yellow (Central File) - Blue (Region) - White (Opt.) Specify _____

SOURCES:

A. Bagfilter (ID No.1) (3405 sq. ft. filter area) installed on dry cell cathode mixing operations

B. A bagfilter (ID No. 2) (3392 sq. ft. filter area) installed on dry cell cathode mixing operations

C. A simple cyclone 120 inch diameter installed on a scrap paper collection system

D. A paper moisturizing room with a carbon bed adsorption filter installed on the exhaust (to be constructed at a later date)

E. A zinc casting tank repair bench exhaust

F. 14 zinc can extrusion machines

G. 3 zinc calot lubricators with an associated bagfilter

H. A zinc drossing operation with associated bagfilter

I. 3 zinc casting furnaces

J. An electrolyte paste weighting operation with an associated bagfilter

The facility is a dry cell battery manufacturer. The source has been repeatedly inspected since 1972 and has maintained compliance. Conducted an in depth inspection of the site on 7/24/87 as follows:

A. Bagfilter I.D. No. 1 is utilized for hooded dust collection systems on dry material mixing, raw material weighing, bobbin cleaners, electrode packers and a bag compactor. This bagfilter was observed with no visible emissions.

B. Bagfilter I.D. No. 2 is utilized for hooded dust collection systems for raw material weighing, dry material mixing, raw material storage, and dry material bag opening operations. This bagfilter was observed in operation with no visible emissions.

CENTRAL FILE COPY

- OVER -

C. A cyclone is utilized to collect scrap paper from various paper cutting processes at the site. This was not in operation at the time of the visit, but previously evaluated to be in compliance. Collected scrap paper is compacted upon collection for disposal.

The three above-described sources have been the only identifiable sources previously noted and permitted at the site. All other operations listed below are not currently permitted, but have a permit application on file, pending review. None of these sources were observed in operation at the time of the visit.

D. The company is planning to install a moisturizing room for paper used in the battery manufacturing operation by the fall of 1987. The purpose of this room is to raise the moisture content of the paper to make it more plyable for use in the process. Upon initial discussions it was felt the exhaust from this room did not require a permit. In discussions with Mr. Sena it was revealed the exhaust will have a carbon bed filter. Mr. Sena proposed the carbon filter due to the fact that the paper is treated with mercurous chloride during the paper manufacturing before being shipped to Everready Battery. While in the moisturizing room there is a potential for mercurous chloride emissions. The addition of the carbon filter would reduce the projected maximum emissions of 0.00008 lb/hr to 0.00001 lb/hr and would comply with any future proposed toxic pollutant regulations. Therefore, it was agreed to apply for a permit for the system.

E. A hood is utilized to exhaust air from a repair bench where zinc dispensings are repaired. This is infrequently used and was not in operation. Emissions from this process are negligible.

F. There are 14 zinc can extrusion machines where zinc pellets are fed into an extruder punch and formed into cans. Each of the machines are enclosed for noise control and are vented atmospherically. Emissions from these operations are negligible.

G. Zinc pellets are lubricated with graphite and silicone in these lubrication machines. These machines vent to a small Torit bagfilter located inside the plant which vents atmospherically. The collector is adequate control for the small amount of generated zinc and graphite emissions.

H. During the melting of zinc alloy in the melting furnaces, the molten material is "drossed" or treated with zinc chloride to remove the zinc oxide from the molten metal. The material is removed from the furnaces and placed in two 55 gallon drums. The drums are hooded and air is transferred to a small Torit bagfilter located inside the plant and exhausting to the atmosphere.

I. Three electric induction furnaces are utilized to melt zinc alloys in the pellet forming process. The emissions from this process should be negligible.

J. An operation in which electrolyte paste is manufactured, the weighing of dry mercuric chloride, starch, and flour to the electrolyte solution. This operation is hooded and exhausts to a small Torit bagfilter located inside the plant, exhausting atmospherically. Emissions from this operation are negligible.

All sources at the site are evaluated to be in compliance with air quality emission regulations. Previous inspections at the site have indicated compliance and have not determined sources E, F, G, H, I, and J to require permits. A permit application for all sources has been submitted and it is felt that a notice of noncompliance is not necessary for unpermitted sources at this time.

REFERENCE 24

Reference 24

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

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

ENTERED
JUL 26 1982
DATA PROCESSING

July 8, 1982

Mr. Vincent Godette
Union Carbide Corporation
P.O. Box 849
Asheboro, NC 27203

Dear Mr. Godette:

On June 22, 1982 Mr. Steve Phibbs of the Solid and Hazardous Waste Management Branch conducted a RCRA inspection of your facility. You were found to be in compliance with the standards.

This office wishes to thank you for your cooperation and please do not hesitate to contact us if we may be of future assistance.

Sincerely,

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

OWS:nlc

cc: Mr. Steve Phibbs

RCRA Inspection Report

1) Facility Information
Union Carbide Corporation
800 Albermarle Road
Asheboro, NC 27203
Randolph County
E.P.A. ID# NCD003216462

2) Facility Contact
Vincent Godette

3) Survey Participants
Vincent Godette, Union Carbide
Ken Brown, Union Carbide
Derrio Sena, Union Carbide
Steve Phibbs, District Sanitarian, Division of Health Services

4) Date of Inspection
June 22, 1982

5) Applicable Regulations
40 CFR Part 262 and Part 265

6) Scope of Survey
RCRA interim status inspection was conducted by the North Carolina Solid and Hazardous Waste Management Branch. The scope of the survey covered record review and site survey. Applicable regulations covered those in 40 CFR Part 262, Generator Standards and Part 265, General Facility Standards; chemical, physical and biological treatment.

7) Facility Description
Union Carbide manufactures dry cell (paste) batteries used for residential and commerical purposes. Waste oils are generated from the lubricating and cleaning of facility equipment. The oils are transported to Holston Oil Company in Waynesville, NC, where they are reprocessed and used as fuel oil. Personnel at Union Carbide has been notified to thoroughly analyze the waste oils to insure that it does not meet the hazardous waste regulations.

Union Carbide has a wastewater pre-treatment system (filtration) used to remove suspended solids prior to discharge to the Asheboro wastewater treatment system. The wastes are genereated from the clean up of the production equipment and all other plant areas. The wastewater goes through a grease settling tank, then to a holding tank, then through a sand filtration unit and finally through a charcoal filter. The filter media in these tanks is removed and recharged ever six (6) months. This material will be analyzed each time prior to disposition because of the fluctuating mercury concentrations. Disposal location will depend on meeting the extraction procedure toxicity test and other relative RCRA standards.

8) Site Deficiencies
None

INSPECTION FORM FOR INTERIM STATUS STANDARDS FOR OWNER/OPERATOR OF HAZARDOUS WASTE MANAGEMENT FACILITIES

Name of Site: Union Carbide
EPA I.D.: NCD003216462
County: Randolph
Location: 800 Albemarle Rd.; Asheboro, N.C.
Signature of Facility Contact: Vincent D. [illegible]
Date: 6/22/82
Signature of Inspector(s): Steve Phillips

INSTRUCTIONS: Place a check to indicate Compliance (C), NonCompliance (NC) or Not Applicable (NA). Cite specific violation by Section No.

	C	NC	NA	Violation(s)
1. GENERAL	✓			
2. GENERAL FACILITY STANDARDS	✓			
3. PREPAREDNESS AND PREVENTION	✓			
4. CONTINGENCY PLAN AND EMERGENCY PROCEDURES	✓			
5. MANIFEST SYSTEM, RECORDKEEPING, AND REPORTING	✓			
6. GROUND-WATER MONITORING			✓	
7. CLOSURE AND POST-CLOSURE	✓			
8. FINANCIAL REQUIREMENTS	✓			
9. USE AND MANAGEMENT OF CONTAINERS	✓			
10. TANKS			✓	
11. SURFACE IMPOUNDMENTS			✓	
12. WASTE PILES			✓	
13. LAND TREATMENT			✓	
14. LANDFILLS			✓	
15. INCINERATORS			✓	
16. THERMAL TREATMENT			✓	
17. CHEMICAL, PHYSICAL, AND BIOLOGICAL TREATMENT	✓			
18. UNDERGROUND INJECTION			✓	

Generator and treatment facility only.

	YES	NO
Imminent Hazard	( )	(✓)

DHS Form 3010 (7-81)
SOLID & HAZARDOUS WASTE

REFERENCE 25

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

Reference 25

GEOGRAPHY

Area and Population

The area covered by this report totals 2,605 square miles. According to the 1960 Bureau of the Census report, the Durham area has a population of 269,741, or about 103 per square mile. There are 15 cities and towns having a population of more than 1,000 each. Of these, Asheboro, Chapel Hill, and Durham have a population in excess of 10,000. The city of Durham is by far the largest with a population of 79,398. With the exception of the Durham-Chapel Hill, and Asheboro-Randleman areas, the report area is almost exclusively rural.

Economic Development

According to the 1960 Census, 62 percent of the Durham area is classed as farmland.

The agricultural products include tobacco, corn, hay, dairy products, livestock, and poultry. Tobacco is the chief cash crop and is the major source of income for many farm families. The broiler industry is an important source of farm income in Chatham County.

Manufacturing is important in the Durham area. Many people who operate small farms are employed on a full or part-time basis by industry. Industries include the manufacture of cigarettes, furniture, textiles, lumber, brick, and tile; the production of crushed stone; and poultry processing.

Mineral resources of economic importance include shale, clay, stone, pyrophyllite, and coal (Broadhurst, 1955). Copper, gold, lead, zinc, quartz, iron ore, and kyanite also are present in the Durham area. Triassic shale and clay used in the manufacture of brick and tile, and stone, which is crushed for road metal and general construction purposes, are the area's most valuable mineral resources. Argillite from the argillite-graywacke unit (pl. 2) meets the rigid requirements for primary highway construction. The argillite, where it is well sheared and jointed, has proved to be an economic source of crushed stone, owing to its ease of excavation and crushing. Where the argillite has a well-developed bedding plane cleavage and is not deformed, it is a potential source of building stone.

Pyrophyllite is mined only at Hillsboro in Orange County. Coal is interbedded with the Triassic rocks in southern Chatham County in economic quantities (Reinemund, 1955), but it is not being mined at the present time. Copper deposits occur in Person County, and in Chatham County near Harpers Cross Roads, but they are not economically important under present market conditions.

Climate

Comparison of U. S. Weather Bureau records at five stations for the 30-year period 1931-60 reveals that the Durham area has a normal annual temperature of 60.1° F. Records of precipitation for the same period show that the normal annual precipitation at nine stations ranges from a maximum of 45.14 in. at Moncure in Chatham County to a minimum of 42.65 in. at Durham in Durham County. The normal monthly precipitation and temperature at the Chapel Hill station are plotted on figure 2.

Physiography and Drainage

The Durham area is within the Piedmont physiographic province. According to Fenneman (1938), the Piedmont is an uplifted peneplain in various stages of dissection, having a general slope from the mountains toward the Coastal Plain. In the southern part of Durham County and in the eastern part of Chatham County (pl. 2) the Piedmont upland is interrupted by a distinct lowland developed on weak Triassic rocks.

Topographic coverage is available for approximately one-tenth of the report area. Where coverage is not available, relief is estimated to rarely exceed 300 feet and to average about 50 feet per mile. An exception is in the vicinity of the Uwharrie Mountains in Randolph County, where relief commonly is in excess of 400 feet per mile. The Piedmont upland slopes from 850 feet in northwestern Randolph County to 180 feet in southeastern Chatham County, and from 700 feet in northeastern Orange County to 250 feet in eastern Durham County.

Surface water, derived from direct runoff and ground-water discharge, is drained by four major stream systems—the Pee Dee, the Cape Fear, the Neuse, and the Roanoke Rivers (fig. 3). Randolph County is drained by the Uwharrie River, which empties into the Pee Dee River, and by the Deep River, which empties into the Cape Fear River. The Deep River, which

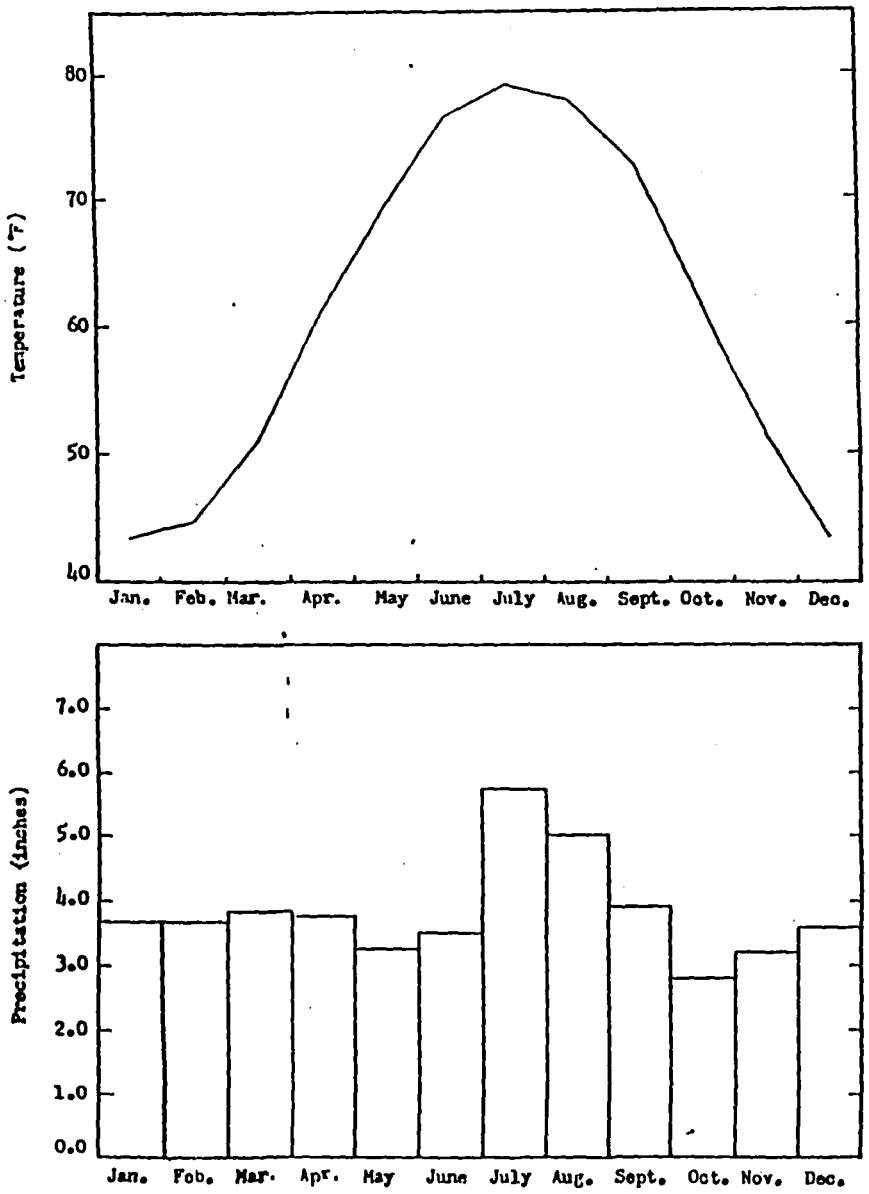


Figure 2. Normal monthly temperature and precipitation at Chapel Hill in Orange County for the period of record, 1931-60.

forms most of the southern border of Chatham County, joins with the Haw River near Moncure to become the Cape Fear River. The remainder of Chatham County is drained by the Rocky, Haw, and New Hope Rivers, which also are part of the Cape Fear system. Most of Durham and Orange Counties are drained eastward into the Neuse by the Eno and Little Rivers. The Flat River, also a tributary of the Neuse, flows through southern Person and northeastern Durham County. In northern and western Person County the Hyco River flows northeastward across the Virginia line into the Roanoke River.

The Deep, Rocky, Haw, Eno, and Little Rivers flow transverse to the northeastward-trending structural elements and are therefore antecedent or superposed. The Uwharrie, New Hope, and Hyco Rivers are flanked by more resistant rocks and reflect structural control. Most minor tributaries and short reaches of the major streams show local adjustment to structure. The en echelon reaches and rectangular offsets exhibited by the Deep River in south-central Chatham County and in the southeast corner of Randolph County are caused by faulting.

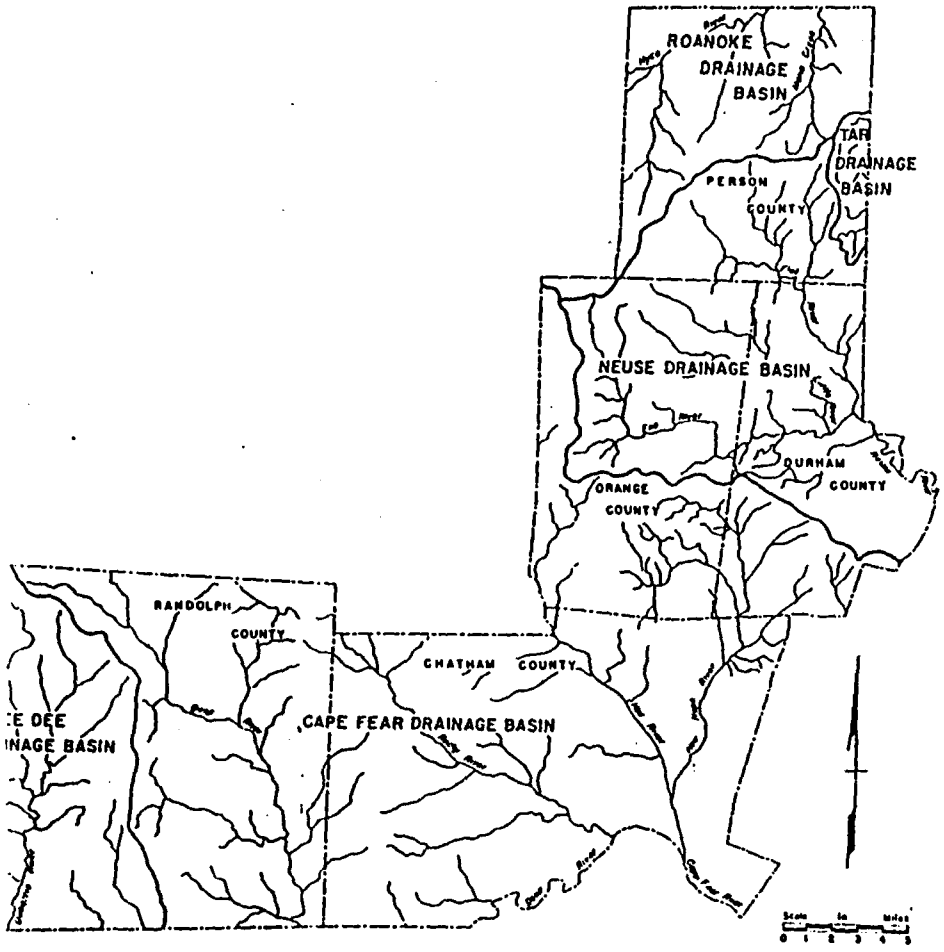


Figure 3. Distribution of major streams and drainage systems in the Durham area.

Stratigraphy

The area described in this report is geologically complex. Most of the area is included within the so-called Carolina slate belt, which actually consists of slightly metamorphosed volcanic and sedimentary rocks that are tightly to openly folded, faulted, and intruded by igneous plutons. The volcanic rocks are felsic to mafic in composition. The plutonic igneous rocks range from granite to gabbro. Mica gneiss and schist, and hornblende gneiss, which appear to be older than the slate belt rocks, crop out in northwestern Person County, eastern Durham County, and southeastern Chatham County. Rocks of Triassic age are exposed in a grabenlike structure in the eastern part of the Durham area.

Owing to the complex geology, short field season, and large size of the area, geologic mapping was done on a reconnaissance basis. The map units are broad and generalized and their contacts are located approximately.

The volcanic and sedimentary rocks in the Durham area have a recognizable stratigraphic order which has permitted division of these rocks into lithostratigraphic map units. Relationships between the map units used in this report and those used in Moore County and in the Denton and Albemarle quadrangles are shown in figure 4. The map units are described below in order of decreasing age.

Mica Gneiss and Schist Unit

This unit is exposed in northwest Person County and in the extreme southeast tip of Chatham County south of Corinth (pl. 2). The mica gneiss usually is a mica-quartz-feldspar gneiss, which when unweathered is a dark-colored rock having bands of biotite mica alternating with bands of quartz and feldspar. The schist is a light-colored foliated rock composed of sericite, biotite, muscovite mica, and lenses of quartz and feldspar.

The mica gneiss and schist unit is deeply weathered and is mantled by light- to dark-red saprolite. Only a few outcrops of unweathered rock were seen; thus, this unit may contain other rock types.

In the northwest corner of Person County, the gneiss and

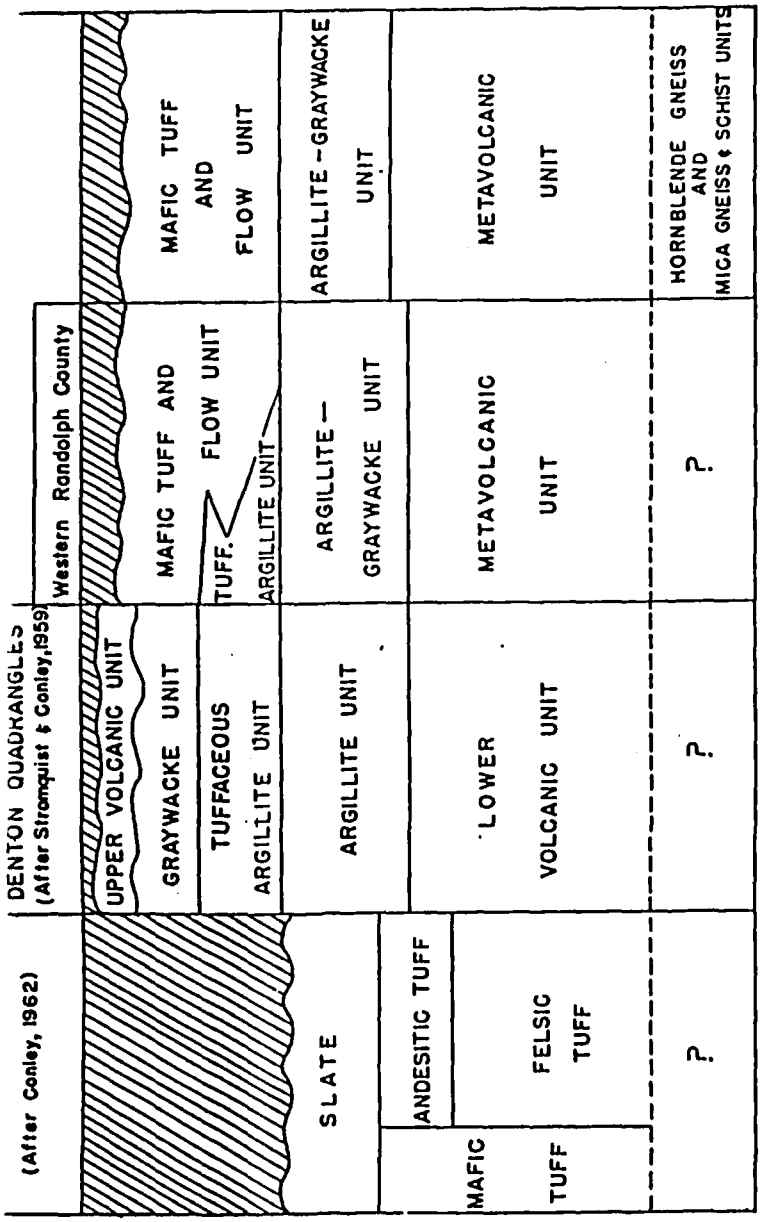


Figure 4. Generalized correlation chart of the slate belt rocks of North Carolina.

schist crops out in a belt trending about N. 45° E. toward the North Carolina-Virginia line. A distinctive outcrop of mica gneiss is exposed in a creekbed on the Person-Caswell County line, just south of the Virginia line.

Another outcrop area, which probably is similar to the mica gneiss and schist described above, was mapped in western Person County. No well-preserved outcrops were found, but it weathers much more like the mica gneiss and schist unit than the hornblende gneiss that surrounds it. Mica gneiss and schist also was mapped in the southeastern tip of Chatham County southeast of the Jonesboro fault. Here, too, the unit is deeply weathered. One unweathered exposure of biotite-quartz-feldspar gneiss occurs south of Corinth near the Cape Fear hydroelectric plant.

The attitude of the mica gneiss and schist unit could not be determined, but these rocks crop out northwest of the southeastward-dipping hornblende gneiss. If these two units are conformable, then the mica gneiss and schist unit lies stratigraphically below the hornblende gneiss and is the older of the two. On this basis the mica gneiss and schist unit has been placed below the hornblende gneiss on figure 4 and plate 2.

Hornblende Gneiss Unit

This unit is confined to northwestern Person County, between the mica gneiss and schist unit in the northwest and the granite and volcanic rocks in the southeast. The hornblende gneiss generally is a black hornblende-plagioclase gneiss interbedded with pink to light-gray quartz-feldspar gneiss and white feldspathic quartzite. On weathering it forms a relatively thin dark-brown sticky soil. Injected pegmatites are generally present. In west-central Person County, pegmatite and amphibolite dikes compose most of hornblende gneiss unit.

The combination of distinctive bedding and interbedded quartzite indicates a sedimentary origin for the hornblende-gneiss unit. Intrusion of diorite and gabbro into older rock (either conformably or otherwise), as postulated by some geologists to explain the source of hornblende, is considered unlikely, at least in Person County. No crosscutting relationships were observed, and the likelihood of silled intrusives remaining sill-like is questionable. Furthermore, quartzite and extrusive

lava are geologically possible but unlikely associates. Hornblende is a possible metamorphic product of impure dolomite or calcareous sediments, as has been suggested by Kesler (1944) and by Parker (1952) for similar rocks in North Carolina. Certainly the carbonate-quartzite assemblage is more tenable, and their association is well established geologically.

Bedding-plane strikes and dips indicate that the hornblende gneiss forms the southeast flank of an anticline trending about N. 55° E. Dips in the hornblende gneiss unit increase from 10° to 30° at its contact with the mica gneiss and schist unit on the northwest to a maximum of 65° to 80° at its contact with the granitic and volcanic rocks to the southeast. One reversal of dip was noted in west-central Person County near the Person-Caswell County line. Several high-angle faults and associated drag folds are present. The outcrop pattern of the hornblende gneiss unit is shown in figure 5.

The age of the hornblende gneiss unit is not known. It is similar to Keith's Roan Gneiss, of former usage, (Mundorff, 1948, p. 7), which has been labeled Precambrian in age.

Metavolcanic Unit

The metavolcanic unit, predominantly pyroclastics deposited in a subaerial environment, is interbedded with flows, argillaceous tuff, and graywacke. As mapped, this unit is the stratigraphic interval between the overlying argillite graywacke unit and the underlying gneiss and schist of Person, Chatham, and Durham Counties.

The textural varieties of tuff present in the metavolcanic unit are highly diverse. Some representative lithologies are crystal lithic tuff, vitric lithic tuff, welded flow tuff, lapilli tuff, and coarse breccia or agglomerate. Nearly all possible textural gradations between any two typical tuffs are present in the Durham area. In addition, there is a series of rocks which are difficult to classify as tuffs in the absence of lithic fragments, or as flows in the absence of flow banding. Many rocks formally classed as rhyolite flows are suspected to be welded flow tuffs.

Flows are interbedded with and are subordinate in amount to the tuffs of the volcanic-sedimentary unit. They are widely distributed both stratigraphically and areally. Three general varieties of flows are present. One rhyolitic variety has porphy-

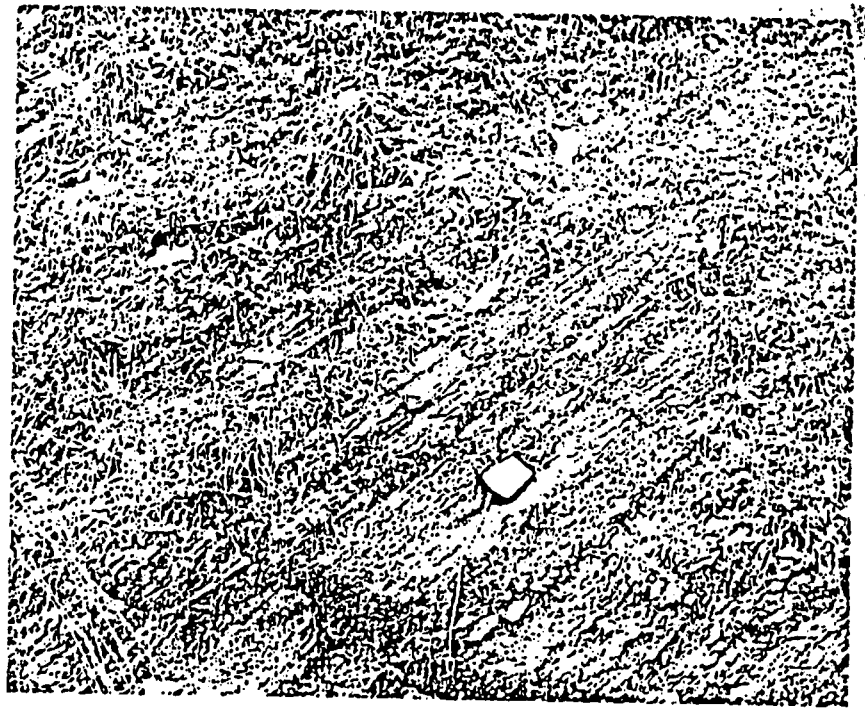


Figure 5. Outcrop of hornblende gneiss unit near McGehees Mill, Person County. Attitude of bedding is about N. 50° E. 40° SE.

roblasts of euhedral feldspar and some beta quartz set in a dark to light-gray aphanitic groundmass. This rhyolitic type is quite dense and "glassy." It has a white weathering "rind" and usually shows swirl banding on the weathered surface. A second rhyolitic variety shows distinct laminar flow banding. It is dense and "glassy," shows an occasional feldspar lath, and many samples contain bombs and lapilli around which the flow lines are bent. The third is a heavy basaltic variety that is dark-green to nearly black when unweathered. Many samples contain amygdules filled with either quartz or calcite and epidote.

Argillaceous tuffs and graywackes are interbedded with the flows and tuffs. They weather much deeper than the more resistant tuffs and flows with which they are interbedded; consequently, they easily go unnoticed. Although exposures were found in only a few deep road cuts, it is estimated that gray-

wacke and argillaceous tuff may compose as much as 30 percent of the metavolcanic unit. One possible mudflow occurs east of Silk Hope in Chatham County. It contains one boulder which is about 2½ feet in diameter (fig. 6).

Rocks similar to the felsic lower volcanic unit of Conley (1962b) and its equivalent in Moore County are exposed in isolated areas in the Durham area. Strike and dip information and distribution of the overlying argillite-graywacke unit suggest that these areas are anticlinal. The largest of these areas is in central and south-central Randolph County. The felsic volcanic rocks are in contact with argillite from southwestern Randolph County to the vicinity of Asheboro (pl. 2). From Asheboro the contact swings northward to form a narrow neck between Cedar Falls and Randleman. From Cedar Falls the contact extends southeastward to a point about 2 miles northwest of Erect, then eastward approximately 3 miles, and then southwestward to the Randolph-Moore County line.

The felsic tuffs and flows are recognizable not only by their quartz and feldspar content and white weathering rinds, but also by their pink and cream-colored soils that are similar in color to those developed on granite and quartz monzonite.

The area outlined above is not composed entirely of felsic tuffs and flows. Minor amounts of mafic tuff, recognized by the dark-red or dun-colored soils and the presence of graywacke and argillaceous beds, are interbedded with the felsic rocks. This area of felsic volcanics is also intruded by gabbro sills and, probably, is unconformably overlain by patches of rocks equivalent to the upper volcanic unit mapped by Conley (1962b) in the Albemarle quadrangle.

The corner of a roughly triangular area of sheared felsic tuff is exposed at Bennett in southwestern Chatham County where it is in fault contact with mafic tuff. From Bennett the area extends northward about 2 miles, then eastward approximately 4 miles.

Felsic crystal tuffs and flows are found in a northeast-trending elliptical area east and southeast of Hillsboro in Orange County. Unweathered exposures can be seen on the U. S. Route 70 bypass from the junction of U. S. Routes 70 and 70A northwestward to the Eno River. Excellent outcrops of unweathered rock are exposed to N. C. Route 86 about 4 miles south of Hillsboro. A very narrow belt of felsic tuffs and flows crops out along county road 1942, southwest of University Lake (southwest of Chapel Hill) toward the WUNC transmitter site. Other isolated patches of felsic rock are located in the extreme southwestern tip of Orange County. The area included between Orange Grove, Dodsons Crossroads and Teer is believed to be underlain by rocks which could be classed as felsic volcanics.

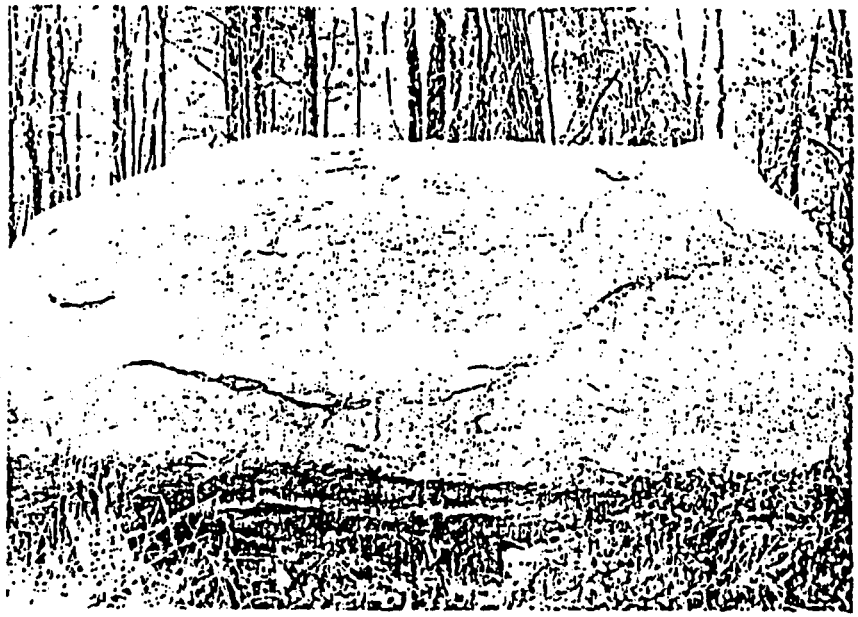


Figure 6. Large float block of volcanic breccia or mudflow of the metavolcanic unit near Silk Hope, Chatham County. Boulder in upper right corner is 2½ to 3 feet in diameter.

A large area of felsic tuffs and flows is exposed in Durham County in a northeast-trending belt adjacent to the Triassic basin. The outcrop belt is about 3 miles wide and 8 miles long. Its northwest contact roughly conforms to a line drawn from the point where U. S. Route 70 crosses the Durham-Orange County line northeastward to Bahama. The area north of Mangum Store and east of the granodiorite body in northwest Durham County is most likely an extension of this belt.

Felsic crystal and crystal lithic tuff and flows are confined to the southeast corner of Person County. They are in contact with granodiorite on the southeast and extend westward to within a mile of Mt. Tirzah and northward to within 2 or 3 miles of Peeds Store.

The remainder of the outcrop area of the metavolcanic unit, not known to be underlain by felsic rocks, consists largely of more mafic rocks which are andesitic to basaltic in composition. Conley (1962a) divided the mafic sequence in Moore County into two units: an andesitic tuff and a mafic tuff. He states that the mafic tuffs ". . . in general are andesitic in composition, but contain some material that might be classified as basalt." They are grayish green to greenish black when unweathered, and they weather to dark, dun-colored soils similar in color to soils usually developed on gabbro. The andesitic tuffs are massive to finely laminated, some shade of purple or lavender (owing to interstitial hematite) when unweathered, sometimes sheared and phyllitic, and mantled with wine- or maroon-colored soils that are typical of diorite. The andesitic tuffs in the Durham area, as in Moore County, become less massive and more argillaceous toward the top of the section.

In some places, andesitic tuff grades upward into laminated argillite, indicating that at least the uppermost section of the andesitic tuff is a facies of the argillite-graywacke unit. This probably explains the conspicuous absence of andesitic tuff in western Randolph County.

The largest exposure of andesitic tuff occupies about 60 square miles of central Chatham County. Weathered andesitic tuff is well exposed on U. S. Route 64 between Pittsboro and Siler City. Additional exposures in Chatham County are along N. C. Route 87 north of Pittsboro and at Bynum. Andesitic tuff crops out in isolated to fairly continuous exposures along a line that begins at a point south of Hillsboro and then trends northeastward to Quail Roost. From Quail Roost the line of exposures trends nearly due north to Mt. Tirzah, and thence northeastward to an isolated exposure southeast of Denny Store. Andesitic tuff is exposed also in the vicinity of Caldwell in Orange County and northward across the Person-Orange County line.

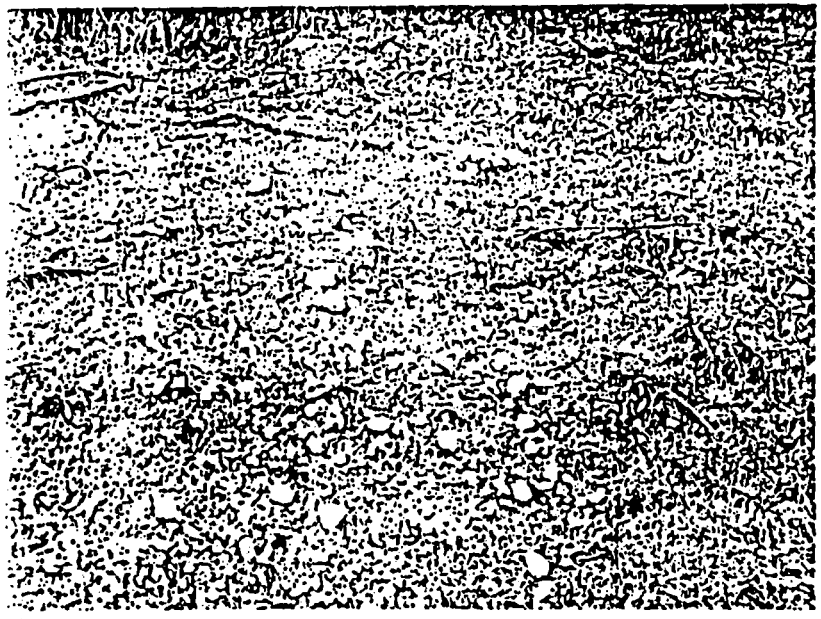
Mafic tuff that weathers to a dun-colored soil is widely distributed throughout the Durham area. It seems to be interbedded with the more typical andesitic variety as well as the felsic tuff and the overlying argillite. Most of the area, south of Pittsboro toward Moncure and southwest of Pittsboro toward Goldston in Chatham County is underlain by rock that could be classed as mafic tuff. The southwestern corner of Chatham County south of Bennett and Harpers Crossroads is underlain

with mafic tuff that in places is bedded and argillaceous. Mafic tuff is exposed in a narrow belt about 15 miles long that begins at a point north of the Siler City water-treatment plant and extends northeastward to the Alamance County line. Additional outcrops are present in the vicinity of Buckhorn in Orange County and in the vicinity of Peeds Store in Person County.

There are several localities in the Durham area in which the rocks of the metavolcanic unit are so deeply weathered, or are in areas with such low relief, or both, that outcrops are either scarce or nonexistent. Most of these localities are on the northwest side of the metavolcanic unit, where granite and granodiorite intrusions are most prominent. Where outcrops occur, the rocks are either badly sheared, schistose, or phyllitic. These rocks probably are similar to the greenstone schist unit mapped by Mundorff (1948) in the Greensboro area.

Rocks of the metavolcanic unit have been folded into northeast-southwest folds that are more tightly compressed in the southeastern part of the area than in the northwest. Axial plane cleavage dips steeply northwestward, except in Person County and northern Orange County, where the dip is vertical or steeply southeastward. Rocks of this unit show little shearing effect in hand specimens, but under higher magnifications an incipient lineation usually can be detected. Quartz dikes are almost universal in extent and range in width from a few millimeters to 3 or 4 feet. These quartz-filled fractures probably are the primary storage spaces for most ground water in the metavolcanic unit. Insufficient data were gathered to learn to what extent faulting has determined the present distribution and attitude of the different rocks of the metavolcanic unit. The occasional inability to trace individual rock types along the strike from one road to another, the presence of quartz and diabase dikes, and the rectangular and en echelon offsets of drainage indicate that faulting is extensive.

The age of the metavolcanic unit is not known. Emmons (1856) classed these rocks as Precambrian. The Hyco Quartz Porphyry and Goshen Schist of Laney (1917) are included within the metavolcanic unit in Person County. Laney gave these two formations an age of Ordovician(?), principally on the basis of their similarity to known Ordovician volcanics in the Arvonia and Quantico synclines. The metavolcanic unit of this report is given a tentative age of Ordovician(?).



:ure 7. Outcrop of graywacke conglomerate of the argillite-graywacke unit near Timberlake, Person County. Largest cobbles are about 2 inches in diameter.

Argillite-Graywacke Unit

The metavolcanic unit is overlain in the Durham area by a ıuence, predominantly sedimentary, consisting of argillite, aywacke, conglomerate, and tuff in order of predominance. ıis sequence is present in the argillite-graywacke unit roughout the Durham area, except in western Randolph Coun- where graywacke and conglomerate may be present but were ·t found. The thick argillite section in western Randolph is e "varved" argillite (fig. 4) of Stromquist and Conley (1959). ıe argillite-graywacke unit of this report includes this argil- e and is at least partially equivalent to the slate unit mapped Conley (1962a) in Moore County.

Graywacke conglomerate (fig. 7) usually is present at the se of the argillite-graywacke unit in the rest of the Durham ea. It crops out in a belt that ranges in width from 10 to 20 iles and extends from southwestern Chatham County to north- sternmost Person County—a distance of 85 miles. Although nglomerate was not found in western Randolph County, Con- (1962b) reports conglomerate at the base of the argillite unit south and along the strike in the Albemarle quadrangle. Conglomerates are interbedded with the graywacke sandstones and usually possess a graywacke matrix, although some conglomerates having a tuffaceous matrix have been seen. Pebbles of acid volcanics, feldspathic quartzites, quartz-hornblende gneisses, and jasper (?) are among the lithologies found in the graywacke conglomerate. Individual pebbles are well to subrounded and range from pea-size to cobbles larger than softballs. Sphericity and sorting are poor.

Graywacke conglomerate grades upward into graywacke sandstone by successively thicker interbeds of sandstone. Graywacke sandstone attains its best development in the Person County outcrop area, where it is massive and shows pronounced graded bedding. Crossbedding occurs in a few thin beds associated with argillite. Individual beds range in thickness from a quarter of an inch to several feet. Where fresh the graywacke sandstone is a massive, dark-gray to greenish-gray rock that breaks with a conchoidal fracture. Pyrite cubes are present in most exposures. The more massive graywacke weathers into structureless bright maroon and vermilion saprolite containing spheroidal residual boulders. The graywacke sandstone is interbedded with and grades upward into argillite or slate.

The slate and argillite are easily distinguished from other rocks by their finely laminated character. The laminae or beds range in thickness from 0.1 mm to 5.0 mm and are graded. Graded bedding can be seen in the thicker beds. According to Conley (1962b), graded bedding is easily observed in thin section consisting "of a bottom silt layer which grades upward to a clay layer." He found that the silt layer was composed of "angular quartz grains with some feldspar fragments, and relic outlines of ferromagnesian minerals now completely changed to chlorite" and that the "clay layers are altered to sericite." The argillite and slate originated as shales which were probably composed of land waste derived from metamorphic and volcanic terranes, and airborne volcanic dust.

Slate having well-defined axial-plane cleavage is confined to the southern part of Chatham County, the southeastern part of Orange County, and the axial region of the Person County outcrop area—that is, where dynamic metamorphism was greatest. Argillite generally has excellent bedding-plane cleavage and an incipient axial-plane cleavage. Porphyroblasts of biotite-seri-

cite-chlorite, which according to Stromquist (Stromquist and Conley, 1959) have retrogressed from chloritoid, are developed across bedding planes in the argillite of western Randolph County. Thin limestone beds are interbedded with the argillite in this area and can be observed in the Superior Stone quarry at Asheboro.

Argillite and slate saprolites are various shades of ocherous red and yellow. Weathering depths are quite variable. Argillite in parts of western Randolph County is weathered deep enough to permit construction of large-diameter bored wells to depths greater than 100 feet, whereas in most of the Durham area casing depths average much less.

The argillite-graywacke unit crops out in northeastward-trending synclines and synclinoriums which are overturned to the southeast in southern Chatham County. The axial-plane regions of the folds generally are sheared. Well-exposed outcrops reveal that argillite in most of the Durham area is offset by many high-angle faults of short throw and that contorted folds having wave lengths of only a few feet are superimposed upon the larger folds.

Laney (1917) named the argillite in Person County the Aaron Slate, which he classed as Ordovician in age on the basis of its similarity to known Ordovician rocks in the Arvonia and Quantico synclines. This unit is given a tentative age of Ordovician (?) in this report.

Tuffaceous Argillite Unit

Argillite in southwestern Randolph County grades upward into massive tuffaceous argillite by an increase of thicker beds of tuffaceous argillite and a decrease of laminated argillite. As mapped the contact is an arbitrary line drawn where the more massive beds of tuffaceous argillite exceed those of laminated argillite. It is equivalent to the felsic tuffaceous argillite unit of Conley (1962b).

The tuffaceous argillite is a dark-gray massive, well-jointed rock which upon weathering passes through successively lighter shades of gray to bright shades of red and yellow when completely decomposed. The unweathered rock breaks into sharp splinters with conchoidal fracture. Pyrite generally is present as cubes disseminated throughout the rock.

The tuffaceous argillite unit is assigned an age of Ordovician (?) because of its conformable relation to the underlying laminated argillite.

Mafic Tuff and Flow Unit

A sequence of mafic tuffs and flows overlies the argillite-graywacke unit. The mafic tuff and flow unit is exposed in Person County, in the western part of Randolph County, and along the Randolph-Chatham County line. The strike and dip relationships of the two units indicate that their contact is conformable in Person County and along the Chatham-Randolph County line. The outcrop in western Randolph County indicates that their contact is disconformable (pl. 2). However, the presence of interbeds of tuffaceous argillite in western Randolph County indicates that the mafic tuffs and flows may be a facies of the tuffaceous argillite unit.

The lithology and weathering characteristics of the mafic tuff and flow unit are strikingly similar to the upper volcanic unit of Conley (1962b), especially in Randolph County. It is possible that part or all of this unit is equivalent to the upper volcanic unit of Conley (fig. 4).

Mafic tuffs and flows exposed in Person County and those distributed along the Randolph-Chatham County line are similar in lithology and weathering characteristics. The tuffs range from gray-green fine-grained, water-laid tuffs to dark-gray coarse, massive breccias and agglomerates. Flows are massive, dark green, and amygdaloidal. Epidote-quartz veins are very distinctive of this unit.

The mafic tuff and flow unit in western Randolph County differs from that in the rest of the Durham area, in that tuffaceous argillite, welded tuff, and lithic-crystal tuff are interbedded with the more basic tuffs.

Rocks of the mafic tuff and flow unit weather to dark, dun-colored soils. Concretionlike pebbles, which cover the soil in some places, probably are quartz-epidote amygdales that have weathered out.

In Person County andesitic tuffs and flows crop out in two linear belts along the axial region of the Virgilina synclinorium. Laney mapped these two outcrop belts and the sheared argillite

slate between them as one unit, which he called the Vir-
ına Greenstone.

The age of the mafic tuff and flow unit is not known. It is
en a tentative age of Ordovician(?) on the basis of its ap-
ent conformity in places to the underlying argillite-gray-
cke unit.

Granite and Granodiorite Unit

Volcanic and sedimentary rocks in the Durham area have
n intruded and locally altered by plutonic igneous rocks
t range in composition from granite to gabbro. Because
ıpositions vary considerably from place to place and within
same pluton, it is difficult to separate the different varie-
s into mappable units. For convenience, rocks ranging in
ıposition from granite to granodiorite were mapped as one
t.

Granite crops out in the northwestern part of Randolph
ınty (pl. 2), in the north-central part of Chatham County,
the southeastern and northwestern parts of Orange County,
l in the southwestern and central parts of Person County.
e granite plutons listed above include xenoliths of volcanic
ks and other igneous varieties too small to map. The granite
pink to gray, medium-grained to porphyritic, well jointed,
l locally sheared. Orthoclase and plagioclase feldspar, biotite
a, and quartz give the granite an equigranular texture. The
nite weathers to pink, light-red or cream-colored soils.

The rest of the granite and granodiorite unit contains rocks
t are mostly granodiorite in composition. As in the case of
granite, the granodiorite includes rocks of other composi-
ıs. Volcanic rocks and dikelike bodies of pegmatite, granite,
rite, and amphibolite are present. The contacts between the
ınodiorite and the country rock are less well defined and the
eration halo wider than that of granite. In some places, such
the area west of Carrboro, the granodiorite appears to have
placed itself by assimilation of volcanic rock. Most rock
ssed as granodiorite is well jointed and is mantled by light-
y to dark-red saprolite.

Both granite and granodiorite weather deep enough in some
ılities to permit construction of large-diameter bored and
wells below the lowest level of the water table. Large
residual boulders and unweathered rock are close to the surface in areas where relief is great enough that the weathered material has been removed by erosion.

Diorite Unit

Diorite occurs in plutons and dikes massive enough to map only in Person County. The largest outcrop of diorite is in the vicinity of Hurdle Mills. Another outcrop is approximately 2 miles south of Hesters Store in southwestern Person County and another is in the northeastern section of the county north of Dixons Store. The diorite generally is fine to medium grained, massive, well jointed, and not deeply weathered. Weathering colors range from dark brown on nearly fresh rock to dark red on thoroughly decomposed rock.

Gabbro Unit

Gabbro sills and dikes are relatively plentiful in the Durham area. This is especially true of western Randolph County, where a swarm of gabbro sills and dikes have intruded the argillite and the metavolcanic unit in a few places. Gabbro sills and dikes in this area show good conformity to regional structure. Most of the high peaks and ridges in western Randolph County are underlain by gabbro. Gabbro also occurs north of Calvander in Orange County, and in Person County southeast of Moriah and north of Denny Store. The gabbro is medium grained to pegmatitic, massive, and well jointed. It weathers from dark, dun-colored to dark-red shallow soils.

The age of the various intrusions is not known. However, they are younger than the mafic tuff and flow unit which they intrude and older than the Triassic which they do not intrude. They are classed as Mississippian(?) in this report.

Triassic Unit

In the Durham area rocks of Late Triassic age are exposed in a northeastward-trending structural and topographic lowland known as the Deep River Triassic basin. This basin is structurally similar to several isolated basins located at intervals within the Piedmont Province from Nova Scotia to South Carolina.

The Deep River basin extends northeastward from western ore County to east-central Granville County. Along its nearly -mile length, it includes parts of southern and southeastern tham County, southeastern Orange County, and most of ham County. Its maximum and minimum widths are about and 5 miles, respectively.

The rocks of Triassic age are principally continental and sist of maroon to reddish-gray sandstones, shales, siltstones, glomerates, and fanglomerates (fig. 8). However, coal beds interbedded with gray to black shales and siltstones, indi- ing that during at least part of Triassic time restricted lakes marshland favorable to the accumulation of vegetable mat- existed and that the rate of sedimentation probably was v.

lthough gross lithologies are similar from outcrop to out- p, individual beds change rapidly in thickness laterally, and ithology both laterally and vertically. These factors have an ortant effect on the location of suitable ground-water sup- s. Wells which penetrate the coarser, better sorted sand- es tend to yield more water than those in the relatively ter shales and siltstones.

he Triassic rocks are separated from the metamorphic and ous rocks to the east by the Jonesboro fault, which generally vell defined by a northwestward-facing fault scarp. The ssic rocks are bordered on the west by volcanic and igneous s of the slate belt. The western contact in the Durham area raight locally, but more often is a sinuous line caused by the inal uneven surface upon which the basal Triassic rocks e deposited and by the notching effect of tranverse streams have eroded through the thin updip edge of the Triassic. re straight, the contact possibly is controlled by a western ler fault such as that found by Conley (1962a) in Moore nty. The western contact is offset locally by cross faults as those mapped by Reinemund in the southern part of tham County.

the Deep River basin the Triassic rocks dip 10° to 20° to southeast, in contrast to those of the Dan River basin of th Carolina and Virginia (Mundorff, 1948) which dip to the hwest. Possibly, the monoclinal dip results in part from an ial dip and in part from contemporaneous and postdeposi- al movements along the Jonesboro fault. A few flowing wells

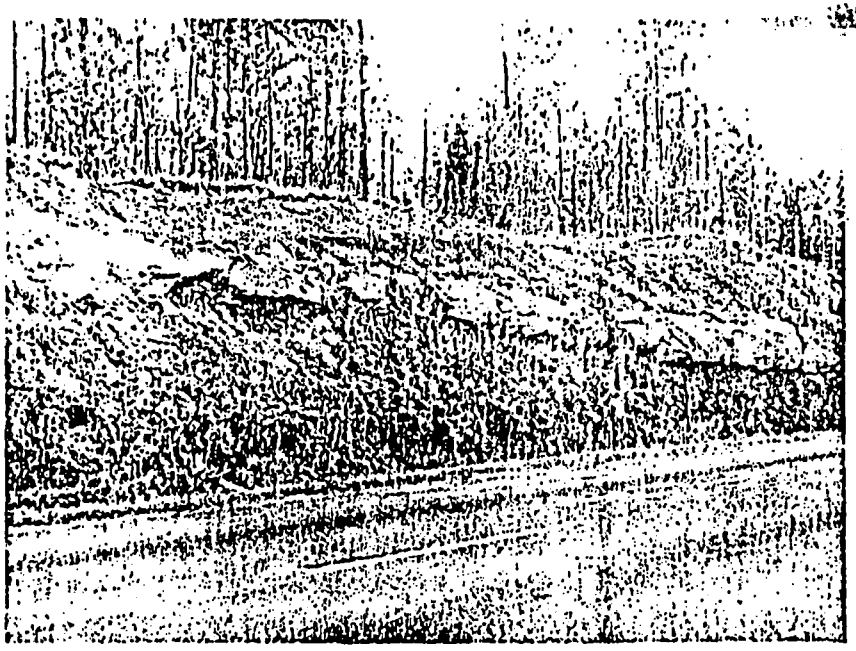


Figure 8. Outcrop of light-gray sandstone in the Triassic unit near Seaforth, Chatham County.

are present in the Triassic rocks of Durham and Chatham Counties. Water percolating downdip through the more permeable sandstones develops sufficient artesian pressure, or head, to produce flowing wells in some localities.

Maximum thickness of the Triassic wedge has been estimated to range from 7,000 to 8,000 feet in the southern part of the basin to 4,000 to 5,000 feet in southeastern Chatham County. Prouty (1931) has estimated that in the northern part of the basin (Durham County area) the Triassic rocks may be as thick as 10,000 feet.

In Late Triassic time the sedimentary rocks were intruded by dikes and sills of diabase, which have formed narrow baked zones along their contacts. These diabase dikes are frequently found in the slate belt of North Carolina. The writer was able to trace one such dike in Randolph County for a distance of 7 miles.

Time did not permit separation of the Triassic into lithologic units. Reinemund divided the Triassic rocks in the vicinty of the Deep River coal field into the following formations, which

GROUND-WATER HYDROLOGY

Hydrologic Cycle

All ground water yielded to wells in the Durham area was ıce precipitation which fell in the form of rain or snow. The ırth contains a vast but fixed supply of water. Through energy ıpplied by the sun, water evaporates from the oceans, lakes, reams, and surface of the earth to become water vapor in the ımosphere. There, water vapor condenses and falls as precipiıtion. Part of the water falling upon the land surface is disıarged directly to streams as surface runoff, part is returned ı the atmosphere by evaporation, and the remainder is retained ı the soil and rocks as ground water. Ground water is eventually ischarged to streams through springs, seeps, and wells or is ıturned to the atmosphere by evaporation and transpiration. he unending circulation of water between the earth and the tmosphere is called the hydrologic cycle.

Occurrence and Movement of Ground Water

Source

Gravity and capillary action cause water derived from preıpitation to percolate downward through the soil cover until reaches a zone of saturation within which all open spaces are ımpletely filled with water. Water in the zone of saturation is ılled ground water. The upper surface of the zone of saturation ; referred to as the water table. The zone between the water able and the land surface is called the zone of aeration (fig. 9).

The percentage of precipitation that becomes ground water ıepends on several interrelated factors, such as the slope of the ınd surface, the relative ability of the soil cover to transmit vater, the intensity and duration of rainfall, the type and amount ıf vegetation, and the temperature. Topographic relief in the)urham area averages about 50 feet per mile, but there are ome broad interstream areas developed on granite and volcanic erranes where lateral movement of surface water would be exıected to be slower than in the Uwharrie Mountains where local elief exceeds 300 feet per mile. Rainfall is greatest during July ınd August and is least in October (fig. 2). The average temperıture also is highest during July and August, so that losses from evaporation and transpiration probably are at their maxi-

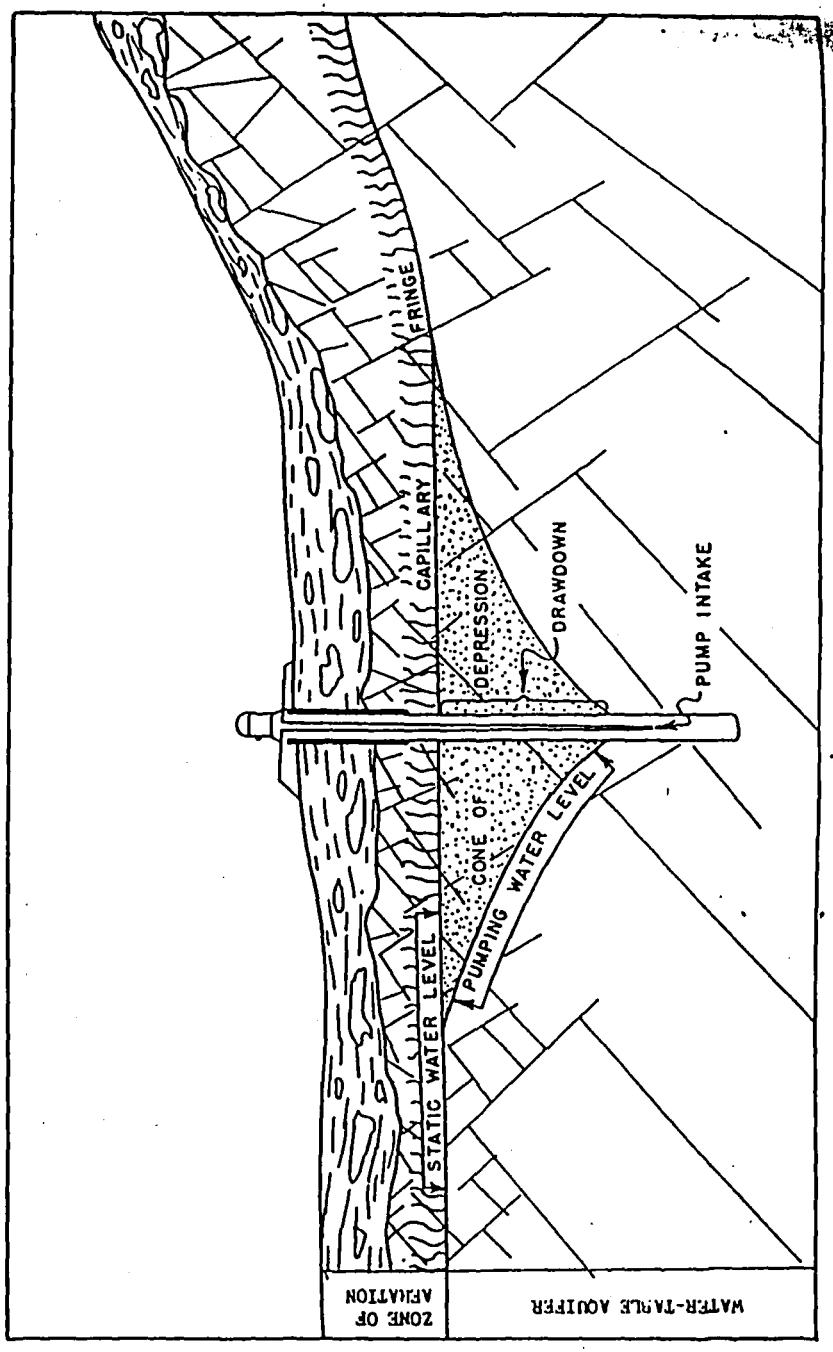


Figure 9. Diagram showing relation of a well to hydrologic conditions in a water-table aquifer.

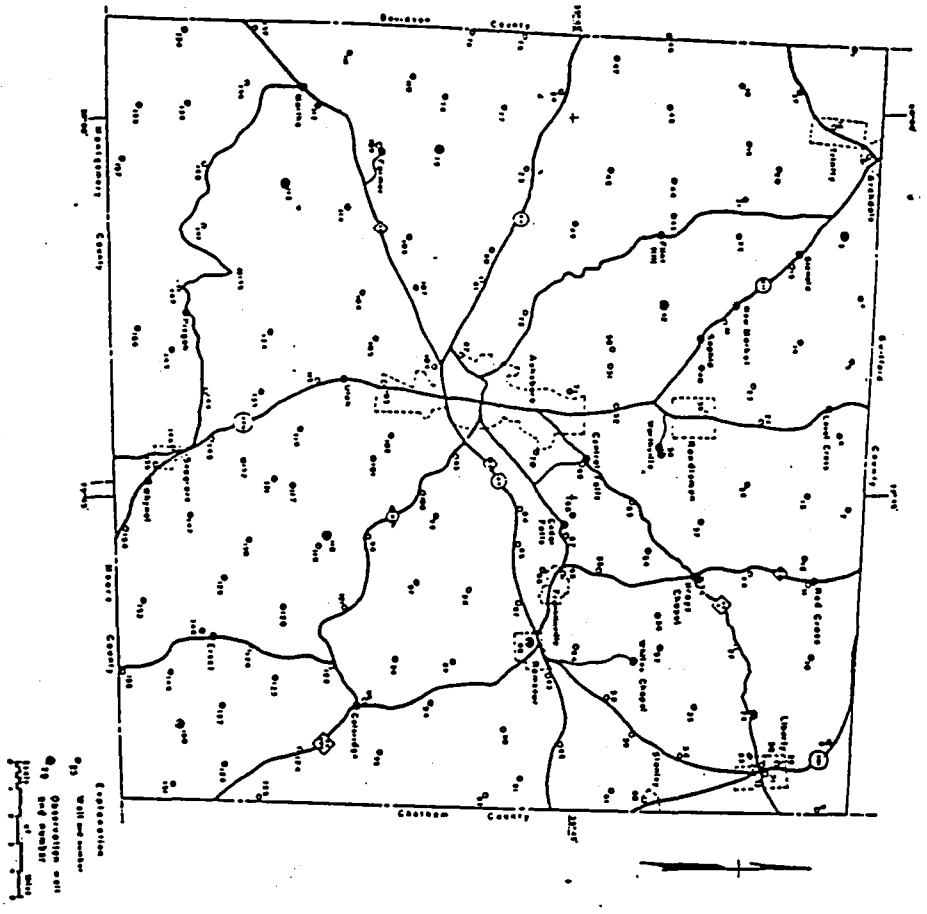


Figure 31. Map of Randolph County showing the location of wells

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. Hull	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	M	
11	Red Cross	O. 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.

(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.

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	

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	Lizy 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--	--D--	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	

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	

(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
75	7.0 mi. NW of Farmer	Joe Ray Dunn	Hill	Dr	66	6	Felsic crystal tuff			4		S	
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	1.8 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.

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	

(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 well.

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	0.40	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. Hamner--	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---	Haldalh 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	

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	Dirty 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 Lanier--	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	-------	H	
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---	Gracy 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.

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	1.6 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	1.5	------	S	

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

	1	16	28	33	42	52	63	73	83	84	101	120	124	130	133	135
Date of collection	12/17/42	12/17/42	12/17/42	3/13/50	12/17/42	12/17/42	12/18/42	12/17/42	12/17/42	12/18/42	10/17/42	10/17/42	10/17/42	10/17/42	12/17/42	10/17/42
Silica (SiO_2)	42	34	42	31	44	31	29	24	23	19	29	22	27	22	29	28
Aluminum (Al)			.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0
Iron (Fe)			.04	.08	.10	.10	.02	.02	.02	.03	.1	.1	.2	.1	.1	.8
Manganese (Mn)			.01	.01	.08		.02									
Calcium (Ca)	21	17	10	22	19	13	26	7.0	4.4	2.6	6.0	4.5	5.2	4.5	3.4	5.8
Magnesium (Mg)	7.3	5.8	7.0	6.0	4.7	7.0	3.3	4.4	1.3	2.3	1.3	2.3	1.4	2.3	2.5	2.5
Sodium (Na)	2.3	3.3	3.1	1.1	1.1	2.4	1.1	2.3	2.3	2.3	1.8	1.2	2.8	1.4	2.8	2.8
Potassium (K)	1.1	2.0	1.2	.7	.7	1.0	.4	.7	.7	.7	1.1	.7	.7	.7	.7	1.7
Lithium (Li)	.0	.7	.0	.0	.0	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Bicarbonate (HCO_3)	202	201	142	130	142	156	82	34	26	20	28	26	42	34	32	33
Sulfate (SO_4)	3.4	3.8	3.4	1.0	2.4	2.4	2.4	1.0	1.0	1.0	2.6	2.0	2.0	2.0	4.0	4.0
Chloride (Cl)	1.0	4.0	6.0	1.1	1.1	2.0	1.4	4.0	2.0	1.0	2.3	2.0	1.7	2.0	4.0	4.0
Fluoride (F)	.0	.1	.2	.0	.0	.0	.2	.1	.1	.0	.0	.0	.1	.0	.1	.1
Nitrate (NO_3)	1.8	2.7	4.2	1.1	.2	1.0	.0	.1	.1	.0	.0	.0	.1	.0	.1	.0
Phosphate (PO_4)	.0	.1	.1	.1	.0	.1	.0	.1	.1	.0	.0	.0	.1	.0	.1	.0
Dissolved solids	232	240	232	200	214	229	152	82	72	62	87	72	88	72	88	88
Hardness as CaCO$_3$	84	81	54	64	57	58	74	34	20	14	20	20	14	20	14	14
Noncarbonate	7	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Specific conductance	175	160	140	130	142	150	110	72	62	52	72	62	74	62	72	72
pH	6.3	7.2	6.5	6.0	6.7	7.2	7.4	6.4	6.1	6.4	6.1	6.4	7.2	6.4	6.5	6.5
Color	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Water	Granite and granite-gneiss	Granite and granite-gneiss	Granite and granite-gneiss	Meta-volcanic	Meta-volcanic	Meta-volcanic	Argillite-graywacke	Meta-volcanic	Meta-volcanic	Granite and granite-gneiss	Meta-volcanic	Meta-volcanic	Argillite-graywacke	Meta-volcanic	Meta-volcanic	Meta-volcanic

[1] Bromide (Br)—0.13 ppm.

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REFERENCE 26

GREENHORNE & O'MARA, INC.

4101 Lake Boone Trail
The Summit - Suite 111
Raleigh, NC 27607
Phone: (919) 782-9088

RECORD OF TELEPHONE CALL

DATE: 6/21/90 TIME: 4:55 pm INCOMING / OUTGOING (circle one)

G&O REP: JAB TALKED WITH: RANDY MACON

OF: CITY OF ASHEBORO WATER PLANT / PHONE: 919 626-1200

G&O JOB NUMBER / FILE REFERENCE: 5035 RNC 126 2957

SUBJECT: WATER SUPPLY DATA - UNION CARBIDE (2957)

NOTES: - SURFACE INTAKE FROM BACK CREEK LAKE & THE UWHARRIE RIVER (@ 9 MILES SOUTH OF HWY 64)
- THE MAIN SOURCE IS BACK CREEK LAKE - 80%
- @ 20,000 PEOPLE ARE SERVED THROUGHOUT ASHEBORO AREA

**FOLLOW-UP ACTION:

COPIES TO:

REFERENCE 27

UNION CAREDE (462)

5/17/90 GRID--0353705/0354545-0794414/0795454-15 PAGE 0001

PWID	PWMANAME	PWMAARCO	PWMAPNUM	PWPLSOC1	PWPLPOPL	PWPLTYPE	PWPLACTV	PWPLLAT1	PWPLLON1
0276010	ASHEBORO, CITY OF	919	6256131	S	000017000	C	A	0354400	0795245
0276114	WESTWOOD PARK	919	6292924	G	000000082	C	A	0354120	0795030
0276121	HICKORY LANE MH COMM	919	6254183	G	000000088	C	A	0353930	0795240
0276128	LEROY'S TRAILER PARK	919	6291319	G	000000088	C	A	0353945	0794935
0276144	WHITE OAK MHP	919	6291319	G	000000182	C	A	0353725	0794930
0276152	HIDDEN VALLEY MOBILE HOME PARK	919	6720028	G	000000072	C	A	0354225	0795250
0276155	SOUTHWEST MHP	919	6295978	G	000000056	C	A	0353840	0795145
0276165	HERITAGE WEST	919	6650817	G	000000040	C	A	0353925	0795240
0276169	ROCKWOOD PARK WTR SYSTEM	919	6254515	G	000000147	C	A	0353920	0794850
0276171	CLAPPS CONV NURSING HOME INC	919	6252074	G	000000026	C	A	0354130	0794640
0276199	RIVER RUN S/D	919	6650817	G	000000063	C	A	0354340	0795155
0276201	RICHLAND VILLAGE MHP	919	6254290	G	000000210	C	A	0353920	0794545
0276202	CEDAR CREEK	919	6650817	G	000000084	C	A	0354350	0795240
0276416	BACK CREEK FRIENDS MEETING	919	6294630	G	000000130	N	A	0354510	0795330
0276420	BETHEL FRIENDSD MEETING CHURCH		0000000	G	000000090	N	A	0353950	0794430
0276422	BILLS EXXON	919	6291677	G	000000050	N	A	0354310	0795114
0276423	BLUE MIST BAR B Q RESTAURANT	919	6253980	G	000000225	N	A	0354325	0794430
0276424	BOONE OIL COMPANY	919	6294641	G	000000100	N	A	0354320	0794450
0276425	BRANDY DODGE	919	6251700	G	000000050	N	A	0354300	0794510
0276431	CAMP CEDARWOOD YMCA	919	6251976	G	000000200	N	A	0354430	0794510
0276435	CARAWAY FURNITURE CO	919	6251720	G	000000125	N	A	0354515	0795340
0276438	CHARLOTTE UNITED METH CHURCH		0000000	G	000000050	N	A	0354400	0795320
0276447	MATLAB INC	919	6294161	G	000000030	N	A	0354100	0795410
0276448	CRESTVIEW WESLEYAN CHURCH	919	6256847	G	000000114	N	A	0353920	0794900
0276452	ECONO OIL CO	919	6293134	G	000000030	N	A	0354115	0795025
0276469	FRIENDSHIP BAPTIST CHURCH	919	6721927	G	000000140	N	A	0354116	0795332
0276476	GOSPEL MISS BAPT CH	919	6293294	G	000000100	N	A	0354116	0795414
0276479	BYRDS FISH HOUSE	919	6290669	G	000000150	N	A	0354235	0795330
0276490	HWY 49 SHELL SERVICE	919	6299857	G	000000050	N	A	0354125	0795030
0276491	JONES SKATING RINK	919	6291364	G	000000250	N	A	0354150	0794700
0276494	ASHEBORO EAST FAMILY CAMPGRD	919	6294069	G	000000120	C	A	0354420	0794430
0276519	CAMP MUNDO VISTA	919	6254828	G	000000285	C	A	0354540	0795430
0276533	COLUMBIA FOODS # 6	919	6293520	G	000000550	N	A	0354325	0794430
0276545	RICHLAND BAPTIST CHURCH	919	6293344	G	000000200	N	A	0354000	0794530
0276549	RUSSELL'S GROVE BAPTIST CHURCH	919	6291711	G	000000100	N	A	0353940	0794529
0276559	SEA KING FISH CAMP	919	6299843	G	000000200	N	A	0354155	0795025
0276565	SMYRNA GROVE CONM CH		0000000	G	000000050	N	A	0354408	0795305
0276568	SOUTHWESTERN RANDOLPH SCHOOL	919	6292131	G	000000900	N	A	0353800	0795300
0276587	WEST BEND UNITED METH CHURCH	919	6255025	G	000000344	N	A	0354108	0795000
0276595	YATES COUNTRY HAM INC	919	6254375	G	000000035	N	A	0354058	0795050
0276605	CARRIE PHARR DAYCARE	919	6290317	G	000000090	N	A	0354025	0794910
0276607	GLENNS NURSERY & DAYCARE	919	6292330	G	000000030	N	A	0354030	0794510
0276609	KIDDIE CORNER DAY CARE	919	6292359	G	000000063	N	A	0354025	0795040
0276624	CARRIE PHARR DAYCARE #2	919	6297369	G	000000030	N	A	0354500	0795000
0276625	TINY TOTS DAYCARE #3	919	6292359	G	000000108	N	A	0354010	0794955
0276627	WEST SIDE DAYCARE	919	6251916	G	000000031	N	A	0354135	0795025

Reference 27

REFERENCE 28

Greenhorne O'Mara, Inc.

Reference 28

Record of Telephone Conversation

Individual : DON BOSTICK

Date : 6/27/90

Organization : WATER PLANT, CITY OF ASHEBORO.

By : CB

Phone No. : 919-626-1242

Project : HARRELSON RUBBER

Subject : SOURCE AND LOCATION OF SURFACE WATER INTAKE FOR THE CITY OF ASHEBORO

Items Discussed :

LAKE LUCAS — 3 MILES NORTHWEST OF THE FILTRATION PLANT - IS THE PRIMARY SOURCE OF WATER FOR THE CITY. LAKE LUCAS HOLDS ABOUT A BILLION AND A HALF GALLONS OF WATER AND IS THEIR PRIMARY SOURCE OF WATER BECAUSE THEIR OTHER SOURCE — A DAMMED UP PORTION OF THE UHWARRIE RIVER CALLED REESE LAKE — BUILT ONLY 5 OR 6 YEARS AGO IS MUCH FURTHER AWAY AND COSTS MORE TO PUMP WATER FROM THERE. STORAGE IN REESE LAKE IS TWO AND A HALF BILLION GALLONS, AND IS WEST TO SOUTHWEST OF ASHEBORO NEAR HIGHWAY 64. DON EXPECTS THAT REESE LAKE WILL EVENTUALLY BECOME THE PRIMARY SOURCE OF WATER BECAUSE OF ITS GREATER CAPACITY.

DON RECOMMENDED I TALK TO THE ENGINEERING SECTION 919-626-1227 TO GET INFO ON THE NUMBER OF CONNECTIONS AND THE EXTENT OF THE SERVICE AREA.

Comments or Action :

cc : HUNTER LOFIN
LARRY RAMSEY
HARRELSON RUBBER FILES (2 FILES)

REFERENCE 29

Record of Telephone Conversation

Individual : ERNIE P CAIN

Date : 6/27/90

Organization : H_2O SUPPLY REGIONAL ENGINEER REGION II

By : CB

Phone No. : 919-761-2390

Project : HARRELSON RUBBER

Subject : SURFACE WATER INTAKES IN RANDOLPH COUNTY.

Items Discussed :

THERE ARE NO SURFACE WATER INTAKES ON RICHLAND CREEK FROM ASHEBORO TO DEEP RIVER.

THERE ARE NO SURFACE WATER INTAKES ON DEEP RIVER IN RANDOLPH COUNTY OR MOORE COUNTY.

INTAKES FOR ASHEBORO : ONE FOR UHWARRIE RIVER IS WEST OF ASHEBORO, SOUTH OF 64, NORTH OF 49 AT END OF ROAD OPPOSITE HOOVER GROVE CHURCH. THE OTHER IS ON BACK CREEK NORTHWEST OF ASHEBORO OFF RTE 1518. INTAKE FOR RANDLEMAN IS ON POLECAT CREEK JUST SOUTH OF 219 AND INTAKE FOR SUPPLY SERVING RAMSEUR AND FRANKLINVILLE IS ON SANDY CREEK AT RTE 22 BETWEEN FRANKLINVILLE AND RAMSEUR

Comments or Action :

cc : HUNTER LOFTIN
LARRY RAMSEY
HARRELSON RUBBER FILES (2 FILES)

REFERENCE 30

Reference 30

alternative FCR values may be used when it is considered necessary to protect localized populations which may be consuming fish at a higher rate;

(ii) Water consumption (including a correction for fish consumption):
WQS = (RfD-DT) x Body Weight / [WCR + (FCRxBCF)]
where:
WQS = water quality standard or criteria;
RfD = reference dose;
DT = estimated non-fish dietary intake (when available);
FCR = fish consumption rate (assumed to be 6.5 gm/person-day);
BCF = bioconcentration factor;
WCR = water consumption rate (assumed to be 2 liters per day for adults).
To protect sensitive groups, exposure may be based on a 10 Kg child drinking one liter of water per day. Standards may also be based on drinking water standards based on the requirements of the Federal Safe Drinking Water Act [42 U.S.C. 300(f)(g)-1.] For non-carcinogens, specific numerical water quality standards have not been included in this Rule because water quality standards to protect aquatic life for all toxic substances for which standards have been considered are more stringent than numerical standards to protect human health from non-carcinogens through consumption of fish; standards to protect human health from non-carcinogens through water consumption are listed under the water supply classification standards in Rule .0211 of this Section; the equations listed in this Subparagraph will be used to develop water quality based effluent limitations on a case-by-case basis for toxic substances which are not presently included in the water quality standards. Alternative FCR values may be used when it is considered necessary to protect localized populations which may be consuming fish at a higher rate;

(B) For carcinogens, the concentrations of toxic substances will not result in unacceptable health risks and will be based on a Carcinogenic Potency Factor (CPF). An unacceptable health risk for cancer will be considered to be more than one case of cancer per one million people exposed (10^{-6} risk level). The CPF is a measure of the cancer-causing potency of a substance estimated by the upper 95 percent confidence limit of the slope of a straight line calculated by the Linearized Multistage Model or other appropriate model according to U.S. Environmental Protection Agency Guidelines [FR 51 (185): 33992-34003; and FR 45 (231 Part V): 79318-79379]. Water quality standards or criteria for water quality based effluent limitations are calculated using the procedures given in Subparagraphs (A) and (B) of this Rule. Standards to protect human health from carcinogens through water consumption are listed under the water supply classification standards in Rule .0211 of this Section; standards to protect human health from carcinogens through the consumption of fish (and shellfish) only are applicable to all waters as follows:

(i) Berylium: 117 ng/l;
(ii) Benzene: 71.4 ug/l;
(iii) Carbon tetrachloride: 4.42 ug/l;
(iv) Dioxin: 0.000014 ng/l;
(v) Hexachlorobutadiene: 49.7 ug/l;
(vi) Polychlorinated biphenyls: 0.079 ng/l;
(vii) Polynuclear aromatic hydrocarbons: 31.1 ng/l;
(viii) Tetrachloroethane (1,1,2,2): 10.8 ug/l;
(ix) Trichloroethylene: 92.4 ug/l;
(x) Vinyl chloride: 525 ug/l;
(xi) Aldrin: 0.136 ng/l;
(xii) Chlordane: 0.588 ng/l;
(xiii) DDT: 0.591 ng/l;
(xiv) Dieldrin: 0.144 ng/l;
(xv) Heptachlor: 0.214 ng/l.

The values listed in (i) through (xv) in Subparagraph (B) of this Rule may be adjusted by the Commission or its designee on a case-by-case basis to account for site-specific or chemical-specific information pertaining to the assumed BCF, FCR or CPF values or other appropriate data.

(b) Temperature. The Commission may establish a water quality standard for temperature for specific water bodies other than the standards specified in Rules .0211 and .0212 of this Section, upon a case-by-case determination that thermal discharges to these waters, which serve or may serve as a source

and/or receptor of industrial cooling water provide for the maintenance of the designated best use throughout a reasonable portion of the water body. Such revisions of the temperature standard must be consistent with the provisions of Section 316(a) of the Federal Water Pollution Control Act as amended and will be noted in Rule .0218 of this Section.

History Note: Statutory Authority G.S. 143-214.1; 143-215.3(a)(1);
Eff. February 1, 1976;
Amended Eff. October 1, 1989; January 1, 1985;
September 9, 1979.

.0209 VARIANCES FROM APPLICABLE STANDARDS
.0210 BEST USE CRITERIA

History Note: Statutory Authority G.S. 143-214.1;
Eff. February 1, 1976;
Amended Eff. September 9, 1979;
Repealed Eff. January 1, 1985.

.0211 FRESH SURFACE WATER CLASSIFICATIONS AND STANDARDS

(a) General. The water quality standards for all fresh surface waters are the basic standards applicable to Class C waters. Additional and more stringent standards applicable to other specific freshwater classifications are specified in Paragraphs (c) through (f) of this Rule.

(b) All fresh surface waters (Class C).

(1) Best Usage of Waters. Aquatic life propagation and maintenance (including fishing, and fish), wildlife, secondary recreation, agriculture and any other usage except for primary recreation or as a source of water supply for drinking, culinary or food processing purposes;

(2) Conditions Related to Best Usage. The waters will be suitable for aquatic life propagation and maintenance, wildlife, secondary recreation, and agriculture; sources of water pollution which preclude any of these uses on either a short-term or long-term basis will be considered to be violating a water quality standard;

(3) Quality standards applicable to all fresh surface waters:

(A) Chlorophyll a (corrected): not greater than 40 ug/l for lakes, reservoirs, and other slow-moving waters not designated as trout waters, and not greater than 15 ug/l for lakes, reservoirs, and other slow-moving waters designated as trout waters (not applicable to lakes and reservoirs less than ten acres in surface area); the Commission or its designee may prohibit or limit any discharge of waste into surface waters if, in the opinion of the Director, the surface waters experience or the discharge would result in growths of microscopic or macroscopic vegetation such that the standards established pursuant to this Rule would be violated or the intended best usage of the waters would be impaired;

(B) Dissolved oxygen: not less than 6.0 mg/l for trout waters; for non-trout waters, not less than a daily average of 5.0 mg/l with a minimum instantaneous value of not less than 4.0 mg/l; swamp waters, lake coves or backwaters, and lake bottom waters may have lower values if caused by natural conditions;

(C) Floating solids; settleable solids; sludge deposits: only such amounts attributable to sewage, industrial wastes or other wastes as will not make the water unsafe or unsuitable for aquatic life and wildlife or impair the waters for any designated uses;

(D) Gases, total dissolved: not greater than 110 percent of saturation;

(E) Organisms of the coliform group: fecal coliforms not to exceed a geometric mean of 200/100ml (MF count) based upon at least five consecutive samples examined during any 30 day period; nor exceed 400/100ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results, the MPN 5-tube dilution technique will be used as the reference method;

(F) Oils; deleterious substances; colored or other wastes: only such amounts as will not render the waters injurious to public health, secondary recreation or to aquatic life and wildlife or adversely affect the palatability of fish, aesthetic quality or impair the waters for any designated uses; for

the purpose of implementing this Rule, oils, deleterious substances, colored or other wastes will include but not be limited to substances that cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines pursuant to 40 CFR 110.4(a)-(b);

(G) pH: shall be normal for the waters in the area, which generally shall range between 6.0 and 9.0 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions;

(H) Phenolic compounds: only such levels as will not result in fish-flesh tainting or impairment of other best usage;

(I) Radioactive substances:

(i) Combined radium-226 and radium-228: the maximum average annual activity level (based on at least four samples collected quarterly) for combined radium-226 and radium-228 shall not exceed five picoCuries per liter;

(ii) Alpha Emitters: the average annual gross alpha particle activity (including radium-226, but excluding radon and uranium) shall not exceed 15 picoCuries per liter;

(iii) Beta Emitters: the maximum average annual activity level (based on at least four samples, collected quarterly) for strontium-90 shall not exceed eight picoCuries per liter; nor shall the average annual gross beta particle activity (excluding potassium-40 and other naturally occurring radio-nuclides) exceed 50 picoCuries per liter; nor shall the maximum average annual activity level for tritium exceed 20,000 picoCuries per liter;

(J) Temperature: not to exceed 2.8 degrees C (5.04 degrees F) above the natural water temperature, and in no case to exceed 29 degrees C (84.2 degrees F) for mountain and upper piedmont waters and 32 degrees C (89.6 degrees F) for lower piedmont and coastal plain waters. The temperature for trout waters shall not be increased by more than 0.5 degrees C (0.9 degrees F) due to the discharge of heated liquids, but in no case to exceed 20 degrees C (68 degrees F);

(K) Turbidity: the turbidity in the receiving water will not exceed 50 Nephelometric Turbidity Units (NTU) in streams not designated as trout waters and 10 NTU in streams, lakes or reservoirs designated as trout waters; for lakes and reservoirs not designated as trout waters, the turbidity will not exceed 25 NTU; if turbidity exceeds these levels due to natural background conditions, the existing turbidity level cannot be increased. Compliance with this turbidity standard can be met when land management activities employ Best Management Practices (BMPs) [as defined by Rule .0202(6) of this Section] recommended by the Designated Nonpoint Source Agency [as defined by Rule .0202(12) of this Section]. BMPs must be in full compliance with all specifications governing the proper design, installation, operation and maintenance of such BMPs;

(L) Toxic substances: numerical water quality standards (maximum permissible levels) to protect aquatic life applicable to all fresh surface waters:

(i) Arsenic: 50 ug/l;

(ii) Beryllium: 6.5 ug/l;

(iii) Cadmium: 0.4 ug/l for trout waters and 2.0 ug/l for non-trout waters;

(iv) Chlorine, total residual: 17 ug/l for trout waters (Tr); (Action Level of 17 ug/l for all waters not classified as trout waters (Tr); see Paragraph (b)(4) of this Rule);

(v) Chromium, total: 50 ug/l;

(vi) Cyanide: 5.0 ug/l;

(vii) Fluorides: 1.8 mg/l;

(viii) Lead: 25 ug/l; collection of data on sources, transport and fate of lead will be required as part of the toxicity reduction evaluation for dischargers that are out of compliance with whole effluent toxicity testing requirements and the concentration of lead in the effluent is concomitantly determined to exceed an instream level of 3.1 ug/l from the discharge;

(ix) MBAS (Methylene-Blue Active Substances): 0.5 mg/l;

(x) Mercury: 0.012 ug/l;

(xi) Nickel: 88 ug/l;

(xii) Pesticides:

(I) Aldrin: 0.002 ug/l;

(II) Chlordane: 0.004 ug/l;

(III) DDT: 0.001 ug/l;

(IV) Demeton: 0.1 ug/l;

(V) Dieldrin: 0.002 ug/l;

(VI) Endosulfan: 0.05 ug/l;

(VII) Endrin: 0.002 ug/l;

(VIII) Guthion: 0.01 ug/l;
(IX) Heptachlor: 0.004 ug/l;
(X) Lindane: 0.01 ug/l;
(XI) Methoxychlor: 0.03 ug/l;
(XII) Mirex: 0.001 ug/l;
(XIII) Parathion: 0.013 ug/l;
(XIV) Toxaphene: 0.0002 ug/l;

(xiii) Polychlorinated biphenyls: 0.001 ug/l;
(xiv) Selenium: 5 ug/l;
(xv) Toluene: 11 ug/l or 0.36 ug/l in trout waters;
(xvi) Trialkyltin compounds: 0.008 ug/l expressed as tributyltin.

(4) Action Levels for Toxic Substances: if the Action Levels for any of the substances listed in this Subparagraph (which are generally not bioaccumulative and have variable toxicity to aquatic life because of chemical form, solubility, stream characteristics and/or associated waste characteristics) are determined by the waste load allocation to be exceeded in a receiving water by a discharge under the specified low flow criterion for toxic substances (Rule .0206 in this Section), the discharger will be required to monitor the chemical and/or biological effects of the discharge; efforts shall be made by all dischargers to reduce or eliminate these substances from their effluents. Those substances for which Action Levels are listed in this Subparagraph may be limited as appropriate in the NPDES permit if sufficient information exists to indicate that any of those substances may be a significant causative factor resulting in toxicity of the effluent;

(A) Copper: 7 ug/l;
(B) Iron: 1.0 mg/l;
(C) Silver: 0.06 ug/l;
(D) Zinc: 50 ug/l;
(E) Chloride: 230 mg/l;
(F) Chlorine, total residual: 17 ug/l in all waters except trout waters (Tr): [a standard of 17 ug/l exists for waters classified as trout waters and is applicable as such to all dischargers to trout waters; see Paragraph (b)(3)(L)(iv) of this Section].

(c) Class WS-I Waters.

(1) Best Usage of Waters. Source of water supply for drinking, culinary, or food-processing purposes for those users desiring maximum protection of their water supplies, and any best usage specified for Class C waters;

(2) Conditions Related to the Best Usage. Waters of this class are protected water supplies within natural and uninhabitated or predominantly undeveloped (not urbanized) watersheds with no permitted point source dischargers except those existing discharges qualifying for a General Permit according to the requirements of 15A NCAC 2H .0131 specifically approved by the Commission at the time of classification; waters within this class must be relatively unimpacted by nonpoint sources of pollution; local land use management programs are required to protect waters from nonpoint source pollution; watersheds must be protected and the waters, following treatment required by the Division of Health Services, will meet the maximum contaminant levels considered safe for drinking, culinary, and food-processing purposes which are specified in the national drinking water regulations and in the North Carolina Rules Governing Public Water Supplies, 10 NCAC 10D .1600; sources of water pollution which preclude any of these uses on either a short-term or long-term basis will be considered to be violating a water quality standard;

(3) Quality Standards Applicable to Class WS-I Waters:

(A) Nonpoint Source Pollution: only that pollution which will not adversely impact the waters for use as a water supply or any other designated use;
(B) Organisms of coliform group: total coliforms not to exceed 50/100 ml (MF count) as a monthly geometric mean value in watersheds serving as unfiltered water supplies;
(C) Phenolic compounds: not greater than 1.0 ug/l (phenols) to protect water supplies from taste and odor problems from chlorinated phenols;
(D) Sewage, industrial wastes: none except those specified in Subparagraph (2) of this Paragraph;
(E) Solids, total dissolved: not greater than 500 mg/l;
(F) Total hardness: not greater than 100 mg/l as calcium carbonate;
(G) Toxic and other deleterious substances:

(i) Water quality standards (maximum permissible levels) to protect human health through water consumption and fish tissue consumption for non-carcinogens in Class WS-I waters:
(I) Barium: 1.0 mg/l;
(II) Chloride: 250 mg/l;
(III) Manganese: 50 ug/l;
(IV) Nickel: 25 ug/l;
(V) Nitrate nitrogen: 10.0 mg/l;
(VI) 2,4-D: 100 ug/l;
(VII) 2,4,5-TP (Silvex): 10 ug/l;
(VIII) Sulfates: 250 mg/l.

(ii) Water quality standards (maximum permissible levels) to protect human health through water consumption and fish tissue consumption for carcinogens in Class WS-I waters:
(I) Beryllium: 6.8 ng/l;
(II) Benzene: 1.19 ug/l;
(III) Carbon tetrachloride: 0.254 ug/l;
(IV) Chlorinated benzenes: 488 ug/l;
(V) Dioxin: 0.000013 ng/l;
(VI) Hexachlorobutadiene: 0.445 ug/l;
(VII) Polynuclear aromatic hydrocarbons: 2.8 ng/l;
(VIII) Tetrachloroethane (1,1,2,2): 0.172 ug/l;
(IX) Tetrachloroethylene: 0.8 ug/l;
(X) Trichloroethylene: 3.08 ug/l;
(XI) Vinyl Chloride: 2 ug/l;
(XII) Aldrin: 0.127 ng/l;
(XIII) Chlordane: 0.575 ng/l;
(XIV) DDT: 0.588 ng/l;
(XV) Dieldrin: 0.135 ng/l;
(XVI) Heptachlor: 0.208 ng/l.

(d) Class WS-II Waters.

(1) Best Usage of Waters. Source of water supply for drinking, culinary, or food-processing purposes for those users desiring maximum protection for their water supplies where a WS-I classification is not attainable and any best usage specified for Class C waters; this classification may also be used to protect critical portions of the watershed of Class WS-III waters;

(2) Conditions Related to Best Usage. Waters of this class are protected as water supplies which are in low to moderately developed (urbanized) watersheds; only domestic wastewater discharges (excluding municipal dischargers required to have a pretreatment program according to 15A NCAC 2H .0904) and industrial non-process discharges specifically approved by the EMC are permitted in these watersheds; local governments must have land use management programs to protect these watersheds from pollution due to land development and other nonpoint sources; the waters, following treatment required by the Division of Health Services, will meet the maximum contaminant levels considered safe for drinking, culinary, and food-processing purposes which are specified in the national drinking water regulations and in the North Carolina Rules Governing Public Water Supplies, 10 NCAC 10D .1600; sources of water pollution which preclude any of these uses on either a short-term or long-term basis will be considered to be violating a water quality standard;

(3) Quality Standards Applicable to Class WS-II Waters:

(A) Industrial Wastes: none except for non-process industrial discharges specifically approved by the Commission;

(B) Nonpoint Source Pollution: only that pollution which will not adversely impact the waters for use as a water supply or any other designated use;

(C) Odor producing substances contained in sewage or other wastes: only such amounts, whether alone or in combination with other substances or wastes, as will not cause taste and odor difficulties in water supplies which cannot be corrected by treatment, impair the palatability of fish, or have a deleterious effect upon any best usage established for waters of this class;

(D) Phenolic compounds: not greater than 1.0 ug/l (phenols) to protect water supplies from taste and odor problems from chlorinated phenols;

(E) Sewage: none which will have an adverse effect on human health or is not effectively treated to the satisfaction of the Commission and in accordance with the requirements of the Division of Health Services, North Carolina Department of Human Resources;
(F) Total hardness: not greater than 100 mg/l as calcium carbonate;
(G) Total dissolved solids: not greater than 500 mg/l;
(H) Toxic and other deleterious substances:
(i) Water quality standards (maximum permissible levels) to protect human health through water consumption and fish tissue consumption for non-carcinogens in Class WS-II waters:
(I) Barium: 1.0 mg/l;
(II) Chloride: 250 mg/l;
(III) Manganese: 200 ug/l;
(IV) Nickel: 25 ug/l;
(V) Nitrate nitrogen: 10.0 mg/l;
(VI) 2,4-D: 100 ug/l;
(VII) 2,4.5-TP: 10 ug/l;
(VIII) Sulfates: 250.0 mg/l.
(ii) Water quality standards (maximum permissible levels) to protect human health through water consumption and fish tissue consumption for carcinogens in Class WS-II waters:
(I) Beryllium: 6.8 ng/l;
(II) Benzene: 1.19 ug/l;
(III) Carbon tetrachloride: 0.254 ug/l;
(IV) Chlorinated benzenes: 488 ug/l;
(V) Dioxin: 0.000013 ng/l;
(VI) Hexachlorobutadiene: 0.445 ug/l;
(VII) Polynuclear aromatic hydrocarbons: 2.8 ng/l;
(VIII) Tetrachloroethane (1,1,2,2): 0.172 ug/l;
(IX) Tetrachloroethylene: 0.8 ug/l;
(X) Trichloroethylene: 3.08 ug/l;
(XI) Vinyl Chloride: 2 ug/l;
(XII) Aldrin: 0.127 ng/l;
(XIII) Chlordane: 0.575 ng l;
(XIV) DDT: 0.588 ng/l;
(XV) Dieldrin: 0.135 ng/l;
(XVI) Heptachlor: 0.208 ng/l.

(e) Class WS-III Waters.
(1) Best Usage of Waters. Source of water supply for drinking, culinary, or food-processing purposes for those users where more protected sources are not feasible and any other best usage specified for Class C waters;
(2) Conditions Related to Best Usage. The waters, after treatment required by the Division of Health Services, will meet the maximum contaminant levels considered safe for drinking, culinary, or food-processing purposes which are specified in the national drinking water regulations and in the North Carolina Rules Governing Public Water Supplies, 10 NCAC 10D .1600; sources of water pollution which preclude any of these uses on either a short-term or long-term basis will be considered to be violating a water quality standard;
(3) Quality Standards Applicable to Class WS-III Waters:
(A) Odor producing substances contained in sewage, industrial wastes, or other wastes: only such amounts, whether alone or in combination with other substances or wastes, as will not cause taste and odor difficulties in water supplies which cannot be corrected by treatment, impair the palatability of fish, or have a deleterious effect upon any best usage established for waters of this class;
(B) Phenolic compounds: not greater than 1.0 ug/l (phenols) to protect water supplies from taste and odor problems from chlorinated phenols; specific phenolic compounds may be given a different limit if it is demonstrated not to cause taste and odor problems and not to be detrimental to other best usage;
(C) Sewage, industrial wastes, or other wastes: none which will have an adverse effect on human health or which are not effectively treated to the satisfaction of the Commission and in accordance with the requirements of the Division of Health Services, North Carolina Department of Human Resources; any discharger or industrial users subject to pretreatment standards may be

required upon request by the Commission to disclose all chemical constituents present or potentially present in their wastes and chemicals which could be spilled or be present in runoff from their facility which may have an adverse impact on downstream water supplies classified WS-III; these facilities may be required to have spill and treatment failure control plans as well as perform special monitoring for toxic substances;

(D) Total hardness: not greater than 100 mg/l as calcium carbonate;

(E) Total dissolved solids: not greater than 500 mg/l;

(F) Toxic and other deleterious substances:

(i) Water quality standards (maximum permissible levels) to protect human health through water consumption and fish tissue consumption for non-carcinogens in Class WS-III waters:

(I) Barium: 1.0 mg/l;
(II) Chloride: 250 mg/l;
(III) Manganese: 200 ug/l;
(IV) Nickel: 25 ug/l;
(V) Nitrate nitrogen: 10.0 mg/l;
(VI) 2,4-D: 100 ug/l;
(VII) 2,4,5-TP (Silvex): 10 ug/l;
(VIII) Sulfates: 250.0 mg/l.

(ii) Water quality standards (maximum permissible levels) to protect human health through water consumption and fish tissue consumption for carcinogens in Class WS-III waters:

(I) Beryllium: 6.8 ng/l;
(II) Benzene: 1.19 ug/l;
(III) Carbon tetrachloride: 0.254 ug/l;
(IV) Chlorinated benzenes: 488 ug/l;
(V) Dioxin: 0.000013 ng/l;
(VI) Hexachlorobutadiene: 0.445 ug/l;
(VII) Polynuclear aromatic hydrocarbons: 2.8 ng/l;
(VIII) Tetrachloroethane (1,1,2,2): 0.172 ug/l;
(IX) Tetrachloroethylene: 0.8 ug/l;
(X) Trichloroethylene: 3.08 ug/l;
(XI) Vinyl Chloride: 2 ug/l;
(XII) Aldrin: 0.127 ng/l;
(XIII) Chlordane: 0.575 ng/l;
(XIV) DDT: 0.588 ng/l;
(XV) Dieldrin: 0.135 ng/l;
(XVI) Heptachlor: 0.208 ng/l.

(f) Class B Waters.

(1) Best Usage of Waters. Primary recreation and any other best usage specified by the "C" classification;

(2) Conditions Related to Best Usage. The waters will meet accepted standards of water quality for outdoor bathing places and will be of sufficient size and depth for primary recreation purposes. Sources of water pollution which preclude any of these uses on either a short-term or long-term basis will be considered to be violating a water quality standard;

(3) Quality standards applicable to Class B waters:

(A) Sewage, industrial wastes, or other wastes: none which are not effectively treated to the satisfaction of the Commission; in determining the degree of treatment required for such waste when discharged into waters to be used for bathing, the Commission will consider the quality and quantity of the sewage and wastes involved and the proximity of such discharges to waters in this class; discharges in the immediate vicinity of bathing areas may not be allowed if the Director determines that the waste can not be reliably treated to ensure the protection of primary recreation;

(B) Organisms of coliform group: fecal coliforms not to exceed geometric mean of 200/100 ml (MF count) based on at least five consecutive samples examined during any 30-day period and not to exceed 400/100 ml in more than 20 percent of the samples examined during such period.

History Note: Statutory Authority G.S. 143-214.1; 143-215.3(a)(1);
Eff. February 1, 1976;
Amended Eff. October 1, 1989; July 1, 1988;

February 1, 1986; January 1, 1985.

.0212 TIDAL SALT WATER CLASSIFICATIONS AND STANDARDS

(a) General. The water quality standards for all tidal salt waters are the basic standards applicable to Class SC waters. Additional and more stringent standards applicable to other specific tidal salt water classifications are specified in Paragraphs (c) and (d) of this Rule.

(b) All tidal salt waters (Class SC).

(1) Best Usage of Waters. Aquatic life propagation and maintenance (including fishing, fish and functioning PNAs), wildlife, secondary recreation, and any other usage except primary recreation or shellfishing for market purposes;

(2) Conditions Related to Best Usage. The waters will be suitable for aquatic life propagation and maintenance, wildlife, and secondary recreation; Any source of water pollution which precludes any of these uses, including their functioning as PNAs, on either a short-term or a long-term basis will be considered to be violating a water quality standard;

(3) Quality standards applicable to all tidal salt waters:

(A) Chlorophyll a (corrected): not greater than 40 ug/l in sounds, estuaries, and other slow-moving waters; the Commission or its designee may prohibit or limit any discharge of waste into surface waters if, in the opinion of the Director, the surface waters experience or the discharge would result in growths of microscopic or macroscopic vegetation such that the standards established pursuant to this Rule would be violated or the intended best usage of the waters would be impaired.

(B) Dissolved oxygen: not less than 5.0 mg/l, except that swamp waters, poorly flushed tidally influenced streams or embayments, or estuarine bottom waters may have lower values if caused by natural conditions;

(C) Floating solids; settleable solids; sludge deposits: only such amounts attributable to sewage, industrial wastes or other wastes, as will not make the waters unsafe or unsuitable for aquatic life and wildlife, or impair the waters for any designated uses;

(D) Gases, total dissolved: not greater than 110 percent of saturation;

(E) Organisms of coliform group: fecal coliforms not to exceed geometric mean of 200/100 ml (MF count) based upon at least five consecutive samples examined during any 30 day period; not to exceed 400/100 ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the MF technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results the MPN 5-tube dilution method will be used as the referee method;

(F) Oils; deleterious substances; colored or other wastes: only such amounts as will not render the waters injurious to public health, secondary recreation or to aquatic life and wildlife or adversely affect the palatability of fish, aesthetic quality or impair the waters for any designated uses; for the purpose of implementing this Rule, oils, deleterious substances, colored or other wastes will include but not be limited to substances that cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines pursuant to 40 CFR 110.4(a)-(b).

(G) pH: will be normal for the waters in the area, which generally will range between 6.8 and 8.5 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions;

(H) Phenolic compounds: only such levels as will not result in fish-flesh tainting or impairment of other best usage;

(I) Radioactive substances:

(i) Combined radium-226 and radium-228: The maximum average annual activity level (based on at least four samples, collected quarterly) for combined radium-226, and radium-228 will not exceed five picoCuries per liter;

(ii) Alpha Emitters. The average annual gross alpha particle activity (including radium-226, but excluding radon and uranium) will not exceed 15 picoCuries per liter;

(iii) Beta Emitters. The maximum average annual activity level (based on at least four samples, collected quarterly) for strontium-90 will not exceed eight picoCuries per liter; nor shall the average annual gross beta particle activity (excluding potassium-40 and other naturally occurring radio-nuclides) exceed 50 picoCuries per liter; nor will the maximum average annual activity level for tritium exceed 20,000 picoCuries per liter;

REFERENCE 31

STATE OF
NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT, HEALTH,
AND NATURAL 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: 15A NCAC 2B .0309
Current through: March 1, 1990

.0309 YADKIN-PEE DEE RIVER BASIN

Name of Stream	Description	Class	Classification Date	Classification Index No.
Flat Swamp Creek	From source to High Rock Lake, Yadkin River	C	7/1/73	12-123
Rocky Meadow Branch	From source to Flat Swamp Creek	C	7/1/73	12-123-1
Dry Branch	From source to Flat Swamp Creek	C	7/1/73	12-123-2
Fourmile Branch	From source to High Rock Lake, Yadkin River	C	7/1/73	12-124
Boss Branch	From source to Fourmile Branch	C	7/1/73	12-124-1
Cedar Creek	From source to Yadkin River	C	9/1/74	12-125
Lick Creek	From source to Tuckertown Lake, Yadkin River	C	9/1/74	12-126
West Branch Lick Creek	From source to Lick Creek	C	9/1/74	12-126-1
East Branch Lick Creek	From source to Denton Water Supply Intake	WS-III	2/1/86	12-126-2-(1)
East Branch Lick Creek	From Denton Water Supply Intake to Lick Creek	C	9/1/74	12-126-2-(2)
Cabin Creek	From source to Tuckertown Lake, Yadkin River	C C	9/1/74 9/1/74	12-127
Flat Creek	From source to Tuckertown Lake, Yadkin River	C	9/1/74	12-128
Riles Creek	From source to Tuckertown Lake, Yadkin River	C	9/1/74	12-129
Ritchies Lake	Entire Lake and connecting stream to Riles Creek	C C	9/1/74 9/1/74	12-129-1
Curl Tail Creek	From source to Riles Creek	C	9/1/74	12-129-2
Ellis Creek	From source to Tuckertown Lake, Yadkin River	C	9/1/74	12-130
Garr Creek	From source to Badin Lake, Yadkin River	C	9/1/74	12-131
Reynolds Creek	From source to Badin Lake, Yadkin River	C	9/1/74	12-132
Alls Fork	From source to Badin Lake, Yadkin River	C	9/1/74	12-133
Beaverdam Creek	From source to Badin Lake, Yadkin River	C	9/1/74	12-134
Glady Fork	From source to Badin Lake, Yadkin River	C	9/1/74	12-135
Spring Branch	From source to Glady Fork	C	9/1/74	12-135-1
Mountain Branch	From source to Glady Fork	C	9/1/74	12-135-2
Reeves Spring Branch	From source to Badin Lake, Yadkin River	C	9/1/74	12-136
Dutch John Creek	From source to Lake Tillery, Yadkin River	WS-III&B	2/1/86	12-137
PEE DEE RIVER (including Lake Tillery and Blewett Falls Lake below normal operating levels)	From Uwharrie River to Blewett Falls Dam	WS-III&B	2/1/86	13-(1)
Uwharrie River	From source to Randolph County	WS-III	2/1/86	13-2-(0.5)

.0309 YADKIN-PEE DEE RIVER BASIN

Name of Stream	Description	Class	Classification Date	Classification Index No.
	SR 1314			
Little Uwharrie River (Wheatmore Pond)	From source to Uwharrie River	WS-III	2/1/86	13-2-1
Brier Creek	From source to Little Uwharrie River	WS-III	2/1/86	13-2-1-1
Plummer Creek	From source to Brier Creek	WS-III	2/1/86	13-2-1-1-1
Uwharrie River	From Randolph County SR 1314 to Lake Tillery, Pee Dee River	C	4/6/55	13-2-(1.5)
Jackson Creek	From source to Uwharrie River	C	4/6/55	13-2-2
South Fork Jackson Creek	From source to Jackson Creek	C	4/6/55	13-2-2-1
Caraway Creek (including proposed Asheboro Water Supply Reservoir)	From source to a point 1,000 feet north of N.C. Hwy. 49A (Old Farmer Road)	WS-III	2/1/86	13-2-3-(1)
Little Caraway Creek	From source to Caraway Creek	WS-III	2/1/86	13-2-3-2
Back Creek (Back Creek Lake)	From source to Caraway Creek	WS-III	2/1/86	13-2-3-3
Greenes Branch	From source to Back Creek Lake, Back Creek	WS-III	2/1/86	13-2-3-3-1
Cedar Fork Creek	From source to Back Creek	WS-III	2/1/86	13-2-3-3-2
Long Branch	From source to Cedar Fork Creek	WS-III	2/1/86	13-2-3-3-2-1
Caraway Creek	From a point 1,000 feet north of N.C. Hwy 49A (Old Farmer Road) to Uwharrie River	C	4/6/55	13-2-3-(4)
Taylors Creek	From source to Caraway Creek	C	9/1/74	13-2-3-5
Toms Creek	From source to Uwharrie River	C	9/1/74	13-2-4
Betty McGees Creek	From source to Uwharrie River	C	9/1/74	13-2-5
Talbotts Branch	From source to Betty McGees Creek	C	9/1/74	13-2-5-1
Second Creek	From source to Uwharrie River	C	9/1/74	13-2-6
South Fork Second Creek	From source to Second Creek	C	9/1/74	13-2-6-1
Twomile Branch	From source to Second Creek	C	9/1/74	13-2-6-2
Twomile Creek	From source to Uwharrie River	C	4/6/55	13-2-7
Silver Run Creek	From source to Uwharrie Creek	C	4/6/55	13-2-8
Hannahs Creek	From source to Uwharrie River	C	4/6/55	13-2-9
North Prong Hannahs Creek	From source to Hannahs Creek	C	4/6/55	13-2-9-1
South Prong Hannahs Creek	From source to Hannahs Creek	C	4/6/55	13-2-9-2
Robbins Branch	From source to Hannahs Creek	C	4/6/55	13-2-9-3
Laniers Creek	From source to Uwharrie River	C	4/6/55	13-2-10
Nanny Branch	From source to Laniers Creek	C	4/6/55	13-2-10-1
Sand Branch	From source to Laniers Creek	C	4/6/55	13-2-10-2
Mill Creek	From source to Uwharrie River	C	4/6/55	13-2-11
Walkers Creek	From source to Uwharrie River	C	4/6/55	13-2-12
Lakes Creek	From source to Uwharrie River	C	4/6/55	13-2-13
Narrows Branch	From source to Uwharrie River	C	4/6/55	13-2-14
Crow Creek	From source to Uwharrie River	C	9/1/74	13-2-15
Wallace Branch	From source to Crow Creek	C	9/1/74	13-2-15-1
Big Creek	From source to Crow Creek	C	9/1/74	13-2-15-2
Horsepen Creek	From source to Uwharrie River	C	4/6/55	13-2-16

REFERENCE 32

Record of Telephone Conversation

Individual : DUMONT BUNKER Date : 6/27/90
Organization : ENGINEERING SECTION PUBLIC WORKS DEPT By : CB
Phone No. : 919-626-1227 CITY OF ASHEBORO

Project : HARRELSON RUBBER

Subject : # of CONNECTIONS AND EXTENT OF CITY OF ASHEBORO'S WATER SYSTEM

Items Discussed :

95% OR MORE OF THE INCORPORATED TOWN AREAS SERVED BY CITY WATER. 7,035 RESIDENTIAL CONNECTIONS
1,215 INDUSTRIAL CONNECTIONS

THERE ARE LINES THAT SERVICE PEOPLE OUTSIDE THE CITY LIMITS — THE STATE ZOO PARK IS SERVICED, AS ARE PEOPLE FOR ABOUT A MILE ALONG RTE 49 TO THE SOUTHWEST OF THE CITY AND SEVERAL OTHER LITTLE POCKETS. HE WILL SEND ME A SERVICE AREA MAP, AND WE'LL TALK MORE ABOUT IT WHEN I GET IT.

Comments or Action :

cc : HUNTER LOFTIN
LARRY RAMSEY
HARRELSON RUBBER FILES (2 FILES)

REFERENCE 33

Established Series
Rev. TRG:JCM
3/86

GEORGEVILLE SERIES

The Georgeville series consists of well drained moderately permeable soils that formed in material mostly weathered from Carolina slate or fine grained rocks of the Piedmont Uplands. Slopes are 2 to 25 percent.

TAXONOMIC CLASS: Clayey, kaolinitic, thermic Typic Hapludults.

TYPICAL PEDON: Georgeville silt loam--forested
(Colors are for moist soil.)

O--1 to 0 inches; decayed leaves and live roots.

A--0 to 4 inches; dark yellowish brown (10YR 4/4) silt loam; weak medium subangular blocky structure; friable; many fine and common medium roots; strongly acid; abrupt smooth boundary. (3 to 9 inches thick)

E--4 to 6 inches; yellowish brown (10YR 5/4) silt loam; weak medium subangular blocky structure; friable; many fine and medium roots; strongly acid; abrupt broken boundary. (0 to 5 inches thick)

Bt1--6 to 10 inches; yellowish red (5YR 5/6) silt clay loam; weak fine subangular blocky structure; friable; common fine and few medium roots; few distinct clay films on faces of peds; common fine pores; strongly acid; clear smooth boundary. (0 to 8 inches thick)

Bt2--10 to 28 inches; red (2.5YR 4/8) clay; moderate fine subangular blocky structure; friable; few fine and medium roots; common distinct clay films on faces of peds; common fine pores; strongly acid; clear smooth boundary. (10 to 2 inches thick)

Bt3--28 to 41 inches; red (2.5YR 4/6) clay with few fine distinct strong brown (7.5YR 5/8) mottles; moderate fine and medium subangular blocky structure; friable; common distinct clay films on faces of peds; few fine pores; strongly acid; gradual smooth boundary. (10 to 25 inches thick)

Bt4--41 to 53 inches; red (2.5YR 4/6) silty clay loam with few fine distinct yellowish brown (10YR 5/6) and few fine prominent brownish yellow (10YR 6/8) mottles; moderate coarse subangular blocky structure; friable; few fine roots; common distinct clay films on faces of peds; few fine pores; few fine flakes of mica; strongly acid; gradual smooth boundary. (0 to 20 inches thick)

BC--53 to 63 inches; red (2.5YR 4/6) silt clay loam with common fine and medium distinct reddish yellow (7.5YR 6/8) and few fine faint dark yellowish brown (10YR 4/6) mottles; weak coarse and very coarse subangular blocky structure; friable; few fine roots; few faint clay films on faces of peds; few fine flakes of mica strongly acid. (10 to 25 inches thick)

TYPE LOCATION: Lancaster County, South Carolina; 6 miles northeast of Lancaster, South Carolina; 1.3 miles east of junction of State Highway 28 and 82; 60 feet south of State Highway 28; and 235 feet southeast of power pole no. COA31.

RANGE IN CHARACTERISTICS: Thickness of the clayey part of the Bt horizon ranges from 24 to 48 inches. Depth to the bottom of the clayey Bt horizon exceeds 30 inches. Depth to bedrock (R horizon) is more than 60 inches. The soil is very strongly acid to neutral in the A horizon and very strongly acid or strongly acid throughout the rest of the profile. Content of coarse fragments range to as much as 20 percent by volume in the A horizon and to as much as 5 percent in the Bt horizon. Few fine flakes of mica are in the lower part of the solum of some pedons.

The A horizon has hue of 5YR to 2.5Y, or it is neutral, value of 4 or 5, and chroma of 0 to 8. The E horizon, where present, has hue of 5YR to 2.5Y, value of 4 or 5, and chroma of 3 to 8. The A and E horizon is silt loam, loam, very fine sandy loam, or the channery analogues of these. Where eroded, the A horizon has hue of 2.5YR to 5YR, value of 4 or 5, and chroma of 4 to 8. It is clay loam or silty clay loam.

The AB horizon, where present, has hue of 2.5YR or 5YR, value of 4 or 5, and chroma of 6 or 8. It is silty clay loam or clay loam.

The upper part of the Bt horizon of many pedons has hue of 5YR, value of 4 or 5, and chroma of 6 or 8. The middle part of the Bt horizon, and in many pedons the upper part of the Bt horizon, has hue of 10R or 2.5YR, value of 4 or 5, and chroma of 6 or 8. The lower part of the Bt horizon has hue of 10R or 2.5YR, value of 4 or 5, and chroma of 6 or 8, commonly with mottles in shades of yellow or brown. The Bt horizon commonly is clay or silty clay but ranges to clay loam or silty clay loam. The particle size control section averages more than 30 percent silt or more than 40 percent silt plus very fine sand.

The BC horizon has hue of 10R to 5YR, value of 4 or 5, and chroma of 6 or 8, commonly with mottles in shades of yellow or brown. It is silt loam, loam, silty clay loam, or clay loam.

The C horizon has hue of 10R to 10YR, value of 4 to 6, and chroma of 3 to 8, commonly with mottles in shades of brown, yellow, gray, or red. In some pedons, the C horizon is coarsely mottled in shades of red, brown, yellow or gray. It is silt loam, loam, very fine sandy loam, or fine sandy loam with as much as 90 percent soft saprolite of Carolina slate or fine-grained rock material. Coarse fragments range to as much as 10 percent in some pedons.

COMPETING SERIES: These are the Appling, Aragon, Bethlehem, Cataula, Cecil, Chestatee, Georgeville, Herndon, Hulett, Kolomaki, Madison, Mahan, Nankin, Nectar, Neeses, Pacolet, Spotsylvania, and Wedowee series. Appling, Cecil, Hulett, Madison, Nankin, Pacolet, and Wedowee soils have less than 30 percent silt in the control section. Aragon soils have Bt horizons that are mottled in the upper part. Aragon and Nectar soils formed in weathered limestone, sandstone, shale, or siltstone. Chestatee soils have more than 15 percent by volume of coarse fragments throughout. Herndon soils have Bt horizons with hue of 5YR or yellower. Spotsylvania soils have a lithologic discontinuity. Mahan soils formed in coastal plain sediments.

GEOGRAPHIC SETTING: Georgeville soils are on gently to strongly sloping Piedmont uplands. Slopes are generally 6 to 12 percent and range from 2 to 25 percent. The soil formed in residuum weathered from fine grained rocks, generally classed as phyllites or Carolina slates. Annual rainfall ranges from 44 to 60 inches. Mean annual temperature is about 63 degrees F., and the growing season is 200 to 240 days.

GEOGRAPHICALLY ASSOCIATED SOILS: In addition to the competing Cecil, Herndon, and Pacolet series, these are the Alamance, Badin, Goldston, Gundy, Kirksey, Nason, and Tatum series. Alamance and Kirksey soils are fine-silty. Goldston soils are loamy-skeletal. Badin, Gundy, Nason, and Tatum soils have mixed mineralogy

DRAINAGE AND PERMEABILITY: Well drained; medium runoff; moderate permeability.

USE AND VEGETATION: Cleared areas are used for cotton, small grains, tobacco, corn, hay, and pasture. Forested areas are in mixed hardwood and pines.

DISTRIBUTION AND EXTENT: Piedmont of Virginia, Alabama, Georgia, North Carolina, and South Carolina. The series is extensive.

SERIES ESTABLISHED: Cabarrus County, North Carolina; 1910.

REMARKS: This revision uses the linear relationship between the thickness of the clayey Bt horizon and depth to the bottom of the clayey Bt horizon as series criteria instead of solum thickness.

Diagnostic features recognized in this pedon are

Ochric epipedon - 0 to 4 inches

Angillic horizon - 6 to 53 inches

National Cooperative Soil Survey
U. S. A.

SC0014

SOIL INTERPRETATION RECORD

MLRA(S): 136
REV: [redacted]

TYPIC HAPLUDULTS, CLAYEY, KAOLINITIC, THERMIC

THE CERDEVILLE SERIES CONSISTS OF WELL DRAINED SOILS ON THE PIEDMONT UPLAND. THE SOIL FORMED IN RESIDUUM FROM SLATE. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS YELLOWISH BROWN SILT LOAM. THE SUBSOIL IS YELLOWISH RED OR RED SILTY CLAY LOAM, SILTY CLAY OR CLAY. SLOPES RANGE FROM 2 TO 25 PERCENT.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT >3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-6	SIL, L, VFSL	ML	A-4, A-6	0-2	90-100	80-100	65-100	65-95	<40	NP-11
0-6	SICL, CL	CL, ML	A-6, A-7	0-2	90-100	90-100	85-100	65-98	30-49	11-20
6-10	SICL, CL	CL, ML	A-6, A-7, A-4	0-1	90-100	90-100	80-100	70-98	30-49	8-20
10-53	C, SIC, SICL	MH, ML	A-7	0-1	95-100	95-100	90-100	75-98	41-79	15-40
53-63	SICL, L, SIL	ML, CL, CL-ML	A-4, A-6	0-5	90-100	90-100	65-100	51-95	<30	NP-12

DEPTH (IN.)	CLAY (PCT)	MOIST BULK DENSITY (G/CM3)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	EROSION FACTORS K	T	WIND ERODIBILITY GROUPS	ORGANIC MATTER (PCT)	CORROSIVITY STEEL	CONCRETE
0-6	5-27	1.20-1.40	0.6-2.0	0.15-0.20	4.5-6.0	-	LOW	.43	4	5	.5-2	HIGH	HIGH
0-6	27-35	1.20-1.40	0.6-2.0	0.13-0.18	4.5-6.0	-	LOW	.49	4	6	<.5		
6-10	27-35	1.20-1.40	0.6-2.0	0.13-0.18	4.5-5.5	-	LOW	.32					
10-53	35-60	1.20-1.40	0.6-2.0	0.13-0.18	4.5-5.5	-	LOW	.28					
53-63	15-40	1.20-1.40	0.6-2.0	0.05-0.10	4.5-5.5	-	LOW	.32					

FLOODING FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE DEPTH (FT)	KIND	MONTHS	CEMENTED PAN DEPTH (IN)	HARDNESS	BEDROCK DEPTH (IN)	HARDNESS	SUBSIDENCE POTENTIAL (IN)	TOTAL (IN)	HYDROLOGIC GROUP	FROST ACTION
NONE			>6.0			-		>60		-		B	-

SANITARY FACILITIES (B)

SEPTIC TANK ABSORPTION FIELDS	2-8%: MODERATE-PERCS SLOWLY 8-15%: MODERATE-PERCS SLOWLY,SLOPE 15+%: SEVERE-SLOPE
SEWAGE LAGOON AREAS	2-7%: MODERATE-SEEPAGE,SLOPE 7+%: SEVERE-SLOPE
SANITARY LANDFILL (TRENCH)	2-8%: MODERATE-TOO CLAYEY 8-15%: MODERATE-SLOPE,TOO CLAYEY 15+%: SEVERE-SLOPE
SANITARY LANDFILL (AREA)	2-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE
DAILY COVER FOR LANDFILL	2-8%: FAIR-TOO CLAYEY,HARD TO PACK 8-15%: FAIR-TOO CLAYEY,HARD TO PACK,SLOPE 15+%: POOR-SLOPE

BUILDING SITE DEVELOPMENT (B)

SHALLOW EXCAVATIONS	2-8%: MODERATE-TOO CLAYEY 8-15%: MODERATE-TOO CLAYEY,SLOPE 15+%: SEVERE-SLOPE
DWELLINGS WITHOUT BASEMENTS	2-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE
DWELLINGS WITH BASEMENTS	2-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE
SMALL COMMERCIAL BUILDINGS	2-4%: SLIGHT 4-8%: MODERATE-SLOPE 8+%: SEVERE-SLOPE
LOCAL ROADS AND STREETS	2-15%: SEVERE-LOW STRENGTH 15+%: SEVERE-LOW STRENGTH,SLOPE
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	2-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE

CONSTRUCTION MATERIAL (B)

ROADFILL	2-15%: GOOD 15-25%: FAIR-SLOPE
SAND	IMPROBABLE-EXCESS FINES
GRAVEL	IMPROBABLE-EXCESS FINES too clayey
TOPSOIL	2-15%: POOR-THIN LAYER 15+%: POOR-THIN LAYER,SLOPE too clayey

WATER MANAGEMENT (B)

POND RESERVOIR AREA	2-3%: MODERATE-SEEPAGE 3-8%: MODERATE-SLOPE,SEEPAGE 8+%: SEVERE-SLOPE
EMBANKMENTS DIKES AND LEVEES	SEVERE-HARD TO PACK
EXCAVATED PONDS AQUIFER FED	SEVERE-NO WATER
DRAINAGE	DEEP TO WATER
IRRIGATION	2-3%: ERODES EASILY 3+%: SLOPE,ERODES EASILY
TERRACES AND DIVERSIONS	2-8%: ERODES EASILY 8+%: SLOPE,ERODES EASILY
GRASSED WATERWAYS	2-8%: ERODES EASILY 8+%: SLOPE,ERODES EASILY

REGIONAL INTERPRETATIONS

GEORGEVILLE SERIES

RECREATIONAL DEVELOPMENT (B)

CAMP AREAS	2-8% SLIGHT 8-15% MODERATE-SLOPE 15+% SEVERE-SLOPE	PLAYGROUNDS	2-6% SICL,CL: MODERATE-SLOPE 2-6% SIL,L,VFSL: MODERATE-SLOPE,SMALL STONES 6+% SEVERE-SLOPE
PICNIC AREAS	2-8% SLIGHT 8-15% MODERATE-SLOPE 15+% SEVERE-SLOPE	PATHS AND TRAILS	SEVERE-ERODES EASILY

CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPA-BILITY	CORN (BU)		COTTON LINT (LBS)		OATS (BU)		GRAIN SORGHUM (BU)		LEGUME HAY (TONS)		TALL FESCUE (AUM)		TOBACCO (LBS)	
	INTRM	INTRM	TIRR.	INTRM	TIRR.	INTRM	TIRR.	INTRM	TIRR.	INTRM	TIRR.	INTRM	TIRR.	INTRM	TIRR.
2-6%	2E	95		700		80		60		3.0		6.0		2200	
6-10%	3E	85		625		70		55		2.8		5.5		2000	
10-15%	4E	70		-		60		45		2.5		5.0		-	
15-25%	6E	-		-		-		-		-		-		-	
2-6% SICL,CL,ERODED	3E	75		525		65		45		2.5		5.0		-	
6-10% SICL,CL,ERODED	4E	60		450		50		35		2.0		4.5		-	
10-15% SICL,CL,ERODED	6E	-		-		-		-		-		-		-	
15-25% SICL,CL,ERODED	7E	-		-		-		-		-		-		-	

WOODLAND SUITABILITY

CLASS-DETERMINING PHASE	ORDI SYMB	EROS HAZARD	WINDTHROW LIMIT	EQUIP LIMIT	SEEDLG MORTY	WINDTHRW HAZARD	PLANT COMPET	POTENTIAL PRODUCTIVITY COMMON TREES	SITE INDX	PROD CLAS	TREES TO PLANT
2-15%	8A	SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT	LOBLOLLY PINE	81	8	LOBLOLLY PINE
15-25%	8R	MODER.	MODER.	SLIGHT	SLIGHT			LONGLEAF PINE	67	5	VIRGINIA PINE
								SHORTLEAF PINE	63	7	EASTERN REDCEDAR
								WHITE OAK	69	4	BLACK WALNUT
								SCARLET OAK	70	4	YELLOW-POPLAR
								SOUTHERN RED OAK	67	3	
2-15% SICL,CL,ERODED	6C	MODER.	MODER.	MODER.	SLIGHT			LOBLOLLY PINE	70	6	LOBLOLLY PINE
15-25% SICL,CL,ERODED	6C	SEVERE	SEVERE	MODER.	SLIGHT			LONGLEAF PINE	60	4	VIRGINIA PINE

WINDBREAKS

CLASS-DETERMINING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
	NONE							

WILDLIFE HABITAT SUITABILITY

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
2-10%	FAIR	GOOD	GOOD	GOOD	GOOD	-	IV. POOR	IV. POOR	GOOD	GOOD	IV. POOR	-
10-15%	POOR	FAIR	GOOD	FAIR	FAIR	-	IV. POOR	IV. POOR	FAIR	FAIR	IV. POOR	-
15-25%	IV. POOR	IV. POOR	POOR	FAIR	FAIR	-	IV. POOR	IV. POOR	POOR	FAIR	IV. POOR	-
2-6% SICL,CL,ERODED	FAIR	FAIR	FAIR	GOOD	FAIR	-	IV. POOR	IV. POOR	FAIR	GOOD	IV. POOR	-
6-15% SICL,CL,ERODED	POOR	POOR	POOR	FAIR	POOR	-	IV. POOR	IV. POOR	POOR	FAIR	IV. POOR	-
15-25% SICL,CL,ERODED	IV. POOR	IV. POOR	POOR	FAIR	POOR	-	IV. POOR	IV. POOR	POOR	FAIR	IV. POOR	-

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPM)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: ALL					
LITTLE BLUESTEM	ANSCZ	37					
PANICUM	PANIC	8					
TALL OATGRASS	AREL3	2					
SWITCHCANE	ARTE4	6					
HONEYSUCKLE	LONIC	29					
GRAPE	VITIS	4					
TICKCLOVER	DESMO	2					
LESPEDEZA	LESPE	4					
UNKNOWNS	UUUU	8					
POTENTIAL PRODUCTION (LBS./AC. DRY WT):							
FAVORABLE YEARS		2950					
NORMAL YEARS		2450					
UNFAVORABLE YEARS		1950					

FOOTNOTES

A EST. BASED ON TEST DATA FROM 8 PEDONS FROM LANCASTER, MCCORMICK, AND SALUDA COS., SC, 3 COS. IN GA. AND 2 COS. IN NC

B RATINGS BASED ON NATIONAL SOILS HANDBOOK, PART 11, SECTION 403.

APPENDIX M

SOIL INTERPRETATIONS FOR THE GENERAL SOIL MAP, RANDOLPH COUNTY, NORTH CAROLINA

ASSOC. NO. % & ACRES	SOIL SERIES % OF ASSOC.	SLOPE RANGE % 1/	DEGREE OF LIMITATIONS AND MAJOR SOIL PROPERTIES AFFECTING CERTAIN LAND USES: DWELLINGS FOOTINGS & BASEMENT 2/	SEPTIC TANK FILTER FIELDS	STREETS & ROADS 3/	LIGHT INDUSTRY 2/	CAMP AREAS	PICNIC AREAS	PLAY GROUNDS	PATHS & TRAILS	SUITABILITY FOR: COMMON CROPS	TREES
1. 31% 158,697 ac.	GEORGEVILLE (40)	2-10	MOD bs-ss	MOD p	SEV tsc	MOD-SEV bs-s	SLT-MOD s	SLT-MOD s	MOD-SEV s	SLT	GOOD	GOOD
	HERNDON (30)	2-10	MOD bs-ss	MOD p	SEV tsc	MOD-SEV bs-s	SLT-MOD s	SLT-MOD s	MOD-SEV s	SLT	GOOD	GOOD
2. 26% 133,000 ac.	TATUM (35)	10-30	SEV-MOD s-bs	SEV s-r	SEV tsc-s	SEV s-bs	SEV-MOD s-r	SEV-MOD s-r	SEV s-r	MOD-SEV s-r	F - P	GOOD
	MASON (20)	10-30	SEV-MOD s-bs	SEV s-r	SEV tsc-s	SEV s-bs	SEV-MOD s-r	SEV-MOD s-r	SEV s-r	MOD-SEV s-r	F - P	GOOD
	GOLDSTON (15)	10-30	SEV s-r	SEV s-r	SEV s-r	SEV s-r	SEV s-r	SEV s-r	SEV s-r	MOD-SEV s-r	POOR	POOR
3. 10% 31,000 ac.	MASON, SLATY (35)	4-15	SEV p-r-s	SEV p-r-s	SEV tsc-s	SEV s-bs	MOD-SEV s-gr	MOD-SEV s-gr	SEV s	MOD s	GOOD-F	GOOD
	ENON (15)	4-15	SEV ss-p	SEV p	SEV ss-tsc	SEV ss-s	MOD p-s	MOD-SEV p-s	SEV p-s	SLT-MOD s-p	FAIR	GOOD-F
	LICHUM (15)	0-6	SEV w-ss	SEV w-p	SEV w-tsc	SEV w-ss	SEV w-p	SEV w-p	SEV w-p	SEV-MOD w-p	POOR	FAIR-G
4. 6% 31,000 ac.	TATUM (30)	6-20	MOD-SEV s-bs	SEV-MOD s-r	SEV tsc	SEV-MOD s-bs	MOD-SEV s	MOD-SEV s	SEV s	SLT-MOD s	GOOD-P	GOOD
	MASON (20)	6-20	MOD-SEV s-bs	SEV-MOD s-r	SEV tsc	SEV-MOD s-bs	MOD-SEV s	MOD-SEV s	SEV s	SLT-MOD s	GOOD-P	GOOD
	ENON (15)	6-20	SEV ss-s	SEV p-s	SEV tsc-ss	SEV ss-s	MOD-SEV s-p-r	MOD-SEV s-p-r	SEV s-r	SLT-MOD s-p	FAIR-P	GOOD-F
5. 11% 36,000 ac.	MECKLENBURG (35)	2-10	SEV ss-p	SEV p	SEV ss-tsc	SEV ss	MOD p	SLT-MOD p-s	MOD-SEV p-s	SLT	GOOD	GOOD
	ENON (20)	4-15	SEV ss-p	SEV p	SEV ss-tsc	SEV ss	MOD p-s	MOD-SEV p-s	SEV p-s	SLT-MOD s-p	FAIR	GOOD-F
	WILKES (15)	6-25	SEV ss-r-s	SEV p-r-s	SEV r-s	SEV bs	MOD-SEV s-r	MOD-SEV s-r	SEV s-r	MOD-SEV s-r	POOR	POOR-F
6. 7% 36,000 ac.	CECIL (45)	2-10	MOD ss-p	MOD p	MOD ss-tsc	MOD-SEV ss-s	SLT-MOD s	SLT-MOD s	MOD-SEV s	SLT	GOOD	GOOD
	APPLING (20)	2-10	MOD ss-p	MOD p	MOD ss-tsc	MOD-SEV ss-s	SLT-MOD s	SLT-MOD s	MOD-SEV s	SLT	GOOD	GOOD
7. 7% 10,000 ac.	HELENA (30)	4-10	SEV ss-w	SEV p-w	SEV ss-tsc	SEV ss-w	MOD-SEV p-w	SLT-MOD w-s	MOD-SEV p-s	SLT	FAIR-G	FAIR-P
	ENON (30)	4-10	SEV ss-p	SEV p	SEV ss-tsc	SEV ss-s	MOD p	SLT-MOD p-s	MOD-SEV p-s	SLT	FAIR-G	GOOD-F
	WILKES (20)	6-25	SEV ss-r-s	SEV p-r-s.	SEV r-s	SEV bs-s	MOD-SEV s-r	MOD-SEV s-r	SEV s-r	MOD-SEV s-r	POOR	POOR-F
8. 7% 36,000 ac.	CHENACLA (60)	0-2	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	POOR-G	EXCELLENT
	WEHADKEE (20)	0-2	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	SEV fl-w	POOR	EXCELLENT

1/ Slope gradient considered in making ratings. Increase in gradient increases degree of hazard.
2/ Footings are in subsoil.
3/ Using subsoil for the base.

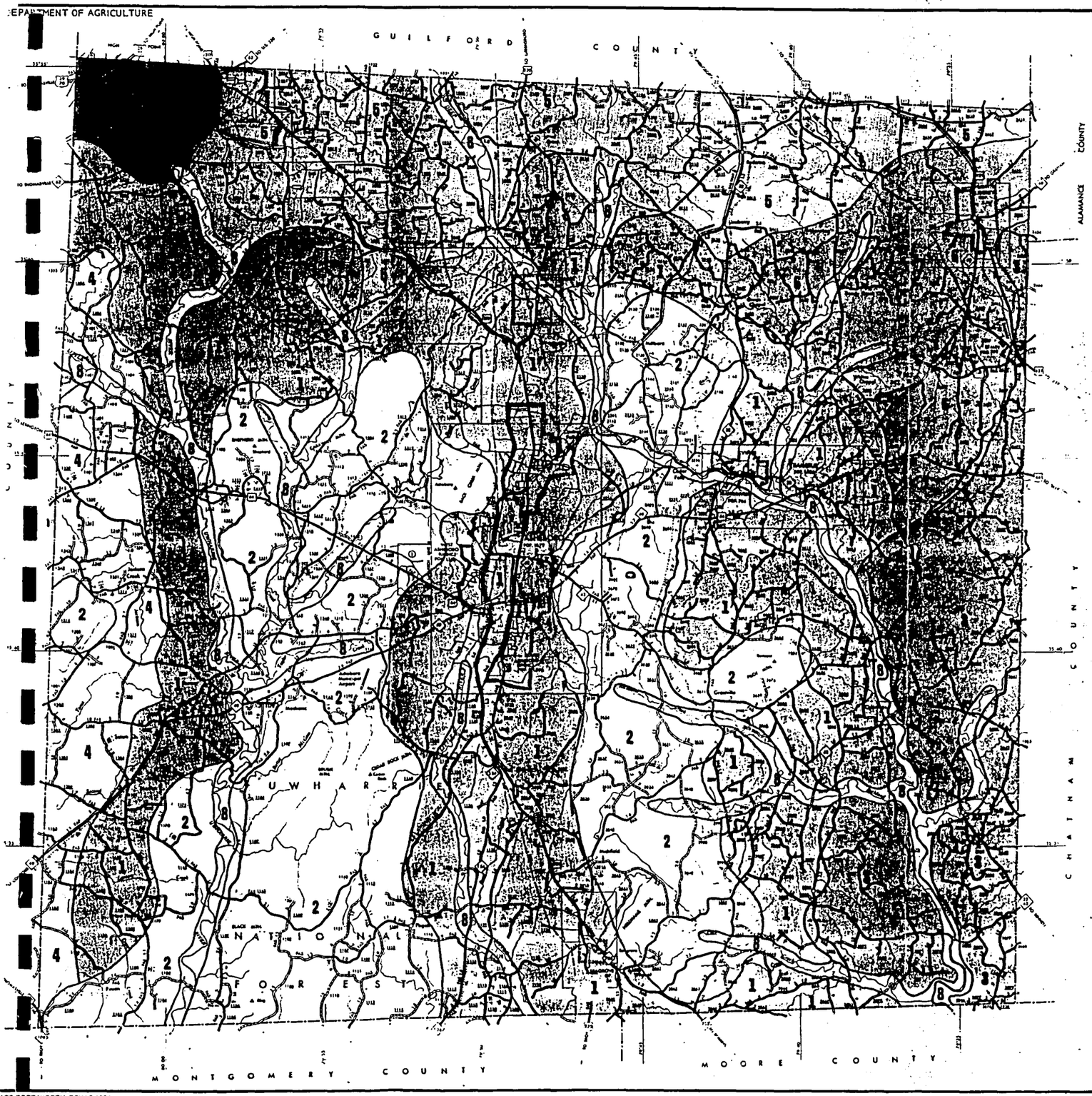
LEGEND FOR ABBREVIATIONS USED

SLT - SLIGHT
MOD - MODERATE
SEV - SEVERE
E - EXCELLENT
G - GOOD
F - FAIR
P - POOR

bs - bearing strength
fl - flood hazard
gr - gravel
lfa - low filtering action
p - permeability
r - rock (surface or subsurface)

s - slope
ss - shrink-swell potential
tex - soil texture
tsc - traffic supporting capacity
w - wetness

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE RALEIGH, NORTH CAROLINA
[illegible]



LEGEND

ASSOCIATION NUMBER	SOIL SERIES AND PERCENT WITHIN THE ASSOCIATION	APPROXIMATE PERCENT	ACR
	WELL TO SOMEWHAT POORLY DRAINED SOILS WITH SILTY SURFACE LAYERS, UNDERLAIN BY WEATHERED "CAROLINA SLATE" ROCK; ON NEARLY LEVEL TO HILLY UPLANDS.	73	373.0
1	GEORGEVILLE (40) HERNDON (30): Soils with moderately permeable silty clay loam to clay subsoils; on long, broad, gently sloping to sloping ridges and short, sloping to moderately steep side slopes.	31	158.0
2	TATUM (35) NASON (20) GOLDSTON (15): Soils, commonly rocky, stony or gravelly with moderately permeable silty clay subsoils; on short, narrow, sloping ridges and hilly land.	26	133.0
3	NASON, SLATY (35) ENON (15) LIGNUM (15): Soils, commonly slaty with moderately to slowly permeable silty clay to clay subsoils; on short, medium width ridges, moderately steep side slopes and flatlands.	10	51.0
4	TATUM (30) NASON (20) ENON (15): Soils, commonly gravelly and occasionally stony with moderately to slowly permeable silty clay to clay subsoils, on gently to strongly sloping, medium width ridges and short, sloping to moderately steep side slopes.	6	31.0
	WELL TO MODERATELY WELL DRAINED SOILS WITH SANDY SURFACE LAYERS; UNDERLAIN BY WEATHERED ACID OR MIXED ACID AND BASIC CRYSTALLINE ROCK: ON GENTLY SLOPING TO MODERATELY STEEP UPLANDS.	20	102.0
5	MECKLENBURG (35) ENON (20) WILKES (15): Soils with moderately slow to slowly permeable plastic clay subsoils; on short, broad, gently sloping to sloping ridges and short, strongly sloping to moderately steep side slopes.	11	56.0
6	CECIL (45) APPLING (20): Soils with moderately permeable clay subsoils, on long, broad, gently sloping ridges and short, sloping to moderately steep side slopes.	7	36.0
7	HELENA (30) ENON (30) WILKES (20): Soils with moderately slow to slowly permeable plastic clay subsoils; on narrow, gently sloping to sloping ridges and short, strongly sloping to moderately steep side slopes.	2	10.0
	SOMEWHAT POORLY TO POORLY DRAINED SOILS WITH LOAMY SURFACE LAYERS, UNDERLAIN BY OLD ALLUVIAL DEPOSITS; ON NEARLY LEVEL BOTTOM LANDS.	7	36.0
8	CHEWACLA (60) WEHADKEE (20): Soils that are wet and have moderately permeable loamy subsoils; on flood plains subject to overflow.	7	36.0
		100	511.0

NOTE: This General Soil Map is suitable for broad planning purposes only. For more detailed planning on individual tracts of land, a detailed soil survey is needed. For additional information consult your local District Conservationist, Soil Conservation Service.

GENERAL SOIL MAP
SEPTEMBER 1972
RANDOLPH COUNTY NORTH CAROLINA

VICINITY MAP

0 1 2 3 4 5
APPROXIMATE SCALE - MILES

Polyconic Projection compiled at 1:126,720 (1"=2 miles) and reproduced at 1:126,720 (1"=2 miles) and 1:253,440 (1"=4 miles) and 1:204,387 (1"=3.2 miles for maximum legibility within sheet size.

Base compiled from General Highway Map, 1971 Revision, North Carolina State Highway Dept. and USDC, Bureau of Public Roads.

N

REVISED OCTOBER 1973 4–

REFERENCE 34

RCVD 5/
HJC

Reference 34

ASHEBORO RANDOLPH
Chamber of Commerce

317 East Dixie Drive

Asheboro, North Carolina 27203

919-626-2626

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

TESTING RESULTS, ASHEBORO CITY SCHOOLS, CAT FORM E

		Asheboro Percentile	Regional Percentile	North Carolina Percentile	National Norm
Grade 3 . .	Reading	63	57	54	50
	Language	70	63	61	50
	Math	65	68	65	50
	TOTAL	**68**	**63**	**60**	**50**
Grade 6 . .	Reading	62	54	51	50
	Language	62	60	58	50
	Math	68	60	58	50
	TOTAL	**62**	**58**	**55**	**50**
Grade 8 . .	Reading	58	54	51	50
	Language	64	57	55	50
	Math	63	57	55	50
	TOTAL	**63**	**56**	**53**	**50**

SOURCE: Asheboro City Schools Report - 1989

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

POPULATION

Classification	Jan., 1990 Estimate	1980 Census	% Change
Randolph County	102,341	91,728	11.6
Archdale	6,378	5,719	11.5
Asheboro	17,441	15,252	14.3
Franklinville	632	607	4.1
Liberty	2,114	1,997	5.8
Ramseur	1,249	1,162	7.4
Randleman	2,466	2,156	14.3
Seagrove	321	294	9.1
Staley	214	205	4.3

SOURCE: NC Data Center, Asheboro/Randolph Chamber of Commerce, 1990

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

TOTAL CIVILIAN LABOR FORCE ESTIMATES, ANNUAL AVERAGES

Category	1989	1988	1987	1986
Civilian Labor Force	61,342	61,210	60,660	57,430
Employment, Total	59,819	59,700	58,510	55,360
Unemployment	1,523	1,510	2,150	2,070
Percent of Labor Force	2.5%	2.5%	3.5%	3.6%

SOURCE: North Carolina Employment Security Commission, 1990

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

POPULATION TOTAL - RACE

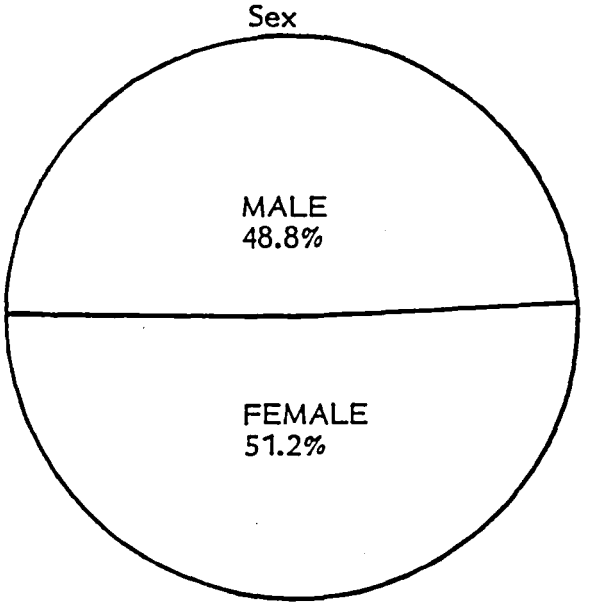
County	White	Black	Spanish Origin	Am. Ind. Eskimo, Aleutian	Asian & Pacific Islander	Other
Randolph	85,610	5,755	488	255	139	102
Rockingham	65,995	17,186	639	68	49	128
Caswell	11,645	9,016	159	13	20	11
Guilford	234,579	79,374	2,404	1,348	1,107	746
Alamance	79,619	19,086	577	144	160	127
Davidson	101,392	11,319	622	206	141	104

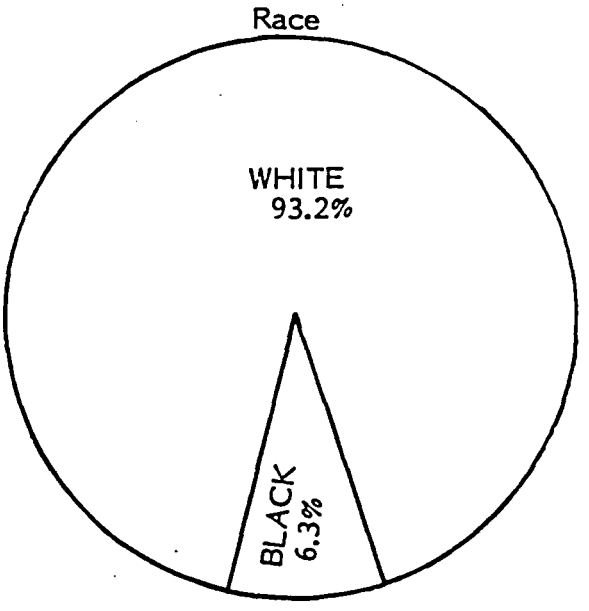
SOURCE: United States Department of Commerce, Bureau of the Census,

Compiled by: PTCOG

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

POPULATION PERCENTAGES

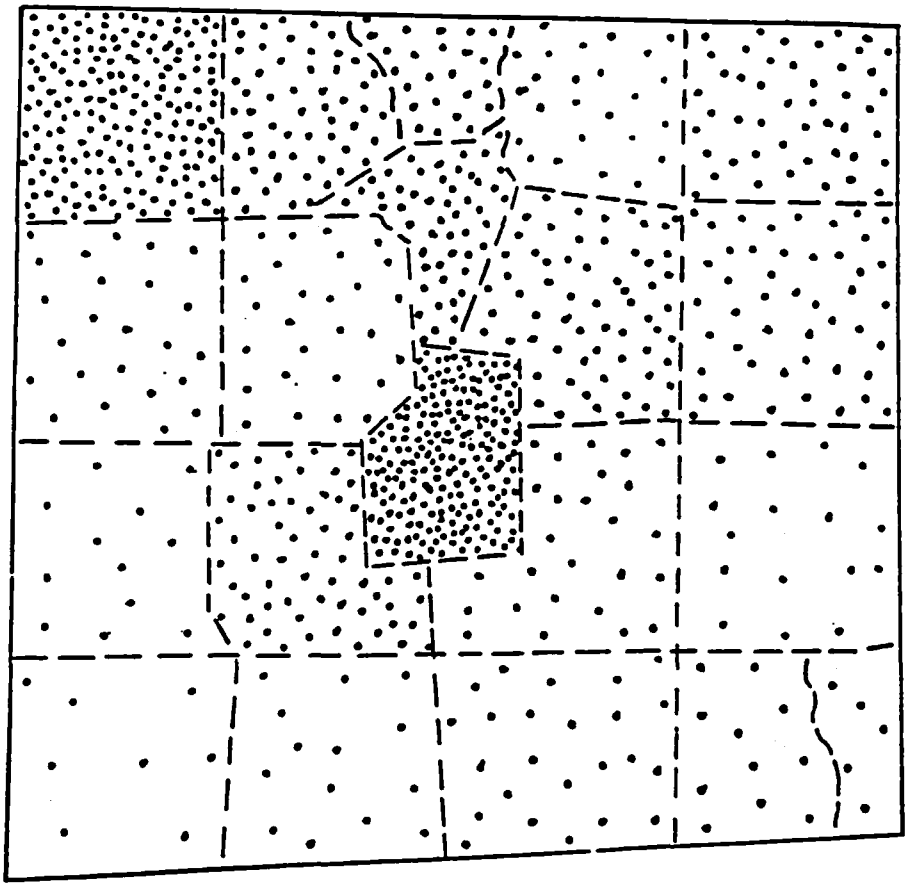




SOURCE: North Carolina Employment Security Commission, 1989

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

POPULATION DENSITY BY TOWNSHIP



SOURCE: Piedmont Triad Council Of Government, 1989

(Each dot represents 100 people.)

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

AGE DISTRIBUTION BY GROUP & TOTAL POPULATION PERCENTAGE

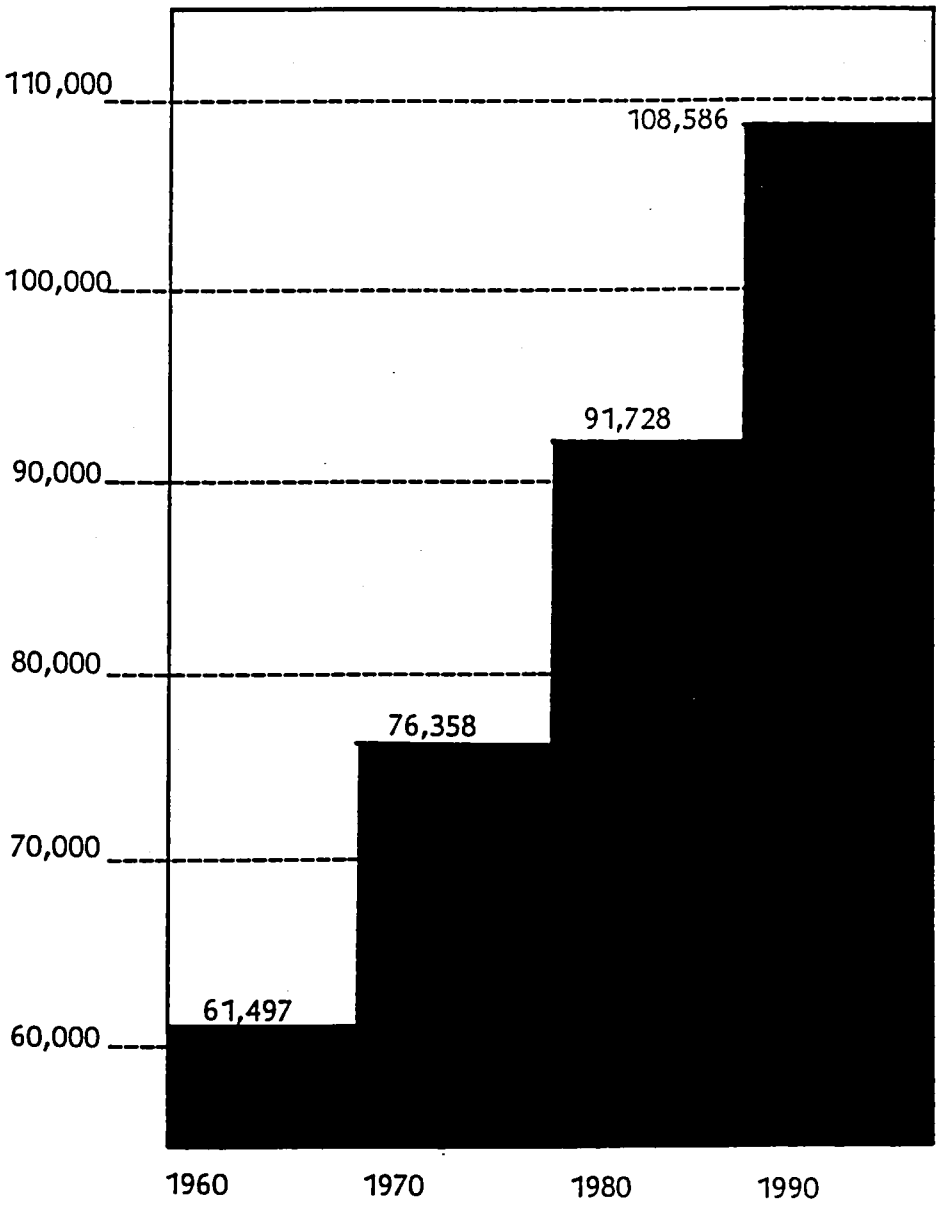
Group	% of Population	Population Est., 1988
17 and below	25.3	25,859
18 to 24	9.0	9,984
25 to 34	17.5	17,472
35 to 49	23.4	21,665
50 and over	24.8	24,861

Households in Randolph County, 1989: 39,230

SOURCES: Sales & Marketing Management Yearbook,
Asheboro/Randolph Chamber of Commerce, 1990.

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

RANDOLPH COUNTY POPULATION GROWTH



SOURCE: Piedmont Triad Council of Government

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

PER CAPITA PERSONAL INCOME

1989	1988	1987	1986	1985	1984
$13,004	$12,801	$12,410	$12,301	$11,833	$11,038

Randolph County $13,004
NC Average $12,109
US Average $14,141

RANDOLPH COUNTY's Per Capita Personal Income is the 18th highest of 100 counties in the State of North Carolina.

SOURCE: North Carolina Office of State Budget and Management, 1990

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

EFFECTIVE BUYING INCOME and PER CAPITA INCOME

TOTAL RANDOLPH COUNTY EFFECTIVE BUYING INCOME $1,110,820,000

EBI GROUP	% OF HOUSEHOLDS
$10,000 - $19,999	25.9%
$20,000 - $34,999	33.5%
$35,000 - $49,999	14.8%
$50,000 & ABOVE	8.6%

Per Capita Household Income $31,683

SOURCE: Sales and Marketing Management Yearbook, 1990

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

FIRMS, CAPITAL INVESTED, NUMBER EMPLOYEES

YEAR	FIRMS	INVESTMENT	NUMBER OF EMPLOYEES
1982	6 New	$11,670,000	471
	12 Expansions	15,998,000	32
1983	9 New	52,679,000	665
	14 Expansions	32,850,000	432
1984	5 New	9,730,000	332
	28 Expansions	18,539,000	509
1985	3 New	4,727,000	300
	9 Expansions	19,027,000	265
1986	6 New	68,000,000	530
	8 Expansions	23,550,000	209
1987	4 New	61,000,000	293
	6 Expansions	24,300,000	218
1988	1 New	4,500,000	50
	5 Expansions	26,788,000	400
1989	2 New	6,348,000	64
	6 Expansions	31,417,000	312

SOURCE: NC Department of Commerce, 1990

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

EFFECTIVE BUYING INCOME and PER CAPITA INCOME

TOTAL RANDOLPH COUNTY EFFECTIVE BUYING INCOME $1,110,820,000

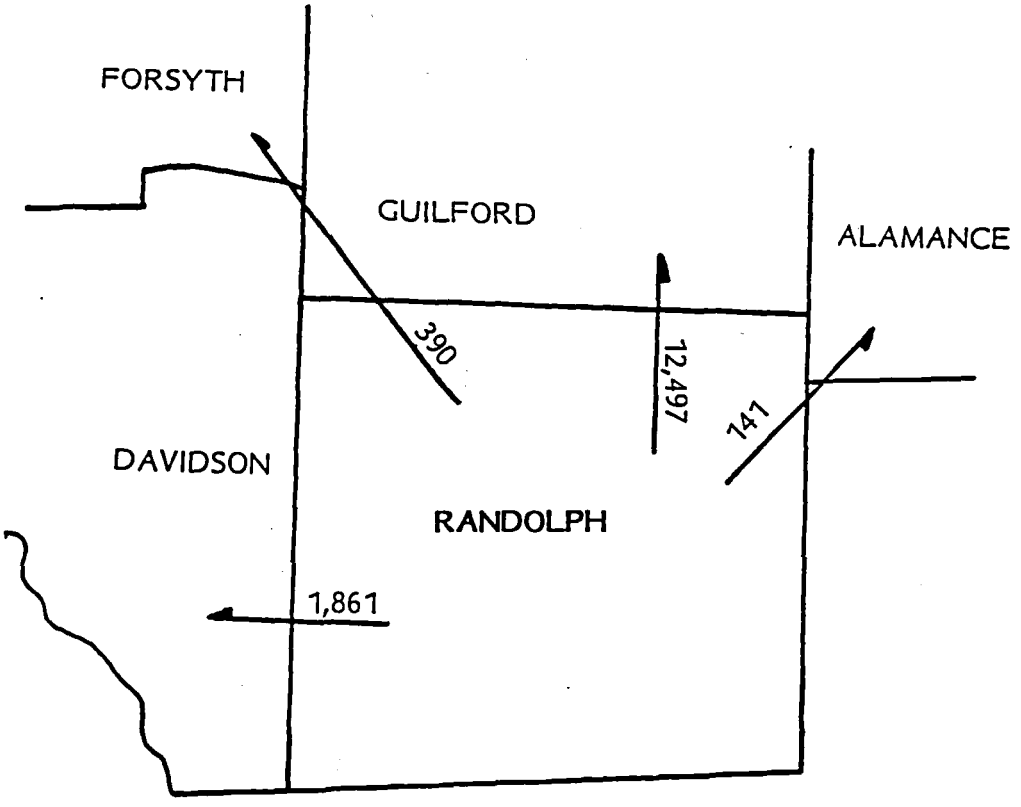
EBI GROUP	% OF HOUSEHOLDS
$10,000 - $19,999	25.9%
$20,000 - $34,999	33.5%
$35,000 - $49,999	14.8%
$50,000 & ABOVE	8.6%

Per Capita Household Income $31,683

SOURCE: Sales and Marketing Management Yearbook, 1990

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

DAILY OUTFLOW OF AVAILABLE WORKERS



SOURCE: Piedmont Triad Council of Governments, 1990

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

LOCAL CITY AND COUNTY TAXES

	City	County
Total Appraised Property Value	$555,320,359.00	$2,823,253,000.00
Bonded Indebtedness (total)	$ 12,174,000.00	$ 8,900,000.00
*Schools		$ 6,425,000.00
Water & Sewer	$ 12,149,000.00	$ 525,000.00
Public Buildings	$ 25,000.00	$ 1,950,000.00
Tax Rate per $100 Total Valuation	$ .56	$ .51
Asheboro School District	$ .145	
TOTAL TAX RATE APPLICABLE for City Residents	$ 1.215	

*includes city, county schools and Randolph Community College

SOURCE: City Finance Officer & County Tax Office - 1989

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

TOTAL CIVILIAN LABOR FORCE ESTIMATES BY RACE AND SEX

Category	Labor Force	Employment	Unemployment	Rate
Total Civilian	61,342	59,819	1,523	2.5
Total White	57,647	56,297	1,350	2.3
White Male	31,412	30,661	751	2.4
White Female	26,235	25,636	599	2.3
Total Nonwhite	3,695	3,522	173	4.7
Nonwhite Male	1,890	1,802	89	4.7
Nonwhite Female	1,805	1,720	85	4.7
Total Male	33,302	32,463	840	2.5
Total Female	28,040	27,356	684	2.4

SOURCE: Labor Market Information Division, North Carolina Employment Security Commission, 1990

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

OCCUPATIONAL DISTRIBUTION OF THE LABOR FORCE BY SEX AND MINORITY STATUS

		WHITE		NONWHITE	
	Total	Male	Female	Male	Female
Total, All Occup.	49,225	24,333	20,861	1,502	1,529
Managerial & Prof. Spec. Occup.	6,196	3,402	2,596	86	112
Technologists & Technicians	718	366	301	30	21
Sales Occup.	3,381	1,925	1,331	52	73
Admin. Support Occup. Includ. Clerical	4,488	-	4,298	-	190
Serv. Occup.	4,101	1,462	2,215	161	263
Farming, For. & Fishing Occup.	1,147	913	193	41	-
Prec. Prod., Craft & Repair Occup.	8,114	7,042	770	274	28
Oper. & Fab.	16,632	6,932	8,408	500	792
Handlers, Equip. Cl., Helpers & Laborers	2,480	1,440	749	241	50

SOURCE NC Employment Security Commission, 1989

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

RETAIL SALES, 1987 and 1989

	1989	1987
RETAIL SALES TOTAL	$469,813,000	$429,634,000
Food	103,094,000	86,271,000
Gasoline	24,858,000	24,436,000
Automotive	94,085,000	79,638,000
Lumber, Building Materials, Hardware	44,918,000	41,002,000
Eating and Drinking Establishments	35,851,000	24,706,000
Apparel	32,042,000	15,341,000
Furniture and Appliances	17,102,000	16,120,000
Drugs	18,327,000	16,934,000
General Merchandise	42,972,000	26,010,000

SOURCE: Editors and Publishers Yearbook, 1990

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

VOTER REGISTRATION

1983	as of 7/31/85	as of 6/2/86	as of 4/9/87	as of 3/7/89
44,293	45,599	46,143	47,103	*46,923

* total includes the following racial breakdown:

44,370	White
2,477	Black
10	Indian
66	Other

Note: There is a purge every four years of active and inactive voters. Any voter who neither voted in the first or second of the two most recent consecutive Presidential elections and who failed to vote in any other election conducted in the period between the two Presidential elections shall be purged.

SOURCE: Randolph County Board of Elections - 1989

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

LEADING MANUFACTURING EMPLOYERS (OVER 100 EMPLOYEES)*

Name	Product	Employees	Year Est.
Klaussner Furniture	Furniture	2,500	1965
Eveready Battery	Batteries	1,260	1947
Acme-McCrary	Hosiery	830	1909
Black & Decker	Small Appliances	820	1943
Ramtex	Cloth	800	1988
Stedman Corporation	T-shirts, underwear	600	1943
Jockey Int./Randleman	Hosiery	550	1947
Kayser-Roth	Hosiery, socks	515	1953
Goodyear Tire & Rubber	Wire Cord	480	1984
Burlington Industries	Hosiery, Cloth	412	1947
Laughlin Hosiery	Hosiery	380	1938
Walker Shoe Co.	Shoes	358	1952
Commonwealth Hosiery	Hosiery	300	1916
Arrow International	Catheters	300	1984
Bossong Hosiery	Hosiery	250	1928
Jockey Int./Cedar Falls	Yarn	230	1947
Dixie Furniture	Bedroom furniture	185	1957
Oliver Rubber	Tire Retread	185	1983
Carson, Inc.	Furniture	170	1983
Asheboro Hosiery	Hosiery	145	1917
Georgia-Pacific	Corrugated Pkg.	140	1988
Knorr Best Foods	Dehydrated Soup	140	1988
Cleveland Twist Drill	Drill bits	121	1982
U. S. Furniture	Furniture	115	1980

*No unions at these plants

SOURCE: Asheboro/Randolph Chamber of Commerce, 1990.

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

OCCUPATION OF JOB APPLICANTS REGISTERED FOR WORK IN RANDOLPH COUNTY

Major Occup. Group	Total	Female		Minority Group	
		Number	% of Total	Number	% of Total
TOTAL	2,487	1,126	45.3	328	13.2
Prof., tech., mgr.	206	102	49.5	13	6.3
Clerical and sales	450	338	75.1	31	6.9
Service	136	83	61.0	22	16.2
Farming, forestry, & fisheries	12	4	33.3	2	16.7
Processing	110	55	50.0	22	20.0
Machine trades	340	98	28.8	44	12.9
Bench work	380	215	56.6	67	17.6
Structural	204	5	2.5	17	8.3
Miscellaneous	530	173	32.6	96	18.1
Occup. group not available	119	53	44.5	14	11.8

SOURCE: North Carolina Employment Security Commission - 1989

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

SELECTED AVERAGE QUARTERLY EMPLOYMENT, PAYROLL & WAGE

	Average Employment	Total Wages	Average Weekly Wage
MANUFACTURING	22,603	$89,039,783	$303
Food & Kindred Products	591	2,422,016	315
Textile Mill Products	6,985	24,845,312	273
Apparel & Other Finished Pdts.	1,168	3,300,193	217
Lumber & Wood Products	943	2,756,794	224
Furniture & Fixtures	5,995	21,714,325	278
Paper & Allied Products	434	2,159,306	383
Printing & Publishing	229	798,730	268
Rubber & Misc. Plastics Pdts.	1,380	5,360,480	299
Stone, Clay, Glass & Concrete Pdts.	95	390,070	317
Fabricated Metal Products	713	3,576,770	386
Industrial Machinery & Equipment	254	1,238,964	375
Electronic & Other Electr. Equip.	2,017	11,657,981	444
Transportation Equipment	65	293,823	346
CONSTRUCTION	1,774	8,214,351	356
WHOLESALE TRADE	1,065	6,574,316	475
RETAIL TRADE	5,138	13,310,178	199
SERVICES	3,668	13,412,308	281
GOVERNMENT	4,063	15,221,540	288

SOURCE: NC Employment Security Commission, 3rd Quarter 1989

MARKET DATA, ASHEBORO, NORTH CAROLINA

NEW AND ADDITIONAL CONSTRUCTION, 1989

	New Buildings	Additions & Alterations	Totals
1986	$ 8,743,604	$2,215,400	$10,959,004
1987	$12,150,731	$3,987,691	$16,138,422
1988	$ 5,454,918	$4,621,783	$10,076,701
1989	$ 8,707,294	$3,776,672	$12,483,966

SOURCE: Building Inspection Department Annual Report, 1989.
City of Asheboro

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

EDUCATION: DESTINATION OF HIGH SCHOOL GRADUATES & PERCENTAGES

CATEGORY	TOTAL NUMBER	PERCENTAGE
High School graduates	1,065	100.0
Public Senior Institution	209	19.6
Private Senior Institution	78	7.3
Community College/Technical School	333	31.3
Private Junior College	11	1.0
Trade or Business Schools	37	3.5
Military	53	5.0
Employment	327	30.7
Other	17	1.6

SOURCE: North Carolina Department of Education - 1989

MARKET DATA, RANDOLPH COUNTY, NORTH CAROLINA

ASHEBORO CITY SCHOOLS - SAT COMPARISON BY GENDER

VERBAL SCORES

	Male	Female
Number taking	63	74
Mean scores	440	419

MATH SCORES

Number taking	63	74
Mean scores	481	446

SOURCE: Asheboro City Schools Report - 1989

REFERENCE 35

North Carolina Superfund Sites
Project No. 5035

Property Ownership History

Site: Union Carbide Corporation (Albemarle Rd.)
County: Randolph
I.D. No.: NCD003216462

Date: 6/8/90

Tract:

Tax Parcel No.: 775000474454
Description: Uwharrie St. & Albemarle Rd.

Area: 24.45 Acres
Zoning:

Owner's Name	Date Transfered	Area (Ac.)	Deed Book/Page
Eveready Battery Co., Inc. c/o Ralston Purina Company Checkerboard Square Saint Louis, MO 63164			
	9/8/86	Tr 1: 26.261 excepting 1.235 Tr 2: 28.657 Tr 3: 5	1186/328
Union Carbide Corporation			

NOTE; This tract (Tract 1 in above deed) is a combination of several smaller tracts purchased by Union Carbide Corp. from various owners as follows:

Glen Keyes & wife, Helen Keys	12/10/80	0.012	1123/583
D. Wescott Moser, Trustee & L.T. Hammond, Jr., Trustee	12/10/80	" (same parcel)	1123/582
Lucille Miller Burke	12/10/80	" (same parcel) & 0.519	1123/581
Dolen L. Hill & wife, Louie Hill	9/20/79	0.354	1113/316
Dolen L. Hill & wife, Louie Hill	8/14/79	0.688	1112/235
Dolen L. Hill & wife, Louie Hill & Opal Hill Morris & husband, Donald W. Morris	12/28/78	0.464	1106/179
Huffman Oil Company of Asheboro, Inc.	12/28/78	.459	1106/178

Bingham Land Company	4/10/78	7.03	1099/68
Lloyd E. Brown & wife, Lillian E. Brown, Arthur L. York & wife Thelma S. York and C.B. Spencer & wife, Lola A. Spencer	4/10/78	7.03 (same parcel)	1099/67
C.B. Spencer & wife, Lola Allred Spencer	4/10/78	.144	1099/66
R. Glen Keyes & wife, Helen Keyes	11/23/77	0.028	1095/420
R. Glen Keyes & wife, Helen Keyes	11/23/77	1.852	1095/419
R. Glen Keyes & wife, Helen Keyes	11/23/77	0.028	1095/418
R. Glen Keyes & wife, Helen Keyes	11/7/77	0.207	1094/962
Randolph County Historical Society	12/1/76	?	1086/36
E.D. Cranford & wife, Hazel M. Cranford and Deward Trogdon & wife, Margaret L. Trogdon	5/9/52	?	475/340
National Carbon Company	1/10/50	3.816 + other land	351/277

583

Excise Tax

Recording Time, Book and Page

Tax Lot No. ..... Parcel Identifier No. .....

Verified by ..... County on the ..... day of ..... , 19 .....

by .....

Mail after recording to .....

This instrument was prepared by Moser, Ogburn & Neely, P. A.

Brief description for the Index

NORTH CAROLINA GENERAL WARRANTY DEED

THIS DEED made this 9th day of December, 19 80, by and between

GRANTOR	GRANTEE
Glen Keyes and wife, Helen Keyes	Union Carbide Corporation

Enter in appropriate block for each party: name, address, and, if appropriate, character of entity, e.g. corporation or partnership.

The designation Grantor and Grantee as used herein shall include said parties, their heirs, successors, and assigns, and shall include singular, plural, masculine, feminine or neuter as required by context.

WITNESSETH, that the Grantor, for a valuable consideration paid by the Grantee, the receipt of which is hereby acknowledged, has and by these presents does grant, bargain, sell and convey unto the Grantee in fee simple, all that certain lot or parcel of land situated in the City of ..... Asheboro, Township, Randolph County, North Carolina and more particularly described as follows:

Parcel No. 2

COMMENCING at an iron pipe in the Northerly right-of-way line of the 60.0 foot wide North Carolina Secondary Road No. 1713, said iron pipe being a common corner between land owned by C. R. Callicutt, et al, by deed dated April 5, 1974, as recorded in Deed Book 1066, Page 81 of the Randolph County Registry, and land owned by Lucille Miller Burke by deed dated March 20, 1970 as recorded in Deed Book 1004, Page 282 of the Randolph County Registry, said iron pipe also being located 30.00 feet Northwardly from and at a right angle to the centerline of said North Carolina Secondary Road No. 1713; thence along the said common line between Callicutt and Burke North 13°-25'-28" West 174.60 feet to an iron pipe located in the South line of Union Carbide Corporation land acquired from Bingham Land Company by deed dated March 9, 1978 as recorded in Deed Book 1099, Page 68 of the Randolph County Registry said iron pipe being the TRUE POINT OF BEGINNING: thence along the said South line of Carbide South 82°-03'-37" East 15.07 feet to an iron pipe, a corner in the said Carbide deed, said iron pipe also being the Southwestern corner of Carbide's land acquired from Glen Keyes, et al, by deed dated November 23, 1977, as recorded in Deed Book 1095, Page 419 in the Randolph

N.C. Bar Assn. Form No. 3A 1 1977

County Registry; thence continuing along the said South line of Carbide South 72°-12'-00" East 100.55 feet to an iron pipe, [illegible]

County Registry; thence continuing along the said South line of Carbide North 73°-12'-00" East 100.55 feet to an iron pipe, located in the North line of the said Lucille Miller Burke land; thence along the said North line of Burke South 69°-08'-05" West 115.39 feet to an existing iron pipe in the East line of said C. R. Callicutt, et al; thence along the said East line of Callicutt North 13°-25'-28" West 14.52 feet to an iron pipe, the True Point of Beginning; said area contains 0.012 acres and is shown on drawing dated July 1980 entitled, "Burke Property to be Conveyed to Union Carbide Corporation", prepared by Moore Gardner and Associates, Inc., Consultant Engineers (Job No. 290733, Book 1133), Asheboro, North Carolina.

82

1122-582

Excise Tax

Recording Time, Book and Page

Tax Lot No. ..... Parcel Identifier No. .....

Verified by ..... County on the ..... day of ....., 19

by .....

Mail after recording to .....

This instrument was prepared by Moser, Ogburn & Neely, P. A.

Brief description for the Index

NORTH CAROLINA GENERAL WARRANTY DEED

THIS DEED made this 9th day of December, 1980, and between

GRANTOR	GRANTEE
D. Wescott Moser, Trustee; and L. T. Hammond, Jr., Trustee	Union Carbide Corporation

Enter in appropriate block for each party: name, address, and, if appropriate, character of entity, e.g. corporation or partnership.

The designation Grantor and Grantee as used herein shall include said parties, their heirs, successors, and assigns, and shall include singular, plural, masculine, feminine or neuter as required by context.

WITNESSETH, that the Grantor, for a valuable consideration paid by the Grantee, the receipt of which is hereby acknowledged, has and by these presents does grant, bargain, sell and convey unto the Grantee in fee simple, all that certain lot or parcel of land situated in the City of ..... Asheboro Township, Randolph County, North Carolina and more particularly described as follows:

Parcel No. 2

COMMENCING at an iron pipe in the Northerly right-of-way line of the 60.0 foot wide North Carolina Secondary Road No. 1713, said iron pipe being a common corner between land owned by C. R. Callicutt, et al, by deed dated April 5, 1974, as recorded in Deed Book 1066, Page 81 of the Randolph County Registry, and land owned by Lucille Miller Burke by deed dated March 20, 1970 as recorded in Deed Book 1004, Page 282 of the Randolph County Registry, said iron pipe also being located 30.00 feet Northwardly from and at a right angle to the centerline of said North Carolina Secondary Road No. 1713; thence along the said common line between Callicutt and Burke North 13°-25'-28" West 174.60 feet to an iron pipe located in the South line of Union Carbide Corporation land acquired from Bingham Land Company by deed dated March 9, 1978 as recorded in Deed Book 1099, Page 68 of the Randolph County Registry, said iron pipe being the TRUE POINT OF BEGINNING; thence along the said South line of Carbide South 82°-03'-37" East 15.07 feet to an iron pipe, a corner in the said Carbide deed, said iron pipe also being the southwesterly corner of Carbide's land acquired from R. Glen Keyes, et al, by deed dated November 23, 1977, as recorded in Deed Book 1095, Page 419 in the Randolph

County Registry; thence continuing along the said South line of Carbide North 73°-12'-00" East 100.55 feet to an iron pipe, located in the North line of the said Lucille Miller Burke land; thence along the said North line of Burke South 69°-08'-05" West 115.39 feet to an existing iron pipe in the East line of said C. R. Callicutt, et al; thence along the said East line of Callicutt North 13°-25'-28" West 14.52 feet to an iron pipe, the True Point of Beginning; said area contains 0.012 acres and is shown on drawing dated July 1980 entitled, "Burke Property to be Conveyed to Union Carbide Corporation", prepared by Moore Gardner and Associates, Inc., Consultant Engineers (Job No. 290733, Book 1133), Asheboro, North Carolina.

1123-581

STATE OF NORTH CAROLINA

Real Estate Excise Tax

41.00

Excise Tax

Recording Time, Book and Page

Tax Lot No. ..... Parcel Identifier No. .....

Verified by ..... County on the ..... day of ....., 19

by .....

Mail after recording to .....

This instrument was prepared by Moser, Ogburn & Neely, P. A.

Brief description for the Index

NORTH CAROLINA GENERAL WARRANTY DEED

THIS DEED made this 9th day of December, 19 80, by and between

GRANTOR	GRANTEE
Lucille Miller Burke (unmarried)	Union Carbide Corporation

Enter in appropriate block for each party: name, address, and, if appropriate, character of entity, e.g. corporation or partnership.

The designation Grantor and Grantee as used herein shall include said parties, their heirs, successors, and assigns, and shall include singular, plural, masculine, feminine or neuter as required by context.

WITNESSETH, that the Grantor, for a valuable consideration paid by the Grantee, the receipt of which is hereby acknowledged, has and by these presents does grant, bargain, sell and convey unto the Grantee in fee simple, all that certain lot or parcel of land situated in the City of ....., ... Township, County, North Carolina and more particularly described as follows:

Parcel No. 1

BEGINNING at an iron pipe in the Northerly right-of-way line of the 60.0 foot wide North Carolina Secondary Road No. 1713 (also known as Albemarle Road and formerly being North Carolina Highway 49) located 30.00 feet Northwardly from and at a right angle to the centerline of the said road, said iron pipe being located in the Westerly line of the Union Carbide Corporation land acquired from R. Glen Keyes by deed dated November 7, 1977, as recorded in Book 1094, Page 962 in the Randolph County Registry; from the Point of Beginning, thence along the common line with Carbide North 09°-08'-11" West 121.34 feet to an iron pipe, said pipe being a corner in Carbide's property acquired from R. Glen Keyes, et al, by deed dated November 23, 1977, as recorded in Deed Book 1095, Page 419 in the Randolph County Registry; thence continuing along the common line with Carbide North 61°-02'-05" West 36.38 feet to an existing iron pipe, a corner in the said Carbide deed; thence continuing along the common line with Carbide South 66°-43'-25" West 7.66 feet to an iron pipe, a corner in the said Carbide deed; thence South 69°-08'-05" West 115.39 feet to an existing iron pipe located in the common line with C. R. Callicutt, et al, (deed dated April 5, 1974, as recorded in Book 1066, Page 81 of the Randolph County Registry); thence along the said common line with Callicutt

Recording Time, Book and Page

South 13°-25'-28" East 149.97 feet to an existing iron pipe in the Northerly right-of-way line of the said North Carolina Secondary Road No. 1713, said iron pipe being located 30.00 feet Northwardly from and at a right angle to the centerline of the said road; thence continuing South 13°-25'-28" East

South 13°-25'-28" East 149.97 feet to an existing iron pipe in the Northerly right-of-way line of the said North Carolina Secondary Road No. 1713, said iron pipe being located 30.00 feet Northwardly from and at a right angle to the centerline of the said road; thence continuing South 13°-25'-28" East a distance of 10.11 feet to a stake in the old Northerly right-of-way line of said North Carolina Secondary Road No. 1713; thence along the said old Northerly right-of-way line North 68°-07'-50" East 140.52 feet to a stake; thence leaving the said old Northerly right-of-way line North 09°-08'-11" West 10.25 feet to an existing iron pipe, the said Point of Beginning; said area contains a total of 0.519 acres of which 0.032 acres is located within the existing right-of-way of the said North Carolina Secondary Road No. 1713, as shown on drawing dated July 1980 entitled "Burke Property to be Conveyed to Union Carbide Corporation", prepared by Moore Gardner and Associates, Inc., Consultant Engineers (Job No. 290733, Book 1133), Asheboro, North Carolina.

Parcel No. 2

COMMENCING at an iron pipe in the Northerly right-of-way line of the 60.0 foot wide North Carolina Secondary Road No. 1713, said iron pipe being a common corner between land owned by C. R. Callicutt, et al, by deed dated April 5, 1974, as recorded in Deed Book 1066, Page 81 of the Randolph County Registry, and land owned by Lucille Miller Burke by deed dated March 20, 1970 as recorded in Deed Book 1004, Page 282 of the Randolph County Registry, said iron pipe also being located 30.00 feet Northwardly from and at a right angle to the centerline of said North Carolina Secondary Road No. 1713; thence along the said common line between Callicutt and Burke North 13°-25'-28" West 174.60 feet to an iron pipe located in the South line of Union Carbide Corporation land acquired from Bingham Land Company by deed dated March 9, 1978 as recorded in Deed Book 1099, Page 68 of the Randolph County Registry, said iron pipe being the TRUE POINT OF BEGINNING; thence along the said South line of Carbide South 82°-03'-37" East 15.07 feet to an iron pipe, a corner in the said Carbide deed, said iron pipe also being the Southwesterly corner of Carbide's land acquired from R. Glen Keyes, et al, by deed dated November 23, 1977, as recorded in Deed Book 1095, Page 419 in the Randolph County Registry; thence continuing along the said South line of Carbide North 73°-12'-00" East 100.55 feet to an iron pipe located in the North line of the said Lucille Miller Burke land; thence along the said North line of Burke South 69°-08'-05" West 115.39 feet to an existing iron pipe in the East line of said C. R. Callicutt, et al; thence along the said East line of Callicutt North 13°-25'-28" West 14.52 feet to an iron pipe, the True Point of Beginning; said area contains 0.012 acres and is shown on drawing dated July 1980 entitled "Burke Property to be Conveyed to Union Carbide Corporation", prepared by Moore Gardner and Associates, Inc., Consultant Engineers (Job No. 290733, Book 1133), Asheboro, North Carolina.

2500 RJS

1113-316

Excise Tax

Recording Time, Book and Page

Parcel Identifier No.

County on the day of , 19

recording

ment was prepared by Moser, Ogburn & Neely, P. A.

scription for the index

NORTH CAROLINA GENERAL WARRANTY DEED

This DEED made this 18th day of September, 19 79, by and between

GRANTOR	GRANTEE
Dolen L. Hill and wife, Louie Hill	Union Carbide Corporation

enter appropriate block for each party: name, address, and, if appropriate, character of entity, e.g. corporation or partnership.

The designation Grantor and Grantee as used herein shall include said parties, their heirs, successors, and assigns, and include singular, plural, masculine, feminine or neuter as required by context.

WITNESSETH, that the Grantor, for a valuable consideration paid by the Grantee, the receipt of which is hereby acknowledged, has and by these presents does grant, bargain, sell and convey unto the Grantee in fee simple, all that certain lot or parcel of land situated in the City of Asheboro Township, Randolph County, North Carolina and more particularly described as follows:

BEGINNING at an iron pipe located in the northerly right of way line of the 60.0 foot wide Albemarle Road, now called North Carolina Secondary Road 1713 and formerly called North Carolina Highway No. 49, at a common corner between Union Carbide Corporation (Deed Book 1112, page 235), and Dolen L. Hill and Louie Hill, his wife (Deed Book 295, page 580) said common corner being located 30.0 feet northwestwardly from and normal to the centerline of said Albemarle Road and being the southwest corner of the herein described parcel of land; from said Point of Beginning; thence along the common line between Carbide and Dolen L. Hill North 18° 23' West 245.92 feet to an iron pipe located in the common line between James G. Goins (Deed Book 619, page 170) and Dolen L. Hill, said iron pipe being the northwest corner of the herein described parcel of land; thence along the said common property line South 82° 48' 30" East 75.00 feet past a corner of the James McGee lot (Deed Book 649, page 158) to an iron pin, a common corner between Dolen L. Hill and Tula B. Jones (Deed Book 695, page 190) for the northwest corner of the herein described parcel of land; thence along the said common property line between Hill and Jones South 19° 51' East 194.85 feet to an iron pin located in the said northerly right of way line of Albemarle Road the southeast corner of the herein described parcel of land; thence along the said northerly right of way line of Albemarle Road South 57° 08' West 75.00 feet to an iron pipe, the said Beginning; said area contains 0.354 acres of land.

N.C. Bar Assoc. Form No. 3A © 1971

Excise Tax

Recording Time, Book and Page

Tax Lot No. ..... Parcel Identifier No. .....

Verified by ..... County on the ..... day of ..... , 19

by .....

Mail after recording to Ogburn

This instrument was prepared by Moser, Ogburn & Neely, P. A.

Brief description for the Index

NORTH CAROLINA GENERAL WARRANTY DEED

THIS DEED made this 6th day of August, 19 79, by and between

GRANTOR	GRANTEE
Dolen L. Hill and wife, Louie Hill and Opal Hill Morris and husband, Donald W. Morris	Union Carbide Corporation (A New York Corporation)

Enter in appropriate block for each party: name, address, and, if appropriate, character of entity, e.g. corporation or partnership.

The designation Grantor and Grantee as used herein shall include said parties, their heirs, successors, and assigns, and shall include singular, plural, masculine, feminine or neuter as required by context.

WITNESSETH, that the Grantor, for a valuable consideration paid by the Grantee, the receipt of which is hereby acknowledged, has and by these presents does grant, bargain, sell and convey unto the Grantee in fee simple, all that certain lot or parcel of land situated in the City of ..... Asheboro Township, Randolph County, North Carolina and more particularly described as follows:

BEGINNING at an iron pipe located in the northerly right-of-way line of the 60-foot wide Albemarle Road, now called North Carolina Secondary Road 1713 and formerly called North Carolina Highway No. 49, the southeast corner of that certain tract of land conveyed by the grantors herein to the grantees herein in Deed Book 1106, Page 179, Randolph County Public Registry; thence North 23° 08' West 234.46 feet the northernmost corner of the triangular tract of land conveyed by the grantors herein to the grantees herein in Deed Book 1106, at Page 179, and in the eastern boundary of the tract of land conveyed to Union Carbide Corporation as set forth in Deed Book 475, Page 340, Randolph County Public Registry; thence along the said eastern boundary of the tract of land conveyed to Union Carbide Corporation in Book 475, Page 340, North 10° 40' East 83.42 feet to an iron pipe in said eastern boundary also being James Goins southwest corner; thence along Goins' southern boundary South 82° 48' 30" East 86.59 feet to an iron pipe in the southern boundary of Goins, the northwest corner of Dolen L. Hill as set forth in Book 295, Page 580, Randolph County Public Registry; thence along Hill's western boundary South 18° 23' East 245.92 feet to an iron pipe the southwest corner of Dolen L. Hill in the northern right-of-way line of Albemarle Road; thence along the northern right-of-way line of Albemarle Road South 58° 22' 30" West 101.85 feet to the point and place

of Beginning, and containing 0.688 acres, more or less. The above description is drawn according to survey prepared by Moore, Gardner & Associates, Inc., Consulting Engineers, and identified as Job No. 290635.

For prior reference see deeds in Books 291, Page 391, Book 1103, Page 680.

The property hereinabove described was acquired by Grantor by instrument recorded in .....

A map showing the above described property is recorded in Plat Book ..... page .....

TO HAVE AND TO HOLD the aforesaid lot or parcel of land and all privileges and appurtenances thereto belonging to the Grantee in fee simple.

And the Grantor covenants with the Grantee, that Grantor is seized of the premises in fee simple, has the right to convey the same in fee simple, that title is marketable and free and clear of all encumbrances, and that Grantor will warrant and defend the title against the lawful claims of all persons whomsoever except for the exceptions hereinafter stated. Title to the property hereinabove described is subject to the following exceptions:

IN WITNESS WHEREOF, the Grantor has hereunto set his hand and seal, or if corporate, has caused this instrument to be signed in its corporate name by its duly authorized officers and its seal to be hereunto affixed by authority of its Board of Directors, the day and year first above written.

.....
(Corporate Name)

By: .....

.....President

ATTEST:

.....

.....Secretary (Corporate Seal)

USE BLACK INK ONLY

Dolen L. Hill .....(SEAL)
Dolen L. Hill

Louie Hill .....(SEAL)
Louie Hill

Opal Hill Morris .....(SEAL)
Opal Hill Morris

Donald W. Morris .....(SEAL)
Donald W. Morris

.....
(Corporate Name)

By: .....

.....President

ATTEST:

.....

BLACK INK ONLY

.....(SEAL)

.....(SEAL)

.....(SEAL)

1106-179

Real Estate Excise Tax

30.00

Excise Tax

Recording Time, Book and Page

Tax Lot No. ..... Parcel Identifier No. .....

Verified by ..... County on the ..... day of ....., 19

by .....

Mail after recording to .....

This instrument was prepared by OGBURN AND HEAFNER, P. A.

Brief description for the Index

NORTH CAROLINA GENERAL WARRANTY DEED

THIS DEED made this 27 day of December, 19 78, by and between

GRANTOR	GRANTEE
Dolen L. Hill and wife, Louie Hill and Opal Hill Morris and husband, Donald W. Morris	Union Carbide Corporation (A New York Corporation)

Enter in appropriate block for each party: name, address, and, if appropriate, character of entity, e.g. corporation or partnership.

The designation Grantor and Grantee as used herein shall include said parties, their heirs, successors, and assigns, and shall include singular, plural, masculine, feminine or neuter as required by context.

WITNESSETH, that the Grantor, for a valuable consideration paid by the Grantee, the receipt of which is hereby acknowledged, has and by these presents does grant, bargain, sell and convey unto the Grantee in fee simple, all that certain lot or parcel of land situated in the City of ..... Asheboro Township, Randolph County, North Carolina and more particularly described as follows:

BEGINNING at an iron pipe located in the northerly right of way line of the 60.0 foot wide Albemarle Road, now called North Carolina Secondary Road 1713 and formerly called North Carolina Highway No. 49, at a common corner between Dolen L. Hill (Deed Book 377; Page 443) and Union Carbide Corporation (Deed Book 475; Page 340) said common corner being located 30.0 feet Northwestwardly from and normal to the centerline of said Albemarle Road and being the westernmost corner of the herein described parcel of land; also being further identified as Union Carbide Corporation's Southeast corner (See Deed Book 475, Page 340), from said point of beginning thence along the common line between Carbide and Dolen L. Hill North 10° 37' East past a stake at 150.00 feet for a total distance of 310 feet to an iron pipe, the northernmost corner of the herein described triangular shaped parcel of land; thence along the common line between Dolen L. Hill, et al (Deed Book 917; Page 413) and Annie Ida Hill (Deed Book 291, Page 349) South 23° 08' East 234.46 feet to an iron pipe located in the said northerly right of way line of Albemarle Road, said iron pipe being the easternmost corner of the herein described parcel of land; thence along the said northerly right of way line of Albemarle Road South 39° 03' 30" West 83.15 feet to a stake for a common corner between two lots owned by Dolen L. Hill et al (Deed Book 917; Page 413 and Deed Book 377; Page 443); thence

N.C. Bar Assoc. Form No. 2A © 1976

continuing along the said northerly right of way line of Albemarle Road South 59° 14' 30" West 90.61 feet to an iron pipe, the said point of beginning; said area contains 0.464 acres of land and is the same land acquired by Dolen L. Hill and his wife, Louie R. Hill, as two lots by two deeds, one dated October 11, 1939 in Book 377, Page 443 and the other dated December 7, 1965 in Book 917, Page 413 as recorded by the Clerk of the Court in Randolph County, North Carolina, also see Deed in Book 291, Page 345.

1106-178

Excise Tax

Recording Time, Book and Page

Tax Lot No. ..... Parcel Identifier No. .....

Verified by ..... County on the ..... day of 19

by .....

Mail after recording to .....

This instrument was prepared by OGBURN AND HEAFNER, P. A.

Brief description for the Index

NORTH CAROLINA GENERAL WARRANTY DEED

THIS DEED made this 27 day of December, 19 78, by and between

GRANTOR	GRANTEE
Huffman Oil Company of Asheboro, Inc.	Union Carbide Corporation (A New York Corporation)

Enter in appropriate block for each party: name, address, and, if appropriate, character of entity, e.g. corporation or partnership.

The designation Grantor and Grantee as used herein shall include said parties, their heirs, successors, and assigns, and shall include singular, plural, masculine, feminine or neuter as required by context.

WITNESSETH, that the Grantor, for a valuable consideration paid by the Grantee, the receipt of which is hereby acknowledged, has and by these presents does grant, bargain, sell and convey unto the Grantee in fee simple, all that certain lot or parcel of land situated in the City of ..... Asheboro Township, Randolph County, North Carolina and more particularly described as follows:

BEGINNING at a point on the North side of N. C. Highway #62 (now Albemarle Road), Asheboro, N. C., County of Randolph, at the intersection of the Easternly boundary line of the property of Walter Stowe and Highway #62 (now Albemarle Road), and thence running parallel with N. C. Highway #62 (now Albemarle Road), in an Easterly direction a distance of 200 feet to a point; thence in a Northern direction a distance of 100 feet to a point; thence in a Westerly direction a distance of 200 feet to a point; thence turning and running in a Southerly direction along the Easterly line of the Walter Stowe property 100 feet to a point or place of beginning.

1099-68 / 160.00
4.50

Brown & Western

FORM WD-101=WARRANTY DEED

Printed and for sale by James Williams & Co., Inc., Yadkinville, N. C.

NORTH CAROLINA, RANDOLPH COUNTY

THIS DEED, made this 9th day of March, A. D. 19 78

by Bingham Land Company (a North Carolina Corporation),

of County and State of

of the first part, to Union Carbide Corporation (a New York Corporation)

of County and State of

of the second part:

WITNESSETH, That said parties of the first part

, in consideration of

Ten Dollars Dollars

to them paid by parties of the second part

the receipt of which is hereby acknowledged has bargained and sold, and by these presents

do grant, bargain, sell and convey to said parties of the second part, and their

heirs and assigns, a certain tract or parcel of land in Asheboro Township

Randolph County, State of North Carolina, adjoining

the lands of

and others, and bounded as follows, viz:

BEGINNING at an iron pipe in the eastern right of way line of Uwharrie Street (N. C. S. R. 1443), said iron pipe being located North 12° 21' 36" East 414.38 feet from the center of the intersection of Uwharrie Street with N. C. Highway 49-A; and said Beginning point being also a new corner with C. B. Spencer and wife, Lola A. Spencer (See Book 357, Page 98, Randolph County Public Registry), thence North 82° 03' 37" West 12.14 feet to an existing iron pipe within the right of way of Uwharrie Street; thence North 12° 40' 42" East 554.67 feet to an iron pipe in said right of way; thence North 82° 06' 46" West 16.36 feet to an iron pipe in said right of way; thence North 14° 50' 02" East 102.34 feet to an iron pipe in said right of way; thence South 82° 25' 48" East 30.24 feet to an iron pipe in the eastern right of way line of S. R. No. 1443; thence South 82° 25' 48" East 25.50 feet to an existing angle iron; thence North 8° 37' 13" East 101.22 feet to an existing flat iron, a common corner with Alex and Dora Hall, being Hall's southwest corner (See Deed Book 295, Page 237), thence along Hall's southern boundary South 82° 16' 11" East 149.33 feet to an existing iron pipe, Hall's southeast corner; thence with Hall's eastern boundary North 9° 21' 27" East 89.67 feet to an axle at a stone pile, Hall's northeast corner; thence South 85° 07' 32" East 329.55 feet to an existing iron pipe, a new corner with Union Carbide Corporation (See Deed Book 475, Page 340, and Book 1086, Page 36), thence along a common line with Union Carbide Corporation South 7° 34' West 309.63 feet to an existing iron pipe, a common corner with Union Carbide Corporation (See Deed Book 351, Page 277, and Book 387, Pages 575 and 576), also being York and Brown's northeast corner; thence along York and Brown's northern boundary, North 83° 24' 45" West 12.86 feet to an existing iron pipe in said northern boundary; thence continuing along the northern boundary with York and Brown North 83° 36' 45" West 155.95 feet to an existing iron pipe, York and Brown's northwest corner; thence continuing along the western boundary of York and Brown South 12° 57' 40" West 30 feet to an existing iron pipe in York and Brown's western boundary also a common corner with Union Carbide Corporation (See Deed Book 1095, Page 419); thence along the common line with Union Carbide Corporation North 80° 52' 45" West 100 feet to an existing iron pipe, a common corner with Union Carbide Corporation; thence along the common line with Union Carbide Corporation, South 4[illegible] 43' West 326.50 feet to an existing iron pipe, a new corner with C. B. Spencer and wife, Lola A. Spencer (See Book 350, Page 98); thence along the new line with Spencer North 82° 03' 37" West 327.39 feet to the point and place of Beginning, containing 7.030 acres, more or less.

[illegible] personally came William [illegible] William [illegible] BINGHAM LAND COMPANY, the corporation [illegible] The above description is drawn from an actual survey prepared by Moore, Gardner & Associates, Inc., Consulting Engineers, and is designated Job No. 290575, dated November [illegible] 1977. [illegible] President and [illegible] The above description is made subject to a right of way and [illegible] easement to the City of Asheboro [illegible] feet permanent sanitary sewer easement as set forth in [illegible] Page 11 in Randolph County Public Registry; and to a right of way and easement for Dwharrie Street (S. R. 1443), [illegible] day of March, [illegible]

STATE OF NORTH CAROLINA

[illegible] Public

The above described lands were conveyed to grantors by _____ See Book _____, Page _____

TO HAVE AND TO HOLD the aforesaid tract or parcel of land, and all privileges and appurtenances thereto belonging, to the said Union Carbide Corporation its heirs and assigns, to its only use and behoof forever.

And the said Bingham Land Company, for its self and its heirs, executors and administrators, covenant with said Union Carbide Corporation its heirs and assigns, that seized of said premises in fee and has right to convey in fee simple; that the same are free and clear from all encumbrances, and that it does hereby forever warrant and will forever defend the said title to the same against the claims of all persons whomsoever.

IN TESTIMONY WHEREOF, the said Bingham Land Company has hereunto set its hand and seal, the day and year first above written.

BINGHAM LAND COMPANY (SEAL)

By: [illegible] President (SEAL)

ATTEST: [illegible] Assistant Secretary (SEAL)

(SEAL)

STATE OF NORTH CAROLINA COUNTY OF RANDOLPH

This is to certify that on this day before me personally came William C. McGee, with whom I am personally acquainted, who, being by me first duly sworn, says that Diane B. McGee is the President and William C. McGee is the Assistant Secretary of BINGHAM LAND COMPANY, the corporation described in and which executed the foregoing deed; that he knows the common seal of said corporation, that the seal affixed to the foregoing instrument is said common seal and the name of the corporation was subscribed hereto by said President, and the said President and Assistant Secretary subscribed their names thereto and said common seal was affixed all by order of the board of directors of said corporation and that the said instrument is the act and deed of said corporation.

WITNESS my hand and notarial seal this the 9th day of March, 1978.

(SEAL)

[illegible] Notary Public

My commission expires: [illegible]

The foregoing certificate(s) of [illegible] is (are) certified to be [illegible] was presented for registration this 10th [illegible]

MICROFILM SYSTEMS

3.3 34
1099-27

THIS DEED, made this the 9th day of March, 1978, by LLOYD E. BROWN AND WIFE, DORIAN E. BROWN, ARTHUR L. YORK AND WIFE, THELMA S. YORK, C. B. SPENCER AND WIFE, LOLA A. SPENCER, all of Randolph County, North Carolina, parties of the first part, to UNION CARBIDE CORPORATION (a New York Corporation), parties of the second part.

WITNESSETH, that the said parties of the first part in consideration of Ten Dollars and other good and valuable consideration paid by the said parties of the second part, the receipt of which is hereby acknowledged, have bargained and sold and by these presents do bargain, sell and convey unto the said parties of the second part and their heirs a tract or parcel of land in Asheboro Township, Randolph County, North Carolina, described as follows:

BEGINNING at an iron pipe in the eastern right of way line of Uwharrie Street (N.C.S.R. 1443), said iron pipe being located North 12° 21' 36" East 414.38 feet from the center of the intersection of Uwharrie Street with N. C. Highway 49-A; and said Beginning point being also a new corner with C. B. Spencer and wife, Lola A. Spencer (See Book 357, Page 98, Randolph County Public Registry), thence North 82° 03' 37" West 12.14 feet to an existing iron pipe within the right of way of Uwharrie Street; thence North 12° 40' 42" East 554.67 feet to an iron pipe in said right of way; thence North 82° 06' 46" West 16.36 feet to an iron pipe in said right of way; thence North 14° 50' 02" East 102.34 feet to an iron pipe in said right of way; thence South 82° 25' 48" East 30.24 feet to an iron pipe in the eastern right of way line of S. R. No. 1443; thence South 82° 25' 48" East 25.50 feet to an existing angle iron; thence North 8° 37' 13" East 101.22 feet to an existing flat iron, a common corner with Alex and Dora Hall, being Hall's southwest corner (See Deed Book 295, Page 237); thence along Hall's southern boundary South 82° 16' 14" East 149.33 feet to an existing iron pipe, Hall's southeast corner; thence with Hall's eastern boundary North 9° 21' 27" East 89.67 feet to an axle at a stone pile, Hall's northeast corner; thence South 86° 07' 32" East 329.5[illegible] feet to an existing iron pipe, a new corner with Union Carbide Corporation (See Deed Book 475, Page 340, and Book 1086, Page 36); thence along a common line with Union Carbide Corporation South 7° 34' West 309.63 feet to an existing iron pipe, a common corner with Union Carbide Corporation (See Deed Book 351, Page 277, and Book 387, Pages 575 and 576), also being York and Brown's northeast corner; thence along York and Brown's northern boundary, North 83° 24' 45" West 12.86 feet to an existing iron pipe in said northern boundary; thence continuing along the northern boundary with York and Brown North 83° 36' 45" West 155.95 feet to an existing iron pipe, York and Brown's northwest corner; thence continuing along the western boundary of York and Brown South 12° 57' 40" West 30 feet to an existing iron pipe in York and Brown's western boundary also a common corner with Union Carbide Corporation (See Deed Book 1095, Page 419); thence along the common line with Union Carbide Corporation North 80° 52' 45" West 100 feet to an existing iron pipe, a common corner with Union Carbide Corporation; thence along the common line with Union Carbide Corporation, South 4° 43' West 528.50 feet to an existing iron pipe, a new corner with C. B. Spencer and wife, Lola A. Spencer (See Book 350, Page 98); thence along the new line with Spencer North 82° 03' 37" West 327.39 feet to the point and place of Beginning, containing 7.030 acres, more or less.

The above description is drawn according to a survey prepared by Moore, Gardner & Associates, Inc., Consulting Engineers, and is designated Job No. 290575, dated November 4, 1977.

The above description is made subject to a right of way and easement to the City of Asheboro for a 25-foot permanent sanitary sewer easement as set forth in Deed Book 921, Page 111, Randolph County Public Registry; and to a right of way and easement for Uwharrie Street (S. R. 1443).

[illegible]

[illegible] Arthur [illegible] Thel[illegible] Spence[illegible] Lola [illegible] Spence[illegible] [illegible] nia, [illegible] ance.

This deed is given by the grantors to the grantee for the purpose of the grantors releasing, quitclaiming and deeding to the grantees any and all right, title, and interest they, or their successors in interest, personal representatives, heirs at law, or assigns, may or might have to a 30 foot easement across the above-described lands as set forth in Book 472, Page 156, Book 472, Page 161, Book 945, Page 81, Randolph County Public Registry.

TO HAVE AND TO HOLD the aforesaid tract or parcel of land and all privileges and appurtenances thereunto belonging to the said parties of the second part and their heirs and assigns forever.

IN TESTIMONY WHEREOF, the said parties of the first part have hereunto set their hands and seals the day and year first above written.

Lloyd E. Brown (SEAL)
Lloyd E. Brown

Lillian E. Brown (SEAL)
Lillian E. Brown

Arthur L. York (SEAL)
Arthur L. York

Thelma S. York (SEAL)
Thelma S. York

C. B. Spencer (SEAL)
C. B. Spencer

Lola A. Spencer (SEAL)
Lola A. Spencer

NORTH CAROLINA
RANDOLPH COUNTY

I, Doris W. Hunt, Notary Public of said County, do hereby certify that Lloyd E. Brown and wife, Lillian E. Brown, personally appeared before me, this day and acknowledged the execution of the foregoing deed of conveyance.

WITNESS my hand and seal, this the 2nd day of February, 1978.

Notary Public

My commission expires: 1/14/79

I, Robin Kindschi, Notary Public of said County, do hereby certify that Arthur L. York and wife, Thelma S. York, C. B. Spencer and wife, Lola A. Spencer, personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

WITNESS my hand and seal, this the [illegible] day of [illegible], 1978.

Notary Public

My commission expires: [illegible]

NORTH CAROLINA — Randolph County

The foregoing certificate(s) of Doris W. Hunt • Robin Kindschi Notaries Public of Randolph Co. N.C.

is (are) certified to be correct. This instrument was presented for re[illegible] Book 1099 Page 67. This 10 day of April 20[illegible]

1099-66

66

THIS DEED, Made this the 9th day of March, A.D., 1978, by C. B. SPENCER and wife, LOLA ALLRED SPENCER, of Randolph County, North Carolina, parties of the first part, to UNION CARBIDE CORPORATION (a New York Corporation), parties of the second part.

WITNESSETH, That the said parties of the first part in consideration of Ten Dollars and other good and valuable consideration paid by the said parties of the second part, the receipt of which is hereby acknowledged, have bargained and sold and by these presents do bargain, sell and convey unto the said parties of the second part and their heirs a tract or parcel of land in Asheboro Township, Randolph County, North Carolina, described as follows:

BEGINNING at an iron pipe within the right of way of Uwharrie Street (S. R. 1443), said iron-pipe being located North 9° 08' 47" East 88 feet from an existing flat iron, the southwestern corner of Alex and Dora Hall's, as described in Deed Book 295, Page 237, Randolph County Public Registry; thence North 9° 08' 47" East 20.51 feet to an iron pipe in the right of way of said Uwharrie Street; thence South 82° 40' East 478.01 feet, to an existing iron pipe, a new corner with Union Carbide Corporation; thence North 86° 07' 32" West 329.55 feet to an existing axle at stone pile; thence North 82° 54' 23" West 149.71 feet to the point and place of Beginning, and containing 6,287 square feet, more or less.

The above description is drawn according to a survey prepared by Moore, Gardner & Associates, Inc., Consulting Engineers, and is designated Job No. 290575, dated February 1, 1978.

For prior reference, see deed recorded in Deed Book 375, Page 344, Randolph County Registry.

TO HAVE AND TO HOLD the aforesaid tract or parcel of land and all privileges and appurtenances thereunto belonging to the said parties of the second part and their heirs and assigns forever.

IN TESTIMONY WHEREOF, the said parties of the first part have hereunto set their hands and seals the day and year first above written.

C. B. Spencer (SEAL)

Lola Allred Spencer (SEAL)

NORTH CAROLINA - Randolph County

I, _____, a Notary Public of said County, do hereby certify that C. B. Spencer and wife, Lola Allred Spencer, personally appeared before me, this day and acknowledged the execution of the foregoing deed of conveyance.

WITNESS my hand and seal, this the ___ day of _____, 1978.

_____
Notary Public

My commission expires: _____

NORTH CAROLINA — Randolph County

The foregoing certificate(s) of Robin Kirdschi Notary Public

Mail to

PREPARED BY MILLER, BECK, O'BRIANT AND GLASS ATTORNEYS, ASHEBORO, NORTH CAROLINA

This Deed, Made this 10th day of November, A. D., 1977

by R. Glen Keyes and wife, Helen Keyes,

of Randolph County, North Carolina, parties of the first part (whether one or more persons) to

Union Carbide Corporation, a New York corporation,

party

of the second part (whether one or more persons): Witnesseth: That the said parties of the first part in consideration of $10.00 and other good and valuable considerations paid by the said party of the second part, the receipt of which is hereby acknowledged, have bargained and sold and by these presents do bargain, sell and convey unto the said party of the second part and its successors and assigns, a tract or parcel of land in Asheboro Township, Randolph County, North Carolina, described as follows:

BEGINNING at an iron pipe in the York and Brown line, said iron pipe being located South 12 degrees 57 minutes 40 seconds West 30 feet from an iron pipe marking York and Brown's Northwest corner; thence North 80 degrees 52 minutes 45 seconds West 100 feet to an iron pipe; thence North 4 degrees 43 minutes East 14.50 feet to a point; thence South 78 degrees 19 minutes 23 seconds East 100.60 feet to a point; thence South 5 degrees 36 minutes 15 seconds West 9.99 feet to the Beginning, and containing 1,228.9 square feet, more or less.

The above land was conveyed to grantor(s) by ..... See Book No. ....., Page .....

To have and to hold the aforesaid tract or parcel of land and all privileges and appurtenances thereunto belonging to the said party of the second part and its successors and assigns, forever.

And the said parties of the first part covenant that they will warrant and defend the said title against the claims of all persons whomsoever.

In Testimony Whereof the said parties of the first part have hereunto set their hands and seals the day and year first above written.

Witness: R. Glen Keyes (SEAL)

Helen Keyes (SEAL)

..... (SEAL)

..... (SEAL)

NORTH CAROLINA — Randolph County

I, Venia B. Young, a Notary Public of said County, do hereby certify that R. Glen Keyes and wife, Helen Keyes, grantors, personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

Witness my hand and seal, this the 23rd day of November, 1977.

My commission expires 5-19-81, 19 Venia B. Young N. P. (SEAL)

NORTH CAROLINA — Randolph County

I, ..., a Notary Public of said County, do hereby certify that ..... grantors, personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

Witness my hand and seal, this the ..... day of ....., 19 .....

My commission expires ....., 19 ..... N. P. (SEAL)

NORTH CAROLINA — Randolph County

The foregoing certificate(s) of Venia B. Young, a Notary Public of Randolph County, N. C. is (are) certified to be correct. This instrument was presented for registration and recorded in this office in Book 1095 Page 420 This 23rd day of November, 1977, at 12:26 o'clock P. M.

ANNIE SHAW, REGISTER OF DEEDS

By Brenda Teague, Deputy Register of Deeds

NORTH CAROLINA

RANDOLPH COUNTY

THIS DEED, Made this 23rd day of November, 1977, by and between R. Glen Keyes and wife, Helen Keyes, of Randolph County, North Carolina, parties of the first part, to Union Carbide Corporation, a New York corporation, its successors and assigns, party of the second part;

W I T N E S S E T H:

That the said parties of the first part in consideration of Ten Dollars ($10.00) and other good and valuable considerations paid by the said party of the second part, the receipt of which is hereby acknowledged, have granted, bargained and sold and by these presents do bargain, sell and convey unto the said party of the second part, and its successors and assigns, a tract or parcel of land in Asheboro Township, Randolph County, North Carolina, described as follows:

BEGINNING at an iron pipe in the Northern right of way line of N. C. Secondary Road No. 1713 (also known as the Albemarle Road and formerly being N. C. Highway No. 49) (said road having a 60 foot right-of-way), said iron pipe being the Southwest corner of the property now owned by Union Carbide Corporation as described in Deed Book 351, Page 277, Randolph County Registry; thence with the Northern right of way line of N. C. Secondary Road No. 1713 South 68 degrees 07 minutes 50 seconds West 30 feet to an iron pipe, the Southeast corner of Mrs. Coy L. Hunt (Davis) property; thence with the Hunt line North 5 degrees 01 minute 04 seconds East 140 feet to a point; thence South 69 degrees 18 minutes West 94.68 feet to a point; thence South 9 degrees 08 minutes 11 seconds East 8.66 feet to a point; thence North 61 degrees 02 minutes 05 seconds West 36.38 feet to an iron pipe; thence South 66 degrees 43 minutes 25 seconds West 7.66 feet to an iron pipe; thence South 73 degrees 12 minutes West 100.55 feet to an iron pipe, Bingham Land Company's Southeast corner; thence with the line of the Bingham Land Company North 4 degrees 43 minutes East 528.50 feet to an iron pipe; thence South 80 degrees 52 minutes 45 seconds East 100 feet to an iron pipe; thence with the line of York and Brown the following courses and distances: South 5 degrees 36 minutes 15 seconds West 334 feet to an iron pipe, North 69 degrees 05 minutes 18 seconds East 182.21 feet to a point on a wall in the line of Union Carbide; thence with the Union Carbide line South 7 degrees 34 minutes West 318.06 feet to the beginning and containing 1.852 acres, more or less.

The above description was drawn according to a survey and plat of said property prepared by Moore, Gardner and Associates, Inc., Consulting Engineers, dated June 2, 1977 and designated as Job No. 290520, Field Book No. 777.

Real Estate Excise Tax 120.00

STATE OF NORTH CAROLINA

NOV 23 77

RANDOLPH CO. REGISTRY

[illegible] seal, th[illegible]

TOGETHER with all [illegible] and interest, if any, of the parties of the first [illegible] to any streets and roads abutting the above described premises to the center lines thereof.

TOGETHER with the appurtenances and all the estate and rights of the parties of the first part in and to said premises.

TO HAVE AND TO HOLD the aforesaid tract or parcel of land and all privileges and appurtenances thereto belonging to the said party of the second part, its successors and assigns, to its only use and behoof forever.

AND the parties of the first part covenant that the parties of the first part have not done or suffered anything whereby the said premises have been incumbered in any way whatever.

IN TESTIMONY WHEREOF, the said parties of the first part have hereunto set their hands and seals, the day and year first above written.

R. Glen Keyes (SEAL)

Helen Keyes (SEAL)

STATE OF NORTH CAROLINA

COUNTY OF RANDOLPH

I, Venia B. Young, a Notary Public, for said County and State, do hereby certify that R. Glen Keyes and wife, Helen Keyes, personally appeared before me this day and acknowledged the due execution of the foregoing instrument.

WITNESS my hand and notarial seal, this 23rd day of November, 1977.

Venia B. Young
Notary Public

My commission expires: 5-19-81

NORTH CAROLINA — Randolph County

The foregoing certificate(s) of Venia B. Young, Notary Public of Randolph Co. N.C. is (are) certified to be correct. This instrument was presented for registration and recorded in this office at Book 1095, Page 419. This 23rd day of November, 1977 at 12:26 o'clock P. M.

Annie Shaw, Register of Deeds

By Brenda Teague, Deputy

Mail to

PREPARED BY MILLER, BECK, O'BRIANT AND GLASS ATTORNEYS, ASHEBORO, NORTH CAROLINA

This Deed, Made this the 11th day of November, A.D. 1977,

by and between R. Glen Keyes and wife, Helen Keyes,

North Randolph County, North Carolina, parties of the first part (whether one or more persons) to

Union Carbide Corporation, a New York corporation,

party of the second part (whether one or more persons) Witnesseth That the said parties of the first part in consideration of $10.00 and other good and valuable considerations paid by the said party of the second part, the receipt of which is hereby acknowledged, have bargained and sold and by these presents do bargain, sell and convey unto the said party of the second part, its successors and assigns, a tract or parcel of land, in Asheboro Township, Randolph County, North Carolina, described as follows:

BEGINNING at an iron pipe, said iron pipe being located the following courses and distances from an iron pipe in the Northern right-of-way line of N. C. Secondary Road No. 1713 (also known as the Albemarle Road and formerly being N. C. Highway No. 49) (said road having a 60 foot right-of-way), said iron pipe last referred to being the Southwest corner of the property now owned by Union Carbide Corporation as described in Deed Book 351, Page 277, Randolph County Registry; South 68 degrees 07 minutes 50 seconds West with the Northern right-of-way line of N. C. Secondary Road No. 1713, 30 feet to an iron pipe, North 5 degrees 01 minutes 04 seconds East 131.05 feet to an iron pipe, the beginning corner; thence North 5 degrees 01 minute 04 seconds East 8.95 feet to a point; thence South 69 degrees 18 minutes West 94.68 feet to a point; thence South 9 degrees 08 minutes 11 seconds East 8.66 feet to a point; thence North 69 degrees 02 minutes 30 seconds East 92.53 feet to the Beginning, and containing .028 acres, more or less.

The above land was conveyed to grantor(s) by ..... See Book No. ..... Page .....

To have and to hold the aforesaid tract or parcel of land and all privileges and appurtenances thereunto belonging to the said party of the second part and its successors and assigns forever.

In Testimony Whereof the said parties of the first part have hereunto set their hands and seals the day and year first above written.

Witness: (SEAL) (SEAL) (SEAL) (SEAL)

NORTH CAROLINA — Randolph County

I, Venia B. Young, a Notary Public of said County, do hereby certify that R. Glen Keyes and wife, Helen Keyes, grantors, personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

Witness my hand and seal, this the 23rd day of November, 1977

My commission expires 5-19-81, 19 ..... N. P. (SEAL)

NORTH CAROLINA — Randolph County

I, ..., a Notary Public of said County, do hereby certify that ..... grantors, personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

Witness my hand and seal, this the ..... day of ....., 19 .....

My commission expires ....., 19 ..... N. P. (SEAL)

NORTH CAROLINA — Randolph County

The foregoing certificate(s) of Venia B. Young, a Notary Public of Randolph County, N. C., is (are) certified to be correct. This instrument was presented for registration and recorded in this office in Book 1095, Page 418. This 23rd day of November, 1977, at 12:24 o'clock P. M.

ANNIE SHAW, REGISTER OF DEEDS

By Brenda Teague, Deputy, Register of Deeds

STATE OF NORTH CAROLINA

COUNTY OF RANDOLPH :

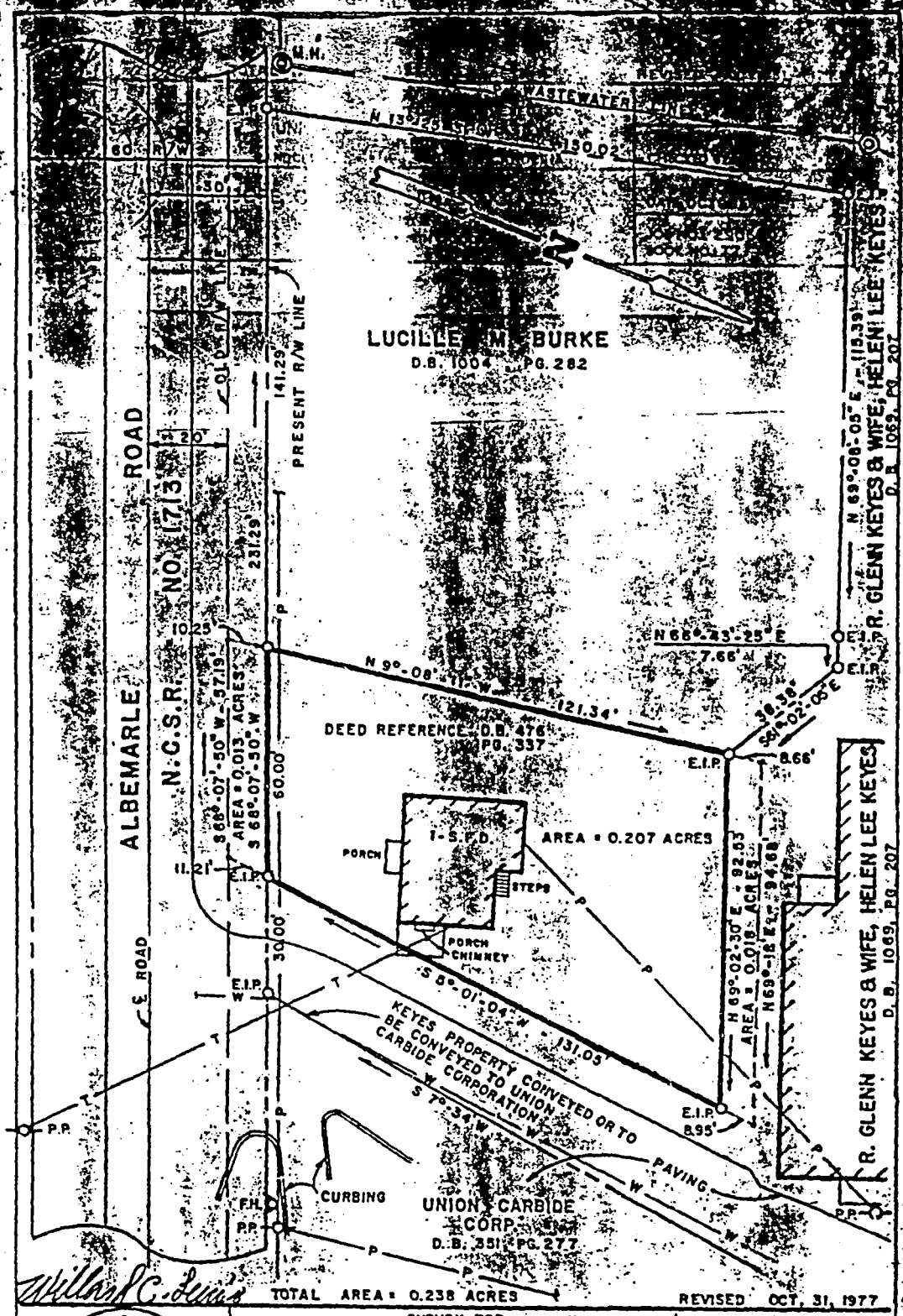
THIS DEED, Made this [illegible] November, 1977, by and [illegible] Eyes, Trustee, of the County of Randolph and State of North Carolina, hereinafter called Grantor, and Union Carbide Corporation, a New York corporation, hereinafter called Grantee;

WITNESSETH: That the Grantor, for and in consideration of the sum of [illegible] Dollars and other good and valuable considerations to him in hand paid by the Grantee, the receipt whereof is hereby acknowledged, has given, granted, bargained, sold and conveyed, and by these presents does give, grant, bargain, sell, convey and confirm unto the Grantee, its successors and assigns, premises in Asheboro Township, Randolph County, North Carolina, described as follows:

BEGINNING at an iron pipe in the Northern right-of-way line of N. C. Secondary Road No. 1713 (also known as Albermarle Road and formerly being N. C. Highway 49) located 30.00 feet from the center line of the said highway, at a point 30.00 feet from an iron pipe, the Southwest corner of lands now owned by Union Carbide Corporation as described in Deed Book 351, Page 277, Randolph County Registry; from the point of beginning, thence running North 5°-01'-04" East 140.00 feet to a stake for a corner; thence running South 69°-18' West 94.68 feet to a stake for a corner; thence running South 9°-08'-11" East 130.00 feet to an iron pipe located in the Northern right-of-way line of said N. C. State Road No. 1713 for a corner; thence running North 68°-07'-50" East along the said Northern right-of-way line 60.00 feet to an iron pipe for a corner, the point of beginning; said area containing acres, more or less, as shown on print entitled, "Hunt Property to be Conveyed to Union Carbide Corporation, Asheboro, Randolph County, North Carolina" dated October 21, 1977, prepared by Moore, Gardner & Associates, Inc., Consultant Engineers (Job 290520; Book 777), Asheboro, North Carolina, attached hereto and made a part hereof.

Together with a perpetual right and easement in and to the use of the 15 foot alleyway situate immediately east of said land for ingress and egress to and from the lands hereinabove described.

The above land was conveyed to Grantor by John William Hunt and wife, Vae C. Hunt by Deed dated November 7, 1977.



Southern Photo Print & Supply Co., Greensboro, N. C. 250 @1000H YP048 8/73

11-7-77

CORPORATION WARRANTY DEED—Form CWD-402. Printed and for sale by James Williams & Co., Inc., Yadkinville, N.C.

STATE OF NORTH CAROLINA, RANDOLPH County.

THIS DEED, Made this 23rd day of November, 1976, by and between Randolph County Historical Society, a non-profit corporation, of Randolph County and State of North Carolina, hereinafter called Grantor, and Union Carbide Corporation, of County and State of North Carolina, hereinafter called Grantee.

WITNESSETH: That the Grantor, for and in consideration of the sum of Ten Dollars and other good and valuable considerations to him in hand paid by the Grantee, the receipt whereof is hereby acknowledged, has given, granted, bargained, sold and conveyed, and by these presents does give, grant, bargain, sell, convey and confirm unto the Grantee, his heirs and/or successors and assigns, premises in Asheboro Township, Randolph County, North Carolina, described as follows:

BEGINNING at a stake on the East side of Uwharrie Street, Richard Hunsucker's Southwest corner, running thence along Hunsucker's South line, North 88 degrees 42 minutes East 137.05 feet to a stake, Hunsucker's Southeast corner; thence North 88 degrees 52 minutes East 495.03 feet to a stake in Dewey L. Caviness' West line; thence along the Caviness line South 1 degree 21 minutes West 132.16 feet to a stake, Caviness' corner; thence South 5 degrees 57 minutes East 23.19 feet to a stake; thence North 86 degrees 44 minutes 30 seconds West 204.59 feet to a stake, Rich's Northwest corner; thence along Rich's West line South 2 degrees 12 minutes 30 seconds West 304.31 feet to a stake in the Union Carbide Corporation North line; thence along Union Carbide Corporation line North 87 degrees 19 minutes 30 seconds West 131.33 feet to a stake; thence North 82 degrees 54 minutes 30 seconds West 136.12 feet to a stake, Robbins' corner; thence along Robbins' line North 4 degrees 25 minutes East 99.95 feet to a stake, Robbins' corner; thence continuing along Robbins' line North 85 degrees 40 minutes West 282.15 feet to a stake in the Eastern right of way line of Uwharrie Street; thence along said right of way line North 24 degrees 26 minutes 30 seconds East 216.65 feet to a stake; thence continuing along said right of way line North 20 degrees 30 minutes 30 seconds East 99.92 feet to the point and place of the beginning.

See map of Moore, Gardner and Associates, Inc., dated July 2, 1976, designated Job No. 6260-479, Book No. 774.

STATE OF NORTH CAROLINA — Real Estate Excise Tax — 15.00 — RB 10710

The above land was conveyed to Grantor by E. M. Armfield, et al. See Book No. 1050, Page 886.

TO HAVE AND TO HOLD The above described premises, with all the appurtenances thereunto belonging, or in any wise appertaining, unto the Grantee, his heirs and/or successors and assigns forever.

And the Grantor covenants that he is seized of said premises in fee, and has the right to convey the same in fee simple; that said premises are free from encumbrances (with the exceptions above stated, if any); and that he will warrant and defend the said title to the same against the lawful claims of all persons whomsoever.

When reference is made to the Grantor or Grantee, the singular shall include the plural and the masculine shall include the feminine or the neuter.

IN WITNESS WHEREOF, the Grantor has caused this deed to be executed by its duly authorized officers and its seal to be hereunto affixed, the day and year first above written.

ATTEST: Charlesanna L. Fox, Secretary

(Corporate Seal) RANDOLPH HIST. SOCIETY

RANDOLPH COUNTY HISTORICAL SOCIETY, INC.

By: Evelyn T. Hayes, President

STATE OF NORTH CAROLINA RANDOLPH COUNTY.

I, Susan M. Stout, a notary public, do hereby certify that Charlesanna L. Fox personally came before me this day and acknowledged that she is Secretary of Randolph County Historical Society, Inc., and that, by authority duly given and as the act of the Corporation, the foregoing instrument was signed in its name by its President, sealed with its corporate seal, and attested by herself as its Secretary.

Witness my hand and official seal this the 23rd day of November, 1976.

My Commission expires: 8/9/77 Susan M. Stout, Notary Public [SEAL]

STATE OF NORTH CAROLINA RANDOLPH COUNTY.

The foregoing certificate(s) of Susan M. Stout, N. Pub. Randolph Co. N.C. is (are) certified to be correct. This instrument was presented for registration this 1st day of December, 1976, at 3:30 o'clock P. M., and duly recorded in the office of the Register of Deeds of Randolph County, North Carolina, in Book 1086 Page 216.

This the 1st day of December, A.D., 1976.

Annie Shaw, Register of Deeds

By Sue Phillips, Assistant, Deputy Register of Deeds

This Deed drawn by Miller, Beck, O'Briant and Glass, Attorneys.

Printed and Sold by Pound & Moore Co., Charlotte, N. C.
FORM R. D. 626

STATE OF NORTH CAROLINA
RANDOLPH County.

This Deed

Made this 9th day of May, A. D. 1952 by and between

E. D. Cranford and wife Hazel M. Cranford,
Deward Trogdon and wife Margaret L. Trogdon,

of the County of Randolph and State of North Carolina

Part ies of the first part, and

Union Carbide and Carbon Corporation, a corporation
of the State of New York, with its principal
Office in the City of New York,

~~of the County of~~ ~~and State of~~

~~part y~~ of the second part:

WITNESSETH, that the said part ies of the first part, in consideration of

Ten Dollars and other valuable considerations ~~Dollars~~

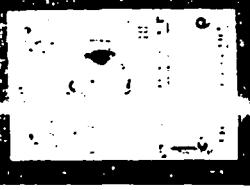
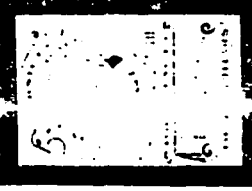
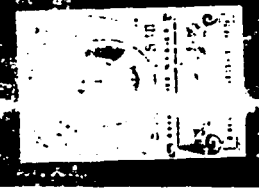
~~to them paid by the part y of the second part, the receipt of which is hereby~~ acknowledged, ~~ha ve~~ bargained and sold, and by these presents do grant, bargain, sell and convey unto the said party of the second part, its successors and assigns ~~and~~ ~~heirs~~ all that lot or parcel

of land, situate, lying and being in

Asheboro Township, Randolph County, State of North Carolina and more particularly described and defined as follows:

Beginning at an iron pipe in the line of way on the North West side of North Carolina State Highway No. 90 [illegible] from the center of said Highway, D. L. Hill's South [illegible] South 61° 12' [illegible] West parallel with the center of said H[illegible] 33.53 feet to an iron pipe, the South East Corner of [illegible] National Carbon Company, Inc. from Cranford Hosiery Mills, Inc.; thence North 29° 18 minutes West 677.05 feet to an iron pipe; thence North 7° [illegible] minutes East 98.40 feet to an iron pipe; thence South 82° 40 minutes East 344.17 feet to an iron pipe in the center line of Brady Avenue (formerly an oak stump and stone); thence South 10° 40 minutes West 562.53 feet to the point and place of the beginning, the same being the tract designated as Cranford & Trogdon as shown on a map made by Richard H. Moore, C. E. in January 1946, and found recorded in Plat Book 4 at Page 38 in the Office of the Register of Deeds for Randolph County, North Carolina.

Together with an easement conveyed in a deed from D. L. Hill et ux to the parties of the first part, dated January 11, 1952, recorded in Book [illegible] Page 391 in the aforesaid Register's Office.

FROM - NATIONAL CARBON COMPANY, INC. TO - UNION CARBIDE AND CARBON CORP.

THIS DEED made the 31st. day of December, 1949, by NATIONAL CARBON COMPANY, INC., a corporation organized and existing under and by virtue of the laws of the State of New York, party of the first part, to Union Carbide and Carbon Corporation, a corporation organized and existing under and by virtue of the laws of the State of New York, party of the second part;

W I T N E S S E T H:

That, the said party of the first part, in consideration of Five Dollars ($5.00) to it paid by the said party of the second part, the receipt of which is hereby acknowledged, has bargained and sold and by these presents does bargain, sell and convey unto the said party of the second part and its successors and assigns, the following described parcels of land situated in the County of Randolph, State of North Carolina:

1. A parcel of land with the buildings and improvements thereon situate in Asheboro Township in said County of Randolph, State of North Carolina and bounded as follows:

Beginning at an iron pipe on the northwest side of Highway No. Forty-nine 30 feet from the center of said highway and running North 65 degrees 20 minutes East parallel with the center line of said Highway No. Forty-nine 286.51 feet to an iron pipe, Cranford Hosiery Mills' corner; thence North 29 degrees 18 minutes West with Cranford Hosiery Mills' line 404.70 feet to an iron pipe; thence South 7 degrees 34 minutes West 476.92 feet to the beginning, containing 57,972 square feet, more or less, as shown on a map made by Richard H. Moore, C. E., in January, 1946, and recorded in Plat Book 4, page 38, in the office of the Register of Deeds for Randolph County, North Carolina; being the same parcel of land conveyed to the party of the first part by C. C. Cranford by deed dated August 21, 1947, and recorded in the office of the Register of Deeds for Randolph County in Book No. 387, Page No. 576.

2. All that parcel of land with the buildings and improvements thereon situate in Asheboro Township, County of Randolph, State of North Carolina, and bounded as follows:

Beginning at an iron pipe on the northwest side of Highway No. Forty-nine 30 feet from the center of said highway, C. C. Cranford's southeast corner, and running North 62 degrees 25 minutes East, parallel with the center line of said Highway No. Forty-nine 200.14 feet to an iron pipe; thence North 29 degrees 18 minutes West 677.05 feet to an iron pipe; thence South 7 degrees 34 minutes West 333.16 feet to an iron pipe; thence South 29 degrees 18 minutes East 404.70 feet to the point of beginning, containing 108,249 square feet, more or less, as shown on a map made by Richard H. Moore, C. E., in January, 1946, and recorded in Plat Book 4, page 38, in the office of the Register of Deeds for Randolph County, North Carolina; being the property conveyed to the party of the first part by Cranford Hosiery Mills, Inc., by deed dated August 21, 1947, and recorded in the office of the Register of Deeds for Randolph County, in Book No. 387, Page 575.

3. All other real property and all rights in real property, whether legal or equitable, owned by the party of the first parton the date of the ensealing of these presents and situated in the County of Randolph, State of North Carolina.

TO HAVE AND TO HOLD THE aforesaid tracts or parcels of land and all privileges and appurtenances thereunto belonging to the said party of the second part and its successors and assigns forever.

IN TESTIMONY WHEREOF, the said party of the first part has caused these presents to be signed by its duly authorized officer and its corporate seal to be affixed and attested the day and year first above written.

NATIONAL CARBON COMPANY, INC.

(CORPORATE SEAL)

BY J. M. Spangler
Vice-President

Attest:

J. S. Behringer
Assistant Secretary

STATE OF NEW YORK
COUNTY OF NEW YORK } ss.:

This 31st day of December, A. D. 1949, personally came before me, a Notary Public for the County and State aforesaid J. M. Spangler, who being by me duly sworn says that he is a Vice President of NATIONAL CARBON COMPANY, INC., and that the seal affixed to the foregoing instrument in writing is the corporate seal of said corporation and that said writing was signed and sealed by him in behalf of said corporation by its authority duly given, and the said J. M. Spangler acknowledged the said writing to be the act and deed of said corporation.

(N.P.SEAL)

Charles A. Falconi

CHARLES A. FALCONI
Notary Public, State of New York
Residing in Richmond Co. Certificate filed in
New York Co. Clerk's No. 142, Register's No. 257-F-0
Commission Expires March 30, 1950

Transfer of properties to give effect to merger of National Carbon Company, Inc. into Union Carbide and Carbon Corporation. No consideration payable and no Federal Tax Stamps required.

NORTH CAROLINA, RANDOLPH COUNTY.

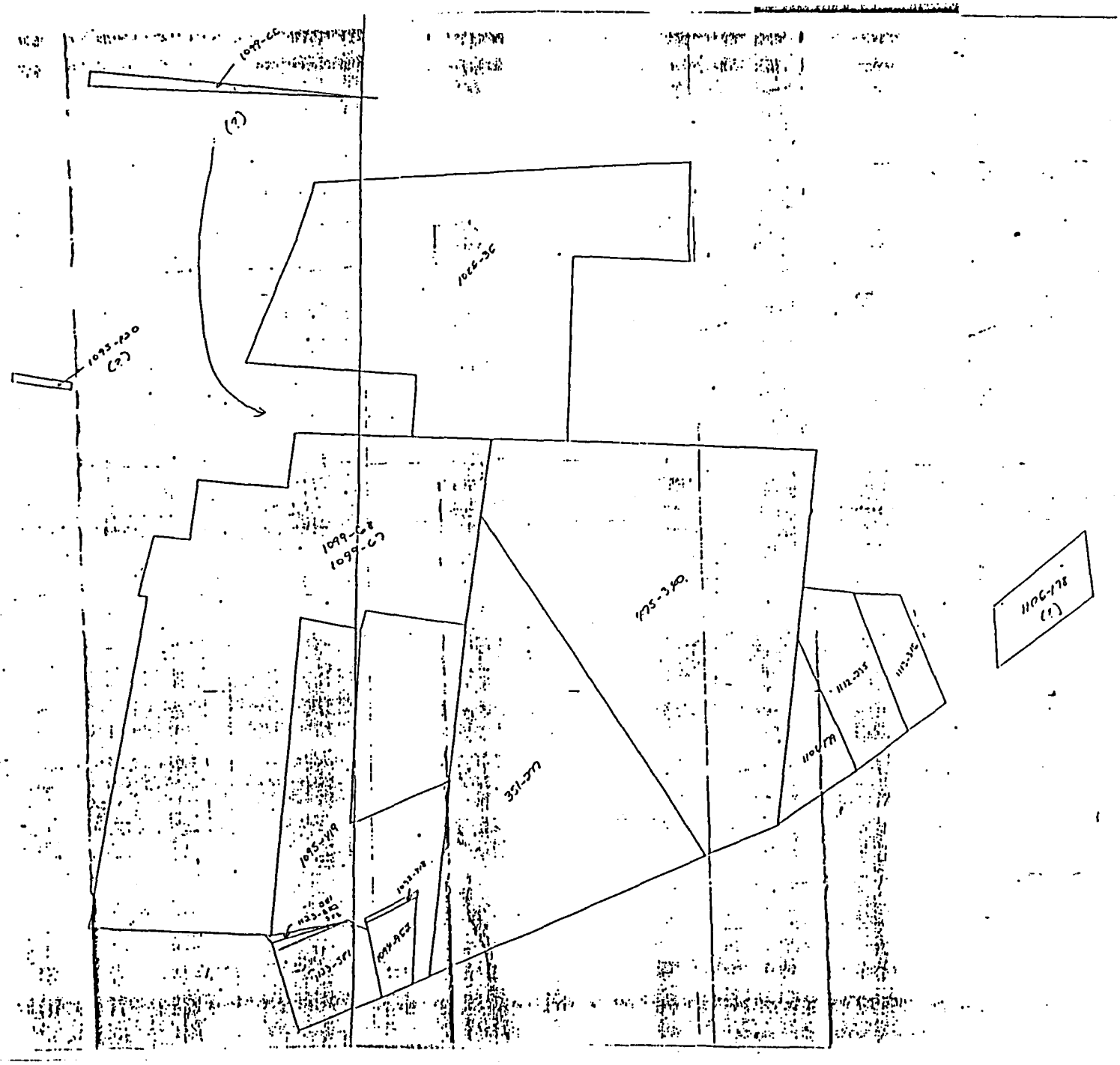
The foregoing Certificate of Charles A. Falconi a Notary Public of Richmond County, State of N. Y. is adjudged to be correct. Let the Instrument, with the certificate, be registered.

This 10 day of Jan., 1950.

Nellie H. Jones, Ass't.
Clerk Superior Court

Filed for registration at 4:30 o'clock P. M. Jan. 10 1950, and registered in the office of the Register of Deeds for Randolph County, in Book No. 351, Page No. 277.

Alese M. Ward
Register of Deeds


1099-CC
(?)
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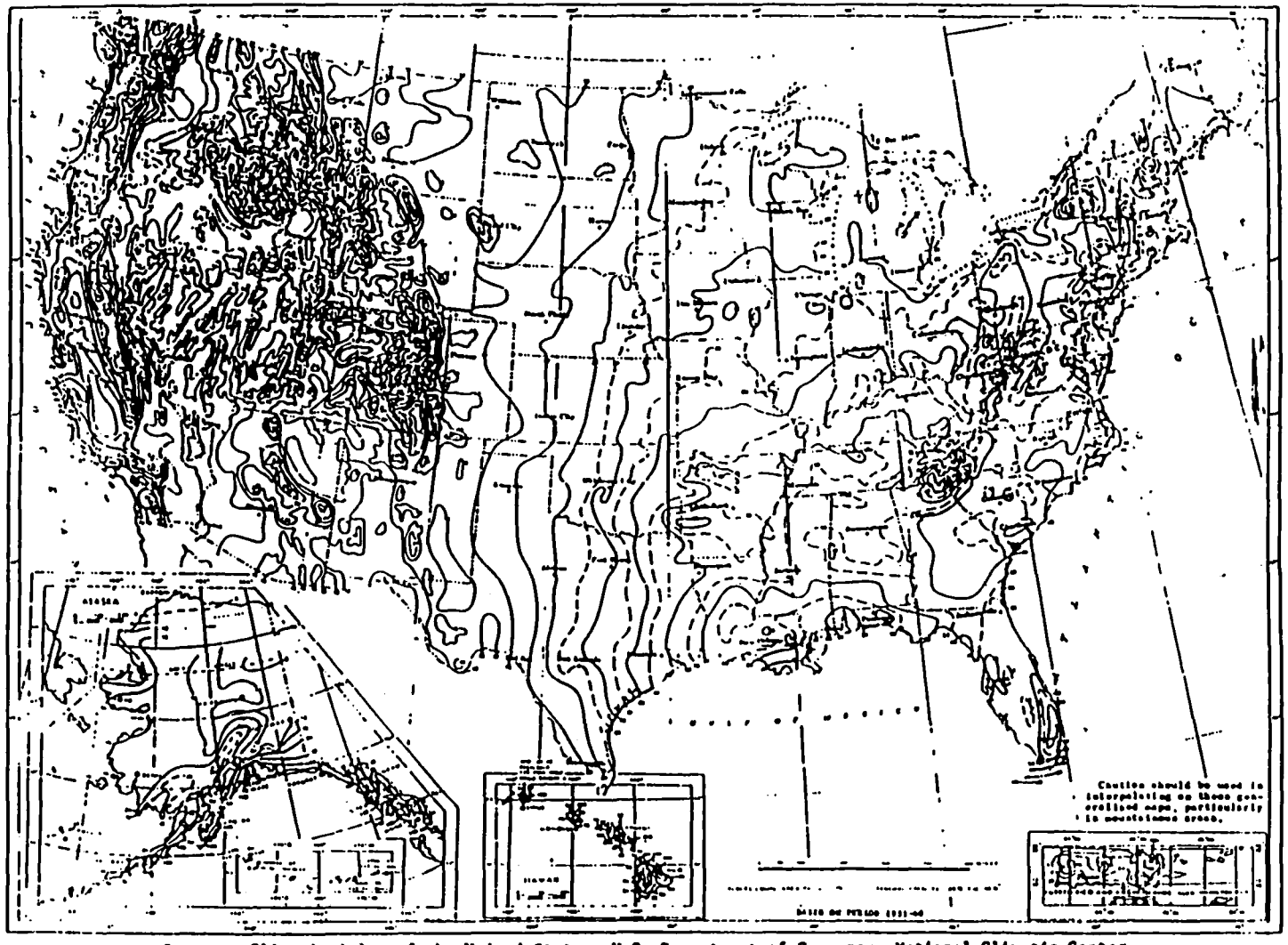
1075-3KO
1110C-17B
(?)
1112-2J5
1112-3C
1110-17
351-2T1
1085-1H
1033-1H
1033-2C1
1033-3C1

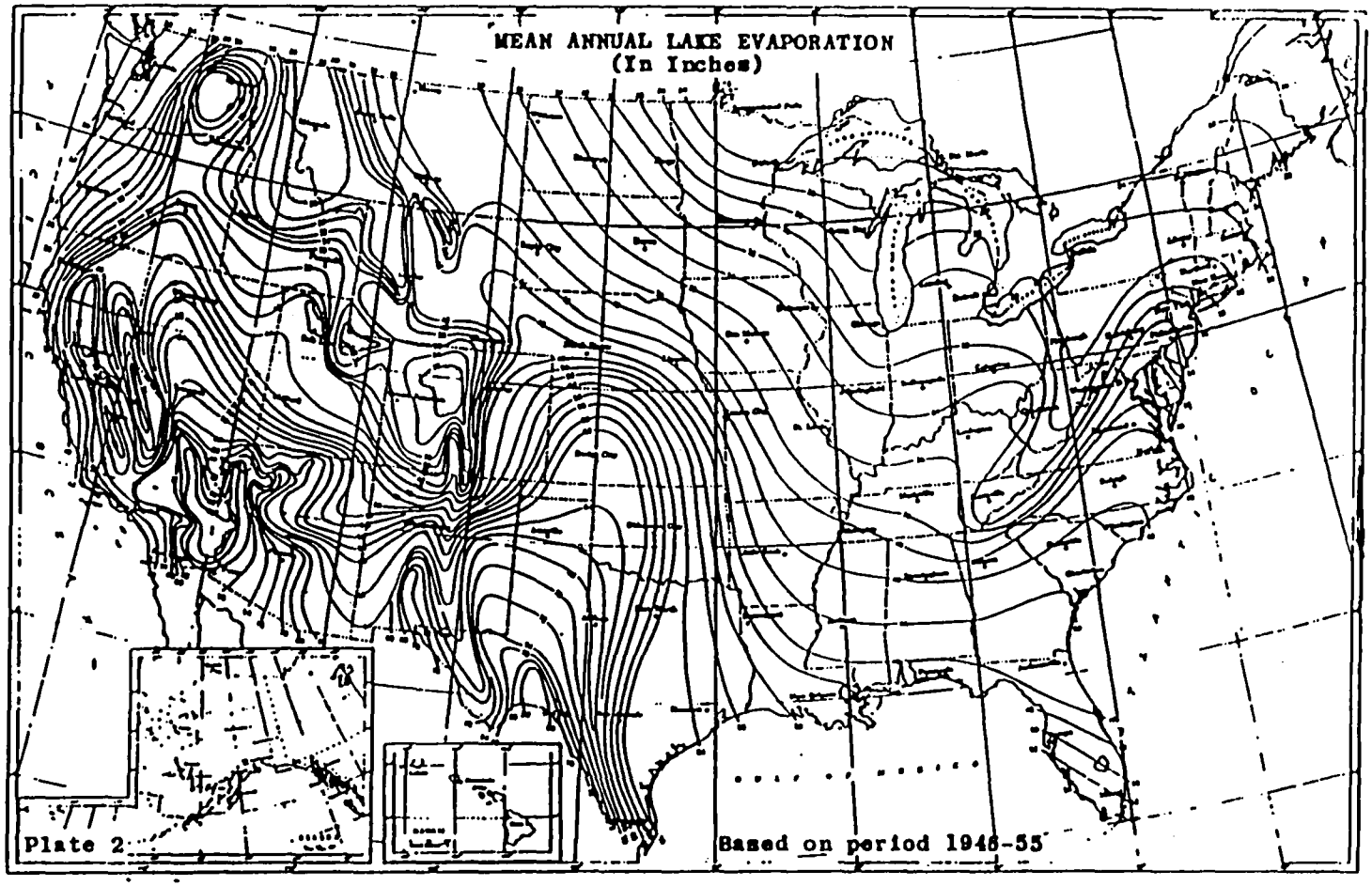
REFERENCE 36



Source: Climatic Atlas of the United States, U.S. Department of Commerce, National Climatic Center, Asheville, N.C., 1979.

FIGURE 5
NORMAL ANNUAL TOTAL PRECIPITATION (INCHES)

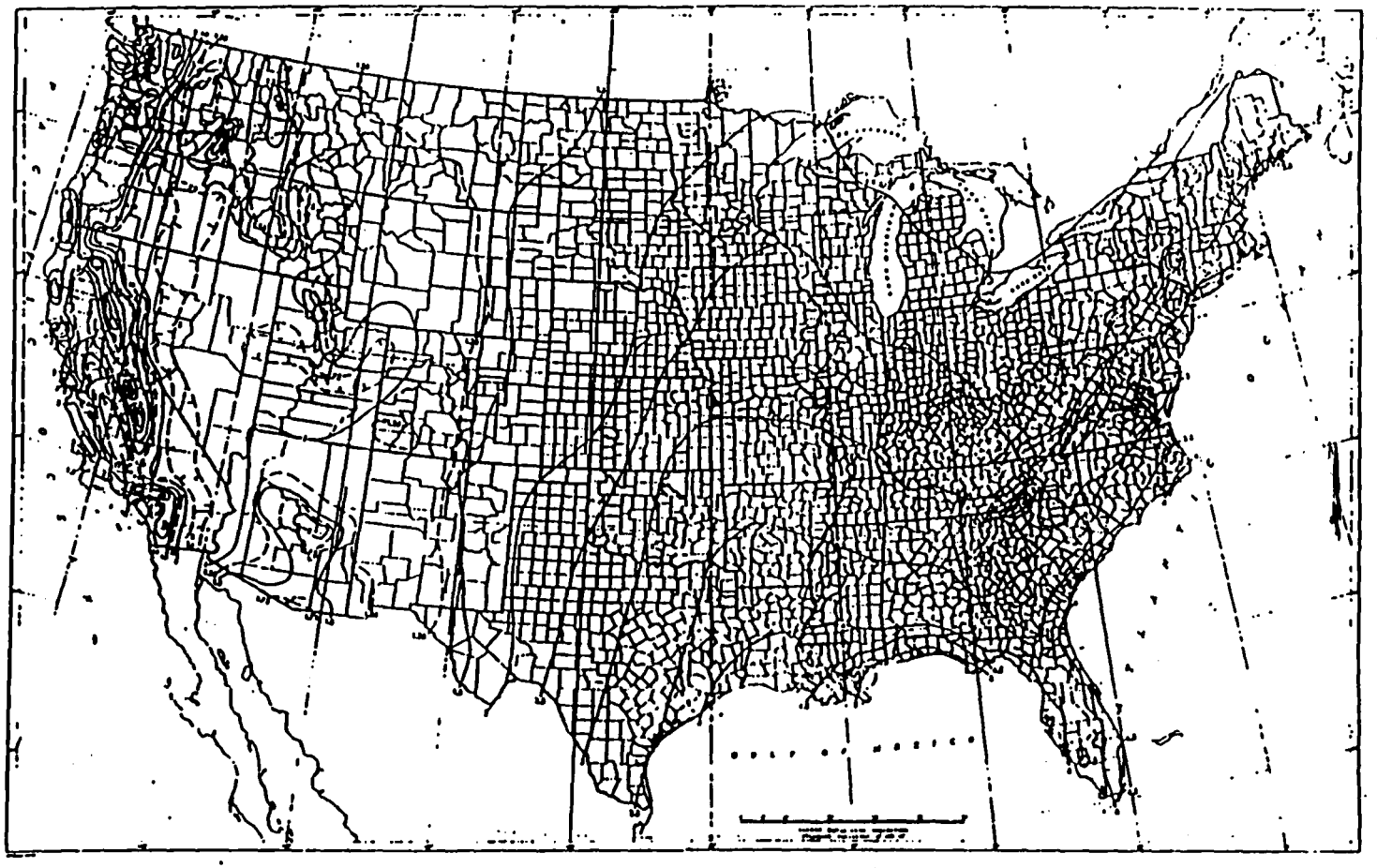
REFERENCE 37



Source: Climatic Atlas of the United States, U.S. Department of Commerce, National Climatic Center, Ashville, N.C., 1979.

FIGURE 4
MEAN ANNUAL LAKE EVAPORATION
(IN INCHES)

REFERENCE 38



Source: Rainfall Frequency Atlas of the United States, Technical Paper No. 40, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C., 1963.

FIGURE 8
1-YEAR 24-HOUR RAINFALL
(INCHES)

REFERENCE 39

REFERENCE 39

SEE FIGURE 2 IN APPENDIX A

REFERENCE 40

REFERENCE 40

SEE FIGURE 3 IN APPENDIX A

REFERENCE 41

REFERENCE 41

SEE FIGURE 4 IN APPENDIX A

REFERENCE 42

May 18, 1989

TO: Superfund Branch Staff

FROM: Pat DeRosa PD

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

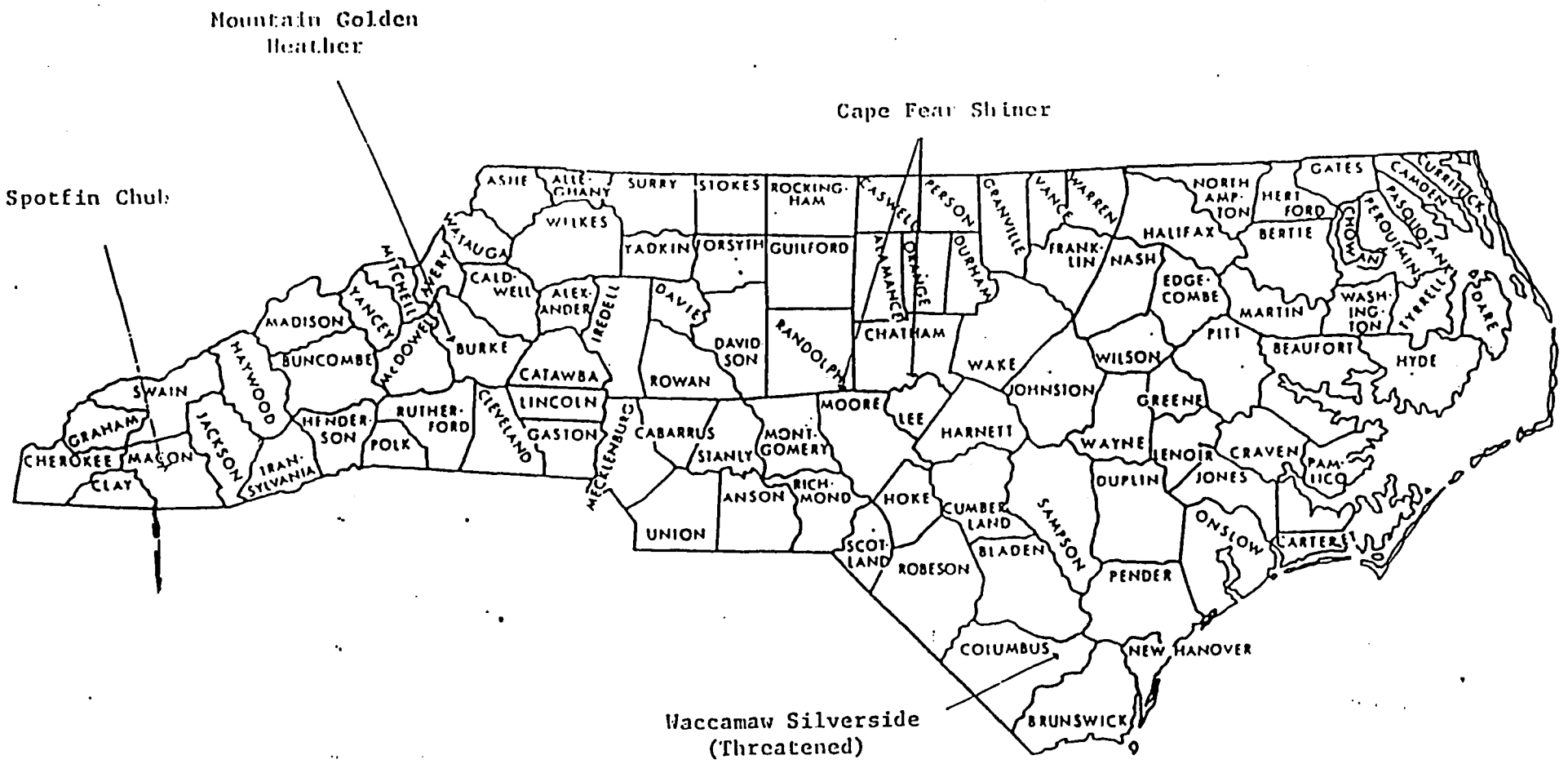
On May 18, 1989, I spoke by telephone with John Fridell, US Fish and Wildlife Service, Asheville, NC (704) 259-0321 to request an update on critical habitats in North Carolina. Mr. Fridell said the Fish and Wildlife Service has been reorganized into a western and eastern office in North Carolina. His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

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

PD/pb/critical.hab

CRITICAL HABITATS OF FEDERALLY LISTED

ENDANGERED SPECIES IN NC



1 inch = approx. 53 miles

RECEIVED
MAY 19 1989
6/88
SUPERFUND BRANCH

~~CAPE~~ FEAR SHINER

Notropis mekistocholas

Order: Cypriniformes

Family: Cyprinidae

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

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

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

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

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

CAPE FEAR SHINER - N. mekistocholas 6/88

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

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

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

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

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

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

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

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

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

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

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

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

References:

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

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

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

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

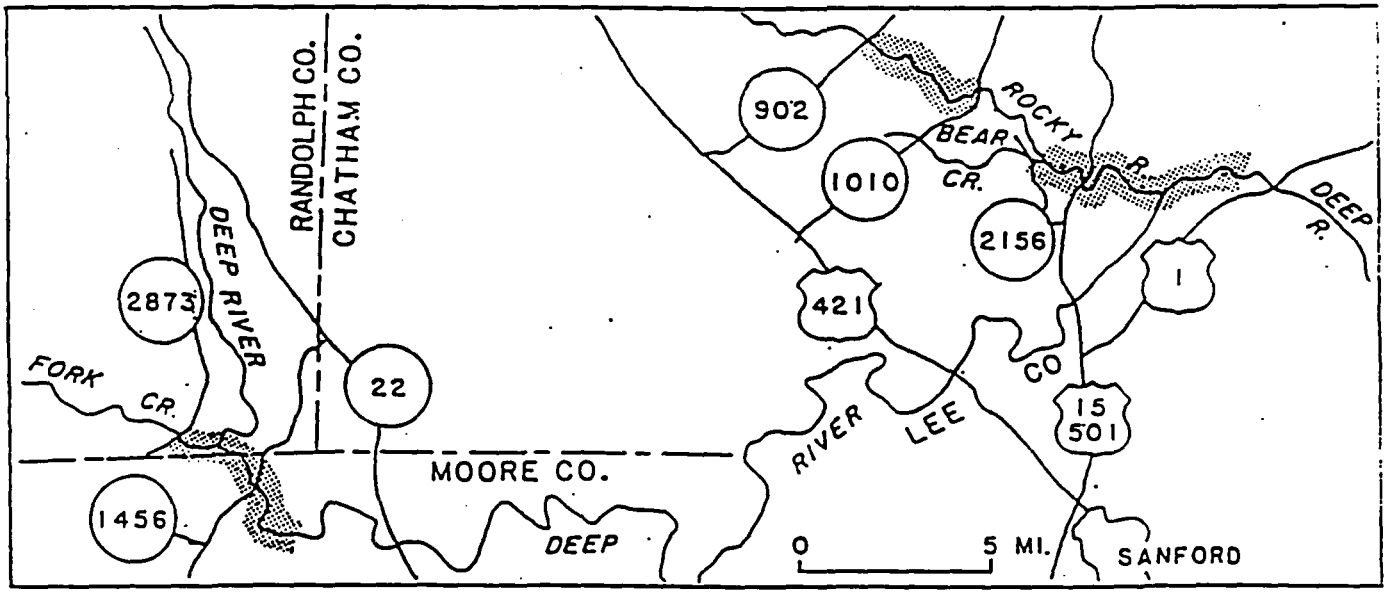
U.S. Fish and Wildlife Service. 1987. Endangered and threatened wildlife and plants; determination of endangered species status and designation of critical habitat for the Cape Fear shiner. Federal Register 52(186):36034-36039.

NORTH CAROLINA - Critical Habitat

Notropis mekistocholas, "Cape Fear shiner"

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

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



RECEIVED
MAY 19 1989
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7/87

~~WACCA~~MAW SILVERSIDE

Menidia extensa

Order: Mugiliformes

Family: Atherinidae

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

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

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

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

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

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

WACCAMAW SILVERSIDE - M. extensa

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

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

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

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

Population level: Estimated to be in the millions.

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

References:

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

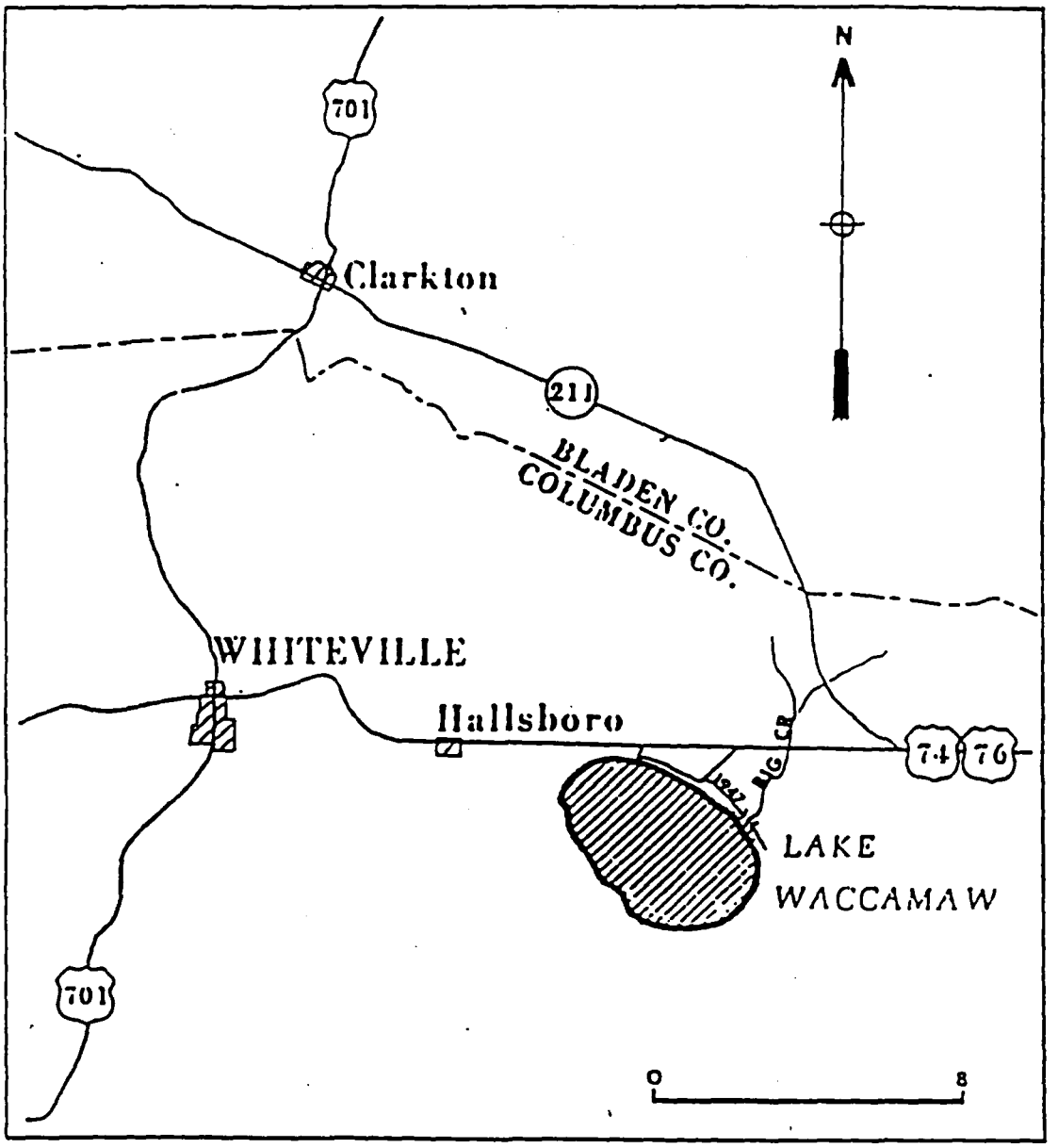
Davis, J.R. and D.E. Louder. 1969. Life History of Menidia extensa. Transactions of the American Fisheries Society 98(3):466-472.

NORTH CAROLINA - Critical Habitat

Menidia extensa, "Waccamaw ~~silverside~~"

Columbus County. Lake Waccamaw in its entirety to mean high water level, and Big Creek from its mouth at Lake Waccamaw upstream approximately 0.6 kilometer (0.4 mile) to where the creek is crossed by County Road 1947.

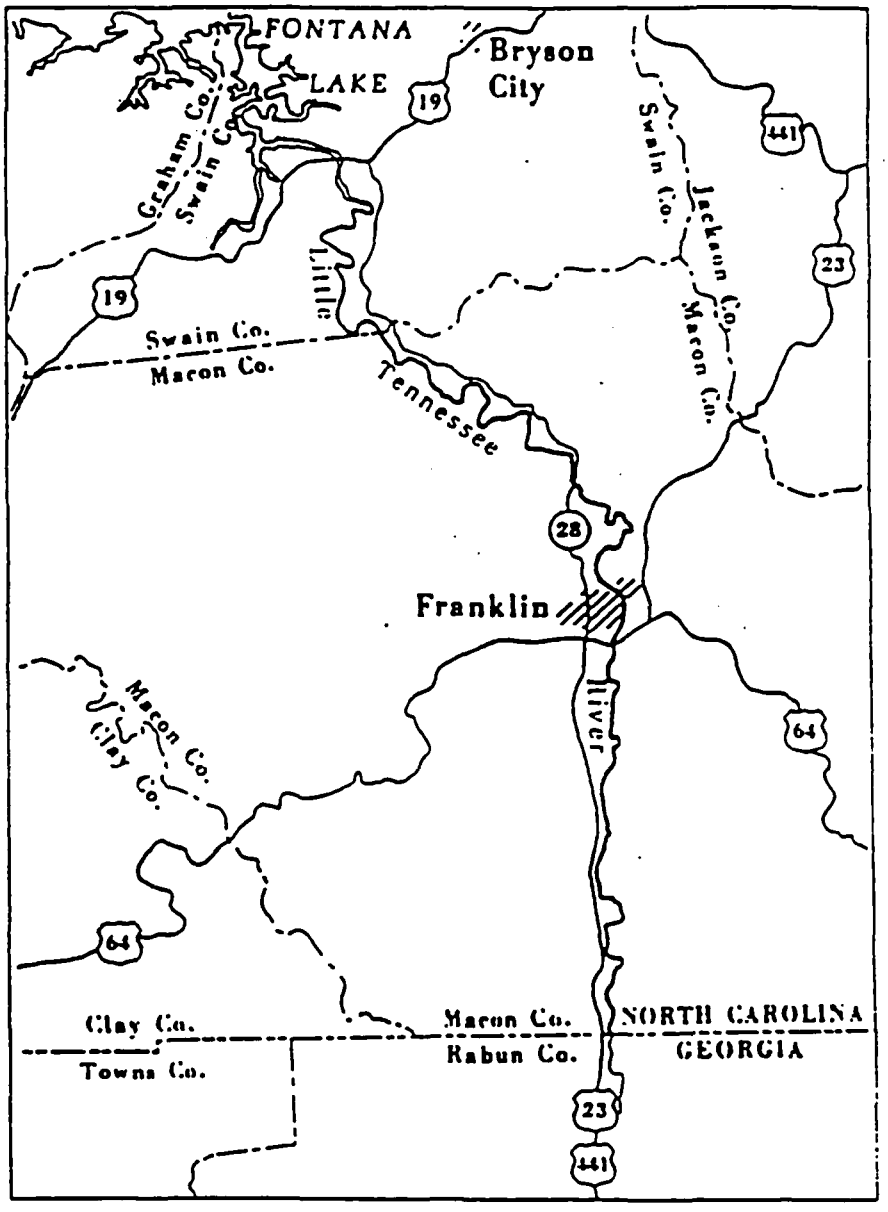
Constituent elements include high quality clear open water, with a neutral pH and clean sand substrate.



NORTH CAROLINA - Critical Habitat

Hybopsis monacha, "spotfin chub"

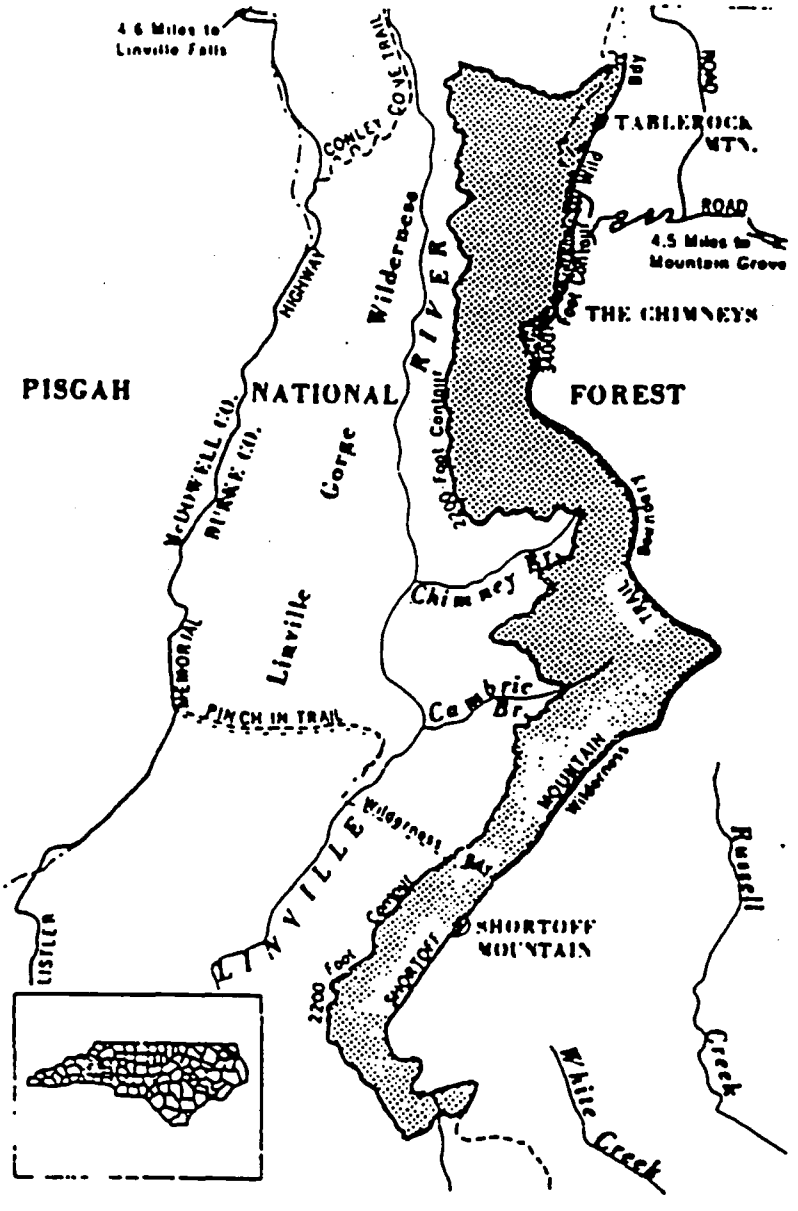
Macon and Swain Counties. Little Tennessee River, main channel from the backwaters of Fontana Lake upstream to the North Carolina-Georgia state line.



NORTH CAROLINA - Critical Habitat

Hudsonia montana, "mountain golden heather"

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



State of North Carolina
Department of Natural Resources and Community Development
Division of Soil and Water Conservation
512 North Salisbury Street • Raleigh, North Carolina 27611

James G. Martin, Governor
S. Thomas Rhodes, Secretary

David W. Sides
Director

June 21, 1988

Ms. Pat DeRosa
Superfund Branch
Bath Building

Dear Ms. DeRosa:

Enclosed is the list of hydric soils of North Carolina. The soils are listed by soil order. The information is presented in the following order: county distribution, acreage, drainage class, capability class, and associated wetland communities. The soils with a red asterisk are floodplain soils and may be of more importance to you. The soil surveys of each county will be a valuable resource for approximate wetland boundaries by using the hydric soil list and the delineated soil maps. If I can be of further assistance to you on hydric soils or wetlands, please call.

Sincerely,

Kevin Moorhead

Kevin Moorhead
Wetlands Program

12 February 1990

To: Staff

From: Ed Wallingford

Re: Wetlands Maps

Th Division of Soil and Water Conservation has wetlands maps available on 7.5 minute USGS topographic quad copies. The maps show areas of wetlands according to the National Wetland Classification System. Also indicated are the type of wetland (i.e. freshwater vs. saltwater), the degree of wetness, and the type of cover. Copies can be sent free upon request; contact Steve Leonard at 733-2302.

THE HYDRIC SOILS OF NORTH CAROLINA

Over 100 hydric soils have been used in soil survey work in North Carolina. Seven of the 10 soil orders are represented and each soil order is discussed separately.

ALFISOLS

Argent - Washington, Tyrrell and Pamlico Counties, 27,200 acres. Poorly drained, 6w. Isolated swamps and pine/hardwood forests, pocosin fringes.

Brookman - Pamlico and Columbus Counties, 9,690 acres. Very poorly drained, 6w.

Grifton - Bladen, Columbus, Brunswick, Pender, Onslow, Duplin, Lenoir, Jones Counties, 64,958 acres. Poorly drained, 6w. Savannahs, bottomland forests, pine/hardwood forests.

Leaksville - Rockingham County, 1,901 acres. Somewhat poorly drained, 3w.

* Meggett - Nash, Edgecombe, Lenoir, Craven, Jones, Pender, Bladen, Robeson, Columbus Counties, 49,114 acres. Poorly drained, 4 to 6w (flooding). Bottomland forests.

Nakina - Columbus County, 18,721 acres. Very poorly drained, 6w.

Stockade - Pamlico and Jones Counties, 23,459 acres. Very poorly drained, 6w. Mixed hardwood/pine forests.

Tuckerman - Pitt County, 8,832 acres. Poorly drained, 3 to 5w (slope).

Yonges - Pamlico County, 27,286 acres. Poorly drained, 6w. Pocosin fringes.

ENTISOLS

Bibb - Pasquotank, Hertford, Bertie, Halifax, Martin, Edgecombe, Nash, Pitt, Greene, Wilson, Nash, Wake, Johnston, Wayne, Lenoir, Duplin, Sampson, Harnett, Moore, Robeson, Scotland Counties, 287,668 acres. Poorly drained, 5w. Bottomland forests.

Bohicket - Onslow, Pender, Brunswick Counties, 23,522 acres. Very poorly drained, 8w. Tidal brackish marsh.

Capers - Hyde County? Very poorly drained, 6w.

Cartecay - Durham County, 1,831 acres. Somewhat poorly drained, 7w. The known acreage of Cartecay may not meet the criteria of hydric soil because this series is considered hydric only when ponded.

Carteret - Dare, Carteret, Onslow, Pender, Brunswick Counties, 24,729 acres. Very poorly drained, 8w. Tidal brackish marsh.

Chastain - Rockingham, North Hampton, Martin, Johnston, Pender, Bladen, Columbus, Richmond Counties, 47,038 acres. Poorly drained, 4 to 6w. Bottomland forests.

* Chowan - Camden, Gates, Chowan, Perquimans, Tyrrell, Brunswick Counties, 27,596 acres. Very poorly drained, 7w. Cypress/gum swamps.

Duckston - Outer banks, 5,000 acres. Brackish marsh/shrub zone, swales between dunes.

Engelhard - New series in Hyde County. Poorly drained, 6w. Formerly mapped as a phase of Weeksville or Pasquotank series.

* Hatboro - Henderson County, 1,674 acres. Poorly drained, 3w. Bottomland forests.

Hobucken - Pamlico and Carteret Counties, 21,134 acres. Very poorly drained, 7w. Tidal brackish marsh.

Kinston - Lenoir, Greene and Wayne Counties, 11,009 acres. Poorly drained, 6w. Bottomland forests.

Muckalee - Washington, Beaufort, Craven, Jones, Onslow, Duplin, Pender, Columbus, Brunswick Counties, 187,878 acres. Poorly drained, 5w. Cypress/gum swamps, bottomland forests.

Nawney - Gates County. Very poorly drained, 7w.

Osier - Pitt, Robeson, Dare and Currituck Counties, 8,827 acres. Poorly drained, 5w. Marsh/shrub transition in the outer banks, ?

* Wehadkee - Cherokee, Graham, Avery, Watagua, Caldwell, Wilke, Alexander, Catawba, Iredell, Cabarras, Yadkin, Forsyth, Rockingham, Guilford, Anson, Moore, Lee, Chatam, Alamance, Person, Granville, Vance, Warren, North Hampton, Hertford, Bertie, Halifax, Edgecombe, Nash, Wilson, Johnston, Harnett, Wake, Durham, Franklin Counties, 218,030 acres. Poorly drained, 6w. Bottomland forests.

Wysocking - Hyde County. Poorly drained, 6w.

HISTOSOLS

Belhaven - Camden, Gates, Dare, Tyrrell, Washington, Beaufort, Hyde, Pamlico, Carteret Counties, 160,346 acres. Very poorly drained, 7w. Pocosins.

Croatan - Martin, Beaufort, Pamlico, Craven, Carteret, Jones, Duplin, Onslow, Pender, Duplin, Cumberland, Bladen, Columbus, Brunswick Counties, 294,822 acres. 7w. Pocosins, Carolina Bays.

Currituck - Currituck, Dare and Beaufort Counties, 44,642 acres. Very poorly drained, 8w. Tidal brackish and freshwater marsh.

Dare - Currituck, Hyde, Beaufort, Craven, Pamlico, Carteret Counties, 83,881 acres. 7w. Pocosins.

* Dorovan - Currituck, Camden, Perquimans, Chowan, Gates, Hertford, Bertie, Martin, Washington, Tyrrell, Hyde, Beaufort, Craven, Carteret, Onslow, Pender, Bladen, New Hanover, Brunswick, Columbus Counties, 255,712 acres. Very poorly drained, 7w. Cypress/gum swamps.

Hobanny - Jones, Dare and Camden Counties, 13,029 acres. Very poorly drained, 7w. Tidal freshwater marsh.

Lafitte - Craven, Pamlico, Onslow, Brunswick, Carteret Counties, 43,821 acres. Very poorly drained, 8w. Tidal brackish marsh.

Mattamuskeet- New series in Hyde County. Very poorly drained, 7w.

Pamlico - Wayne, Lenoir, Sampson, Bladen, New Hanover Counties, 42,834 acres. Very poorly drained, 7w. Pocosins.

Ponzer - Currituck, Dare, Hyde, Tyrrell, Beaufort, Washington, Craven, Carteret, Robeson Counties, 123,258 acres. 7w. Pocosins, isolated deciduous hardwood forests.

Pungo - Gates, Camden, Washington, Tyrrell, Dare, Hyde Counties, 250,811 acres. Very poorly drained, 7w. Pocosins.

Scuppernong - Chowan, Perquimans and Washington Counties, 9,810 acres. 7w. Pocosins.

INCEPTISOLS

Arapahoe	- Chowan, Perquimans, Washington, Tyrrell, Beaufort, Craven, Pamlico, Carteret Counties, 88,436 acres. Very poorly drained, 6w. Mixed hardwood/pine forests, pocosin fringes.
Ballahack	- Gates, Edgecombe and Pamlico Counties, 11,817 acres. Very poorly drained, 6w. Pocosin fringes, bottomland forests.
Chenneby	- Columbus County (in association with Chastain). Somewhat poorly drained, 4w. Only the ponded phase of this series is considered hydric so the known acreage of Chenneby may not be considered a hydric soil.
Conaby	- Currituck, Washington and Dare Counties, 7,337 acres. Very poorly drained, 6w. Mixed hardwood/pine forests, brackish marsh/shrub zone, bottomland forests.
Fortescue	- Washington County, 720 acres. Very poorly drained, 6w.
* Johnston	- Bertie, Edgecombe, Greene, Wayne, Lenoir, Duplin, Sampson, Hoke, Cumberland, Bladen, Robeson, Columbus, Scotland, New Hanover Counties, 245,727 acres. Very poorly drained, 7w. Bottomland forests, cypress-gum swamps.
Liddell	- Wayne and Pender Counties, 29,658 acres. Poorly drained, 6w.
* Masontown	- Pamlico, Craven, Carteret and Onslow Counties, 21,182 acres. Very poorly drained, 7w. Cypress-gum swamps.
* Nikwasi	- Proposed mountain floodplain series in Haywood, Jackson, Clay and Macon Counties. Poorly and very poorly drained, 6w.
Pasquotank	- Currituck and Pasquotank Counties, 17,669 acres. Poorly drained, 6w.
Pettigrew	- New series in Hyde County. Very poorly drained, 6w.
Polawana	- Harnett County, 791 acres. Very poorly drained, 6w.
Roper	- Camden, Washington, Tyrrell and Dare Counties, 38,442 acres. Very poorly drained, 6w. Mixed pine/hardwood forests, pocosin fringes.
Rutledge	- Scotland, Robeson and Pamlico Counties, 9,306 acres. Very poorly drained, 6w.
Sylva	- New series in Jackson and Macon Counties. Poorly drained, 3w.
Torhunta	- Beaufort, Craven, Carteret, Jones, Lenoir, Wayne, Onslow, Duplin, Sampson, Cumberland, Pender, Bladen, Hoke, Robeson, Columbus, Brunswick, New Hanover Counties, 276,924 acres. Very poorly drained, 6w. Carolina Bays, Pocosin fringes, mixed pine/hardwood forests.
* Toxaway	- Graham, Clay, Transylvania, Henderson, Buncombe, Yancey, Ashe, Watagua, Avery, Mitchell Counties, 19,453 acres. Very poorly drained, 4w. Bottomland forests.
Wasda	- Currituck, Camden, Tyrrell, Washington, Beaufort, Hyde, Pamlico, Carteret, Bladen Counties, 66,658 acres. Very poorly drained, 6w. Pocosin fringes.
Weeksville	- Pasquotank, Hyde and Tyrrell Counties, 44,706 acres. Very poorly drained, 6w.
Wilbanks	- Hertford, Halifax, Wilson and Bladen Counties, 11,447 acres. Very poorly drained, 6w.

MOLLISOLS

Armenia	- Davie, Davidson and Cabarrus Counties, 2,445 acres. Poorly drained, 3 to 6w.

Picture - Granville County. Poorly drained.
Stono - Pasquotank County, 923 acres. Very poorly drained, 6w.

SPODOSOLS

Leon - Beaufort, Pamlico, Carteret, Jones, Craven, Lenoir, Wayne, Duplin, Onslow, Sampson, Pender, Cumberland, Hoke, Robeson, Bladen, Columbus, Brunswick, New Hanover, Gates, Dare Counties, 261,332 acres. Poorly drained, 4w. Pine flatwoods, savannahs.
Lynn Haven - Cumberland, Hoke, Sampson, Bladen, New Hanover, Chowan, Perquimans Counties, 62,670 acres. Poorly drained, 4w. Pine flatwoods, savannahs.
Murville - Pitt, Craven, Lenoir, Jones, Carteret, Onslow, Duplin, Pender, New Hanover, Brunswick, Columbus Counties, 178,870 acres. Very poorly drained, 5w. Pine flatwoods, savannahs, Carolina Bays.
Olustee - Pitt County, 1,265 acres. Poorly drained, 3w. Has recently been correlated to Murville soil.

ULTISOLS

Bayboro - Pasquotank, Hyde, Beaufort, Craven, Jones, New Hanover Counties, 80,781 acres. Very poorly drained, 6w.
Bethera - North Hampton, Halifax, Martin and Columbus Counties, 59,682 acres. Poorly drained, 6w. Bottomland forests.
Bladen - Gates, Hyde, Pitt and Pasquotank Counties, 64,610 acres. Poorly drained, 6w. Mixed hardwood/pine forests.
Byars - Hoke, Cumberland, Robeson, Bladen and Pitt Counties, 15,826 acres. Very poorly drained, 6w. Mixed pine/hardwood forests, Carolina bays, pocosin fringes.
Cape Fear - Cumberland, Bladen, Pitt, Edgecombe, Beaufort, Washington, Tyrrell, Dare, Currituck, Camden, Perquimans, Chowan, Gates Counties, 90,915 acres. Very poorly drained, 6w. Pocosin fringes, bottomland forests.
Chatuge - Jackson and Clay Counties. Poorly drained, 4w.
Coxville - Edgecombe, Franklin, Pitt, Wilson, Lenoir, Wayne, Harnett, Sampson, Bladen, Cumberland, Hoke, Robeson, Scotland, Columbus Counties, 90,771 acres. Poorly drained, 4w. Mixed hardwood/pine forests, pocosin fringes.
Deloss - Cumberland, Craven and Carteret Counties, 54,574 acres. Very poorly drained, 6w. Mixed pine/hardwood forests, pocosin fringes.
Elkton - Pasquotank County, 32,626 acres. Poorly drained, 5w. Has recently been correlated to Roanoke soil.
Fallsington - Pasquotank County, 1,712 acres. Poorly drained, 4w. Has recently been correlated to Tomotley soil.
Grantham - Bertie, Halifax, Edgecombe, Wilson, Greene, Craven, Jones, Johnston, Harnett, Sampson, Cumberland, Pender, Bladen, Columbus Counties, 81,959 acres. Poorly drained, 6w. Mixed pine/hardwood forests.
Hemphill - Haywood, Jackson, Macon Counties. Very poorly drained, 4w.
Hyde - Dare, Hyde, Tyrrell, Washington, Beaufort, Camden Counties, 81,813 acres. Very poorly drained, 6w. Pocosin fringes.

Icaria - Gates, Chowan, Perquimans and Dare Counties, 9,731 acres. Poorly drained, 6w.

Kenansville - Although on the hydric soil list, none of the known acreage in North Carolina meets the frequency of flooding criteria. Therefore, the mapped units do not meet the criteria of a hydric soil.

Kinkora - Henderson, Buncombe, Madison, Haywood Counties. 1221 acres. Poorly drained, 3w.

Leaf - Hertford, Bertie, Beaufort, Pitt, Craven, Pamlico, Jones, Lenoir, Wayne, Johnston Counties, 259,758 acres. Poorly drained, 4w. Pine/hardwood forests.

Lenoir - See the note for Kenansville soil above.

Lumbee - Edgecombe, Greene, Wayne, Lenoir, Duplin, Sampson, Pender, Brunswick, Columbus, Robeson, Scotland Counties, 76,087 acres. Poorly drained, 6w. Bottomland forest.

McColl - Hoke, Cumberland, Robeson and Scotland Counties, 19,183 acres. Poorly drained, 6w. Carolina Bays.

Myatt - Wayne, Hyde Counties, 20,637 acres. Poorly drained, 3 to 5w (flooding).

Nimmo - Currituck, Camden, Perquimans, Chowan Counties, 6,567 acres. Poorly drained, 4w.

Othello - Pasquotank County, 18,721 acres. Poorly drained, 3 to 5w (slope).

Pantego - Gates, Bertie, Beaufort, Martin, Pitt, Craven, Carteret, Jones, Lenoir, Wayne, Johnston, Onslow, Duplin, Sampson, Cumberland, Hoke, Robeson, Bladen, Pender, New Hanover, Columbus, and Brunswick Counties, 206,110 acres. Poorly drained, 6w. Pocosin fringes, pine/hardwood forests, Carolina bays.

Paxville - Greene, Pamlico, Sampson and Bladen Counties, 20,932 acres. Very poorly drained, 6w.

Perquimans - Camden, Chowan, Perquimans, Tyrrell and Beaufort Counties, 41,467 acres. Poorly drained, 6w.

Plummer - Wake, Robeson, Scotland and Anson Counties, 7,027 acres. Poorly drained, 5w.

Pocomoke - Pasquotank County, 5,312 acres. Very poorly drained, 3w.

Portsmouth - Currituck, Camden, Chowan, Perquimans, Pasquotank, Dare, Tyrrell, Washington, Beaufort, Pitt, Edgecombe, Lenoir, Harnett, Bladen, Robeson, Scotland Counties, 145,023 acres. Very poorly drained, 6w. Pocosin fringes, pine/hardwood forests.

Rains - Gates, Hertford, North Hampton, Halifax, Bertie, Martin, Beaufort, Pitt, Edgecombe, Nash, Wake, Johnston, Wayne, Wilson, Greene, Craven, Pamlico, Carteret, Jones, Lenoir, Onslow, Duplin, Sampson, Harnett, Cumberland, Hoke, Scotland, Richmond, Robeson, Bladen, Pender, New Hanover, Brunswick, Columbus Counties, 836,029 acres. Poorly drained, 3w. Pine/hardwood forests, Pocosin fringes, Carolina bays, bottomland forests.

* Roanoke - Currituck, Camden, Pasquotank, Perquimans, Chowan, Gates, Hertford, North Hampton, Halifax, Bertie, Washington, Tyrrell, Beaufort, Martin, Edgecombe, Pitt, Craven, Carteret, Wilson, Franklin, Wake, Johnston, Durham, Chatham, Lee, Harnett, Cumberland, Sampson, Bladen, Davie, Iredell, Caldwell Counties, 352,125 acres. Poorly drained, 4 to 6w. Bottomland forests, mixed pine/hardwood forests.

Toisnot - Wilson, Franklin, Johnston, Harnett, Sampson, Bladen, Robeson Counties, 15,689 acres. Poorly drained, 5w.

Tomotley - Currituck, Camden, Pasquotank, Perquimans, Chowan, Gates, Hertford, Bertie, North Hampton, Halifax, Nash, Wilson, Johnston, Craven, Carteret, Beaufort, Tyrrell, Washington Counties, 170,764 acres. Poorly drained, 4w. Pocosin fringes, mixed pine/hardwood forests.

Trebloc - Robeson County, 9,774 acres. Poorly drained, 3 to 5w (flooding).

Weston - Wayne County, 9,544 acres. Poorly drained, 3w.

Woodington - Martin, Lenoir, Jones, Onslow, Duplin, Sampson, Cumberland, Hoke, Bladen, Pender, Brunswick, New Hanover Counties, 190,108 acres. Poorly drained, 6w. Pocosin fringes, mixed pine/hardwood forests.

Worsham - Cherokee, Avery, Watagua, Yadkin, Catawba, Lincoln, Gaston, Alamance, Anson, Wake. Yancey, Warren, Franklin, Nash, Halifax Counties, 30,267 acres, Poorly drained, 5w. Drainage heads.

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"Wetlands" Definition for the HRS (40 CFR 230)

230.3 Definition.

(t) The term "wetlands" means those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

230.41 Wetlands.

(a)(1) Wetlands consist of areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions.

(2) Where wetlands are adjacent to open water, they generally constitute the transition to upland. The margin between wetland and open water can best be established by specialists familiar with the local environment, particularly where emergent vegetation merges with submerged vegetation over a broad area in such places as the lateral margins of open water, headwaters, rainwater catch basins, and groundwater seeps. The landward margin of wetlands also can best be identified by specialists familiar with the local environment when vegetation from the two regions merges over a broad area.

(3) Wetland vegetation consists of plants that require saturated soils to survive (obligate wetland plants) as well as plants, including certain trees, that gain a competitive advantage over others because they can tolerate prolonged wet soil conditions and their competitors cannot. In addition to plant populations and communities, wetlands are delimited by hydrological and physical characteristics of the environment. These characteristics should be considered when information about them is needed to supplement information available about vegetation, or where wetland vegetation has been removed or is dormant.

REFERENCE 43

REFERENCE 43

SEE FIGURE 1 IN APPENDIX A

REFERENCE 44

Reference 44

THE MERCK INDEX

AN ENCYCLOPEDIA OF
CHEMICALS, DRUGS, AND BIOLOGICALS

ELEVENTH EDITION

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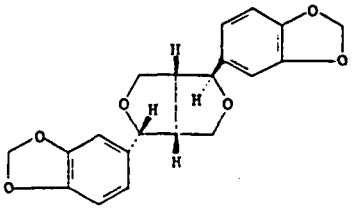
seulensis Nakai, *A. blumei* Duch., *Aristolochiaceae:* Colton, *Am. J. Pharm.* **52**, 191 (1880); Eberhardt, *ibid.* **62**, 231 (1890); Gordin, *J. Am. Chem. Soc.* **28**, 1649 (1906); H. Dieterle *et al., Arch. Pharm.* **269**, 384 (1931); Huang-Minlon, *Ber.* **70**, 951 (1937); T. Kaku *et al., Keijo J. Med.* **9**, 1 (1934); *C.A.* **32**, 9090[1] (1938). Structure: H. Dieterle, K. Schwenger, *Arch. Pharm.* **277**, 33 (1939). Synthesis of *dl*-form: M. Beroza, M. S. Schechter, *J. Am. Chem. Soc.* **78**, 1242 (1956); K. Freudenberg, E. Fischer, *Ber.* **89**, 1230 (1956); D. R. Stevens, D. A. Whiting, *Tetrahedron Letters* **27**, 4629 (1986). Diastereoisomeric with sesamin, *q.v.* Stereochemistry of the *d*-form: K. Freudenberg, G. S. Sidhu, *ibid.* **94**, 851 (1961). Antitubercular activity: Ramaswamy, *Naturwiss.* **44**, 380 (1957).

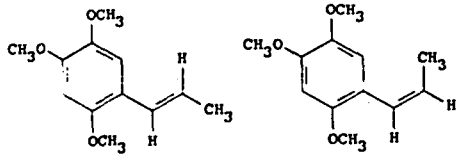


Crystals from alc, mp 121°. $[\alpha]_D^{20}$ −118.6°; $[\alpha]_D^{13}$ −122° (chloroform). Practically insol in water. Freely sol in boiling methanol, alcohol, chloroform, acetone, benzene.

d-Form, *episesamin*, (+)-*episesamin*. Crystals from ethanol, mp 121.5°. $[\alpha]_D^{15}$ +124° (chloroform).

dl-Form, crystals, mp 134-135°.

849. Asarones. *1,2,4-Trimethoxy-5-(1-propenyl)benzene;* 2,4,5-trimethoxy-1-propenylbenzene; asarin; asarum camphor; asarabacca camphor. $C_{12}H_{16}O_3$; mol wt 208.25. C 69.21%, H 7.74%, O 23.05%. From root of *Asarum europaeum* L., *Aristolochiaceae* by distillation with water. Also found in the ethereal oils of *A. europaeum* and *A. arifolium* L., *Aristolochiaceae* and in *Acorus calamus* L., *Araceae.* Occurs in nature as a mixture of two isomeric forms, *α-asarone* being the *(E)*- or *trans*-isomer, *β-asarone*, the *(Z)*- or *cis*-isomer. The unqualified term asarone is often used synonymously with α-asarone. Isoln: Gattermann, Eggers, *Ber.* **32**, 289 (1899). Early syntheses: Seshadri, Thiruvengadam, *Proc. Indian Acad. Sci.* **32A**, 110 (1950); Sharma, Dandiya, *Indian J. Appl. Chem.* **32**, 236 (1969). Stereochemistry of isomers: Baxter *et al., Can. J. Chem.* **40**, 154 (1962). Insect chemosterilant activity of β-asarone: B. P. Saxena *et al., Nature* **270**, 512 (1977); *see also* G. Motolesy *et al., Z. Naturforsch.* **35B**, 1449 (1980). Stereospecific synthesis of β-asarone: M. T. S. Hsia *et al.*, 177th Am. Chem. Soc. Meet. (Honolulu, April 1979), *Abstracts of Papers*, PEST 98. Synthetic and HPLC study of α- and β-asarone: L. Gracza, *Arch. Pharm.* **314**, 972 (1981).



α-asarone β-asarone

α-Asarone, needles from light petroleum, mp 62-63°. bp 296°. n_D^{11} 1.5719. Practically insol in water; sol in alcohol, ether, glacial acetic acid, carbon tetrachloride, chloroform, petr ether.

850. Asarum. Wild ginger; Canada snakeroot; Indian ginger. Dried rhizome and roots of *Asarum canadense* L., *Aristolochiaceae. Habit.* Canada to N. Carolina and Kansas. *Constit.* Acrid resin, arom. volatile oil, methyl eugenol.

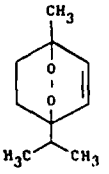
851. Asbestos. Amianthus. Fibrous mineral silicates. Divided into two groups: *serpentine* and *amphibole.* Most common form is *chrysotile* $[Mg_6(Si_4O_{10})(OH)_8]$, the fibrous form of serpentine (*see also* magnesium silicates). Subdivisions of amphibole are *anthophyllite* $[(Mg,Fe)_7(Si_8O_{22})(OH)_2]$ (low iron content); *amosite* $[Fe_5Mg_2(Si_8O_{22})(OH)_2]$; *actinolite* $[Ca_2(Mg,Fe)_5(Si_8O_{22})(OH)_2]$; *tremolite* $[Ca_2Mg_5(Si_8O_{22})(OH)_2]$; *crocidolite* or *blue asbestos* $[Na_2Fe_3^{3+}Fe_2^{3+}(Si_8O_{22})(OH)_2]$. Reviews of carcinogenicity and toxicology: T. J. Haley, *J. Pharm. Sci.* **64**, 1435-1449 (1975); *IARC Monographs* **14**, 1-106 (1977); *Arch. Pathol. Lab. Med.* **106**, 541-596 (1982). Review of properties and industrial applications: W. C. Streib in Kirk-Othmer *Encyclopedia of Chemical Technology* vol. 3 (Wiley-Interscience, New York, 3rd ed., 1978) pp 267-283.

Fire resistant fibers. Chrysotile attacked by acid; amphiboles, acid resistant.

Caution: Occupational exposure to the dust can result in mesothelioma, squamous cell carcinoma and adenocarcinoma of the lung after a long latent period. This substance has been listed as a known carcinogen: *Fourth Annual Report on Carcinogens* (NTP 85-002, 1985) p 29.

USE: Heat-resistant insulators, cements, furnace and hot pipe coverings, inert filler medium (laboratory & commercial), fireproof gloves, clothing, brake linings. NaOH treated asbestos, *Ascarite*, has been used to absorb CO_2 in combustion analysis.

852. Ascaridole. *1-Methyl-4-(1-methylethyl)-2,3-dioxabicyclo[2.2.2]oct-5-ene;* 1,4-peroxido-*p*-menthene-2; Ascarisin. $C_{10}H_{16}O_2$; mol wt 168.23. C 71.39%, H 9.59%, O 19.02%. An organic peroxide which constitutes 60-80% of oil of chenopodium. Synthesis from α-terpinene by treatment with oxygen, chlorophyll, and light: Schenck, Ziegler, *Naturwiss.* **1944**, 157. Purification: Beckett *et al., J. Pharm. Pharmacol.* **7**, 55 (1955).



Liquid; unstable; prone to explode when heated or when treated with organic acids. d_4^{20} 1.0103; d_{20}^{20} 1.0113. mp +3.3°. $bp_{0.2}$ 39-40°. $[\alpha]_D^{20}$ ±0.00. Sol in hexane, pentane, ethanol, toluene, benzene, castor oil.

THERAP CAT: Has been used as anthelmintic (Nematodes).

THERAP CAT (VET): Anthelmintic.

853. Asclepias. Pleurisy root; butterfly weed. Dried root of *Asclepias tuberosa* L., *Asclepiadaceae. Habit.* Ontario to Minnesota. *Constit.* Asclepiadin, resins, volatile oil.

854. Asclepias syriaca. Milkweed; silkweed; wild cotton. Root of *Asclepias syriaca* L. (*A. cornuti* Decaisne), *Asclepiadaceae. Habit.* Canada to North Carolina and Kansas. *Constit.* Asclepiadin, asclepion—a bitter principle; tannin, volatile oil.

855. Ascorbic Acid. L-*Ascorbic acid;* vitamin C; L-xyloascorbic acid; 3-oxo-L-gulofuranolactone (enol form); L-3-ketothreohexuronic acid lactone; antiscorbutic vitamin; cevitamic acid; Cebid; Cebion; Cantaxin; Celaskon; Cevalin; Cevatine; Cevimin; Cevitex; Cewin; Cipca; Cebicure; C-Vimin; Cevitamin; Testascorbic; Allercorb; Cecon; Cetebe; Ce-Vi-Sol; Ascorin; Ascorteal; Cegiolan; Adenex; Ascorvit; Cevex; Lemascorb; Ciamin; Hybrin; Vitacee; Cantan; Catavin C; Celin; Cenetone; Cescorbat; Cereon; Cergona; Cetemican; Cetamid; Planavit C; Colascor; Concemin; Duoscorb; Scorbacid; Davitamon C; Proscorbin; Redoxon; Scorbu-C; Ribena; Vicelat; Vitacin; Vitacimin; Vitascorbol; Xitix; Cevitan; Laroscorbine. $C_6H_8O_6$; mol wt 176.12. C 40.91%, H 4.58%, O 54.51%. Widely distributed in the plant and animal kingdom. Good sources are citrus fruits, hip berries, acerola, fresh tea leaves. Isolated from the adrenal cortex of ox and later from lemons and paprika (originally called hexuronic acid): Szent-Györgyi, *Biochem. J.* **22**, 1387 (1928); Haworth, Szent-Györgyi, *Nature* **131**, 24 (1933). Structure studies: Herbert *et al., J. Chem. Soc.* **1933**, 1270. Crystal structure: Hvoself, *Acta Chem. Scand.* **18**, 841 (1964). Synthesis: Ault *et al., J. Chem. Soc.* **1933**, 1419;

Reichstein *et al., Hel* 311, 510 (1934); Bal 175; R. J. Ferrier, F Crawford, R. Breite. *al., ibid.* 740. Revie Crawford, *Advan.* *Reviews:* E. L. Hirs 159 (1939); H. R. I *the Vitamins* (Inter *Acad. Sci.* **92**, entitl pp 1-332; A. K. Sim *Ann. N.Y. Acad. Sc* Vitamin C", C. G. Discussion of the us common cold: Ka 1038 (1975); Dykes **17**, 1, 18 (March 2 plications in immu *J. Vit. Nutr. Res.* 1 description: I. A. *ical Profiles of Drug* demic Press, New chemistry, physiol *J. Med.* **314**, 892-

Crystals (usual system). mp 19 taste. Stable to many natural pr air and light. d +48° (c = 1 in m mg/ml); pK_1 = soln); 265 nm (n at pH 5.0 is ϵ_0' = ml water, 30 ml 20 ml propylene at 45°. Insol in fats, fat solvents er, decolorizes m air. The reacti Forms stable m *ceutical Incomp* sodium salicylat ylate, methenan *Delo* **2**, 7 (1952 Calcium hyp *scorbat, Calscor* *Note:* One u activity of 0.0 standard.

USE: As anti THERAP CAT: THERAP CAT primates, guin

856. Asco *lyxo-3-hexulof indol-3-ylmeth tone.* $C_{15}H_{15}N$ 4.59%, O 31.4 cházka, Sanda Prepn from L- tanan, *Suome* (1961); from cházka, *Coll.* from L-ascorb diastereoisom ascorbigen B *Chim. Acta* (1966).

Snell, Brown, "Pantethine and Related Forms of the Lactobacillus Bulgaricus Factor (LBF)" in *Advan. Enzymol.* 14, 49-71 (1953).

5267. Lead. Pb; at. wt 207.2; at. no. 82; valence 2, 4. Four naturally occurring isotopes: 204 (1.40%); 206 (25.2%); 207 (21.7%); 208 (51.7%); artificial, radioactive isotopes: 195-203; 205; 209-214. One of the metals known to the ancient world. Extent of occurrence in earth's crust about 15 g/ton, also expressed as 0.002% (depth of crust: 16 km). Occurs chiefly as sulfide in galena, other minerals include anglesite ($PbSO_4$), *cerussite* ($PbCO_3$), *mimetite* [$PbCl_2.3Pb_3(AsO_4)_2$] and *pyromorphite* [$PbCl_2.3Pb_3(PO_4)_2$]. Recovery from ore and purification: Heuser, *Metall.* 9, 675 (1955), *C.A.* 49, 14609 (1955); Ziegfeld, *Eng. Mining J.* 153, 82 (1952), *C.A.* 46, 2975 (1952). Prepn of high purity lead: Piontelli, Fagnani, *Chim. Ind. (Milan)* 34, 629 (1952), *C.A.* 47, 12062 (1953); Giesen, *Technik (Berlin)* 2, 393 (1947), *C.A.* 42, 852 (1948); Hughes *J. Electrochem. Soc.* 101, 267 (1954); Baralis, Marone, *Met. Ital.* 59, 494 (1967), *C.A.* 67, 119613a (1967). Reviews of lead, its alloys and compds: W. Hofmann, *Lead and Lead Alloys, Properties and Technology* (Springer, New York, Eng. Ed., 1970) 551 pp; Abel in *Comprehensive Inorganic Chemistry* vol. 2, J. C. Bailar, Jr. *et al.*, Eds. (Pergamon Press, Oxford, 1973) pp 105-146; H. E. Howe in Kirk-Othmer *Encyclopedia of Chemical Technology* vol. 14 (Wiley-Interscience, New York, 3rd ed., 1981) pp 98-139. Review of carcinogenicity studies of lead and lead compds: *IARC Monographs* 23, 325-415 (1980).

Bluish-white, silvery, gray metal. Highly lustrous when freshly cut, tarnishes upon exposure to air. Very soft and malleable, easily melted, cast, rolled, and extruded. Cubic crystal structure. mp 327.4°; bp 1740°. d_4^{20} 11.34; d at mp 10.65: Schneider *et al.*, *Naturwiss.* 41, 326 (1954). Heat of vaporization (1740°) 206 cal/g. Heat capacity (20°): 0.031 cal/g/°C. Resistivity (μ-ohm-cm) at 20°: 20.65; at 100°: 27.02; at 320°: 54.76; at 330°: 96.74. Vapor pressure at 1000°: 1.77 mm Hg. E° (aq) Pb/Pb^{2+} +0.126 v. Coefficient of linear expansion (0-100°) 29×10^{-6}, (20-300°) 31.3×10^{-6}, (−183° to +14°) 27×10^{-6}; thermal conductivity varies from 0.083 at 50° to 0.077 at 225°: Francl, Kingery, *J. Am. Ceram. Soc.* 37, 80 (1954); viscosity of molten lead (327.4°) 3.2 centipoises, (400°) 2.32 cp, (600°) 1.54 cp, (800°) 1.23 cp. Heat capacity and heat of fusion study: Douglas, Dever, *J. Am. Chem. Soc.* 76, 4824 (1954); hardness 1 on Mohs' scale; Brinell hardness (high purity Pb) 4.0: McLellan, *Am. Mineralogist* 30, 635 (1945). Reacts with hot concd nitric acid, with boiling concd hydrochloric or sulfuric acid. Attacked by pure water, weak organic acids in the presence of oxygen. Resistant to tap water, hydrofluoric acid, brine, solvents.

Human Toxicity: Acute: most common in young children with history of pica; anorexia, vomiting, malaise, convulsions due to increased intracranial pressure. May leave permanent brain damage. Blood lead increased above 0.05 mg %. *Chronic:* children show weight loss, weakness, anemia. Lead poisoning in adults is usually occupational due mainly to inhalaton of lead dust or fumes. Wristdrop and colic rarely occur. More often there are vague G.I. and CNS complaints. Pb content of blood >0.05 mg % and of urine >0.08 mg per liter support a diagnosis of Pb poisoning. Provocative excretion test using Edathamil may be helpful in confirming excess Pb absorption. Review of toxicity: *Clinical Toxicology of Commercial Products*, R. E. Gosselin *et al.*, Eds. (Williams & Wilkins, Baltimore, 4th ed., 1976) Section III, pp 194-202; *Lead Toxicity*, R. L. Singhal, J. A. Thomas, Eds. (Urban & Schwarzenberg, Baltimore, 1980) 514 pp.

USE: Construction material for tank linings, piping, and other equipment handling corrosive gases and liqs used in the manuf of sulfuric acid, petr refining, halogenation, sulfonation, extraction, condensation; for x-ray and atomic radiation protection; manuf of tetraethyllead, pigments for paints, and other organic and inorganic lead compds; bearing metal and alloys; storage batteries; in ceramics, plastics, and electronic devices; in building construction; in solder and other lead alloys; in the metallurgy of steel and other metals. *Review* of uses, corrosion metallurgy: Mullarkey, *Ind. Eng. Chem.* 49, 1607 (1957).

5268. Lead Acetate. Neutral lead acetate; normal lead acetate; sugar of lead; salt of Saturn. $C_4H_6O_4Pb$; mol wt 325.28. C 14.77%, H 1.86%, Pb 63.70%, O 19.67%. $Pb(CH_3COO)_2$. Toxicity data: Bradley, Frederick, *Ind. Med.* 10, *Ind. Hyg. Sect.* 2, 15 (1941).

Trihydrate, colorless crystals or white granules or powder; slight acetic odor; slowly effloresces. *Poisonous!* Takes up CO_2 from air and becomes incompletely sol. d 2.55. mp 75° when rapidly heated; at a little above 100° it begins to lose acetic acid; dec completely above 200°. One gram dissolves in 1.6 ml water, 0.5 ml boiling water, 30 ml alcohol; freely sol in glycerol. Aq solns of lead acetate dissolve lead monoxide. pH of 5% aq soln at 25° = 5.5-6.5. *Keep well closed. Incompat:* Acids, sol sulfates, citrates, tartrates, chlorides, carbonates, alkalies, tannin, phosphates, resorcinol, salicylic acid, phenol, chloral hydrate, sulfites, vegetable infusions, tinctures. LD_{50} i.p. in rats: 200 mg/kg (Bradley, Frederick).

Caution: Avoid breathing dust. This substance may reasonably be anticipated to be a carcinogen: *Fourth Annual Report on Carcinogens* (NTP 85-002, 1985) p 121.

USE: Dyeing and printing cottons; weighting silks; manuf lead salts, chrome-yellow; also for various analytical procedures, e.g. detection of sulfide, determination of CrO_3, MoO_3.

THERAP CAT: Astringent.

THERAP CAT (VET): Astringent and sedative (usually in lotions) for bruises and superficial inflammation. Has been used internally in diarrheas.

5269. Lead Antimonate(V). Naples yellow. Approx $Pb_3(SbO_4)_2$.

Orange-yellow powder. Insol in water, dil acids.

USE: As pigment in oil painting, staining glass, crockery and porcelain.

5270. Lead Arsenate. Approx $PbHAsO_4$. Occurs in nature as the mineral *schultenite.*

White, heavy powder. *Poisonous!* d 5.79. At about 280° loses H_2O and is converted into pyroarsenate. Insol in water; sol in HNO_3, caustic alkalies. LD_{50} in rats, rabbits: approx 825, 125 mg/kg orally, Voigt *et al.*, *J. Am. Pharm. Assoc.* 37, 122 (1948).

USE: As constituent of various insecticides for larvae of gypsy moth, boll weevil, etc.

THERAP CAT (VET): Has been used as a teniacide; insecticide.

5271. Lead Arsenite. Approx $Pb(AsO_2)_2$.

White powder. *Poisonous!* d 5.85. Insol in water; sol in dil HNO_3.

USE: As insecticide like the arsenate.

5272. Lead Azide. N_6Pb; mol wt 291.26. N 28.86%, Pb 71.14%. $Pb(N_3)_2$. Prepd from sodium azide and lead nitrate: Schenk in *Handbook of Preparative Inorganic Chemistry* vol. 1, G. Brauer, Ed. (Academic Press, New York, 2nd ed., 1963) p 763. Most complete description: B. T. Fedoroff *et al.*, *Encyclopedia of Explosives and Related Items* vol. 1 (Picatinny Arsenal, Dover, N.J., 1960) pp A545-A587.

Needles or white powder. Explodes at 350° or on percussion. Heat of formation (25°): +110.5 kcal/mol. Soly in water: 0.023% at 18°; 0.09% at 70°. Freely sol in acetic acid. Insol in NH_4OH.

USE: As primer in explosives. Generally used in the form of dextrinated lead azide.

5273. Lead Borate. Approx $Pb(BO_2)_2.H_2O$.

White powder. *Poisonous!* Insoluble in water; soluble in dil HNO_3.

USE: Drier for varnishes and paints; with other metals (e.g., Ag) in galvanoplasty for production of conducting coatings on glass, pottery, porcelain, and chinaware.

5274. Lead Bromate. Br_2O_6Pb; mol wt 463.01. Br 34.52%, O 20.73%, Pb 44.75%. $Pb(BrO_3)_2$.

Monohydrate, colorless crystals. *Poisonous!* d 5.53. Dec at 180°. Slightly sol in cold water, moderately in hot water.

Note: Pure lead bromate is not dangerous, but when made by pptng lead acetate with an alkali bromate, it may detonate or explode on heating, striking or rubbing because some acetate is occluded.

Actinomycin C_2. $C_{63}H_{88}N_{12}O_{16}$. R = D-valine; R' = D-alloisoleucine. Red bipyramids, prisms or needles from ethyl acetate, mp 237-239°. $[\alpha]_D^{21}$ −325° ± 10° (c = 0.23 in methanol). Abs max (methanol): 443 nm (ε 25,400).

Actinomycin C_3. $C_{64}H_{90}N_{12}O_{16}$. R = R' = D-alloisoleucine. Red hexagonal bipyramids from ethyl acetate or methanol, dec 235°. $[\alpha]_D^{17}$ −328° (c = 0.5 in ethanol). Absorption max (methanol): 443 nm (ε 24,100). Weak base.

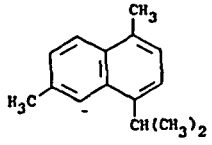
THERAP CAT: Antineoplastic.

1606. Cactus Grandiflorus. Night-blooming cereus; large-flowered cereus. Fresh, succulent stems of *Selenicereus grandiflorus* (L.) Britt. and Rose, *Cactaceae. Habit.* Tropical America. *Constit.* Cactine(?), acrid resinous glucoside, fat, wax. Extract containing combined principles from freshly tinctured stems and petals is known as *cactoid.*

THERAP CAT: Cardiotonic.

THERAP CAT (VET): Has been used as circulatory stimulant.

1607. Cadalene. *1,6-Dimethyl-4-(1-methylethyl)naphthalene; 4-isopropyl-1,6-dimethylnaphthalene;* cadalin. $C_{15}H_{18}$; mol wt 198.29. C 90.85%, H 9.15%. Obtained from cadinene and other sesquiterpenes or sesquiterpene alcohols by dehydrogenation: Ruzicka, Meyer, *Helv. Chim. Acta* 4, 505 (1921); Ruzicka, Stoll, *ibid.* 7, 84 (1924). Synthesis: Ruzicka, Seidel, *ibid.* 5, 369 (1922); Barnett, Cook, *J. Chem. Soc.* 1933, 22; Johnson, Jones, *J. Am. Chem. Soc.* 69, 792 (1947); Kohli *et al., Experientia* 28, 131 (1972).



Liquid. d_4^{25} 0.9667. bp_{720} 291-292°; bp_{10} 149°. n_D^{25} 1.5785. uv max: 228, 232, 280, 284, 295, 310, 317, 325 nm. Insol in water; sol in fat solvents, oils.

1608. Cadaverine. *1,5-Pentanediamine;* pentamethylenediamine; animal coniine. $C_5H_{14}N_2$; mol wt 102.18. C 58.77%, H 13.81%, N 27.42%. $NH_2(CH_2)_5NH_2$. Biogenic polyamine and homolog of putrescine, *q.v.*, produced by decarboxylation of lysine. Formed through action of comma bacillus on meat, fish, albumin, etc. Found in cholera discharge. Isoln: Bocklisch, *Ber.* 18, 1922 (1885); Ackermann, *Z. Physiol. Chem.* 54, 16 (1907). Prepn: Ladenburg, *Ber.* 18, 2956 (1885). GC determn in foods: W. F. Staruszkiewicz, J. F. Bond, *J. Assoc. Offic. Anal. Chem.* 64, 584 (1981). Metabolism study of ^{14}C-cadaverine in rat brain: S. K. Salzman, M. Stepita-Klauco, *J. Neurochem.* 37, 1308 (1981). Biosynthetic study in *S. ruminantium:* Y. Kamio *et al., J. Biol. Chem.* 257, 3326 (1982).

Colorless, syrupy liquid; characteristic odor. Strong base, fumes and attracts CO_2 on exposure to air. pKa_1 10.25; pKa_2 9.13. *Poisonous!* d_4^{25} 0.873. mp 9°. bp 178-180°. n_D^{20} 1.463. Sol in water, alcohol; slightly sol in ether. *Keep well closed.*

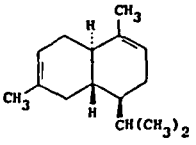
Dihydrochloride, $C_5H_{14}N_2.2HCl$, needles from water, mp 225-230°. Sol in water. Practically insol in abs alc.

Caution: Skin irritant and possible sensitizer.

1609. Cadexomer Iodine. Iodosorb. A hydrophilic modified starch polymer containing 0.9% (w/w) iodine within a helical matrix. Produced by the reaction of dextrin with epichlorohydrin coupled with ion exchange groups and iodine. Clinical use in venous ulcers: E. Skog *et al., Brit. J. Dermatol.* 109, 77 (1983); M. C. Ormiston *et al., Brit. Med. J.* 291, 308 (1985); L. Hillström, *Acta Chir. Scand. Suppl.* 544, 53 (1988).

THERAP CAT: Vulnerary.

1610. Cadinenes. $C_{15}H_{24}$; mol wt 204.34. C 88.16%, H 11.84%. Sesquiterpenes occurring in essential oils from Juniper species and cedars (oil of cade). Nine possible isomers differing in stereochemistry and position of the double bonds, the principal isomer being β-cadinene: Sykora *et al., Chem. Listy* 52, 1314 (1958). Prepn and structure: Campbell, Soffer, *J. Am. Chem. Soc.* 64, 417 (1942); Campbell *et al., ibid.* 425; Rao *et al., Tetrahedron Letters* 1960, 27; Herout *et al., Coll. Czech. Chem. Commun.* 31, 3012 (1966). Synthesis: Soffer, Günay, *Tetrahedron Letters* 1965, 1355. Of the nine possible isomers, all able to yield (−)-cadinene dihydrochloride, six are known: Herout, Sykora, *Tetrahedron* 4, 246 (1958); Kartha *et al., ibid.* 19, 241 (1963). Structure and configuration of isomers: Sykora *et al., Coll. Czech. Chem. Commun.* 23, 2181 (1958). Isoln of α-*cadinene* from Japanese hop: Y. Naya, M. Kotake, *Bull. Chem. Soc. Japan* 42, 1468 (1969). Synthesis: O. P. Vig, *Indian J. Chem.* 21B, 145 (1982). Brief review in *Rodd's Chemistry of Carbon Compounds,* vol. 2, pt. C, S. Coffey, Ed. (Elsevier, New York, 1969) pp 268-270.



β-cadinene

β-Cadinene, oil. Slight pleasant odor. bp_9 124°. d_4^{20} 0.9239. n_D^{20} 1.5059. $[\alpha]_D^{20}$ −251°.

1611. Cadmium. Cd; at. wt 112.41; at. no. 48; valence 2. Group 2b element. Abundance in earth's crust: 0.1 to 0.2 ppm. Natural isotopes: 114 (28.86%); 112 (24.07%); 111 (12.75%); 110 (12.39%); 113 (12.26%); 116 (7.58%); 106 (1.22%); 108 (0.88%); known isotopes range in mass number from 103 to 121. Found in zinc ores; also as CdS, greenockite; $CdCO_3$, otavite. Obtained in vapor form when roasting zinc ores, as sludge from zinc sulfate purification. Lab prepns from $CdSO_4$: Treadwell, *Helv. Chim. Acta* 4, 551 (1921). *Review:* Aylett "Group IIB" in *Comprehensive Inorganic Chemistry,* vol. 3, J. C. Bailar Jr. *et al.,* Eds. (Pergamon Press, Oxford, 1973) pp 187-328; M. L. Hollander, S. C. Carapella in Kirk-Othmer *Encyclopedia of Chemical Technology* vol. 4 (Wiley-Interscience, New York, 3rd ed., 1978) pp 387-396. Review of carcinogenicity studies: *IARC Monographs* 11, 39-74 (1976).

Silver-white, blue-tinged, lustrous metal; distorted hexagonal close-packed structure; easily cut with a knife; available in the form of bars, sheets or wire or a gray, granular powder. mp 321°. bp 765°. d^{25} 8.65. Specific heat at constant pressure (25°) 6.22 cal/mole deg. Slowly oxidized by moist air to form CdO. E° (aq) Cd/Cd^{2+} 0.4025 V. Insol in water; reacts readily with dil HNO_3; reacts slowly with hot HCl; does not react with alkalies. Other reactions similar to those of zinc. Solns of cadmium salts and H_2S or Na_2S yield a yellow ppt insol in excess Na_2S. Cadmium and its salts are highly toxic.

Caution: Ingestion of metal and sol compounds causes increased salivation, choking, vomiting, abdominal pain, anemia, renal dysfunction, diarrhea, tenesmus. *Inhalation* (dust or fumes): throat dryness, cough, headache, vomiting, chest pain, extreme restlessness and irritability, pneumonitis, possibly bronchopneumonia. Implicated as causative agent in Itai-Itai disease in Japan. *See* E. Browning, *Toxicity of Industrial Metals* (Appleton-Century-Crofts, New York, 2nd ed., 1969) pp 98-108; Flick *et al., Environ. Res.* 4, 71-85 (1971); Fassett, *Ann. Rev. Pharmacol.* 15, 425-435 (1975). This substance and certain cadmium compounds may reasonably be anticipated to be carcinogens: *Fourth Annual Report on Carcinogens* (NTP 85-002, 1985) p 48.

USE: A constituent of easily fusible alloys, e.g., Lichtenberg's, Abel's, Lipowitz', Newton's, and Wood's metal; soft solder and solder for aluminum; electroplating (major use), deoxidizer in Ni plating; process engraving, electrodes for cadmium vapor lamps, photoelectric cells; photometry of ultraviolet sun-rays; in Ni-Cd storage batteries. The powder is also used as an amalgam (1Cd:4Hg) in dentistry. To charge Jones reductors.

THERAP CAT (VET): Many cadmium salts, especially the oxide and anthranilate, are used or have been suggested as anthelmintics in swine and poultry.

1612. Cadmium Acetate. $C_4H_6CdO_4$; mol wt 230.49. C

15.07%, H 1.90%, Hg 62.95%, O 20.08%. $Hg(CH_3COO)_2$. Prepd from HgO and acetic acid: Wagenknecht, Juza in *Handbook of Preparative Inorganic Chemistry*, vol. 2, G. Brauer, Ed. (Academic Press, New York, 2nd ed., 1965) pp 1120-1121.

Crystals or cryst powder; slight acetic odor; sensitive to light. *Poison!* d 3.28. mp 178-180° (overheating results in decompn). One g dissolves in 2.5 ml cold, 1 ml boiling water; sol in alcohol. *Keep well closed and protected from light.* Aq solns decomp on standing, yielding a yellow ppt.

USE: Chiefly for mercuration of organic compounds; for the absorption of ethylene.

5767. Mercuric Arsenate. $AsHHgO_4$; mol wt 340.53. As 22.00%, H 0.30%, Hg 58.91%, O 18.79%. $HgHAsO_4$.

Yellow powder. *Poison!* Insoluble in water; sol in HCl or HNO_3.

5768. Mercuric Benzoate. $C_{14}H_{10}HgO_4$; mol wt 442.82. C 37.97%, H 2.28%, Hg 45.30%, O 14.45%. $Hg(C_7H_5O_2)_2$.

Monohydrate, odorless, cryst powder; sensitive to light. *Poison!* Sol in 90 parts cold, 40 parts boiling water; freely sol in NaCl soln; slightly sol in alcohol. When boiled with water or alc it hydrolyzes to a basic salt and free benzoic acid. *Protect from light.*

THERAP CAT: Formerly as antisyphilitic.

5769. Mercuric Bromide. Br_2Hg; mol wt 360.44. Br 44.34%, Hg 55.66%. $HgBr_2$. Usually prepd from the elements: Jander, Brodersen, *Z. Anorg. Chem.* 261, 261 (1950).

White crystals or cryst powder; sensitive to light. *Poison!* d 6.05. mp 237°; sublimes at higher temp. Sol in about 200 parts cold, 25 parts boiling water; freely sol in hot alcohol, in methanol, HCl, HBr, alkali bromide solns; slightly sol in chloroform. *Protect from light.*

5770. Mercuric Chloride. Mercury bichloride; corrosive sublimate; mercury perchloride; corrosive mercury chloride. Cl_2Hg; mol wt 271.52. Cl 26.12%, Hg 73.88%. $HgCl_2$.

Crystals or white granules or powder. *Violent poison! May be fatal if swallowed.* d 5.4. mp 277°; volatilizes unchanged at about 300°; also slightly volatile at ordinary temp; appreciably so at 100°. One gram dissolves in 13.5 ml water (soly is increased by HCl or alkali chlorides), in 2.1 ml boiling water, 3.8 ml alc, 1.6 ml boiling alc, 200 ml benzene, 22 ml ether, 12 ml glycerol, 40 ml acetic acid; also sol in methanol, acetone, ethyl acetate; slightly sol in carbon disulfide, pyridine. pH about 4.7. Also reported as 3.2 for 0.2 molar aq soln. Coagulates albumin; produces with NaOH a yellow ppt (difference from calomel, which turns black). *Incompat:* Formates, sulfites, hypophosphites, phosphates, sulfides, albumin, gelatin, alkalies, alkaloid salts, ammonia, lime water, antimony and arsenic, bromides, borax, carbonates; reduced iron; copper, iron, lead, silver salts; infusions of cinchona, columbo, oak bark or senna; tannic acid; vegetable astringents.

Human Toxicity: Highly toxic. Corrosive to mucous membranes. Ingestion may cause severe nausea, vomiting, hematemesis, abdominal pain, diarrhea, melena, renal damage, prostration. 1 or 2 g is frequently fatal. Poisoning and death also have occurred from intrauterine douches and application of alcoholic soln to large areas of skin. Do not breathe dust. Keep away from feed or food products. Wash hands before eating or smoking. *Antidote:* Dimercaprol (BAL). Review of clinical toxicology of mercury and its compounds: H. B. Gerstner, J. E. Huff, *J. Toxicol. Environ. Health* 2, 491-526 (1977).

USE: Preserving (kyanizing) wood and anatomical specimens; also embalming; disinfecting; browning and etching steel and iron; intensifier in photography; white reserve in fabric printing; tanning leather; electroplating aluminum; depolarizer for dry batteries; freeing gold from lead; magic photograms; mordant for rabbit and beaver furs; staining wood and vegetable ivory pink; manuf of ink for mercurography; treating seed potatoes; manuf other mercury compds. As an important reagent in anal. chemistry.

THERAP CAT: Topical antiseptic, disinfectant.

THERAP CAT (VET): Caustic, antiseptic, disinfectant.

5771. Mercuric Chloride, Ammoniated. *Mercury amide chloride;* aminomercuric chloride; mercury ammonium chloride; ammoniated mercury; white precipitate; white mercuric precipitate. ClH_2HgN; mol wt 252.09. Cl 14.07%, H 0.80%, Hg 79.58%, N 5.56%. $HgNH_2Cl$. Prepn: Sen, *Z. Anorg. Allgem. Chem.* 33, 197 (1903); Wagenknecht, Juza in *Handbook of Preparative Inorganic Chemistry*, vol 2, G. Brauer, Ed. (Academic Press, New York, 2nd ed., 1965) p 1114.

Odorless powder; d 5.38; earthy, styptic, metallic taste. *Poison!* Volatile without melting at dull red heat. Insoluble in water or alcohol; sol in warm HCl, HNO_3, acetic acid, in cold soln ammonium carbonate or sodium thiosulfate.

Caution: French "White Precipitate" (Precipité Blanc) is calomel. Do not confuse the two when French prescriptions are filled.

Human Toxicity: May produce allergic dermatitis; prolonged use may cause local pigmentation of skin or eyelids. Absorption following vigorous dermal application has been reported with resulting ptyalism. Oral ingestion causes epigastric pain, nausea, purging. *Antidote:* Dimercaprol (BAL). *Caution:* Not to be used in conjunction with sulfur or iodine.

THERAP CAT: Topical anti-infective.

THERAP CAT (VET): Topical anti-infective.

5772. Mercuric Cyanide. Cianurina. C_2HgN_2; mol wt 252.65. C 9.51%, Hg 79.40%, N 11.09%. $Hg(CN)_2$. Obtained by evaporating a soln of HgO in aq HCN: Biltz, *Z. Anorg. Allgem. Chem.* 170, 161 (1928).

Colorless, odorless, tetragonal crystals or white powder; darkens on exposure to light. *Violent poison!* d 3.996. Dec at 320°. One gram dissolves in 13 ml water, 3 ml boiling water, 13 ml alcohol, 4 ml methanol; slowly sol in glycerol; slightly sol in ether. *Protect from light.*

THERAP CAT: Topical antiseptic.

THERAP CAT (VET): Has been used as a topical antiseptic.

5773. Mercuric Dichromate(VI). Mercury bichromate. Cr_2HgO_7; mol wt 416.63. Cr 24.97%, Hg 48.15%, O 26.88%. $HgCr_2O_7$.

Red, heavy, cryst powder. Practically insol in water; sol in HCl or HNO_3. *Poison!*

5774. Mercuric Fluoride. Mercury difluoride. F_2Hg; mol wt 238.61. F 15.93%, Hg 84.07%. HgF_2. Prepd from $HgCl_2$ and F_2: Henne, Midgley, *J. Am. Chem. Soc.* 58, 886 (1936).

White powder or cubic crystals. Very sensitive to moisture. d^{15} 8.95. mp 645°. bp above 650°. Turns yellow and hydrolyzes in the prolonged presence of water.

Dihydrate, obtained when mercuric oxide is dissolved in excess of 50% HF.

USE: In the fluorination of organic compds.

5775. Mercuric Iodate. HgI_2O_6; mol wt 550.45. Hg 36.44%, I 46.11%, O 17.44%. $Hg(IO_3)_2$.

White powder. *Poisonous!* On warming, dec at 175° to give mercuric iodide and oxygen. Soly in water (20°) 0.002 g/100 g; soly increased by NaCl or KI.

5776. Mercuric Iodide, Red. Mercury biniodide. HgI_2; mol wt 454.45. Hg 44.14%, I 55.86%.

Scarlet-red, heavy, odorless, almost tasteless powder; sensitive to light; at 130° becomes yellow, and then red on cooling. *Poison!* d 6.28. mp 259°. bp about 350° and sublimes. Soly in water (25°) 0.006 g/100 g. 1 g dissolves in 115 ml alcohol, 20 ml boiling alcohol, about 120 ml ether, about 60 ml acetone, 910 ml chloroform, 75 ml ethyl acetate, 260 ml carbon disulfide, readily in alkali iodides. $HgCl_2$, $Na_2S_2O_3$; sol in 230 ml olive oil, 50 ml castor oil. *Protect from light.*

USE: In anal. chemistry for preparation of Nessler's Reagent (alkaline mercuric potassium iodide solution).

THERAP CAT: Topical antiseptic.

THERAP CAT (VET): Has been used as a topical antiseptic, counterirritant, vesicant.

5777. Mercuric Nitrate. Mercury pernitrate. HgN_2O_6; mol wt 324.66. Hg 61.80%, N 8.63%, O 29.57%. $Hg(NO_3)_2$.

Hydrate, white or slightly yellow, deliquesc, cryst powder; odor of nitric acid. *Poison!* d 4.3. Sol in a small amount of water; with much water or on boiling with water, an insol basic salt is formed; sol in dil acids. *Keep well closed and protect from light.*

USE: Manufacture of felt; mercury fulminate; destroying phylloxera.

86.22%, S 13.78%. Occurs in nature as the mineral *cinnabar*. Prepd from mercuric acetate, ammonium thiocyanate, glacial acetic acid and hydrogen sulfide: Newell *et al.*, *Inorg. Syn.* 1, 19 (1939). *See also Colour Index* vol. 4 (3rd ed., 1971) p 4682.

Bright scarlet-red powder, lumps, hexagonal crystals (α-form); blackens on exposure to light, particularly in presence of H_2O or alkali hydroxides. At about 250° becomes brownish, at higher temp black, but red again on cooling. When ignited in air it dec into metal and sulfur, the latter burning to SO_2. Practically insol in water; not attacked by HNO_3 or cold HCl; dec by hot concd H_2SO_4; sol in aqua regia with separation of S, in warm hydriodic acid with evolution of H_2S. *Protect from light.*

USE: For coloring plastics, sealing wax, and with $FeSO_4$ for marking linen; manuf fancy colored papers; as pigment.

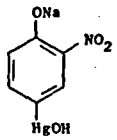
THERAP CAT: Antibacterial.

5790. Mercuric Thiocyanate. Mercuric sulfocyanate; mercuric sulfocyanide. $C_2HgN_2S_2$; mol wt 316.79. C 7.58%, Hg 63.33%, N 8.84%, S 20.25%. $Hg(SCN)_2$. Prepd from $Hg(NO_3)_2$ + KSCN: Peters, *Z. Anorg. Allgem. Chem.* 77, 157 (1912).

Odorless powder. When crystalline, usually in radially arranged needles. *Poisonous!* When heated it swells up to many times its original vol, decomposing finally into mercury, nitrogen, etc., at about 165°. Slightly sol in cold water (0.069 g/100 ml H_2O at 25°), more sol in boiling water with decompn; sol in dil HCl, in solns of alkali cyanides, chlorides. *Protect from light.*

USE: For Pharaoh's serpents (fireworks); intensifier in photography.

5791. Mercurophen. Sodium 4-(hydroxymercuri)-2-nitrophenolate; sodium hydroxymercuri-*o*-nitrophenolate; 4-(hydroxymercuri)-2-nitrophenol sodium salt. $C_6H_4HgNNaO_4$; mol wt 377.70. C 19.08%, H 1.07%, Hg 53.11%, N 3.71%, Na 6.09%, O 16.94%. Prepn from *o*-nitrophenol and $Hg(OCOCH_3)_2$: Schamberg *et al.*, U.S. pat. 1,390,972 (1922). Structure: Malcolm, *J. Bacteriol.* 22, 403 (1931).



Brick-red, odorless powder. *Poison!* Sol in hot water. Solns are deep amber in color.

THERAP CAT: Local antiseptic; disinfectant.

THERAP CAT (VET): Antiseptic, disinfectant.

5792. Mercurous Acetate. $C_4H_6Hg_2O_4$; mol wt 519.31. C 9.25%, H 1.17%, Hg 77.26%, O 12.32%. $Hg_2(CH_3COO)_2$. Prepd from $Hg_2(NO_3)_2$ + CH_3COONa: Wagenknecht, Juza, in *Handbook of Preparative Inorganic Chemistry* vol. 2, G. Brauer, Ed. (Academic Press, New York, 2nd ed., 1965) p 1120.

Lustrous leaflets or cryst powder. Darkens on exposure to light. Sol in about 100 parts water; sol in dil acetic acid. Practically insol in alcohol, ether. Aq solns dec quickly under the influence of light and heat. *Keep well closed and protected from light.*

THERAP CAT: Antibacterial.

5793. Mercurous Bromide. Br_2Hg_2; mol wt 560.99. Br 28.49%, Hg 71.51%. Hg_2Br_2.

White, odorless powder; darkens on exposure to light. d 7.3. Sublimes at approx 390° (dec). Insol in water, alcohol, ether; dec by hot HCl or alkali bromides. *Protect from light.*

5794. Mercurous Chlorate. $Cl_2Hg_2O_6$; mol wt 568.08. Cl 12.48%, Hg 70.62%, O 16.90%. $Hg_2(ClO_3)_2$.

White crystals; dec at about 250° to form oxygen, mercuric oxide and mercuric chloride. d 6.41. Sparingly sol in water; hydrolyzed in hot water to form basic salts.

5795. Mercurous Chloride. Calomel; mild mercury chloride; mercury monochloride; mercury protochloride; mercury subchloride; precipité blanc; Calogreen; Cyclosan. Cl_2Hg_2; mol wt 472.09. Cl 15.02%, Hg 84.98%. Hg_2Cl_2.

White, odorless, tasteless, heavy powder; slowly dec by sunlight into mercuric chloride and metallic mercury; sublimes at 400-500° without melting. d 7.15. Practically insol in water (0.00020g/100 ml H_2O at 25°); HCl or alkali and alkaline earth chlorides increase soly in water. Insol in alcohol, ether. Dec by solns of alkali iodides, bromides or cyanides into the mercuric salt and metallic mecury; solns of alkali chlorides act similarly but slowly. It is blackened by ammonia, caustic alkali and alkaline earth solns. *Protect from light. Incompat:* Bromides, iodides, alkali chlorides, sulfates, sulfites, carbonates, hydroxides, lime water, acacia, ammonia, golden antimony sulfide, cocaine, cyanides, copper salts, hydrogen peroxide, iodine, iodoform, lead salts, silver salts, soap, sulfides.

Human Toxicity: Excessive doses may cause mercury poisoning. *Antidote:* Dimercaprol (BAL). *Caution:* If laxation from oral mercurous chloride should not occur, saline laxative must be administered to prevent possibility of mercury poisoning, *cf. Clinical Toxicology of Commercial Products*, R. E. Gosselin *et al.*, Eds. (Williams & Wilkins, Baltimore, 4th ed., 1976) Section II, p 95.

USE: Dark green Bengal lights; calomel paper, mixed with gold in painting on porcelain; for calomel electrodes; as fungicide; in agriculture to control root maggots on cabbage and onions.

THERAP CAT: Cathartic, diuretic, antiseptic, anti-syphilitic.

THERAP CAT (VET): Has been used as a cathartic, and locally as an antiseptic and desiccant.

5796. Mercurous Fluoride. F_2Hg_2; mol wt 439.22. F 8.65%, Hg 91.35%. Hg_2F_2. Prepd from Hg_2CO_3 + HF: Henne, Renoll, *J. Am. Chem. Soc.* 60, 1060 (1938); also by addition of sodium fluoride to mercurous nitrate soln. Probably formed in the reaction between fluorine and mercury at room temp: Emeléus in *Fluorine Chemistry* vol. 1, J. H. Simons, Ed. (New York, 1950) p 39. The prepn should be carried out in the dark.

Small, yellow cubic crystals, d_4^{15} 8.73. mp 570° (dec). Sublimes at around 240°. The crystals blacken in light or with ammonia fumes. Hydrolyzed in water to form mercury, mercuric oxide and hydrofluoric acid.

5797. Mercurous Iodide. Yellow mercury iodide; mercury protoiodide. Hg_2I_2; mol wt 654.99. Hg 61.25%, I 38.75%.

Bright-yellow, amorphous, heavy, odorless powder. Darkens or becomes greenish on exposure to light, HgI_2 and metallic mercury being formed. d 7.70. mp 290° when rapidly heated with partial decompn into Hg and HgI_2. Insol in water, alcohol or ether; sol in solns of mecurous or mercuric nitrates; cold ammonia, its solns or alkali iodide dec it into mercury and mercuric iodide. *Protect from light.* "Green" mercury iodide is made from metallic mercury and iodine, the green color being due to presence of some uncombined mercury. *Incompat:* Soluble iodides. *Caution:* Never prescribe mercury iodide yellow (or green) with a sol iodide, because a highly *poisonous* mercuric iodide is formed!

THERAP CAT: Antibacterial.

5798. Mercurous Nitrate. Mercury protonitrate. $Hg_2N_2O_6$; mol wt 525.19. Hg 76.39%, N 5.33%, O 18.28%. $Hg_2(NO_3)_2$. Normally exists as dihydrate. Prepn of anhydr salt: Potts, Allred, *Inorg. Chem.* 5, 1066 (1966).

Dihydrate, colorless crystals, usually with slight odor of HNO_3. mp at about 70° with decompn. *Poisonous!* d 4.78. Sol in 13 parts water-contg 1% HNO_3; with water alone a basic salt is formed. Blackened by ammonia, caustic alkali, and alkaline earth solns. *Keep well closed and protected from light.*

USE: Fire gilding, blackening brass.

5799. Mercurous Oxide. Mercury oxide black. No evidence that Hg_2O has been isolated. X-ray data shows that solid formed by addition of sodium hydroxide to mercurous nitrate is an intimate mixture of mercury and mercuric oxide: Fricke, Ackemann, *Z. Anorg. Allgem. Chem.* 211, 233 (1933).

Black or brownish-black powder. d 9.8. Insol in water; sol in HNO_3. HCl converts it into calomel. *Protect from light.*

when freshly prepd, giving blue or green soln; becomes insol in acids on aging.

$Cr(OH)_3.nH_2O$, shining, vitrous, jet-black particles. Useful as catalyst in dehydrogenation of alcohols and paraffins, hydrogenation of olefins.

USE: As pigment; in tanning industry; as mordant; as catalyst for organic reactions.

2228. Chromic Nitrate. CrN_3O_9; mol wt 238.03. Cr 21.85%, N 17.65%, O 60.50%. $Cr(NO_3)_3$. Prepn of anhydr salt from N_2O_5 and $Cr(CO)_6$: Addison, Chapma, *J. Chem. Soc.* 1964, 539; prepn of nonahydrate from $Cr(OH)_3$ and dil HNO_3 or by reducing CrO_3 in the presence of HNO_3: *Chromium* vol. 1, M. J. Udy, Ed., A.C.S. Monograph Series, no. 132 (Reinhold, New York, 1956) pp 203-204.

Pale green, extremely deliquesc powder. Non-volatile. Dec above 60°. Sol in water, ethyl acetate, DMSO; practically insol in benzene, CCl_4, $CHCl_3$; reacts with ether, sometimes vigorously.

Nonahydrate, deep violet, rhombic, monoclinic crystals. mp about 60°; dec above 100°. Sol in water, alcohol. Aq soln slowly becomes green on heating and rapidly recovers the reddish-violet color on cooling. LD_{50} in rats: 3.25 g/kg orally, Smyth *et al.*, *Am. Ind. Hyg. Assoc. J.* 30, 470 (1969).

USE: Prepn of Cr catalyst; in textile printing; corrosion inhibitor.

2229. Chromic Oxide. Anadonis green; chrome green; chrome ocher; chrome oxide green; chromia; chromium sesquioxide; green cinnabar; green oxide of chromium; green rouge; leaf green; oil green; ultramarine green; C.I. Pigment Green 17; C.I. 77288. Cr_2O_3; mol wt 152.02. Cr 68.43%, O 31.57%. Prepd by reaction of sodium dichromate or chromate with sulfur: Copson in *Chromium* vol. 1, M. J. Udy, Ed., ACS Monograph Series no. 132 (Reinhold, New York, 1956) pp 277-278. *Review:* Wiesburg, *Paint Ind. Mag.* 71(2), 11 (1956). *See also Colour Index* vol. 4 (3rd ed., 1971) p 4662. Use as catalyst: R. Uma, J. C. Kuriacose, *Indian Chem. Mfr.* 8, 11 (1970). Cytotoxic effects: V. Bianchi *et al.*, *Toxicology* 17, 219 (1980).

Light to dark green, fine, hexagonal crystals. mp about 2435°. bp about 3000°. d^{25} 5.22. Turns brown on heating but reverts to green color on cooling. Cryst Cr_2O_3 is extremely hard; will scratch quartz, topaz, zircon. Practically insol in water, alc, acetone. Slightly sol in acids, alkalies.

Caution: Trivalent chromium may cause skin irritation: S. Fregert, H. Rorsman, *Arch. Derm.* 90, 4 (1964).

USE: In abrasives, refractory materials, electric semiconductors; as pigment, particularly in coloring glass; in alloys; printing fabrics and banknotes; as catalyst for organic and inorganic reactions.

2230. Chromic Phosphate. CrO_4P; mol wt 146.99. Cr 35.38%, O 43.54%, P 21.07%. $CrPO_4$. Prepn: Ness *et al.*, *J. Am. Chem. Soc.* 74, 4685 (1952); Eickhoff, Kebrich, U.S. pat. 2,749,214 (1956 to National Lead); Wegenknecht, Ger. pats. 1,046,597 (1958); 1,056,104 (1959).

Gray-brown to black crystals of amorphous solid. Does not melt by 1800°. $d^{32.5}$ 2.94. Partially oxidizes to CrO_3 on heating in air. Practically insol in water, acetic acid, HCl, aqua regia.

Hemiheptahydrate, *Arnaudon's green, Plessy's green.* Blue-green powder. d 2.15. Practically insol in water; sol in acids.

Hexahydrate, violet crystals. Loses water gradually on heating, becoming anhydr after one hour at 800° or 3-4 hrs at 500°. d^{14} 2.121. Practically insol in water; slightly sol in acetic acid solns; readily sol in mineral acids, alkalis, oxalic acid solns.

Radioactive form, $Cr^{32}PO_4$, *Phosphocol.*

USE: Green pigment; in wash primers; in catalysts for dehydrogenation of hydrocarbons or polymerization of olefins.

THERAP CAT: $Cr^{32}PO_4$ as radioactive agent.

2231. Chromic Potassium Oxalate. *Tripotassium tris(ethanedioato)chromate(3−); tripotassium tris(oxalato)chromate(3−);* potassium trioxalatochromate(III); potassium chromic oxalate. $C_6CrK_3O_{12}$; mol wt 433.38. C 16.63%, Cr 12.00%, K 27.06%, O 44.30%. $K_3[Cr(C_2O_4)_3]$. Prepd by treatment of oxalic acid and $K_2C_2O_4$ with $K_2Cr_2O_7$: Bailar, Jr., Jones, *Inorg. Syn.* 1, 37 (1939); Hein, Herzog in *Handbook of Preparative Inorganic Chemistry* vol. 2, G. Brauer, Ed. (Academic Press, New York, 2nd ed., 1965) p 1372.

Trihydrate, *potassium trioxalatotriaquochromate(III).* Black-green, monoclinic scales with transparent blue edges. Freely sol in water; practically insol in alcohol.

USE: In tanning industry; dyeing chromate colors on wool.

2232. Chromic Potassium Sulfate. Potassium chromic sulfate; potassium disulfatochromate(III). $CrKO_8S_2$; mol wt 283.23. Cr 18.36%, K 13.81%, O 45.19%, S 22.64%. $KCr(SO_4)_2$. Dodecahydrate produced by reduction of $K_2Cr_2O_7$ with SO_2: Copson in *Chromium* vol. 1, M. J. Udy, Ed., A.C.S. Monograph Series no. 132 (Reinhold, New York, 1956) p 281; electrolytic manuf: Nishihara *et al.*, Japan. pat. 2164('60), *C.A.* 55, 5200e (1961).

Dodecahydrate, *chrome alum,* $K[Cr(SO_4H_4)_2(H_2O)_2].6H_2O$: Duval, *Chim. Anal. (Paris)* 44, 102 (1962), *C.A.* 57, 9479d (1962). Large, violet-red to black, octahedral, cubic crystals; ruby-red under transmitted light. d^{25} 1.83. mp 89°; at 400° loses all its H_2O. Sol in 4 parts cold, 2 parts boiling water; practically insol in alcohol. The aq soln is violet when cold, green when hot. The violet color returns after a few weeks at room temp.

USE: Mordant for dyeing fabrics uniformly; tanning leather; printing calico; rendering glue and gum insol; manuf ink, other chromium salts; waterproofing fabrics; hardening photographic emulsions.

2233. Chromic Sulfate. $Cr_2O_{12}S_3$; mol wt 392.20. Cr 26.52%, O 48.95%, S 24.52%. $Cr_2(SO_4)_3$. Prepn of anhydr salt by dehydration of hydrated forms: Rollinson, Bailar, Jr., *Inorg. Syn.* 2, 197 (1946).

Peach-colored solid. d 3.012. Practically insol in water and acids. MLD i.v. in mice: 247 mg/kg, *Handbook of Toxicology* vol. 1, W. S. Spector, Ed. (Saunders, Philadelphia, 1956) pp 70-71.

Hydrates are known in both green and violet modifications, and have several degrees of hydration up to $18H_2O$: Lukaszewski, Redfern, *Nature* 190, 805 (1961); Udy in *Chromium* vol. 1, M. J. Udy, Ed., A.C.S. Monograph Series no. 132 (Reinhold, New York, 1956) pp 213-217, 288. The technical product comes in the form of a finely granular, dark-green flake or powder approximating the formula $Cr_2(SO_4)_3.10H_2O$. Readily sol in water; almost insol in alc.

Basic chromic sulfates of the type $Cr(OH)SO_4.nH_2O$ are of importance in the tanning industry: Udy, *loc. cit.* and pp 278-280, 305-308. Technical grades are available in two degrees of basicity, one-third and one-half, as finely granular dark-green flakes or powder contg about 25% Cr_2O_3. Readily sol in water.

USE: Insolubilization of gelatin; in catalyst prepn; as mordant in textile industry; in tanning of leather; in chrome plating; in manuf of Cr, CrO_3, and Cr alloys; to improve dispersibility of vinyl polymers in water; in manuf of green varnishes, paints, inks, glazes for porcelain.

2234. Chromium. Cr; at. wt 51.996; at. no. 24; valences 1-6. Four naturally occurring isotopes: 50 (4.35%); 52 (83.79%); 53 (9.50%); 54 (2.36%); artificial radioactive isotopes: 46-49; 51; 55; 56; longest-lived isotope is ^{51}Cr ($T_{1/2}$ 27.8 days) prepd by (n,γ) reaction from ^{50}Cr. Reported abundance in earth's crust varies from 100 to 300 ppm. Discovered by 1797 by Vauquelin. Obtained from chrome ore, *chromite* ($FeCr_2O_4$), by a silicothermic or aluminothermic process. Reviews of chromium, its alloys and compds: *Chromium,* M. J. Udy, Ed., A.C.S. Monograph Series, no. 132 (Reinhold, New York, 1956) vol. 1, 433 pp; vol. 2, 402 pp; Rollinson, "Chromium, Molybdenum and Tungsten" in *Comprehensive Inorganic Chemistry* vol. 3, J. C. Bailar, Jr. *et al.*, Eds. (Pergamon Press, Oxford, 1973) pp 623-700; J. H. Westbrook in Kirk-Othmer *Encyclopedia of Chemical Technology* vol. 6 (Wiley-Interscience, New York, 3rd ed., 1979) pp 54-82. Important trace element. Review of biological function of the chromium(III) ion: Mertz, *Physiol. Rev.* 49, 163-239 (1969). Review of carcinogenicity studies of chromium and chromium compds: *IARC Monographs* 2, 100-125 (1973); *ibid.* 23, 205-323 (1980). Book: *Chromium: Metabolism and Toxicity,* D. Burrows, Ed. (CRC Press, Boca Raton, 1983) 172 pp.

Steel-gray, lustrous metal; body-centered cubic structure; hard as corundum and less fusible than platinum. Takes a high polish. d 7.14. mp 1
(25°): 5.58 cal/g-atom deg.
3.5 kcal/g-atom; latent hea
kcal/g-atom. Reacts with d
attacked by caustic alkalies
dized by air, even in presen
Caution: Chromic acid or
trial hazards. Irritant effe
passages lead to ulceration.
vere irritation of the gastroi
and renal damage. Chrom
or no toxicity. This substa
pounds have been listed a
Annual Report on Carcinog
USE: In manuf of chrome
loys (stainless steel); for g
durability of metals; for chr
man-made ^{51}Cr isotope as
and in the determination of
as Na chromate).

2235. Chromium Carbo
C_6CrO_6; mol wt 220.07. C
$Cr(CO)_6$. Prepn from Cr s
Grignard reagent: Owen *e*
the presence of Mg and eth
(1961 to Diamond Alkali):
glyme: Podall *et al.*, *J. Am*
the presence of Na and an
Wyman, U.S. pat. 3,053,62
presence of I_2 and a nitrile:
to Diamond Alkali).
Orthorhombic, highly r
room temp. Sinters at 90
Burns with a luminous fl
(mm): 0.04 (0°); 1.0 (48°);
ter, ethanol, methanol; sol
solvents. Solns or impure
100 mg/kg i.v., Strohmeier
USE: In catalysts for olef
tion; gasoline additive to i
chromous oxide, CrO.

2236. Chromium Dioxi
61.90%, O 38.10%. Prepn
Thamer *et al.*, *J. Am. Chem*
al., *J. Appl. Phys.* 32, Supp
thur, Ingraham, U.S. pats.
both to du Pont). *Reviews*
(1972); Rollinson in *Comp*
3, J. C. Bailar, Jr. *et al.*,
1973) pp 689-690.
Black, ferromagnetic cr
Metastable in air; various
for decompn to Cr_2O_3.
USE: In magnetic record

2237. Chromium Tetra
Cr 40.63%, F 59.37%. Pr
$CrCl_3$: von Wartenberg,
(1941); Clark, Sadana, *Ca*
Very dark greenish-blac
to moist air becomes bro
mp (estimated) 277°: Fer
3, V. Gutmann, Ed. (Ac
242. bp about 400° evol
vacuo above 100°; d 2.89.
readily form Werner com
SO_2, SO_3, pyridine. Sol in
tically insol in most organ
nitely *in vacuo* in well dri
Caution: A strong irrit

2238. Chromium Trio
hydride. CrO_3; mol wt 1
duced commercially by th
of chromate or dichromat
al Chemicals, F. A. Lowe
Interscience, New York,
Dark red, deliquesc bi
or granular power. d 2.7

high polish. d 7.14. mp 1900°. bp 2642°. Heat capacity (25°): 5.58 cal/g-atom deg. Latent heat of fusion: approx 3.5 kcal/g-atom; latent heat of vaporization: approx 81.7 kcal/g-atom. Reacts with dil HCl, H_2SO_4; not with HNO_3; attacked by caustic alkalies and alkali carbonates. Not oxidized by air, even in presence of much moisture.

Caution: Chromic acid or chromate salts constitute industrial hazards. Irritant effects on the skin and respiratory passages lead to ulceration. Oral ingestion may lead to severe irritation of the gastrointestinal tract, circulatory shock and renal damage. Chromium(III) compounds show little or no toxicity. This substance and certain chromium compounds have been listed as known carcinogens: *Fourth Annual Report on Carcinogens* (NTP 85-002, 1985) p 58.

USE: In manuf of chrome-steel or chrome-nickel-steel alloys (stainless steel); for greatly increasing resistance and durability of metals; for chromeplating of other metals. The man-made ^{51}Cr isotope as tracer in various blood diseases and in the determination of blood volume (as the chloride or as Na chromate).

2235. Chromium Carbonyl. Chromium hexacarbonyl. C_6CrO_6; mol wt 220.07. C 32.75%, Cr 23.63%, O 43.62%. $Cr(CO)_6$. Prepn from Cr salts and CO in the presence of a Grignard reagent: Owen *et al., Inorg. Syn.* 3, 156 (1950); in the presence of Mg and ether: Wender, U.S. pat. 3,012,858 (1961 to Diamond Alkali); in the presence of Na and diglyme: Podall *et al., J. Am. Chem. Soc.* 83, 2057 (1961); in the presence of Na and an aromatic hydrocarbon: Pruett, Wyman, U.S. pat. 3,053,629 (1962 to Union Carbide); in the presence of I_2 and a nitrile: Wotiz, U.S. pat. 3,100,687 (1963 to Diamond Alkali).

Orthorhombic, highly refractive crystals. Sublimes at room temp. Sinters at 90°; dec at 130°; explodes at 210°. Burns with a luminous flame. d^{18} 1.77. Vapor pressure (mm): 0.04 (0°); 1.0 (48°); 66.5 (100°). Almost insol in water, ethanol, methanol; sol in ether, $CHCl_3$, other organic solvents. Solns or impure solid dec by light. LD_{50} in mice: 100 mg/kg i.v., Strohmeier, *Z. Naturforsch.* 19b, 540 (1964).

USE: In catalysts for olefin polymerization and isomerization; gasoline additive to increase octane number; prepn of chromous oxide, CrO.

2236. Chromium Dioxide. CrO_2; mol wt 84.00. Cr 61.90%, O 38.10%. Prepn: Wöhler, *Ann.* 111, 117 (1859); Thamer *et al., J. Am. Chem. Soc.* 79, 547 (1957); Swoboda *et al., J. Appl. Phys.* 32, Suppl. no. 3, 374 (1961); Arthur; Arthur, Ingraham, U.S. pats. 2,959,955; 3,117,093 (1960, 1964 both to du Pont). *Reviews:* Hund, *Farbe + Lack* 78, 11-16 (1972); Rollinson in *Comprehensive Inorganic Chemistry* vol 3, J. C. Bailar, Jr. *et al.*, Eds. (Pergamon Press, Oxford, 1973) pp 689-690.

Black, ferromagnetic crystals; rutile structure. d 4.89. Metastable in air; various temperatures (250-500°) reported for decompn to Cr_2O_3.

USE: In magnetic recording tapes; as catalyst.

2237. Chromium Tetrafluoride. CrF_4; mol wt 128.01. Cr 40.63%, F 59.37%. Prepd by reaction of F_2 with Cr or $CrCl_3$: von Wartenberg, *Z. Anorg. Allgem. Chem.* 247, 136 (1941); Clark, Sadana, *Can. J. Chem.* 43, 50 (1964).

Very dark greenish-black, amorphous solid; on exposure to moist air becomes brown on surface due to hydrolysis. mp (estimated) 277°: Fergusson in *Halogen Chemistry* Vol. 3, V. Gutmann, Ed. (Academic Press, New York, 1967) p 242. bp about 400° evolving steel-blue vapor; sublimes *in vacuo* above 100°; d 2.89. Less reactive than CrF_3, does not readily form Werner complexes; does not react with NH_3, SO_2, SO_3, pyridine. Sol in water with rapid hydrolysis; practically insol in most organic solvents. Can be stored indefinitely *in vacuo* in well dried Pyrex or silica vessels.

Caution: A strong irritant.

2238. Chromium Trioxide. Chromic acid; chromic anhydride. CrO_3; mol wt 100.01. Cr 52.00%, O 48.00%. Produced commercially by the action of concd H_2SO_4 on a soln of chromate or dichromate: Faith, Keyes & Clark, *Industrial Chemicals*, F. A. Lowenheim, M. K. Moran, Eds. (Wiley-Interscience, New York, 4th ed., 1975) pp 270-274.

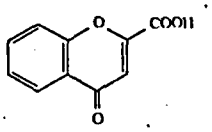
Dark red, deliquesc bipyramidal prismatic crystals, flakes or granular power. d 2.70. mp 197°. Dec at 250° to Cr_2O_3 and O_2. Very sol in water; sol in H_2SO_4. Powerful oxidizer; oxidizes alcohol and most other organic substances, sometimes with dangerous violence. *Contact with combustible material may cause fire. Pharmaceutical Incompat:* Alcohol, ether, glycerol, spirit nitrous ether and almost every organic substance; bromides, chlorides, iodides, hypophosphites, sulfites, sulfides.

Caution: Dermal contact can cause primary irritation and ulceraton as well as allergic eczema. Inhalation can cause nasal irritation, septal perforation. Pulmonary irritation, bronchogenic carcinoma may result from breathing chromate dust. Ingestion causes violent G.I. irritation with vomiting, diarrhea. Renal injury has been reported in exptl animals: E. Browning, *Toxicity of Industrial Metals* (Appleton-Century-Crofts, New York, 2nd ed., 1969) pp 119-131; *Clinical Toxicology of Commercial Products*, R. E. Gosselin *et al.*, Eds. (Williams & Wilkins, Baltimore, 4th ed., 1976) Section II, p 75.

USE: Chromium plating; copper stripping; aluminum anodizing; corrosion inhibitor; photography; purifying oil and acetylene; hardening microscopical prepns; oxidizing agent in organic chemistry.

THERAP CAT (VET): Has been used in solution as a topical antiseptic and astringent.

2239. Chromocarb. *4-Oxo-4H-1-benzopyran-2-carboxylic acid;* 2-chromonecarboxylic acid; 4-oxo-4*H*-chromene-2-carboxylic acid; benzo-γ-pyronecarboxylic acid. $C_{10}H_6O_4$; mol wt 190.16. C 63.16%, H 3.18%, O 33.66%. Prepn: S. Ruhemann, H. E. Stapleton, *J. Chem. Soc.* 77, 1179 (1900); J. Schmutz *et al., Helv. Chim. Acta* 34, 767 (1951); G. Pifferi *et al., J. Heterocycl. Chem.* 14, 1257 (1977). Prepn of diethylamine salt: P. A. Tronche, S. Afr. pat. 68 7352; *eidem*, U.S. pat. 3,816,470 (1969, 1974 both to Ferlux). Pharmacology of diethylamine salt in animals: J. Couquelet *et al., C.R. Soc. Biol.* 164, 329 (1970); P. Conquet *et al., ibid.* 800. Clinical comparison with dipyridamole of effect on platelet function: A. Vittoria *et al., Curr. Ther. Res.* 35, 1033 (1984). Clinical trial in diabetes with vascular disease: N. Ciavarella *et al., ibid.* 36, 293 (1984). Bioavailability in humans: J.-M. Aiache *et al., Biopharm. Drug Dispos.* 7, 301 (1986).



Colorless needles from alcohol, mp 250-251° (dec) (Ruhemann, Stapleton); also reported as mp 255-256° (Pifferi). uv max: 230, 305 nm (ε 20220, 8075). Sol in alcohol, ammonia. Sparingly sol in water.

Diethylamine, $C_{14}H_{17}NO_4$. *Angiophtal, Campel, Fludarene.* Microcrystalline powder from alcohol + acetone, mp 138°. Sol in water. LD_{50} in mice: ~800 mg/kg i.v.; > 5 g/kg orally (Tronche, 1974).

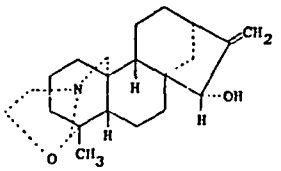
THERAP CAT: Diethylamine salt as capillary protectant.

2240. Chromomycins. An antibiotic complex produced by *Streptomyces griseus;* composed of chromomycins group A, group B, and C, with chromomycin A_3 as the major component. Isoln of complex and antibacterial activity: M. Shibata *et al., J. Antibiot.* 13B, 1 (1960), *C.A.* 54, 22835g (1960). Separation of components: Mizuno, and Tatsuoka *et al., ibid.* 13B, 329, 332 (1960), *C.A.* 56, 1745gi (1962); Miyake *et al.*, Japan. pat. 7842('60) and Ger. pat. 1,072,775 (both 1960 to Takeda), *C.A.* 55, 7758b, 26361f (1961); Mizuno, *J. Antibiot.* 16A, 22 (1963). Structure of A_3: Miyamoto *et al., Tetrahedron Letters* 1964, 2367, 2371; Tatsuoka *et al., Proc. Japan Acad.* 40(3), 236 (1964), *C.A.* 61, 10767h (1964); Miyamoto *et al., Tetrahedron* 23, 421 (1967). Abs config of A_3: Harada *et al., J. Am. Chem. Soc.* 91, 5896 (1969). Revised structure of A_3: J. Thiem, B. Meyer, *J. Chem. Soc. Perkin Trans. II* 1979, 1331. Series of articles on partial syntheses: *Ber.* 113, 3039-3074 (1980); J. H. Dodd *et al., J. Org. Chem.* 47, 4045 (1982). Pharmacology and toxicity: M. Slavik, S. K. Carter, *Adv. Pharmacol. Chemother.* 12, 1 (1975). *Review:* J. D. Skarbek, M. K. Speedie in *Antitumor*

U.S. *Constit.* Alliin, allicin, volatile and fatty oils, mucilage, albumin. Effect of garlic oil in hypercholesterolemic rabbits: R. C. Jain, D. B. Konar, *Atherosclerosis* **29**, 125 (1978); in humans: A. Bordia, H. C. Bansal, *Lancet* **2**, 1491 (1973).

USE: As a spice and seasoning in foods.

4269. Garryine. $C_{22}H_{33}NO_2$; mol wt 343.49. C 76.92%, H 9.68%, N 4.08%, O 9.32%. From bark of *Garrya veatchii* Kellog, *Garryaceae*, where it occurs together with veatchine and other alkaloids: Oneto, *J. Am. Pharm. Assoc.* **35**, 204 (1946); Wiesner *et al.*, *Can. J. Chem.* **30**, 608 (1952). Structure: Wiesner *et al.*: *J. Am. Chem. Soc.* **76**, 6068 (1954); Djerassi *et al.*, *ibid.* **77**, 4801 (1955). Stereochemistry: Solo, Pelletier, *Chem. & Ind. (London)* **1960**, 1108. Racemic syntheses and resolution: Masamune, *J. Am. Chem. Soc.* **86**, 290 (1964); Nagata *et al.*, *ibid.* 929, **89**, 1499 (1967); Guthrie *et al.*, *Coll. Czech. Chem. Commun.* **31**, 602 (1966).



Monohydrate, crystals from dil acetone. Bitter taste, mp 74-82°. pK 8.70. $[\alpha]_D^{27.5}$ −84.23° (c = 1.44 in ethanol). Sol in water, alcohol.

Hydrochloride, $C_{22}H_{33}NO_2.HCl$, crystals from abs ethanol + ether, dec 263-268°. Soluble in water.

4270. Gasoline. Petrol (British); Benzin (German). A mixture of C_4 to C_{12} hydrocarbons. Natural gasoline, obtained by fractional distillation of petroleum contains mostly saturated hydrocarbons; but the ordinary commercial grades of motor gasoline contain paraffins, olefins, naphthenes, and aromatics, all in substantial concns. Motor gasolines are made chiefly by cracking processes, in which heavier petr fractions are converted into more volatile fractions by thermal or catalytic decompn. (Where petr is scarce, as in Germany, gasoline also has been made commercially by catalytic high-pressure hydrogenation of soft coal and by catalytic synthesis of hydrocarbons from carbon monoxide and hydrogen.) Some gasolines sold in the U.S.A. contain a minor proportion of tetraethyllead, which is added in concns not exceeding 3 ml per gallon of motor gasoline to prevent "knock" in engines in which the gasoline is used as fuel. Knock is the audible manifestation of an excessive rate of pressure rise when the gasoline vapor is ignited under compression in an engine. (The relative knocking tendencies of gasolines are measured in terms of "Octane Number," which is defined as the percentage of iso-octane, having "100 Octane No.," to be blended with *n*-heptane, having "0 Octane No." by definition, in order to obtain the same degree of knock as is obtained with the gasoline being rated, under standard conditions in a standardized test engine.)

Commercial grades of tetraethyllead or Ethyl fluid typically contain about 63% tetraethyllead and about 35% ethylene dichloride or dibromide, which aids in evacuating the products of combusion of the lead compd from engines. In addition, the fluid contains a red or a blue dye. All leaded gasolines are dyed for recognition and should be used only as motor fuel. Other materials occasionally blended in gasoline to decrease knock, particularly in Europe, are benzene and ethanol. Comprehensive review: J. C. Lane, "Gasoline and Other Motor Fuels" in Kirk-Othmer *Encyclopedia of Chemical Technology* vol. 11 (Wiley-Interscience, New York, 3rd ed., 1980) pp 652-695.

Gasoline is a highly flammable, mobile liq with characteristic odor. Evaporates quickly: Flash pt ~−50°F (−4-5°C). Explosive limits, vol % in air: lower 1.3, upper 6.0; sp gr 60/60°F: 0.72 to 0.76. Initial bp 39°C; after 10% distilled bp 60°; after 50% bp 110°; after 90% bp 170°; final bp 204°. Insol in water; freely sol in abs alcohol, ether, chloroform, benzene. Dissolves fats, oils, natural resins.

USE: As fuel in internal combusion engines of the spark-ignited, reciprocating type. *Caution:* Ingestion causes inebriation, vomiting, vertigo, fever, drowsiness, confusion, cyanosis; aspiration causes bronchitis or pneumonia. Inhalation causes intense burning in throat and lungs; possibly bronchopneumonia.

4271. Gastrins. Gastrointestinal hormones isolated from the mucosal lining of the gastric antrum of various mammalian species. Highly potent gastric secretion stimulants, first discovered by J. S. Edkins: *Proc. Roy. Soc. London* **76B**, 376 (1905). Several gastrins have been identified; they are referred to as "little gastrin", "big gastrin" and "minigastrin". "Little gastrin" or G-17 exists in two forms, 18-34-gastrin I or G-17-I and 18-34-gastrin II or G-17-II, which are heptadecapeptides that are identical in amino acid sequence, with the latter having sulfated tyrosine residues. There are relatively small species differences in amino acid sequences of G-17, although there are differences in the ratio of the non-sulfated to the sulfated forms. This ratio is about 3:4 in hog compared to about 2:1 in man. "Big gastrin" or 1-34-gastrin, also found in two forms, consists of the heptadecapeptides of "little gastrins" extended from their *N*-termini by additional heptadecapeptides with amino acid compositions different from G-17. For each species, the G-17-I and G-17-II portions of the G-34 gastrin are identical. Pairs of shorter gastrins, or "minigastrins" (22-34-gastrin) are C-terminal tetradecapeptides.

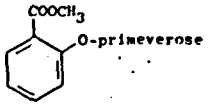
5-oxo-Pro-Gly-Pro-Trp-Leu-Glu-Glu-Glu-Glu-Glu-

Ala-Tyr-Gly-Trp-Met-Asp-Phe-NH_2

18-34-gastrin I (human)

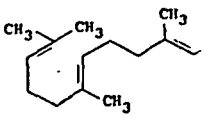
Structure of porcine "little gastrins": Gregory *et al.*, *Nature* **204**, 391 (1964); human: Bentley *et al.*, *ibid.* **209**, 583 (1966). Synthesis of porcine "little gastrins": Anderson *et al.*, *ibid.* **204**, 933 (1964); human: Beecham *et al.*, *ibid.* **209**, 585 (1966); human and canine: Agarwal, Kenner, *J. Chem. Soc. (C)* **1969**, 2213; ovine: Agarwal *et al.*, *ibid.* 954; feline: *eidem*, *Experientia* **25**, 346 (1969). General synthetic method: E. Brown *et al.*, *Chem. Commun.* **1980**, 1093. Isoln of "big gastrins" from Zollinger-Ellison tumor tissue: R. A. Gregory, H. J. Tracy, *Lancet* **2**, 797 (1972). Isoln of "minigastrins" from Zollinger-Ellison tumor tissue: *eidem*, *Gut* **15**, 683 (1974). Amino acid sequences of porcine and human "big gastrins": *eidem*, in *Gastrointestinal Hormones*, J. C. Thompson, Ed. (Univ. Texas Press, Austin, 1975) pp 13-14. Revised sequence of porcine: G. J. Dockray *et al.*, *Bioorg. Chem.* **8**, 465 (1979); of human: A. M. Choudhury *et al.*, *Z. Physiol. Chem.* **361**, 1719 (1980). Synthesis of human: G. Wendlberger *et al.*, *Monatsh.* **112**, 1297 (1981). Structure and synthesis of "minigastrins": R. A. Gregory *et al.*, *Z. Physiol. Chem.* **360**, 73 (1979). Review of chemical studies: Kenner, Sheppard, *Proc. Roy. Soc. London* **170B**, 89 (1968). Review of physiological advances: Gregory, *ibid.* **81**. General reviews: Sanders, Schimmel, *Am. J. Med.* **49**, 380 (1970); McGuigan, *Vitam. Horm.* **32**, 47-88 (1974); V. Mutt, *ibid.* **39**, 231-426 (1982).

4272. Gaultherin. *2-[(6-O-β-D-Xylopyranosyl-β-D-glucopyranosyl)oxy]benzoic acid methyl ester;* methyl salicylate-2-glucoxyloside; methyl salicylate-2-primeveroside; monotropitin; monotropitoside. $C_{19}H_{26}O_{12}$; mol wt 446.40. C 51.12%, H 5.87%, O 43.01%. In the wintergreen plant, *Gaultheria procumbens* L., in *Monotropa hypopitys* L., *Ericaceae* in *Betula lenta* L., *Betulaceae*, in *Spiraea ulmaria* L. and *S. filipendula* L., *Rosaceae:* Bridel, *Compt. Rend.* **177**, 642 (1923); **179**, 991 (1924); **180**, 1421, 1864 (1925); Bridel, Grillon, *ibid.* **187**, 609 (1928). Synthesis: Robertson, Waters, *J. Chem. Soc.* **1931**, 1881. On hydrolysis with 3% H_2SO_4 gaultherin forms 1 mol methyl salicylate, 1 mol D-glucose and 1 mol D-xylose. Enzymatic hydrolysis gives methyl salicylate and primeverose (glucoxylose).



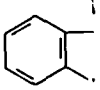
Needles in star formati
$[\alpha]_D^{20}$ −58° (c = 2). Sol in
ethyl acetate, acetone. Ins
Note: The older literatu
salicylate-D-glucoside.
Gaultherioside, $C_{13}H_{24}O_{1}$
$[\alpha]_D$ −58°. Gaultherioside
on hydrolysis with 3% H_2

4273. Gefarnate. 5,9,
enoic acid 3,7-dimethyl-2,
ylacetate; DA-688; Alsan
Gefarnil; Gefarnyl; Gef
Zackal. $C_{27}H_{44}O_2$; mol wt
7.99%. Prepn: Cardani *et*
Belg. pat. 617,994 (1962 t
Coppi *et al.*, *Arzneimittel-*
evaluation in duodenal ulc
gomery, *Brit. J. Clin. Prac*



Slightly yellowish liq
165-168°. n_D^{20} 1.4900. uv
alc, ether, dimethylforman
ly insol in water, forma
glycol, glycerine.
THERAP CAT: Antiulcera

4274. Geissoschizoline
N_2O; mol wt 298.41. C
5.36%. From bark of *Geis*
aceae: Hesse, *Ann.* **202**, 1
241 (1934). Identity with
48, 49 (1961). Structure:
4383 (1960); Bertho, Kol
Hymon, Schmid, *Helv.* C
form: Dadson, Harley-N
Harley-Mason, Taylor, *il*

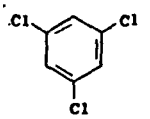


Coarse crystals from a
+32° (ethanol). uv max
3.93, 3.47). Sol in alco
insol in water.
Methyl chloride, $C_{19}H_{2}$
anol, mp 297°.
Methiodide, $C_{19}H_{26}N_2$
mp 254°.

4275. Geissospermine
[(10β,13β,21β)-23-deoxy
strychnidin-10-yl]coryna
didehydro-16-(15-ethyl-
ethano-1H,3H-[1,3]oxazi
1-yl)-corynan-17-oic aci
ethylidene-1,2,3,4,6,7,12-
izin-2-yl)-curan-1-propa
O_3; mol wt 632.82. C 7
From bark of *Geissosper*
Hesse, *Ann.* **202**, 141 (1
Compt. Rend. **252**, 902
(1961). Crystal structure
tallogr. **35B**, 1820 (1979
seau, *Ann. Pharm. Fran*
with HCl splits into geis

Liquid; mp 17°; d_{25}^{25} 1.4634; bp 213°; n_D^{25} 1.5524. Flash pt 110° (230°F). Volatile with steam. Insol in water. Sparingly sol in alc. Miscible with ether, benzene, petr ether, carbon disulfide.

9544. 1,3,5-Trichlorobenzene. *sym*-Trichlorobenzene. $C_6H_3Cl_3$; mol wt 181.46. C 39.71%, H 1.67%, Cl 58.62%. Prepd from 2,4,6-trichloraniline by diazotization and treatment with alcohol: Jackson, Lamar, *Am. Chem. J.* 18, 667 (1896); Backer, van der Baan, *Rec. Trav. Chim.* 56, 1177 (1937).



Crystals; mp 63.4°; bp 208.4°. n_D^{19} 1.5662. Flash pt 107° (224.6°F). Volatile with steam. Insol in water. Sparingly sol in alc. Freely sol in ether, benzene, petr ether, carbon disulfide, glacial acetic acid.

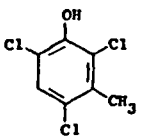
9545. α,α,β-Trichloro-*n*-butyraldehyde. *2,2,3-Trichlorobutanal;* butylchloral; anhydr butylchloral; butyrchloral; crotonchloral. $C_4H_5Cl_3O$; mol wt 175.45. C 27.38%, H 2.87%, Cl 60.63%, O 9.12%. $CH_3CHClCCl_2CHO$. Prepd by the action of chlorine on acetaldehyde: Krämer, Pinner, *Ber.* 3, 883 (1870); Pinner, *Ann.* 179, 24 (1875); on paraldehyde: *idem;* on crotonaldehyde after saturation with gaseous HCl: High, U.S. pat. 2,280,290 (1942); Brown, Plump, U.S. pat. 2,351,000 (1944). From crotonaldehyde and chlorine: Ropp *et al., Org. Syn.* coll. vol. IV, 130 (1963). *See also* Butylchloral Hydrate.

Oily liquid. Pungent, disagreeable odor; d_4^{20} 1.3956; bp_{760} 164.5-165.5°; bp_{25} 57-60°. n_D^{20} 1.47554. Freely sol in water forming butylchloral hydrate; sol in alcohol forming an alcoholate; sol in ether. Polymerizes.

9546. 2,3,6-Trichloro-*p*-cresol. *2,3,6-Trichloro-4-methylphenol;* 2,3,5-trichloro-4-hydroxytoluene; 2,3,5-trichloro-4-hydroxy-1-methylbenzene. Prepared by chlorination of *p*-cresol: Zincke *et al., Ann.* 328, 268 (1903).

Long needles from glacial acetic acid or petr ether. mp 66-67°. Slightly sol in water; freely sol in the usual organic solvents, and in dil alkali and soda solns.

9547. 2,4,6-Trichloro-*m*-cresol. *2,4,6-Trichloro-3-methylphenol;* 2,4,6-trichloro-3-hydroxytoluene. $C_7H_5Cl_3O$; mol wt 211.48. C 39.75%, H 2.38%, Cl 50.30%, O 7.57%. Prepd by chlorination of *m*-cresol, chlorination of thymol in the presence of iron, or by action of concd sulfuric acid on 2,4,4-trichloro-3-methyl-6-isopropyl-$\Delta^{2,5}$-cyclohexadienone: Crowther, McCombie, *J. Chem. Soc.* 103, 536 (1913).



Needles or plates from water or petr ether. mp 45-47°; bp 265°, bp_{14} 142-144°. Volatile with steam. Slightly sol in water, benzene, petr ether, glacial acetic acid. Freely sol in methanol, alc, chloroform, xylene, ether and in alkali solns.

9548. 4,5,6-Trichloro-*o*-cresol. *2,3,4-Trichloro-6-methylphenol;* 3,4,5-trichloro-2-hydroxytoluene; 1-methyl-2-hydroxy-3,4,5-trichlorobenzene. Prepd by chlorination of 1-methyl-2-hydroxy-4-chlorobenzene: Kohn, Syreia, *J. Am. Chem. Soc.* 70, 3950 (1948).

Needles from petr ether, mp 77°. Slightly soluble in water; freely sol in the customary organic solvents and in caustic alkali solns.

9549. 1,1,1-Trichloroethane. Methylchloroform; Chlorothene. $C_2H_3Cl_3$; mol wt 133.42. C 18.00%, H 2.27%, Cl 79.72%. CH_3CCl_3. Prepd by the action of chlorine on 1,1-dichloroethane: Sutton, *Proc. Roy. Soc.* A133, 673 (1931); by the catalytic addition of HCl to 1,1-dichloroethylene: Ger. pat. 523,436 (1931); U.S. pat. 2,209,000 (Nutting, Hucher, 1940). Review of mfg processes: Faith, Keyes & Clark's *Industrial Chemicals,* F. A. Lowenheim, M. K. Moran, Eds. (Wiley-Interscience, New York, 4th ed., 1975) pp 836-843.

Liquid. Nonflammable. mp −32.5°. d_4^{20} 1.3376. bp_{760} 74.1°. n_D^{20} 1.43838. Insoluble in water. Absorbs some water. Sol in acetone, benzene, carbon tetrachloride, methanol, ether.

USE: In cold type metal cleaning, also in cleaning plastic molds. *Caution:* Irritating to eyes, mucous membranes, and, in high concns, narcotic.

9550. 1,1,2-Trichloroethane. Vinyl trichloride. $C_2H_3Cl_3$; mol wt 133.42. C 18.00%, H 2.27%, Cl 79.73%. $CH_2ClCHCl_2$. Prepd by catalytic chlorination of ethane or ethylene: Joseph, U.S. pat. 2,752,401 and Pye, U.S. pat. 2,752,402 (both 1956 to Dow); Reynolds, U.S. pat. 2,783,286 (1957 to Olin Mathieson). Toxicity data: H. F. Smyth *et al., Am. Ind. Hyg. Assoc. J.* 30, 470 (1969).

Nonflammable liquid; pleasant odor; d_4^{20} 1.4416. mp −35°. bp 113-114°. n_D^{20} 1.4711. Insol in water; misc with alcohol, ether, and many other organic liquids. LD_{50} orally in rats: 0.58 ml/kg (Smyth).

USE: Solvent for fats, waxes, natural resins, alkaloids. *Caution:* Irritating to eyes, mucous membranes, and, in high concns, narcotic.

9551. 2,2,2-Trichloroethanol. Trichloroethyl alcohol. $C_2H_3Cl_3O$; mol wt 149.42. C 16.08%, H 2.02%, Cl 71.19%, O 10.71%. CCl_3CH_2OH. Prepd by reduction of the corresponding ester, acid chloride, or acid with lithium aluminum hydride: Sroog *et al., J. Am. Chem. Soc.* 71, 1710 (1949). Manufacture by reduction of chloral hydrate with an amine borane: Chamberlain, Schechter, U.S. pat. 2,898,379 (1959 to Callery Chem.).

Hygroscopic liquid, ethereal odor. At low temps it crystallizes in rhombic tablets. mp at 18°; bp 151-153°; d_{20}^{20} 1.53. Sol in about 12 parts water; miscible with alcohol or ether. pH of aq soln is 5-6, but on prolonged contact with water some free acid is formed. *Keep well closed and protected from light.* LD_{50} orally in rats: 600 mg/kg, *Handbook of Toxicology* vol. 1, W. S. Spector, Ed. (Saunders, Philadelphia, 1955) pp 302-303.

THERAP CAT: Sedative, hypnotic.

9552. Trichloroethylene. *Trichloroethene;* ethinyl trichloride; Tri-Clene; Trielene; Trilene; Trichloran; Trichloren; Algylen; Trimar; Triline; Tri; Trethylene; Westrosol; Chlorylen; Gemalgene; Germalgene. C_2HCl_3; mol wt 131.40. C 18.28%, H 0.77%, Cl 80.95%. $CCl_2{=}CHCl$. Usually prepd from *sym*-tetrachloroethane by elimination of HCl (by boiling with lime): Ger. pat. 171,900. By passing tetrachloroethane vapor over $CaCl_2$ catalyst at 300°: Ger. pat. 263,457; without catalyst at 450-470°: Brit. pat. 575,530 (1946 to du Pont). Review of mfg processes: S. A. Miller, *Chem. Process Eng.* 47, 268 (1966); Faith, Keyes & Clark's *Industrial Chemicals,* F. A. Lowenheim, M. K. Moran, Eds. (Wiley-Interscience, New York, 4th ed., 1975) pp 844-848. Toxicity and metabolism: E. Browning, *Toxicity and Metabolism of Industrial Solvents* (Elsevier, New York, 1965) pp 189-212. Toxicity data: Smyth *et al., Am. Ind. Hyg. Assoc. J.* 30, 470 (1969).

Nonflammable, mobile liquid. Characteristic odor resembling that of chloroform. d_4^4 1.4904; d_4^{15} 1.4695; d_4^{20} 1.4649. Vapor density: 4.53 (air = 1.00). mp −84.8°. bp_{760} 86.7°; bp_{400} 67.0°; bp_{200} 48.0°; bp_{100} 31.4°; bp_{60} 20.0°; bp_{20} −1.0°; bp_{10} −12.4°; bp_5 −22.8°; $bp_{1.0}$ −43.8°; n_D^{17} 1.47914; n_D^{18} 1.45560. Practically insol in water; misc with ether, alcohol, chloroform. Dissolves most fixed and volatile oils. Slowly dec (with formn of HCl) by light in the presence of moisture. Trichloroethylene for medicinal purposes may contain some thymol or ammonium carbonate (not more than 20 mg/100 ml) as a stabilizer. Industrial grades of trichloroethylene may contain other stabilizers such as triethanolamine stearate and cresol. LD_{50} orally in rats: 4.92 ml/kg; LC (4 hr) in rats: 8000 ppm (Smyth).

Caution: Use with adequate ventilation. Preserve trichloroethylene in sealed, light-resistant ampuls or in frangible, light-resistant glass tubes. Avoid prolonged exposure of the product to excessive heat. It must be dispensed in the ma-

$$HO(CH_2CH_2O)_a[CH(CH_3)CH_2O]_b(CH_2CH_2O)_cH$$

average values for a, b, c are:
a = 12; b = 34; c = 12

A liquid nonionic surfactant polymer.
USE: Pharmaceutic aid (surfactant).
THERAP CAT (VET): Prevention of bloat in cattle.

7537. Poloxamers. *Methyl oxirane polymers, polymer with oxirane; polyethylenepolypropylene glycols, polymers;* α-hydro-ω-hydroxypoly(oxyethylene)poly(oxypropylene)-poly(oxyethylene) block copolymers; Pluronics. Series of nonionic surfactants with the structure $HO(CH_2CH_2O)_a(CH(CH_3)CH_2OH)_b(CH_2CH_2O)_cH$ where b is at least 15 and $(CH_2CH_2O)_{a+c}$ is varied from 20 to 90% by weight. Mol wt ranges from 1000 to greater than 16,000. The poly(oxypropylene) segment is hydrophobic; the poly(oxyethylene) segment hydrophilic. Comprehensive reviews: I. R. Schmolka, *Am. Perfumer Cosmet.* 82(7), 25-30 (1967); *idem* "Polyalkylene Oxide Block Copolymers" in *Nonionic Surfactants*, M. Schick, Ed. (Dekker, New York, 1967) pp 300-371. *See also* Poloxalene.

Mobile liquids, pastes or flakeable solids. Relatively nonhygroscopic. Vary from water-insol to very water-sol compds; more sol in cold than hot water. In general, sol in aromatic solvents (benzene, toluene, xylene), chlorinated solvents, acetone, alc, propylene or hexylene glycol, butyl cellosolve, butyl carbitol, methyl ethyl ketone, cyclohexanone. Insol in ethylene glycol, kerosene, mineral oil. Low-foaming properties. Stable to acids, alkalies, metallic ions.

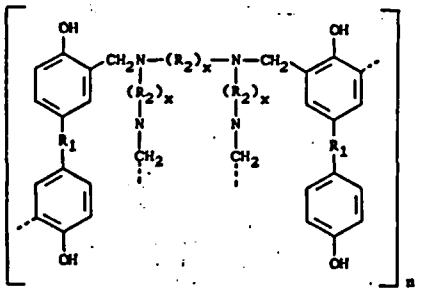
Poloxamer 182LF, Pluronic L62LF. a = 7, b = 30, c = 7; av. mol wt 2450. Low-foaming liquid. d_{25}^{25} 1.035. Brookfield viscosity (25°) 375 cp; cloud pt (10% aq soln): 22°.

Poloxamer 188, poloxalkol (obsolete), Exocorpol, Pluronic F68. a = 75, b = 30, c = 75; av. mol wt 8350. Flakeable solid. mp 50° (minimum); cloud pt (10% aq soln): > 100°.

Poloxamer 331, Pluronic L101. a = 7, b = 54, c = 7; av. mol wt 3800. Liquid. d_{25}^{25} 1.018; Brookfield viscosity (25°): 756 cp; cloud pt (10% aq soln): 11°.

USE: Food additives; defoamers; antistatic agents; demulsifiers; detergents, wetting agents, gelling agents; emulsifiers; foam controllers; dispersants; dye levelers.
THERAP CAT: Poloxamer 182LF as pharmaceutic aid; 188 as cathartic.

7538. Polyamine-Methylene Resin. Resinat; Exorbin. Phenol condensation product with polyamines. An ion-exchange resin specially purified for medicinal use.



Light amber, granular, free-flowing powder. Insol in water, alcohol, ether, aq solns of acids and alkalies. Under the conditions of the old N.N.R. assay for acid-consuming capacity, not less than 50 ml 0.1*N* hydrochloric acid is consumed by 0.2 g of the resin.
THERAP CAT: Antacid.

7539. Polybenzarsol. *(4-Hydroxyphenyl)arsonic acid polymer with formaldehyde;* Benzodol. A polymeric mixture obtained by adding formaldehyde (40%) (0.116 mole) over a 3-hr period to *p*-hydroxybenzenearsonic acid (0.209 mole) in 180 g of 90% H_2SO_4 at 0-5° and keeping it cold for 21 hrs. Dilution of the mixture with H_2O precipitates the product: Faith, *J. Am. Chem. Soc.* 72, 837 (1950). Description: Jones *et al., Antibiot. & Chemother.* 8, 400 (1958).

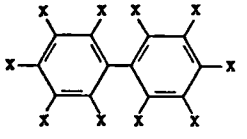
White powder. Somewhat sol in water; sol in alcoholic NaOH. LD_{50} i.p. in mice: 235 mg/kg. No deaths after 4 g/kg i.g. in mice.
THERAP CAT: Antiamebic.

7540. Polybrominated Biphenyls. PBB's; brominated biphenyls; polybromobiphenyls. Mixtures with structures similar to polychlorinated biphenyls, *q.v.*, where each X = H or Br. Once widely used commercially. Prepn: H. Hahn *et al.*, Ger. pat. 1,161,547 (1964 to Chem. Fabrik Kalb); G. A. Burk, U.S. pat. 3,733,366 (1973 to Dow); L. C. Mitchell, D. R. Breckenridge, U.S. pats. 3,763,248 and 3,833,674 (1973, 1974 both to Ethyl Corp.). Persistence in soils: L. W. Jacobs *et al., J. Agr. Food Chem.* 24, 1198 (1976). Photodegradation: L. O. Ruzo *et al., ibid.* 1062. Review of environmental hazards: K. Kay, *Environ. Res.* 13, 74-93 (1977); F. J. DiCarlo *et al., Environ. Health Perspect.* 23, 351-365 (1978).

Firemaster BP-6, major component is *2,2',4,4',5,5'-hexabromobiphenyl.* Softens at 72°, dec above 300°. Low vapor pressure; degraded by uv light. Very sol in benzene, toluene. Insol in water.

Note: The 1973 "Michigan Incident" in which BP-6 was accidentally added to animal feed, and resulted in widespread destruction of contaminated farm animals, led to the removal of BP-6 from the market: L. J. Carter, *Science* 192, 240 (1976). This substance may reasonably be anticipated-to be a carcinogen: *Fourth Annual Report on Carcinogens* (NTP 85-002, 1985) p 169.
USE: Flame retardant.

7541. Polychlorinated Biphenyls. PCBs; chlorinated biphenyls; chlorobiphenyls; Aroclor; Clophen; Fenclor; Kanechlor; Phenoclor; Pyralene; Santotherm. Once widely used industrial chemicals whose high stability contributed to both their commercial usefulness and their long-term deleterious environmental and health effects. Early synthesis: H. Schmidt, G. Schulz, *Ann.* 207, 338 (1881). Commercially available since 1930: C. Penning, *Ind. Eng. Chem.* 22, 1180 (1930). Commercial PCBs are mixtures. The Aroclors are characterized by four digit numbers. The first two digits indicate that the mixture contains biphenyls (12), triphenyls (54) or both (25, 44); the last two digits give the weight percent of chlorine in the mixture (e.g. Aroclor 1242 contains biphenyls with approx 42% chlorine). Reviews of environmental impact and toxicity: L. Fishbein, *Ann. Rev. Pharmacol.* 14, 139-156 (1974); R. D. Kimbrough, *CRC Crit. Rev. Toxicol.* 2, 445-498 (1974); *National Conference on Polychlorinated Biphenyls*, Nov. 19-21, 1975 (EPA-560/6-75-004, 1976) 487 pp. Accumulation of airborne PCBs in foliage: E. H. Buckley, *Science* 216, 520 (1982). *Reviews:* H. L. Hubbard in *Kirk-Othmer Encyclopedia of Chemical Technology* vol. 5 (Interscience, New York, 2nd ed., 1964) pp 289-297; O. Hutzinger *et al., The Chemistry of PCB's* (CRC Press, Cleveland, Ohio, 1974) 269 pp; J. W. Lloyd *et al., J. Occup. Med.* 18, 109-113 (1976). Review of carcinogenicity studies: *IARC Monographs* 18, 43-103 (1978).



X = H or Cl

Aroclor 1242, clear, mobile liquid; av. number Cl/molecule: 3.10. d_4^{25} 1.381, $d_4^{15.5}$ 1.392. Distillation range 325-366°. Flash point (open cup) 348-356°F. n_D^{20} 1.627-1.629. Dielectric constant (1000 cycles) 5.6 (25°), 4.9 (100°).

Aroclor 1254, light yellow, viscous liquid; av. number Cl/molecule: 4.96. d_4^{65} 1.495; $d_4^{15.5}$ 1.505. Distillation range 365-390°. No open cup flash point to boiling. n_D^{20} 1.629-1.641. Dielectric constant (1000 cycles) 5.0 (25°), 4.3 (100°). LD_{50} orally in weanling rats: 1295 mg/kg (Kimbrough).

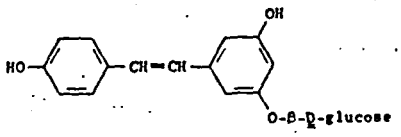
Aroclor 1260, light yellow, soft, sticky resin; av. number

Cl/molecule: 6.30. d_4^{90} 1.555; d_4^{155} 1.566. Distillation range 385-420. No open cup flash point to boiling. n_D^{20} 1.647-1.649. Dielectric constant (1000 cycles) 4.3 (25°); 3.7 (100°). LD_{50} orally in weanling rats: 1315 mg/kg (Kimbrough).

Caution: Toxic effects in humans include chloracne, pigmentation of skin and nails, excessive eye discharge, swelling of eyelids, distinctive hair follicles, gastrointestinal disturbances. In Japan, accidental contamination of rice bran oil with Kanechlor 400 led to an outbreak of what became known as "Yusho disease", see M. Kuratsune *et al.*, in EPA-560/6-75-004, *loc. cit.*, p 14. Toxic symptoms in animals include hepatocellular carcinoma, hypertrophy of the liver, adenofibrosis, weight and hair loss, mouth and eyelid edema, acneform lesions, decreased hemoglobin + hematocrit, gastric mucosal ulceration and reduced ability to reproduce. These substances may reasonably be anticipated to be carcinogens: *Fourth Annual Report on Carcinogens* (NTP 85-002, 1985) p 170.

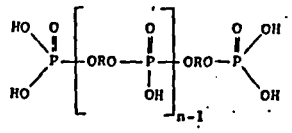
USE: In electrical capacitors, electrical transformers, vacuum pumps, gas-transmission turbines. Formerly used in U.S. as hydraulic fluids, plasticizers, adhesives, fire retardants, wax extenders, dedusting agents, pesticide extenders, inks, lubricants, cutting oils, in heat transfer systems, carbonless reproducing paper.

7542. **Polydatin.** *3-Hydroxy-5-[2-(4-hydroxyphenyl)ethenyl]phenyl-β-D-glucopyranoside; 3-hydroxy-5-(p-hydroxystyryl)phenyl glucoside;* 3,4',5-trihydroxystilbene-3-β-D-glucoside; resveratrol-3-β-mono-D-glucoside; piceid. $C_{20}H_{22}O_8$; mol wt 390.40. C 61.53%, H 5.68%, O 32.79%. Isoln from fresh root of *Polygonum cuspidatum* Sieb. & Zucc., *Polygonaceae*, and structure: Nonomura *et al.*, *Yakugaku Zasshi* 83, 988 (1963).



Trihydrate, crystals, mp 225-226°. $[\alpha]_D^{27}$ −74.9° (c = 1.709 in ethanol).

7543. **Polyestradiol Phosphate.** *Estradiol phosphate polymer;* PEP; Estradurin. Polymeric ester of phosphoric acid and estradiol. Mol wt ~26,000. Prepn: Diczfalusy, *Endocrinology* 54, 471 (1954); Diczfalusy *et al.*, U.S. pat. 2,928,849 (1960 to AB Leo); Fernö *et al.*, *Acta Chem. Scand.* 12, 1675 (1958). Proposed structure: Fernö *et al.*, *loc. cit.*



(—ORO— is the estradiol radical and n is about 80)

Solid, mp 195-202°. Very sol in aq pyridine; sol in aq alkali; very slightly sol in ethanol, ethanol + water (1:1), water, dioxane, acetone, chloroform. Intrinsic viscosity [η] in 0.25*M* NaCl soln at pH 7.5 = 0.04.

THERAP CAT: Estrogen (used in prostatic carcinoma).

7544. **Polyethylene.** *Ethene homopolymer;* Agilene; Alathon; Alkathene; Courlene; Lupolen; Platilon; Polythene; Pylen; Reevon. Mol wt about 1500-100,000. C 85.7%, H 14.3%. Prepd by polymerization of liq ethylene at high temps and high or low pressure. *Reviews:* Aggarwal, Sweeting, *Chem. Rev.* 57, 665-742 (1957); Raff, Allison, *Polyethylene*, vol. XI of High Polymers series (Interscience, New York, 1956); Faith *et al.*, *Industrial Chemicals* (Wiley, New York, 3rd ed., 1965) pp 624-630.

Plastic solid of milky transparency. d_4^{20} 0.92. Tough and flexible at room temps, mp 85-110°. Breaks with cryst fracture at −50°. Good electrical insulator. Surface resistivity: 10^{14} ohms. Will burn, but hardly supports combustion. Stable to water, non-oxidizing acids and alkalies, alcohols, ethers, ketones, esters at ordinary temps. Attacked by oxidizing acids such as nitric acid and perchloric acid, free halogens, benzene, petr ether, gasoline and lubricating oils, aromatic and chlorinated hydrocarbons.

USE: Laboratory tubing; in making prostheses; electrical insulation; packaging materials; kitchenware; tank and pipe linings; paper coatings; textile stiffeners.

7545. **Polyethylene Glycol.** *α-Hydro-ω-hydroxypoly(oxy-1,2-ethanediyl);* macrogol; PEG; Carbowax; Jeffox; Nycoline; Pluracol E; Poly-G; Polyglycol E; Solbase. Liquid and solid polymers of the general formula $H(OCH_2CH_2)_nOH$, where *n* is greater than or equal to 4. In general, each PEG is followed by a number which corresponds to its average mol wt. Synthesis: Fordyce, Hibbert, *J. Am. Chem. Soc.* 61, 1905, 1910 (1939). *Reviews: Glycols*, G. O. Curme, Jr., F. Johnston, Eds., A.C.S. Monograph Series no. 114 (Reinhold, New York, 1952) pp 176-202; Kastens in *High Polymers*, H. Mark *et al.*, Eds., vol. 13 entitled *Polyethers*, part 1 (Interscience, New York, 1963) pp 169-189, 274-291; G. M. Powell, III in *Handbook of Water-Soluble Gums & Resins*, R. L. Davidson, Ed. (McGraw-Hill, New York, 1980) pp 18/1-18/31.

Clear, viscous liquids or white solids which dissolve in water forming transparent solns. Sol in many organic solvents. Readily sol in aromatic hydrocarbons. Only slightly sol in aliphatic hydrocarbons. Do not hydrolyze or deteriorate on storage, will not support mold growth. Polyethylene glycols are compds of low toxicity: Smyth *et al.*, *J. Am. Pharm. Assoc., Sci. Ed.* 39, 349 (1950). Toxicity data (PEG 400): W. Bartsch *et al.*, *Arzneimittel-Forsch.* 26, 1581 (1976).

Polyethylene glycol 200, average value of *n* is 4, mol wt range 190-210. Viscous, hygroscopic liq; slight characteristic odor; d_{25}^{25} 1.127. Viscosity (210°F): 4.3 centistokes. Supercools upon freezing.

Polyethylene glycol 400, average value of *n* between 8.2 and 9.1, mol wt range 380-420. Viscous, slightly hygroscopic liq; slight characteristic odor; d_{25}^{25} 1.128. mp 4-8°. Viscosity (210°F): 7.3 centistokes. LD_{50} orally in rats: 30 ml/kg (Bartsch).

Polyethylene glycol 600, average value of *n* between 12.5 and 13.9, mol wt range 570-630. Viscous, slightly hygroscopic liq; characteristic odor; d_{25}^{25} 1.128. mp 20-25°. Viscosity (210°F): 10.5 centistokes.

Polyethylene glycol 1500, average value of *n* between 29 and 36, mol wt range 1300-1600. White, free-flowing powder; d_{25}^{25} 1.210. mp 44-48°. Viscosity (210°F): 25-32 centistokes.

Polyethylene glycol 4000, average value of *n* between 68 and 84, mol wt range 3000-3700. White, free-flowing powder or creamy-white flakes; d_{25}^{25} 1.212. mp 54-58°. Viscosity (210°F): 76-110 centistokes. LD_{50} orally in rats (divided doses): 59 g/kg (Smyth).

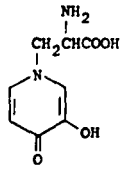
Polyethylene glycol 6000, average value of *n* between 158 and 204, mol wt range 7000-9000. Powder or creamy-white flakes; d_{25}^{25} 1.21. mp 56-63°. Viscosity (210°F): 470-900 centistokes. LD_{50} orally in rats: >50 g/kg (Smyth).

USE: As water-soluble lubricants for rubber molds, textile fibers, and metal-forming operations. In food and food packaging. In hair prepns, in cosmetics in general. Pharmaceutic aid (ointment and suppository base). As a stationary phase in gas chromatography. Also in water paints, paper coatings, polishes and in the ceramics industry. *Caution: Solvent action on some plastics!*

THERAP CAT (VET): Ointment base.

7546. **Polyethylene Terephthalates.** PET. Fiber forming polyesters prepd from terephthalic acid, *q.v.* or its esters and ethylene glycol: Whinfield, Dickson, U.S. pat. 2,465,319 (1949 to du Pont). Review of structures, definition of trade names: R. W. Moncrieff, *Man-Made Fibres* (John Wiley & Sons, New York, 4th ed., 1963) pp 361-389, 707-723.

isoln: N. K. Hart *et al.*, *Heterocycles* 7, 265 (1977). Structure: Adams, Jones, *J. Am. Chem. Soc.* 69, 1803 (1947). Synthesis: Adams, Johnson, *ibid.* 71, 705 (1949). Identity of mimosine and leucenol: Kleipool, Wibaut, *Rec. Trav. Chim.* 69, 37 (1950); Wibaut, Schuhmacher, *ibid.* 71, 1017 (1952). Crystal structure: A. Mostad *et al.*, *Acta Chem. Scand.* 27, 164 (1973). Shown to cause inhibition of hair growth and loss of hair in mice: Crounse *et al.*, *Nature* 194, 694 (1962). Explanation of the toxicity in animals: J. F. Thompson *et al.*, *Ann. Rev. Biochem.* 38, 137 (1969).



dl-Form, crystals from water, mp 235-236°. Slightly sol in water, much less sol in methanol and ethanol; practically insol in the higher alcohols, in dioxane, ethyl acetate, ether, benzene, chloroform, glacial acetic acid, pyridine, Cellosolve. Sol in dil acids or bases and may be recovered from these solns by adjusting the pH so that it is just acid to bromcresol green. uv max: 282 nm (log ε 4.23).

dl-Hemihydrate, crystals, darkens at 215-226°, mp 227-228°.

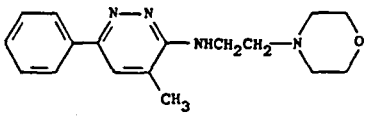
l-Form, crystals from water, mp 225°. $[\alpha]_D^{22}$ −20°.

Hydrochloride, $C_8H_{11}ClN_2O_4$, dec 175°, sol in water.

Hydrobromide, $C_8H_{11}BrN_2O_4$, dec 179.5°, sol in water.

USE: Depilatory agent, Hegarty *et al.*, *Aust. J. Agr. Res.* 15, 153 (1964), *C.A.* 60, 16405e (1964).

6119. Minaprine. *N-(4-Methyl-6-phenyl-3-pyridazinyl)-4-morpholineethanamine; 4-[2-[(4-methyl-6-phenyl-3-pyridazinyl)amino]ethyl]morpholine.* $C_{17}H_{22}N_4O$; mol wt 298.40. C 68.43%, H 7.43%, N 18.78%, O 5.36%. Prepn: H. Laborit, Ger. pat. 2,229,215; *idem*, U.S. pat. 4,169,158 (1973, 1979 to Centre Etudes Exper. Clin. Physio-Biologie); C.-G. Wermuth, A. Exinger, *Agressologie* 13, 285 (1972). Pharmacology: H. Laborit *et al.*, *ibid.* 291. Metabolism of ^{14}C-minaprine: A. G. Rico *et al.*, *J. Pharmacol.* 9, 170 (1978). Pharmacokinetics: J. P. Jeanniot *et al.*, *ibid.* 169. Clinical evaluation: A. Garcia-Maffla, M. H. de Garcia, *Pharmatherapeutica* 2, 265 (1979). Pharmacological evaluation in depression: K. Bizière *et al.*, *Arzneimittel-Forsch.* 32, 824 (1982). Toxicologic study: A. G. Mazure *et al.*, *Agressologie* 13, 319 (1972).



Fine buff-colored needles from isopropanol, mp 122°. Insol in water. Slightly sol in cold ethanol, sol in hot ethanol, chloroform.

Dihydrochloride, $C_{17}H_{24}Cl_2N_4O$. *Agr 1240, CB-30038, Brantur, Cantor.* Crystals from abs ethanol, mp 182°.

THERAP CAT: Psychotropic.

6120. Mineral Spirits. *Petroleum spirits;* white spirits; turpentine substitutes. Name applied to various types of hydrocarbon solvents, primarily petroleum distillates, which have flash points above 100°F (38°C) and distillation ranges between 300°F (149°C) and 415°F (213°C). *See: A.S.T.M. Standard Specifications* D 235-83, 71-73 (1983).

Type I, *Stoddard solvent, Texsolve S, Varsol 1.* Regular mineral spirits. Clear liquid. Flash pt (min): 38°C (100°F). $d_{15.6}^{15.6}$ 0.754-0.820. Distillation range: initial bp (min), 149°C (300°F); 50% recovered (max), 182°C (360°F); dry pt (max), 208°C (407°F).

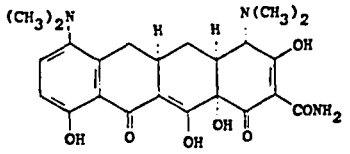
Type II. High flash point mineral spirits. Flash pt (min): 60°C (140°F). $d_{15.6}^{15.6}$ 0.768-0.820. Distillation range: initial bp (min), 177°C (350°F); 50% recovered (max), 196°C (385°F); dry pt (max), 211°C (412°F).

Type III. Odorless mineral spirits. Flash pt (min): 38°C (100°F). $d_{15.6}^{15.6}$ 0.775 (max). Distillation range: initial bp (min), 149°C (300°F); 50% recovered (max), 196°C (385°F); dry pt (max), 213°C (415°F).

Type IV, *Texsolve S-2, Varsol 3.* Low dry point mineral spirits. Flash pt (min): 38°C (100°F). $d_{15.6}^{15.6}$ 0.754-0.800. Distillation range: initial bp (min), 149°C (300°F); 50% recovered (max), 174°C (345°F); dry pt (max), 185°C (365°F).

USE: Solvent; paint thinner. In the coatings and dry cleaning industries.

6121. Minocycline. *4,7-Bis(dimethylamino)-1,4,4a,5,-5a,6,11,12a-octahydro-3,10,12,12a-tetrahydroxy-1,11-dioxo-2-naphthacenecarboxamide;* 7-dimethylamino-6-demethyl-6-deoxytetracycline; Minocyn. $C_{23}H_{27}N_3O_7$; mol wt 457.49. C 60.38%, H 5.95%, N 9.18%, O 24.48%. Semi-synthetic antibiotic effective against tetracycline-resistant staphylococci. Prepn: Boothe, Petisi, U.S. pats. 3,148,212 and 3,226,436 (1964 and 1965 to Am. Cyanamid). Synthesis: Martell, Boothe, *J. Med. Chem.* 10, 44 (1967); Church *et al.*, *J. Org. Chem.* 36, 723 (1971); Bernardi *et al.*, *Farmaco Ed. Sci.* 30, 736 (1975). Activity data: Kradolfer *et al.*, *Antimicrob. Ag. Chemother.* 1966, 359. Metabolism: Kelly, Kanegis, *Toxicol. Appl. Pharmacol.* 11, 171 (1967). Toxicity studies: Noble *et al.*, *ibid.* 128. Clinical evaluation: Frisk, Tunevall, *Antimicrob. Ag. Chemother.* 1968, 335; Cappel, Klastersky, *Curr. Ther. Res.* 13, 227 (1971). Comprehensive description: V. Zbinovsky, G. P. Chrekian in *Analytical Profiles of Drug Substances* vol. 6, K. Florey, Ed. (Academic Press, New York, 1977) pp 323-339.



Bright yellow-orange amorphous solid. $[\alpha]_D^{25}$ −166° (c = 0.524). uv max (0.1*N* HCl): 352, 263 nm (log ε 4.16, 4.23); (0.1*N* NaOH): 380, 243 nm (log ε 4.30, 4.38).

Hydrochloride, $C_{23}H_{28}ClN_3O_7$, *Minocin, Klinomycin, Minomycin, Vectrin.* Yellow crystalline powder. Slightly hygroscopic; sensitive to light and to surface oxidation.

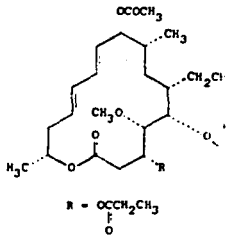
THERAP CAT: Antibacterial.

6122. Minoxidil. *6-(1-Piperidinyl)-2,4-pyrimidinediamine 3-oxide; 6-amino-1,2-dihydro-1-hydroxy-2-imino-4-piperidinopyrimidine;* 2,3-dihydro-3-hydroxy-2-imino-6-(1-piperidinyl)-4-pyrimidinamine; 2,4-diamino-6-piperidinopyrimidine 3-oxide; 6-piperidino-2,4-diaminopyrimidine 3-oxide; PDP; U-10,858; Alopexil; Alostil; Loniten; Lonolox; Minoximen; Prexidil; Regaine; Rogaine; Tricoxidil. $C_9H_{15}N_5O$; mol wt 209.25. C 51.66%, H 7.22%, N 33.47%, O 7.65%. Prepn: Neth. pat. Appl. 6,615,385; W. C. Anthony *et al.*, U.S. pat. 3,382,247 (1967, 1968 both to Upjohn); J. M. McCall *et al.*, *J. Org. Chem.* 40, 3304 (1975). *See also* W. C. Anthony, U.S. pat. 3,644,364 (1972 to Upjohn). Metabolism: R. C. Thomas *et al.*, *J. Pharm. Sci.* 64, 1360 (1975). Pharmacology and pharmacokinetics: D. T. Lowenthal *et al.*, *J. Clin. Pharmacol.* 18, 500 (1978). Percutaneous absorption and excretion: T. J. Franz, *Arch. Dermatol.* 121, 203 (1985). Clinical studies: O. Andersson, R. Sivertsson, *Acta Med. Scand.* 205, 213 (1979); M. Moser, *Advan. Cardiol.* 26, 38 (1979). Clinical trial in early male pattern baldness: E. A. Olsen *et al.*, *J. Am. Acad. Dermatol.* 13, 185 (1985). Toxicology: R. G. Carlson, E. S. Feenstra, *Toxicol. Appl. Pharmacol.* 39, 1 (1977). Review of pharmacology and therapeutic use: V. M. Campese, *Drugs* 22, 257-278 (1981). Review of topical application in baldness: E. Novak *et al.*, *Int. J. Dermatol.* 24, 82 (1985). Comprehensive description: D. K. J. Gorecki in *Analytical Profiles of Drug Substances* vol. 17, K. Florey, Ed. (Academic Press, New York, 1988) 185-219.

Crystals from methan
261° (Anthony, 1972). p
261, 285 nm (ε 35210, 1
280 nm (ε 26350, 23850):
(ε 36100, 11400, 12040).
75, methanol 44, ethanol
oxide 6.5, water 2.2, chl
acetate <0.5, diethyl eth
<0.5. LD_{50} in rats, m
Feenstra).

THERAP CAT: Antihyper

6123. Miokamycin.
dipropanoate; 9,3''-diace
mycin; Miocamycin.
60.18%, H 7.97%, N 1.56
deriv of midecamycin A
Kokai 74 124087 (1974 to
Omoto *et al.*, *J. Antibiot.*
Chem. Letters 1978, 1293
ties of crystalline and no
et al., *Chem. Pharm. Bul*
vivo antibacterial activity:
34, 436 (1981). Metab
Pharm. Bull. 29, 2413
studies: U. Shibata *et al.*,
C.A. 96, 62631x (1982).
studies: Y. Toyonaga *et*
216y (1983). Mutagenicit
Antibiot. 34, 443 (1981).



Tasteless crystals from
coloration). $[\alpha]_D^{25}$ −53° (c
(c = 1 in methanol): 231
acetone, chloroform. Ver
crystalline form converts
aqueous suspension. In 0
soln, the non-crystalline s
than the crystalline form.

THERAP CAT: Antibacter

6124. Mipafox. *N,N*
amidic fluoride; N,N'-di
ride; bis(isopropylamino)
Pestox XV. $C_6H_{16}FN_2O$
8.85%, F 10.43%, N 15.3
Pound *et al.*, Brit. pat. 68
Chem. Soc. 1956, 3796.

(CH_3)

(CH_3)

Crystals, mp 65°.

USE: Insecticide. *Cautic*

6125. Miraculin. Tast

REFERENCE 45

Reference 45

Hawley's Condensed Chemical Dictionary

ELEVENTH EDITION

Revised by

N. Irving Sax
and
Richard J. Lewis, Sr.

VNR VAN NOSTRAND REINHOLD COMPANY
New York

Use: Fluorinating reagent, catalyst, ion implantation source and dopant.

arsenic trioxide. (crude arsenic; white arsenic; arsenious acid; arsenious oxide; arsenous anhydride). CAS: 1327-53-3. As_2O_3.
Properties: White, odorless, tasteless powder, slightly soluble in water, soluble in acids and alkalies, soluble in glycerol, d 3.865. Sublimes on heating.
Derivation: Smelting of copper and lead concentrates. Flue dust to which pyrite or galena concentrations are added, yields As_2O_3 vapor. Condensation gives product of varying purity called crude arsenic (90–95% pure). A higher-purity oxide called white arsenic is obtained by resubliming the crude As_2O_3 (99+% pure).
Hazard: A human carcinogen, a poison.
Use: Pigments, ceramic enamels, aniline colors, decolorizing agent in glass, insecticide, rodenticide, herbicide, sheep and cattle dip, hide preservative, wood preservative, preparation of other arsenic compounds.

arsenic trisulfide. (arsenious sulfide; arsenic sulfide[yellow]; arsenous sulfide; arsenic tersulfide). CAS: 1303-33-9. As_2S_3.
Properties: Yellow crystals or powder, changes to a red form at 170C, d 3.43, mp 300C, insoluble in water and hydrochloric acid, dissolves in alkaline sulfide solutions and nitric acid.
Derivation: Occurs in nature as the mineral orpiment. May be precipitated from arsenious acid solution by the action of hydrogen sulfide.
Grade: Technical, pigment, single crystals.
Use: Pigment, reducing agent, pyrotechnics, glass used for infrared lenses, semiconductors, hair removal from hides.

arsine. (arsenic hydride). CAS: 7784-42-1. AsH_3.
Properties: Colorless gas, fp −113.5C, bp −62C, decomposes 230C, soluble in water, slightly soluble in alcohol, alkalies.
Derivation: Reaction of aluminum arsenide with water or hydrochloric acid, electrochemical reduction of arsenic compounds in acid solutions.
Grade: Technical, 99% pure or in mixture with other gases.
Hazard: Poison by inhalation. TLV 0.05 ppm.
Use: Organic synthesis, military poison, doping agent for solid state electronic components.

arsphenamine. A specific for syphilis originally developed by Ehrlich, but no longer in use. It was a derivative of arsenic and benzene.
See Ehrlich.

"Artic."[28] TM for refrigeration grade of methyl chloride.

artificial cinnabar. See mercuric sulfide, red.

artificial snow. A copolymer of butyl and isobutyl methacrylate, often dispersed from an aerosol bomb or other atomizing device, used in decorative window displays, etc. Man-made snow is crystallized water vapor made by mechanical means.

"Arubren CP."[470] TM for a highly chlorinated aliphatic hydrocarbon compound used in rubber compounds to decrease flammability of vulcanizates.

arylalkyl. A compound containing both aliphatic and aromatic structures, e.g., alkyl benzenesulfonate. Also called aralkyl.

aryl. A compound whose molecules have the ring structure characteristic of benzene, naphthalene, phenanthrene, anthracene, etc, i.e., either the six-carbon ring of benzene or the condensed six-carbon rings of the other aromatic derivatives. For example, an aryl group may be phenyl C_6H_5 or naphthyl $C_{10}H_9$. Such groups are often represented in formulas by "R."
See also alkyl.

As. Symbol for arsenic.

as-. Abbreviation for asymmetrical, same as uns-.

ASA. Abbreviation for acrylic ester-modified styrene acrylonitrile terpolymer.
See also "Luran sulfur."

asarone. See 2,4,5-trimethoxy-1-propenylbenzene.

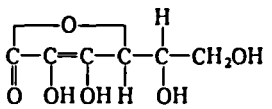
asbestine. A soft fibrous magnesium silicate. Used as a filler in paper, rubber, and plastics.

asbestos. CAS: 1332-21-4. A group of impure magnesium silicate minerals which occur in fibrous form. Colors: white, gray, green, brown. D 2.5. Noncombustible.
(1) Serpentine asbestos is the mineral chrysotile, a magnesium silicate. The fibers are strong and flexible so that spinning is possible with the longer fibers. A microcrystalline form, TM "Avibest," has been developed.
(2) Amphibole asbestos includes various silicates of magnesium, iron, calcium and sodium. The fibers are generally brittle and cannot be spun, but are more resistant to chemicals and to heat than serpentine asbestos.
(3) Amosite.
(4) Crocidolite.

Occurrence: Vermont, Arizona, California, North Carolina, Africa, Italy, Yukon, Quebec, Mexico,
Hazard: A carcinogen. Highly toxic by inhalation of dust particles. TLV (amosite) 0.5 fibers/cc more than 5 microns long; (chrysotile) 2 fibers/cc more than 5 microns long; (crocidolite) 0.2 fibers/cc more than 5 microns long; (other forms) 2 fibers/cc more than 5 microns long.
Use: Fireproof fabrics, brake lining, gaskets, roofing compositions, electrical and heat insulations, paint filler, chemical filters, reinforcing agent in rubber and plastics, component of paper dryer felts, diaphragm cells, cement reinforcement.
Note: A promising substitute for asbestos for cement reinforcement is glass fiber made from slate and limestone.

ascaridole. 1,4-peroxido-p-menthene-2). $C_{10}H_{16}O_2$.
Properties: A liquid, naturally occurring peroxide, bp 84C (5 mm), d 1.011 (13/15C), refr index 1.4743 (20C).
Derivation: By vacuum distillation of chenopodium oil.
Hazard: Strong oxidizing agent, explodes on heating to 130C or in contact with organic acids.
Use: Initiator in polymerization, medicine.

ascorbic acid. (l-ascorbic acid; vitamin C). CAS: 5081-7. $C_6H_8O_6$.



A dietary factor which must be present in the diet of man to prevent scurvy. It cures scurvy and increases resistance to infection. Ascorbic acid presumably acts as an oxidation-reduction catalyst in the cell. It is readily oxidized; citrus juices should not be exposed to air for more than a few minutes before use.
Properties: White crystals (plates or needles), mp 192C, soluble in water, slightly soluble in alcohol, insoluble in ether, chloroform, benzene, petroleum ether, oils and fats, stable to air when dry.
Sources: Food source: acerola (West Indian cherry); citrus fruits; tomatoes; potatoes; green, leafy vegetables. Commercial sources: Synthetic product made by fermentation of sorbitol.
Units: One international unit is equivalent to 0.05 milligram of l-ascorbic acid. Grade: USP, FCC.
Use: Nutrition, color fixing, flavoring and preservative in meats and other foods, oxidant in bread doughs, abscission of citrus fruit in harvesting, reducing agent in analytical chemistry. The iron, calcium and sodium salts are available for biochemical research.

ascorbic acid oxidase. An enzyme found in plant tissue which acts upon ascorbic acid in the presence of oxygen to produce dehydroascorbic acid.
Use: Biochemical research.

ascorbyl palmitate. $C_{22}H_{38}O_7$. A white or yellowish-white powder having a citrus-like odor. Mp 116–117C; soluble in alcohol, animal and vegetable oils; slightly soluble in water.
Derivation: Palmitic and l-ascorbic acids.
Grade: FCC.
Use: Antioxidant for fats and oils, source of vitamin C, stabilizer, emulsifier.

-ase. A suffix characterizing the names of many enzymes, e.g., diastase, cellulase, cholinesterase, etc. However, the names of some enzymes end in -in (i.e., pepsin, rennin, papain).

ash. (1) In analytical chemistry, the residue remaining after complete combustion of a material. It consists of mineral matter (silica, alumina, iron oxide, etc.) the amount often being a specification requirement. (2) The end product of large-scale coal combustion as in power plants; now said to be the sixth most plentiful mineral in the US. It consists principally of fly ash, bottom ash, and boiler ash. Some of its values are recoverable and there are a number of industrial uses of fly ash, e.g., in cement products and road fill.
See also fly ash.

askarel. A generic descriptive name for synthetic electrical insulating (dielectric) material which, when decomposed by the electric arc, evolves only nonexplosive gases or gaseous mixtures, i.e., chlorinated aromatic derivatives, particularly pentachlorodiphenyl and trichlorobenzene, but also including pentachlorodiphenyl oxide, pentachlorophenylbenzoate, hexachlorodiphenylmethane, pentachlorodiphenyl ketone, and pentachloroethylbenzene. Nonflammable.
Use: Insulating medium in transformers, dielectric fluid.
See also dielectric, transformer oil.

ASM. Abbreviation for American Society for Metals.

asparagic acid. See aspartic acid.

l-asparaginase. (l-asnase; colaspase; elspar). CAS: 9015-68-3. An enzyme used in the treatment of certain types of leukemia. Produced by biochemical activity of certain bacteria, yeasts, and fungi. Yields are in excess of 3500 units/g of source.

lava. Molten rock (magma) that has reached the surface of the earth.

lavandin oil. See lavender oil.

lavender oil. CAS: 8000-28-0. 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] TM for a series of synthetic lavender oil substitute of various types.

Lavoisier, Antoine Laurent. (1743–1794) A French chemist generally regarded as the "father" of chemistry. His "Traite 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 Mendeleef.

Lawrence, Ernest O. (1901–1958) An American physicist who invented the cyclotron in 1929. Both the element lawrencium and the Lawrence Livermore Research Laboratory at the University of California were named after him.
See also cyclotron, bombardment.

lawrencium. CAS: 22537-19-5. Lr. A synthetic radioactive element with atomic number 103, discovered in 1961, aw 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. The test applies not only to gases and vapors but to fumes, 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 necessary to kill 50% of exposed animals in laboratory tests within a specified time. A substance having an oral LD_{50} of less than 400 mg/kg of body weight is considered to be highly toxic.

LDPE. Abbreviation for low-density polyethylene.

leaching. See solvent extraction.

lead. CAS: 7439-92-1. Pb. (from Latin plumbum). Metallic element of atomic number 82, Group IVA of the periodic table, aw 207.2, valences = 2,4, four stable isotopes. The isotopes are the end products of the disintegration of three series of natural radioactive elements uranium (206), thorium (208), and actinium (207).
Properties: Heavy, ductile, soft, gray solid, d 11.35, mp 327.4C, bp 1755C, 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. Noncombustible.
Occurrence: US, Mexico, Canada, South 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), pyrometallurgical refining (Harris process). Bismuth is removed by Betterton-Kroll process.
Grade: 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. TLV (as Pb): (fumes and dusts and inorganic compounds) 0.15 mg/m³ of air. For ambient air the EPA standard is 1.5 micrograms/m³. A cumulative poison. FDA regulations require zero lead content in foods and less than 0.05% in house paints.
Use: 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). CAS: 301-04-2. $Pb(C_2H_3O_2)_2 \cdot 3H_2O$.
Properties: White crystals or flakes (commercial grades are frequently brown or gray lumps),

C

C. Symbol for carbon.

^{14}C. (carbon-14). The naturally occurring radioactive isotope of carbon used in chemical dating, tracer studies, etc.

Ca. Symbol for calcium.

CA. Abbreviation for cellulose acetate and cortisone acetate, also for controlled atmosphere.

C_3A. Abbreviation for tricalcium aluminate as used in cement.
See cement, Portland.

CAB. Abbreviation for cellulose acetate butyrate.

"Cab-O-Sil."[275] TM for colloidal silica particles sintered together in chain-like formations. Surface area ranges from 50 to 400 m^2/g, depending on grade.
Grade: Standard M-5, L-5, SD-20.
Use: Thickening and emulsifying agent for oil/water systems, drilling muds, cattle-feed supplements, tile cleaners, disperson of oil slicks on sea water, plastics, solar-heated ceiling tiles.

"Cab-O-Sperse."[275] TM for aqueous dispersions of pyrogenic silica for use in the paper and textile industries.

cacao butter. (cocoa butter). See theobroma oil.

C acid. (2-naphthylamine-4,8-disulfonic acid). $C_{10}H_5(NH)_2(SO_3H)_2$.
Properties: White, crystalline solid; slightly soluble in water.
Derivation: Reduction of 2-nitronaphthalene-4,8-disulfonic acid. The sodium salt is recrystallized from water.
Use: Azo dye intermediate.

cacodylic acid. (dimethylarsinic acid). $(CH_3)_2AsOOH$.
Properties: Colorless, odorless, deliquescent crystals; mp 200C; soluble in water, alcohol, and acetic acid; insoluble in ether.
Derivation: By distilling a mixture of arsenic trioxide and potassium acetate, and oxidizing the resulting product with mercuric oxide.
Hazard: Toxic by ingestion.
Use: Herbicide especially for control of Johnson grass on cotton, soil sterilant, chemical warfare, timber thinning.

cactinomycin. USAN name for an antibiotic produced from *Streptomyces* which is 10% dactinomycin and 90% two kinds of actinomycin C.

"Cadalume" L.[238] TM for a bright cadmium electroplating process for a protective coating on iron and steel. Materials used are CdO, NaCN, and addition agents.

"Cadalyte."[28] TM for a series of compounds for cadmium electroplating.

cadaverine. (1,5-diaminopentane; pentamethylenediamine). $NH_2(CH_2)_5NH_2$. A ptomaine formed in the decay of animal proteins after death, also made synthetically.
Properties: Syrupy, colorless, fuming, odorous liquid; mp 9C; bp 178–179C; soluble in water and alcohol, slightly soluble in ether.
Hazard: Toxic by ingestion, absorbed by skin, a skin and eye irritant.
Use: Preparation of high polymers, intermediate, biological research.

"caddy."[48] TM for a liquid cadmium fungicide used on turf grass.
Hazard: See cadmium.

Cade oil. See juniper tar oil.

cadiene. See sesquiterpene.

"Cadmate."[69] TM for cadmium diethyldithiocarbamate.
Hazard: See cadmium.

"Cadminate."[329] TM for a turf fungicide containing 60% cadmium succinate and 40% inert matter.
Hazard: See cadmium.

cadmium. CAS: 7440-43-9. Cd.
Metallic element of atomic number 48, group IIB of the periodic table. Aw 112.40. Valence 2. There are eight stable isotopes.
Properties: Soft, blue-white, malleable metal or grayish-white powder. Tarnishes in moist air, corrosion resistance poor in industrial atmospheres, becomes brittle at 80C. Resistant to alkalies, high neutron absorber. D 8.642, mp

320.9C, bp 767C, refr index 1.13, Mohs hardness 2.0. Soluble in acids, especially nitric, and in ammonium nitrate solution. Lowers melting point of certain alloys when used in low percentages. Combustible.
Occurrence: A greenockite (cadmium sulfide) ore containing zinc sulfide also with lead and copper ores containing zinc. Canada, central and western US, Peru, Australia, Mexico, Zaire.
Derivations: (1) Dust or fume from roasting zinc ores is collected, mixed with coal or coke and sodium or zinc chloride, and sintered. The cadmium fume is collected in an electrostatic precipitator, leached, fractionally precipitated, and distilled. (2) By direct distillation from cadmium-bearing zinc (3) By recovery from electrolytic zinc process (approximately 40%).
Hazard: Flammable in powder form. Toxic by inhalation of dust or fume. A carcinogen. Cadmium plating of food and beverage containers has resulted in a number of outbreaks of gastroenteritis (food poisoning). Soluble compounds of cadmium are highly toxic; however, ingestion usually induces a strong emetic action which minimizes the risk of fatal poisoning. Use as fungicide may be restricted. TLV: (Dust and soluble compounds) 0.05 mg/m³ of air; (oxide fume as Cd) ceiling 0.05 mg/m³ of air.
Grade: Technical, powder, pure sticks, ingots, slabs, high-purity crystals (less than 10 ppm impurities).
Use: Electrodeposited and dipped coatings on metals, bearing and low-melting alloys, brazing alloys, fire protection systems, nickel-cadmium storage batteries, power transmission wire, TV phosphors, basis of pigments used in ceramic glazes, machinery enamels, baking enamels, Weston standard cell control of atomic fission in nuclear reactors, fungicide, photography and lithography, selenium rectifiers, electrodes for cadmium-vapor lamps and photoelectric cells.

cadmium acetate. (a) $Cd(OOCCH_3)_2 \cdot 3HOH$; (b) $Cd(OOCCH_3)_2$.
Properties: Colorless crystals, soluble in water and alcohols. (a) d 2.01, mp loses water at 130C; (b) d 2.341, mp 256C.
Derivation: Interaction of acetic acid and cadmium oxide.
Hazard: See cadmium.
Use: Ceramics (iridescent glazes), manufacture of acetates, assistant in dyeing and printing textiles, electroplating baths, laboratory reagent.

cadmium ammonium bromide. (ammonium-cadmium bromide). $CdBr_2 \cdot 4NH_4Br$.
Properties: Colorless crystals. Soluble in alcohol and water.
Hazard: See cadmium.

cadmium antimonide. A semiconductor used in thermoelectric devices.
Hazard: See cadmium and antimony.

cadmium-base Babbitt. See Babbitt metal.

cadmium borotungstate. $Cd_5(BW_{12}O_{40}) \cdot 18HOH$.
Properties: Yellow, heavy crystals; mp 75C; soluble in water. The solution is yellow to light brown.
Grade: Technical.
Hazard: See cadmium.
Use: Separating minerals.

cadmium bromate. $Cd(BrO_3)_2 \cdot HOH$.
Properties: White crystals or crystalline powder, d 3.758, mp decomposes. Soluble in water, insoluble in alcohol.
Derivation: By adding cadmium sulfate to a solution of barium bromate.
Hazard: Strong oxidizer, dangerous in contact with organics. Highly toxic, irritant, oxidizer.
Use: Analytical reagent.

cadmium bromide. CAS: 7789-42-6. $CdBr_2$ or $CdBr_2 \cdot 4HOH$.
Properties: White to yellowish efflorescent crystalline, d 5.192, mp (anhydrous) 568C, bp 863C, soluble in water, acetone, alcohol, and acids.
Derivation: By heating cadmium in bromine vapor.
Grade: Technical, reagent.
Hazard: See cadmium.
Use: Photography, process engraving, lithography.

cadmium carbonate. CAS: 513-78-0. $CdCO_3$.
Properties: White, amorphous powder; d 4.258; decomposes at less than 500C; soluble in dilute acids and in concentrated solution of ammonium salts; insoluble in water.
Hazard: See cadmium.
Grade: Reagent.

cadmium chlorate. $Cd(ClO_3)_2 \cdot 2HOH$.
Properties: Colorless, prismatic crystals. Hygroscopic, d 2.28 (18C), mp 80C, soluble in alcohol, water, and acetone.
Grade: Technical.
Hazard: Dangerous in contact with organic materials.

cadmium chloride. CAS: 10108-64-2. (a) $CdCl_2$; (b) $CdCl_2 \cdot 2.5HOH$.
Properties: Small, white, odorless crystals; d (a) 4.05, (b) 3.327; mp (a) 568C; bp (a) 960C; soluble in water and acetone.

fonamide). CAS: 741-58-2. $C_6H_5SO_2NH(CH_2)_2SP(S)[OCH(CH_3)_2]_2$.
Properties: Colorless liquid, slight odor, d 1.25 (22C), insoluble in water, soluble in kerosene and xylene.
Hazard: Highly toxic, cholinesterase inhibitor, use may be restricted.
Use: Herbicide.

2-mercapto-4-hydroxypyrimidine. See thiouracil.

2-mercaptoimidazoline. See "NA-22."

β-mercaptopropionic acid. $HSCH_2CH_2COOH$.
Properties: Clear liquid, d 1.218 (21C), mp 16.8C, bp 111C (15 mm), soluble in water and alcohol.
Use: Stabilizer, antioxidant, catalyst, chemical intermediate.

6-mercaptopurine. (6-MP; 6-purinethiol).
CAS: 50-44-2. $C_5H_4N_4S \cdot HOH$. A sulfur-containing purine base not found in animal nucleoproteins.
Properties: Yellow, crystalline powder; mp 308C (decomposes); nearly odorless. Insoluble in water, soluble in hot alcohol and dilute alkali solutions, slightly soluble in dilute sulfuric acid.
Grade: USP.
Use: Medicine (to prevent rejection of kidney transplants).

mercaptosuccinic acid. See thiomalic acid.

2-mercaptothiazoline. C_2H_4NSSH. White crystals.
Use: Synthesis of pharmaceuticals.

D-3-mercaptovaline. See penicillamine.

mercerized cotton. See cotton, mercerized.

mercerizing assistant. A compound used to increase the penetration of mercerizing baths. Cresylic acid derivatives, special sulfonated oils and other wetting agents are typical.

mercuric acetate. (mercury acetate).
CAS: 1600-27-7. $Hg(C_2H_3O_2)_2$.
Properties: White, crystalline powder; soluble in alcohol and water; sensitive to light; d 3.2544.
Hazard: Toxic by ingestion, inhalation, and skin absorption; strong irritant. TLV (as mercury): 0.01 mg/m³ of air.
Use: Catalyst in organic synthesis, pharmaceuticals.

mercuric arsenate. (mercury arsenate).
CAS: 7784-37-4. $HgHAsO_4$.
Properties: Yellow powder, soluble in hydrochloric acid, slightly soluble in nitric acid, insoluble in water.
Hazard: Toxic by ingestion, inhalation, and skin absorption; strong irritant. TLV (as mercury): 0.05 mg/m³ of air.
Use: Waterproof paints, antifouling paints.

mercuric barium bromide. (barium mercury bromide; mercury barium bromide).
$HgBr_2 \cdot BaBr_2$.
Properties: Colorless, crystalline mass; very hygroscopic; soluble in water.
Hazard: Toxic by ingestion, inhalation, and skin absorption; strong irritant. TLV (as mercury): 0.05 mg/m³ of air.

mercuric barium iodide. (barium mercury iodide; mercury barium iodide). $HgI_2 \cdot BaI_2 \cdot 5HOH$.
Properties: Reddish or yellow crystalline mass, unstable, deliquescent, soluble in alcohol and water.
Hazard: Toxic by ingestion, inhalation, and skin absorption; strong irritant. TLV (as mercury): 0.05 mg/m³ of air.
Use: Microanalysis (testing for alkaloids), preparing Rohrbach solution.

mercuric benzoate. (mercury benzoate).
CAS: 583-15-3. $Hg(C_7H_5O_2)_2 \cdot H_2O$.
Properties: White crystals, mp 165C, sensitive to light, soluble in solutions of sodium chloride and ammonium benzoate, slightly soluble in alcohol and water.
Derivation: By the interaction of a mercuric salt and sodium benzoate.
Hazard: Toxic by ingestion, inhalation, and skin absorption; strong irritant. TLV (as mercury): 0.01 mg/m³ of air.
Use: Medicine (antisyphilitic).

mercuric bromide. (mercury bromide).
CAS: 7789-47-1. $HgBr_2$.
Properties: White, rhombic crystals; sensitive to light. Soluble in alcohol and ether, sparingly soluble in water, d 6.11, mp 235C, bp 322C.
Derivation: By adding potassium bromide to a solution of a mercuric salt and crystallizing.
Hazard: Toxic by inhalation, ingestion, and skin absorption; strong irritant. TLV (as mercury): 0.05 mg/m³ of air.
Use: Medicine.

mercuric chloride. (mercury bichloride; mercury chloride; corrosive sublimate).
CAS: 7487-94-7. $HgCl_2$.
Properties: White crystals or powder, odorless. Soluble in water, alcohol, ether, pyridine, glycerol, and acetic acid; d 5.44 (25C); bp 303C; mp 276C.
Derivation: (a) Direct combination of chlorine with mercury heated to volatilizing point, (b)

by subliming mercuric sulfate with common salt.
Method of purification: Recrystallization and sublimation. Impurities: Mercurous chloride.
Grade: Technical, crystals, granular, powder, CP, NF.
Hazard: Toxic by ingestion, inhalation, and skin absorption; a poison. TLV (as mercury): 0.05 mg/m³ of air.
Use: Manufacture of calomel and other mercury compounds, disinfectant, organic synthesis, analytical reagent, metallurgy, tanning, catalyst for vinyl chloride, sterilant for seed potatoes; fungicide, insecticide, and wood preservative; embalming fluids, textile printing, dry batteries, photography, process engraving and lithography.

mercuric chloride, ammoniated. See mercury, ammoniated.

mercuric cuprous iodide. (copper mercury iodide; mercury copper iodide). $HgI_2 \cdot 2CuI$.
Properties: Dark red, crystalline powder; d 6.12. Insoluble in alcohol and water.
Hazard: Highly toxic. TLV (as mercury): 0.05 mg/m³ of air.
Use: Thermoscopy (detecting overheating of machine bearings) by reversible color change.

mercuric cyanate. See mercury fulminate.

mercuric cyanide. (mercury cyanide).
CAS: 592-04-1. $Hg(CN)_2$.
Properties: Colorless, transparent prisms darkened by light. Soluble in water and alcohol, d 4.018, mp decomposes.
Derivation: Interaction of mercuric oxide and an aqueous solution of hydrogen cyanide.
Grade: Technical, CP.
Hazard: Toxic by ingestion, inhalation, and skin absorption. TLV (as mercury): 0.05 mg/m³ of air.
Use: Medicine (antiseptic), germicidal soaps, manufacturing cyanogen gas, photography.

mercuric dichromate. See mercury dichromate.

mercuric dimethyldithiocarbamate.
$C_6H_{12}N_2S_4Hg$.
Hazard: Highly toxic by ingestion, inhalation, and skin absorption. TLV (as mercury): 0.01 mg/m³ of air.
Use: Turf fungicides.

mercuric fluoride. (mercury fluoride).
CAS: 7783-39-3. HgF_2.
Properties: Transparent crystals, d 8.95, mp 645C decomposes, moderately soluble in water and alcohol.
Derivation: Mercuric oxide and hydrogen fluoride.
Hazard: Highly toxic by ingestion, inhalation, and skin absorption; strong irritant. TLV (as mercury): 0.05 mg/m³ of air.
Use: Synthesis of organic fluorine compounds.

mercuric iodide. (mercury iodide, red).
CAS: 7774-29-0. HgI_2.
Properties: Red, tetragonal crystals; turn yellow when heated to 130C, returning to red on cooling. Soluble in boiling alcohol and in solutions of sodium thiosulfate or potassium iodide or other hot alkali chloride solutions, almost completely insoluble in water, d 6.28, mp 259C, bp 349C.
Derivation: By the direct union of mercury and iodine.
Grade: Technical, reagent.
Hazard: Highly toxic by ingestion, inhalation, and skin absorption; strong irritant. TLV (as mercury): 0.05 mg/m³ of air.
Use: Medicine (antiseptic), analytical reagents (Nessler's reagent, Mayer's reagent).
See also mercuric potassium iodide.

mercuric lactate. $Hg(C_3H_5O_3)_2$.
Properties: White, crystalline powder; soluble in water; decomposed by heat.
Hazard: Toxic by ingestion, inhalation, and skin absorption. TLV (as mercury): 0.01 mg/m³ of air.
Use: Fungicide.

mercuric naphthenate. (mercury naphthenate).
Properties: Dark amber liquid, soluble in lubricating oils and mineral spirits, bulk d 10.4 lb/gal.
Grade: 25% mercury.
Hazard: Toxic by ingestion, inhalation, and skin absorption. TLV (as mercury): 0.05 mg/m³ of air.
Use: Mildew-resistance promoter in paints.

mercuric nitrate. (mercury nitrate; mercury pernitrate). CAS: 10045-94-0.
$Hg(NO_3)_2$.
Properties: Colorless crystals or white, deliquescent powder; d 4.3; mp 79C. Decomposed by heat, soluble in water and nitric acid, insoluble in alcohol.
Derivation: By action of hot nitric acid on mercury.
Hazard: Dangerous fire risk in contact with organic materials. Very toxic. TLV (as mercury): 0.05 mg/m³ of air.
Use: Nitration of aromatic organic compounds, felt manufacture, mercury fulminate manufacturing.

mercuric oleate. (mercury oleate).
CAS: 1191-80-6C010. $C_{36}H_{66}HgO_4$.
Properties: Yellowish to red semi-solid or solid mass, soluble in fixed oils, insoluble in water, slightly soluble in alcohol or ether.

longed heating), hot concentrated sulfuric acid, hot ammonium carbonate or ammonium succinate solutions; sparingly soluble in water; insoluble in alcohol and ether; d 7.307; sublimes at 340–350C; mp 405C.
Derivation: (a) Action of potassium bromide on solution of mercurous nitrate in dilute nitric acid. (b) Sublimation from mixture of mercury and mercuric bromide.
Hazard: Highly toxic by ingestion, inhalation, and skin absorption. TLV (as mercury): 0.05 mg/m³ of air.

mercurous chlorate. (mercury chlorate). CAS: 10294-44-7. $Hg_2(ClO_3)_2$.
Properties: White crystals, d 6.409, mp 250C (decomposes), soluble in alcohol, water, and acetic acid.
Hazard: Explodes in contact with organic or combustible materials, keep away from light. Highly toxic.

mercurous chloride. (mercury monochloride; mercury protochloride; mercury chloride, mild; calomel). CAS: 10112-91-1. Hg_2Cl_2.
Properties: White, rhombic crystals or crystalline powder; odorless; stable in air but darkens on exposure to light; insoluble in water, ether, alcohol, and cold dilute acids; d 6.993; mp 302C; bp 384C; decomposed by alkalies.
Derivation: By heating mercuric chloride and mercury with subsequent sublimation.
Grade: Technical, CP, NF.
Hazard: Toxic dose is uncertain.
Use: Fungicide, electrodes, pharmaceuticals, pyrotechnics, ceramic painting, maggot control in agriculture.

mercurous chromate. (mercury chromate). Hg_2CrO_4.
Properties: Brick-red powder, variable composition, decomposes on heating, soluble in nitric acid (concentrated), insoluble in alcohol and water.
Hazard: Moderate fire hazard in contact with organic materials. Highly toxic. TLV (as mercury): 0.05 mg/m³ of air.
Use: Ceramics (coloring green).

mercurous iodide. (mercury protoiodide). CAS: 15385-57-6. HgI or Hg_2I_2.
Properties: Bright yellow powder, becoming greenish on exposure to light due to decomposition into metallic mercury and mercuric iodide. Becomes dark yellow, orange, and orange-red on heating. Undergoes same color change in opposite order on cooling. Odorless and tasteless; soluble in castor oil, liquid ammonia, aqua ammonia; insoluble in water, alcohol, and ether; d 7.6445–7.75; sublimes at 140C; mp 290C (with partial decomposition).
Derivation: (a) Action of potassium iodide on a mercurous salt. (b) Boiling a solution of mercurous nitrate containing nitric acid with excess of iodine.
Grade: Technical.
Hazard: Toxic by ingestion, inhalation, and skin absorption. TLV (as mercury): 0.05 mg/m³ of air.
Use: Medicine (topical antibacterial).

mercurous nitrate, hydrated. CAS: 10415-75-5. $HgNO_3 \cdot 2HOH$.
Properties: Short prismatic crystals, effloresces and becomes anhydrous in dry air, sensitive to light, soluble in small quantities of warm water (hydrolyzes in larger quantities)and water acidified with nitric acid, d 4.785 (3.9C), mp 70C (decomposes).
Derivation: Action of cold dilute nitric acid upon an excess of mercury and warming slightly.
Hazard: May be explosive if shocked or heated. Highly toxic. TLV (as mercury): 0.05 mg/m³ of air.
Use: Analytical agent.

mercurous oxide. CAS: 15829-53-5. Hg_2O.
Properties: Black powder, d 9.8, decomposes at 100C, soluble in acids, insoluble in water.
Derivation: Action of sodium hydroxide on mercurous nitrate.
Hazard: Highly toxic. TLV (as mercury): 0.05 mg/m³ of air.

mercurous sulfate. CAS: 7783-36-0. Hg_2SO_4.
Properties: White to yellow, crystalline powder; soluble in hot sulfuric acid, dilute nitric acid; slightly soluble in water, d 7.56, decomposes on heating.
Derivation: (a) Dissolving mercury in sulfuric acid and heating gently. (b) Adding sulfuric acid to mercurous nitrate solution.
Hazard: Highly toxic. TLV (as mercury): 0.05 mg/m³ of air.
Use: Chemical (admixed with sulfuric acid as a catalyst, in oxidation of naphthalene to phthalic acid), batteries (Clark cell, Weston cell).

mercury. (quicksilver; hydrargyrum). CAS: 7439-97-6. Hg. Metallic element of atomic number 80, group IIB of the Periodic Table, aw 200.59, valences = 1,2; 4 stable isotopes and 12 artificially radioactive isotopes.
Properties: Silvery, extremely heavy liquid, sometimes found native; insoluble in hydrochloric acid; soluble in sulfuric acid upon boiling; readily soluble in nitric acid; insoluble in water, alcohol, and ether; soluble in lipids;, extremely high sur-

(a) 3.012; (b) 1.867; (c) 1.70. (a) Insoluble in water and acids; (b) soluble in water, insoluble in alcohol; (c) soluble in water and alcohol.
Derivation: Action of sulfuric acid on chromium hydroxide with subsequent crystallization.
Use: Chrome plating, chromium alloys, mordant, catalyst, green paints and varnishes, green ink, ceramics (glazes). The basic form (reduction of sodium dichromate) is used in tanning.

chromite. (chrome iron ore).
CAS: 1308-31-2. $FeCr_2O_4$. A natural oxide of ferrous iron and chromium, sometimes with magnesium and aluminum present. Usually occurs in magnesium and iron rich igneous rocks.
Properties: Color iron-black to brownish-black, streak dark brown, luster metallic to submetallic, d 3.6, Mohs hardness 5.5.
Grade: Metallurgical, refractory, chemical.
Occurrence: USSR, South Africa, Zimbabwe, Philippines, Cuba, Turkey.
Hazard: A carcinogen. TLV: 0.05 mg/m³ of air.
Use: Only commercial source of chromium and its compounds.

chromium. CAS: 7440-47-3. Cr. Metallic element of atomic number 24, group VIB of the Periodic Table, aw 51.996, valences=2,3,6; 4 stable isotopes. Name derived from Greek for color.
Properties: Hard, brittle, semi-gray metal; d 7.1; mp 1900C; bp 2200C. Compounds have strong and varied colors. Cr ion forms many coordination compounds. Exists in active and passive forms, the latter giving rise to its corrosion resistance due to a thin surface oxide layer that passivates the metal when treated with oxidizing agents. Active form reacts readily with dilute acids to form chromous salts. Soluble in acids (except nitric) and strong alkalies, insoluble in water.
Occurrence: USSR, South Africa, Turkey, Philippines, Zimbabwe, Cuba.
Derivation: From chromite by direct reduction (ferrochrome), by reducing the oxide with finely divided aluminum or carbon, and by electrolysis of chromium solutions.
Grade: (ore): Chromium ores are classified as (1) metallurgical, (2) refractory, and (3) chemical and their consumption in the US is in that order. (1) Must contain a minimum of 48% Cr_2O_3 and have Cr-Fe ratio of 3:1; (2) must be high in Cr_2O_3, and Al_2O_3 and low in iron; (3) must be low in SiO_2 and Al_2O_3 and high in Cr_2O_3.
Forms available: (1) Chromium metal as lumps, granules or powder; (2) high- or low-carbon ferrochromium; (3) single crystals, high-purity crystals, or powder run 99.97% pure.
Hazard: Hexavalent chromium compounds are carcinogenic (OSHA) and corrosive on tissue, resulting in ulcers and dermatitis on prolonged contact. TLV: For chromium dust and fume is 0.5 mg/m³ of air.
Use: Alloying and plating element on metal and plastic substrates for corrosion resistance, chromium-containing and stainless steels, protective coating for automotive and equipment accessories, nuclear and high-temperature research, constituent of inorganic pigments.

chromium-51. Radioactive Chromium of mass number 51.
Properties: Half-life 26.5D, radiation: gamma (0.32 MeV).
Grade: USP (as sodium chromate Cr-51 injection).
Hazard:Radioactive poison.
Use: Diagnosis of blood volume (as tracer).

chromium acetate. See chromic acetate.

chromium acetylacetonate.
$[CH_3COCHC(CH_3)O]_3Cr$.
Properties: Purple powder or red-violet crystals, mp 216C, bp 340C, insoluble in water, soluble in acetone and alcohol.
Derivation: Reaction of chromium chloride, acetylacetone and sodium carbonate.
Use: Reduction of detonation of nitromethane.

chromium ammonium sulfate. (ammonium chromium sulfate; chrome ammonium alum).
$CrNH_4(SO_4)_2 \cdot 12HOH$.
Properties: Green powder or deep violet crystals, d 1.72, mp 94C. Soluble in water, slightly soluble in alcohol. The aqueous solution is violet when cold, green when hot.
Grade: Technical.
Use: Mordant, tanning.

chromium boride. One of several compounds of chromium and boron, e.g., CrB, CrB_2, and Cr_3B_2. They have high melting points, are very hard and corrosion-resistant and may be suitable for use in jet and rocket engines.
Properties: CrB may be crystals, d 6.2, mp 1550C, Mohs hardness 8.5, resistivity 67 μ-ohm cm (20C). CrB_2: d 5.15, mp 1850C, hardness 2010 (Knoop), resists oxidation up to 1100C. Cr_3B_2: may be crystals, d 6.1, Mohs hardness 9+.
Use: Metallurgical additives, high-temperature electrical conductors, cermets, refractories, coatings resistant to attack by molten metals.

chromium bromide. See chromous bromide.

chromium carbide. Cr_3C_2.
Properties: Ortho-rhombic crystals, d 6.65, microhardness 2700 kg/sq mm (load 50 g), mp 1890C,

fuels were produced from coal on large scale in Germany by both hydrogasification and Fischer-Tropsch methods. More recently, large-scale coal conversion has been successfully achieved by the Lurgi and Sasol methods; the latter, in South Africa, is the only large-scale installation utilizing the Fischer-Tropsch technology. The Lurgi technique is in production at a number of locations.

Catalytic gasification of peat for production of methanol is now utilized on a commercial scale, use of lignite and wood for this purpose is under development.

See also Fischer-Tropsch process, synthesis gas.

gas, inert. See noble gas, inert.

gas laws. See Boyle's law, Charles' law, Gay-Lussac's law, ideal gas.

gas, liquefied petroleum. See liquefied petroleum gas.

gas liquid. See light hydrocarbon.

gas, natural. See natural gas.

gas, noble. See noble.

gas oil. A liquid petroleum distillate with viscosity and boiling range between kerosene and lubricating oil. Boiling range 232–426C, flash p 150F (65.5C), autoign temperature 640F (337C). Combustible.

Use: Absorption oil, manufacture of ethylene.

gasoline. CAS: 8006-61-9. A mixture of volatile hydrocarbons suitable for use in a spark-ignited internal combustion engine and having an octane number of at least 60. The major components are branched-chain paraffins, cycloparaffins, and aromatics. There are several methods of production: distillation or fractionation which yields straight-run product of relatively low octane number, used primarily for blending; thermal and catalytic cracking; reforming; polymerization; isomerization; and dehydrocyclodimerization. All but the first are various means of converting hydrocarbon gases into motor fuels by modifications of chemical structure, usually involving catalysis. The present source of gasoline is petroleum, but it may also be produced from shale oil and Athabasca tar sands as well as by hydrogenation or gasification of coal.

antinock gasoline A gasoline to which a low percentage of methyl-tert-butyl ether (MBTE) has been added to eliminate knocking and increase octane number. This compound has almost completely replaced tetraethyllead. Gasolines of octane number 100 or more are used chiefly as aviation fuel; those having a research octane number of approximately 90 are in general automotive use.

See also antiknock agent, octane number.

casinghead gasoline, see natural gasoline (below).

cracked gasoline Gasolines produced by the catalytic decomposition of high-boiling components of petroleum. In general, such gasolines have much higher octane ratings (80–100) than that produced by fractional distillation. The difference is due to the prevalence of unsaturated, aromatic and branched-chain hydrocarbons in the cracked gasoline. The actual properties vary widely with the nature of the starting material and the temperature, time, pressure, and catalyst used in cracking.

high-octane gasoline A gasoline with an octane number of 90–100.

See antiknock gasoline, octane number.

lead-free gasoline An automotive fuel containing no more than 0.05 g of lead per gallon, designed for use in engines equipped with catalytic converters.

natural gasoline A gasoline obtained by recovering the butane, pentane, and hexane hydrocarbons present in small proportion in certain natural gases. Used in blending to produce a finished gasoline with adjusted volatility but low octane number. Do not confuse with natural gas.

polymer gasoline A gasoline produced by polymerization of low molecular weight hydrocarbons such as ethylene, propene, and butenes. Used in small amounts for blending with other gasolines to improve their octane number.

pyrolysis gasoline Gasoline produced by thermal cracking as a byproduct of ethylene manufacture. It is used as a source of benzene by the hydrodealkylation process.

reformed gasoline A high octane gasoline obtained from low octane gasoline by heating the vapors to a high temperature or by passing the vapors through a suitable catalyst.

straight-run gasoline Gasoline produced from petroleum by distillation without use of cracking or other chemical conversion processes. Its octane number is low.

white gasoline An unleaded gasoline especially designed for use in motorboats; it is uncracked and strongly inhibited against oxidation to avoid gum formation and is usually not colored to distinguish it from other grades. It also serves as a fuel for camp lanterns and portable stoves.

Hazard: Highly flammable, dangerous fire and explosion risk. TLV 300 ppm.

gas, perfect. See ideal gas.

Gastaldi synthesis. Formation of dicyanopyrazines by cyclization of two molecules of an ami-

Use: Bacteriostat in soaps and detergents, plastics.

1,1,1-trichloroethane. (methyl chloroform). CAS: 71-55-6. CH_3CCl_3.
Properties: Colorless liquid, d 1.325, bp 75C, fp −38C, insoluble in water, soluble in alcohol and ether, flash p none. Nonflammable.
Hazard: Irritant to eyes and tissue. TLV: 350 ppm in air.
Use: Solvent for cleaning precision instruments, metal degreasing, pesticide, textile processing.

1,1,2-trichloroethane. (vinyl tichloride; β-trichloroethane). CAS: 79-00-5. $CHCl_2CH_2Cl$.
Properties: Clear, colorless liquid, characteristic sweet odor, bp 113.7C, d 1.4432 (20C/4C), refr index 1.4458, vap press 16.7 mm (20C), bulk d 12.0 lbs/gal (20C), fp −36.4C, flash p none. Miscible with alcohols, ethers, esters and ketones; insoluble in water. Nonflammable.
Grade: Technical.
Hazard: Irritant, absorbed by skin. TLV: 10 ppm in air.
Use: Solvent for fats, oils, waxes, resins, other products; organic synthesis.

trichloroethanol. CAS: 115-20-8. CCl_3CH_2OH.
Properties: Viscous liquid, ether-like odor, hygroscopic. Slightly soluble in water, miscible with alcohol, ether, and carbon tetrachloride. Bp 150C, fp 13C, d 1.541 (25/4C). Combustible.
Use: Intermediate, anesthetic.

trichloroethylene. (tri). CAS: 79-01-6. $CHCl{:}CCl_2$.
Properties: Stable, low-boiling, colorless, photoreactive liquid; chloroform-like odor; will not attack the common metals even in the presence of moisture. Bp 86.7C, fp −73C, d 1.456–1.462 (25/25C), refr index 1.4735 (27C), miscible with common organic solvents, slightly soluble in water. Nonflammable.
Derivation: From tetrachloroethane by treatment with lime or alkali in the presence of water, or by thermal decomposition, followed by steam distillation.
Grade: USP, technical, high purity, electronic, metal degreasing, extraction.
Hazard: Toxic by inhalation. Use as solvent not permitted in some states. FDA has prohibited its used in foods, drugs, and cosmetics. TLV: 50 ppm in air.
Use: Metal degreasing; extraction solvent for oils, fats, waxes; solvent dyeing; dry cleaning; refrigerant and heat exchange liquid; fumigant; cleaning and drying electronic parts; diluent in paints and adhesives; textile processing; chemical intermediate; aerospace operations (flushing liquid oxygen).

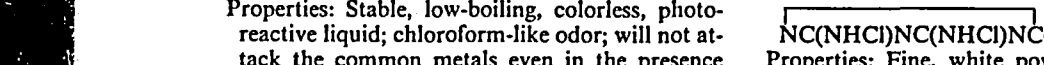
trichlorofluoromethane. (fluorotrichloromethane; fluorocarbon-11). CAS: 75-69-4. CCl_3F.
Properties: Colorless, nearly odorless, volatile liquid. Bp 23.7C, fp −111C, d 1.494 (17.2C), critical pressure 43.2 atmospheres. Noncombustible.
Derivation: From carbon tetrachloride and hafnium, in the presence of fluorinating agents such as antimony tri- and pentafluoride.
Grade: Technical, 99.9% min.
Hazard: TLV: CL of 1000 ppm in air.
Use: Solvent, fire extinguishers, chemical intermediate, blowing agent.

trichloroisocyanuric acid. (1,3,5-trichloro-s-triazine-2,4,6-trione). CAS: 87-90-1.

Properties: White, slightly hygroscopic, crystalline powder or granules; loose bulk d 31 lbs/cu ft, granular 60 lbs/cu ft; available chlorine 85%; decomposes 225C.
Hazard: Fire risk in contact with organic materials, strong oxidizing agent. Toxic by ingestion.
Use: Active ingredient in household dry bleaches, dishwashing compounds, scouring powders, detergent-sanitizers, commercial laundry bleaches, swimming pool disinfectant, bactericide, algicide, bleach, and deodorant.

trichloroisopropyl alcohol. See isopral.

trichloromelamine. (N,N',N'-trichloro-2,4,6-triamine-1,3,5-triazine).



Properties: Fine, white powder, slightly soluble in water and glacial acetic acid, insoluble in carbon tetrachloride and benzene, pH of saturated aqueous solution 4, autoign temperature 320F (160C).
Derivation: By chlorination of melamine.
Grade: 89% available chlorine.
Hazard: Dangerous fire risk, can ignite spontaneously in contact with reactive organic materials.
Use: Chlorine bleach and bactericide.

trichloromethane. See chloroform.

α-(trichloromethyl)benzyl acetate. See trichloromethylphenylcarbinyl acetate.

trichloromethyl chloroformate. (diphosgene). $ClCOOCCl_3$.
Properties: Colorless liquid; odor similar to phosgene (new mown hay); decomposed by heat, po-

Hazard (liquid): By ingestion and inhalation; skin irritant.
See also polymer, stereospecific.

polybutene. See polybutylene.

polybutylene. (polybutene; polyisobutylene; polyisobutene). Any of several thermoplastic isotactic (stereo-regular) polymers of isobutene of varying molecular weight, also polymers of butene-1 and butene-2. Butyl rubber is a type of polyisobutene to which has been added 2% of isoprene, which provides sulfur linkage sites for vulcanization. Isobutene can be homopolymerized to various degrees in chains containing from 10 to 1000 units, the viscosity increasing with molecular weight. Combustible.
See also "Vistanex."
Use: Lubricating-oil additive, hot-melt adhesives, sealing tapes, special sealants, cable insulation, polymer modifier, viscosity index improvers, films and coatings.

polybutylene terephthalate. An engineering plastic derived from 1,4-butanediol, it is a thermoplastic polyester with a broad spectrum of uses.

"Polycarbafil."[539] TM for a glass fiber-reinforced polycarbonate.

polycarbonate. $(COOC_6H_5C(CH_3)_2C_6H_5O)_n$.
A synthetic thermoplastic resin derived from bisphenol A and phosgene, a linear polyester of carbonic acid: Can be formed from any dihydroxy compound and any carbonate diester, or by ester interchange. Polymerization may be in aqueous emulsion or in nonaqueous solution.
Properties: Transparent (90% light transmission), noncorrosive, weather and ozone-resistant, nontoxic, stain-resistant. Combustible but self-extinguishing, low water absorption, high impact strength, heat-resistant, high dielectric strength, dimensionally stable, soluble in chlorinated hydrocarbons and attacked by strong alkalies and aromatic hydrocarbons, stable to mineral acids, insoluble in aliphatic alcohols. Excellent for all molding methods, extrusion, thermoforming etc.; easily fabricated by all methods including thermoforming and fluidized bed coating.
Use: Molded products, solution-cast or extruded film, structural parts, tubes and piping, prosthetic devices, meter face plates, nonbreakable windows, street-light globes, household appliances.

polycarboxylic acid. An organic acid containing two or more carboxyl (COOH) groups.

polychlor. General name for synthetic chlorinated hydrocarbons.
Use: Pesticides.

polychlorinated biphenyl. (PCB).
CAS: 1336-36-3. One of several aromatic compounds containing two benzene nuclei with two or more substituent chlorine atoms. They are colorless liquids with d 1.4–1.5. Because of their persistance, toxicity, and ecological damage via water pollution their manufacture was discontinued in the US in 1976.
Hazard: Highly toxic.

polychloroprene. See neoprene.

polychlorotrifluoroethylene. (PCTFE).
See chlorotrifluoroethylene polymer.

"Polycin."[202] TM for (1) an elastic, tacky, gel-like solid resulting from the polymerization of castor oil, used in rubber compounding, floor tile manufacture, and as a polymeric plasticizer; (2) a series of polyols used in the preparation and curing of urethane polymers for protective coatings, foamed insulation, and elastomers.

"Polyco."[65] TM for a series of thermoplastic polymers in the form of water emulsions or solvent solutions, applied to vinyl acetate polymers and copolymers, butadiene-styrene copolymer latics, polystyrenes, vinyl and vinylidene chloride copolymers, acrylic copolymers and water-soluble polyacrylates.
Use: Adhesives and coatings, in paint, leather, textiles, paper, cosmetics, and construction fields.

polycondensation. See condensation (1), polymerization.

polycoumarone resin. See coumarone-indene resin.

polycyclic. An organic compound having three or more ring structures, which may be the same or different, e.g., anthracene, naphthacene.
See polynuclear.

poly(1-4-cyclohexylenedimethylene)terephthalate.
TM "Kodel." A linear polyester film or fiber obtained by condensation of terephthalic acid with 1,4-cyclohexanedimethanol. It has good electrical resistivity and hydrolytic stability.
Use: Carpet fibers and chemically resistant films.
See also terephthalic acid.

"Polycyclol 1222."[214] TM for an intermediate for the preparation of alkyd-type resins used for coatings. These are known by the coined name "cyclyd."

poly-1,1-dihydroperfluorobutyl acrylate.
Properties: White, rubber-like polymer. D 1.5, be-

REFERENCE 46

SOURCE:

Callahan et al. Water Related Environmental Fate of 129 Priority Pollutants. U.S. Environmental Protection Agency, Office of Water Planning and Standards, Washington, DC. EPA-440/4-79-029b. 1979.

36. POLYCHLORINATED BIPHENYLS

36.1 Statement of Probable Fate

Polychlorinated biphenyls (PCBs) are a family of compounds which vary widely in physical, chemical, and biological properties. For those compounds with four or fewer chlorine atoms per molecule, biodegradation appears to be the dominant fate process and results in significant destruction and transformation. Polychlorinated biphenyls with five or more chlorine atoms per molecule have been photolyzed in experimental situations but it is difficult to extrapolate these results to environmental conditions.

Non-destructive processes which affect the distribution and transport of polychlorinated biphenyls are adsorption, volatilization, and bioaccumulation. In natural water systems, the greatest concentration of these compounds is sorbed to suspended and bed sediments due to the very low solubility in water. The tendency of polychlorinated biphenyls for adsorption increases with the degree of chlorination and with the organic content of the absorbent. The biota are another environmental compartment into which these compounds are strongly partitioned (measured bioconcentration factors range up to 10^6).

Volatilization and transport as an aerosol followed by fallout with dust or rain is the probable cause of the ubiquitous distribution of polychlorinated biphenyls. The more highly chlorinated species are less volatile than the lighter species. The presence of suspended solids tends to reduce volatilization, presumably because the solids adsorb the polychlorinated biphenyls and reduce the concentration in solution.

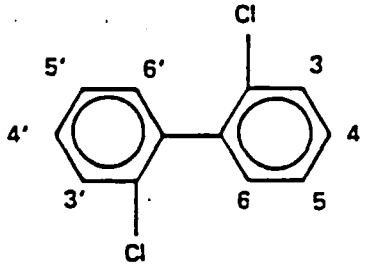
The available empirical evidence indicates that polychlorinated biphenyls, especially those with four or more chlorines, are persistent in the environment. The composition of polychlorinated biphenyls in the atmosphere is similar to that of Aroclor 1242 or 1016, while those in surface waters (mostly adsorbed to suspended solids) approach the composition of Aroclor 1254. Polychlorinated biphenyls in biota are heavier and more chlorinated still, and approximate the composition of Aroclor 1260. Thus the processes controlling distribution are somewhat selective, with the lighter species more likely to volatilize and the heavier species more likely to be incorporated into sediments and biota.

36.2 Identification

The Aroclors are technical mixtures of a number of the individual polychlorinated biphenyls made by the partial chlorination of biphenyl in the

presence of a suitable catalyst. In the designation of the individual Aroclors (Monsanto TM) a set of four digits was used, the first two, 12, to designate that the preparation is a mixture. The second set of two numbers is used to denote the approximate chlorine content by weight. Thus, Aroclor 1242 is a mixture having an average chlorine content of 42 percent. When it was determined that there was a significant environmental problem associated with the more heavily chlorinated species, Monsanto (the major American manufacturer) prepared a new mixture that was limited primarily to the mono, di and trichloro isomers. This product carried the designation Aroclor 1016.

Of the total of 209 possible compounds resulting from the partial or total chlorination of biphenyl, some 100 individual compounds have been detected in the various Aroclors (Hutzinger et al. 1974). The structure of a typical (2,2'-dichlorobiphenyl) member of the class of polychlorinated biphenyls is shown below.



CAS NO.: Each of the polychlorinated biphenyls compounds has been given an individual CAS number. The CAS numbers of the Aroclors are listed in Table 36-2.

TSL NO.: TSL numbers NZ32800, NZ3300, and NZ33500 have been assigned to three polychlorinated biphenyls mixtures. However, none of these mixtures coincide with the molecular composition of Aroclor species as listed by Monsanto.

The appropriate molecular compositon of the Aroclors is shown in Table 36-1.

36.3 Physical Properties

Individual polychlorinated biphenyls vary widely in their physical properties according to the degree and position of chlorination. However, all have a very low water solubility, low vapor pressure, and a high dielectric constant. The properties that make these compounds so widely used in industrial applications include excellent thermal stability, strong resistance to both acidic or basic hydrolysis, and general inertness (Gustafson 1970). The environmentally relevant physical properties of the Aroclors are presented in Table 36-2. Again, it is important to remember that the Aroclors are mixtures of many different polychlorinated biphenyls species. The physical properties of a mixture cannot be properly defined as

Table 36-1

Approximate Molecular Composition of Aroclors

(Percent) [Hutzinger *et al*. 1974]

Empirical Formula	Aroclor Number						
	1016	1221	1232	1242	1248	1254	1260
$C_{12}H_{10}$	<0.1	11	<0.1	<0.1	ND*	<0.1	ND
$C_{12}H_9Cl$	1	51	31	1	ND	<0.1	ND
$C_{12}H_8Cl_2$	20	32	24	16	2	0.5	ND
$C_{12}H_7Cl_3$	57	4	28	49	18	1	ND
$C_{12}H_6Cl_4$	21	2	12	25	40	21	1
$C_{12}H_5Cl_5$	1	<0.5	4	8	36	48	12
$C_{12}H_4Cl_6$	<0.1	ND	<0.1	1	4	23	38
$C_{12}H_3Cl_7$	ND	ND	ND	<0.1	ND	6	41
$C_{12}H_2Cl_8$	ND	ND	ND	ND	ND	ND	8
$C_{12}H_1Cl_9$	ND	ND	ND	ND	ND	ND	ND
Average Molecular Weight	257.9	200.7	232.2	266.5	299.5	328.4	375.7

*ND denotes none detected.

Table 36-2

Properties of Aroclors[a,b]

Property	1016	1221	1232	1242	1248	1254	1260
Appearance	Clear Oil	Clear Oil	Clear Oil	Clear Oil	Clear Oil	Light Yellow Viscous Liquid	Light Yellow Sticky Resin
Chlorine (Percent)	41	20.5-21.5	31.4-32.5	42	48	54	60
Density (gm/cm^3) (25°C)	1.33	1.15	1.24	1.35	1.41	1.50	1.58
Distillation Range (°C)	325-356	275-320	290-325	325-366	340-375	365-390	385-420
Evaporation Loss (%) 100°C/6 hrs	NA	1-1.5	1-1.5	0-0.4	0-0.3	0-0.2	0-0.1
Aqueous Solubility (mg/l)	0.42[c]	[15.0]	[1.45]	0.24 0.34[c] 0.13[d]	0.054	0.012 0.024[d] 0.056[i]	0.0027
Vapor Pressure (mm Hg @ 25°C)	[4×10^{-4}]	[6.7×10^{-3}]	[4.06×10^{-3}]	4.06×10^{-4}	4.94×10^{-4}	7.71×10^{-5}	4.05×10^{-5}
Octanol/Water Partition Coefficient (Log P)	4.38[c] >5.58[e,f]	[2.8] 4.09[f,g]	[3.2] >4.54[f,g]	4.11[c] >5.58[e,f]	[5.75][h] >6.11[e,f]	[6.03][h]	[7.14][h] >6.11[e,f]
CAS NO.		111-042-82	111-411-65	534-692-19	126-722-96	110-976-91	110-968-25

a. All values not subscripted are from Monsanto (1974).
b. Bracketed data are estimated.
c. Paris *et al.* (1978).
d. Dexter and Pavlou 1978.
e. Chiou *et al.* 1977.
f. Partition coefficient of lowest chlorinated polychlorinated biphenyl present in significant quantities.
g. Tulp and Hutzinger 1978.
h. Hansch *et al.* 1974 and Chiou *et al.* 1977.
i. Haque *et al.* 1974.

constants. The true solubility of a mixture for example is undefined because the water concentration at equilibrium is controlled by partitioning of the individual components between water and the mixture itself. The physical properties of the individual polychlorinated biphenyls are not identical, and, consequently, selective solubilization of the more soluble lower chlorinated components will occur. Conversely, the more highly chlorinated compounds will be selectively partitioned into the mixture. The measured solubilities or the equilibrium mass concentration as well as the other properties of the mixture will be an average of the properties of the individual chlorinated biphrnyls. Theoretically, from a knowledge of the equilibrium mass concentrations, the individual solubilities can be determined or visa versa (Dexter and Pavlou 1978; Paris et al. 1978; Tulp and Hutzinger 1978). In Table 36-2, the physical properties of several mixtures are presented.

36.4 Summary of Fate Data

36.4.1 Photolysis

Irradiation of polychlorinated biphenyls with short-wave ultraviolet light has been shown to produce partial dechlorination in the vapor phase (Maugh 1973) and, in water with ozone, essentially complete destruction (Versar 1976). Experimental results of Bunce and Kumar (1978) indicate that the more highly chlorinated species are susceptible to photolysis, resulting in the formation of dehalogenated or substituted products. These products may be accompanied by chlorinated biphenylenes and chlorinated dibenzofurans (Safe et al. 1976). Photoproducts of polychlorinated biphenyls isomers are listed in Table 36-3 (from Safe et al. 1976). There is some doubt as to the applicability of these experiments to environmental conditions, however, since such experiments are carried out in media other than water due to the low aqueous solubility of polychlorinated biphenyls.

Safe and co-workers (1976) suggest the following mechanism for photochemical breakdown or transformation of polychlorinated biphenyls:

"The accepted route for the photochemical excitation of aromatics in the 280-320 nm region occurs by a transition of electrons in the π ground state to an excited state (π^*). From the excited state, which can be of singlet or triplet multiplicity, the carbon-halogen bond undergoes fission giving rise to an aryl and a hydrogen radical. The radicals then abstract hydrogen from the medium or dimerize and, in addition, a hydrogen halide can also be detected. Prior to bond fission an alternative reaction between the excited state and a nucleophilic species can occur giving the appropriate substitution product at the C-X bond."

Table 36-3

PHOTOPRODUCTS OF PCB ISOMERS (from Safe *et al.* 1976)

PCB Isomer	Photoproducts	Solvent
4,4'-dichlorobiphenyl	4-chlorobiphenyl	methanol
2,4,6-trichlorobiphenyl	2,4-dichlorobiphenyl 4-chlorobiphenyl	cyclohexane
2,4,5-trichlorobiphenyl	3,4-dichlorobiphenyl 4-chlorobiphenyl	cyclohexane
3,4,2'-trichlorobiphenyl	3,4-dichlorobiphenyl	cyclohexane
2,2',4,4'-tetrachlorobiphenyl	2,4,4'-trichlorobiphenyl 4,4'-dichlorobiphenyl 2,4,4'-trichloro-2'-methoxy-biphenyl	methanol
2,2',5,5'-tetrachlorobiphenyl	2,5,3'-trichlorobiphenyl 3,3'-dichlorobiphenyl 3-chlorobiphenyl trichloromethoxybiphenyl dichlorodimethoxybiphenyl chlorohydroxybiphenyls	methanol dioxane-water
2,2',3,3'-tetrachlorobiphenyl	2,3,3'-trichlorobiphenyl 3,3'-trichlorobiphenyl trichloromethoxybiphenyl	methanol
2,2',6,6'-tetrachlorobiphenyl	2,2',6-trichlorobiphenyl 2,2'-dichlorobiphenyl trichloromethoxybiphenyl	methanol
3,3',4,4'-tetrachlorobiphenyl	3,4,4'-trichlorobiphenyl 4,4'-dichlorobiphenyl trichloromethoxybiphenyl	methanol
3,3',5,5'-tetrachlorobiphenyl	3,3',5-trichlorobiphenyl	methanol
2,3,4,5-tetrachlorobiphenyl	3,4,5-trichlorobiphenyl 3,4-dichlorobiphenyl	cyclohexane
2,3,5,6-tetrachlorobiphenyl	2,3,5-trichlorobiphenyl 3,5-dichlorobiphenyl	cyclohexane
2,2',4,4',6,6'-hexachlorobiphenyl	dechlorinated product (mono pentachlorobiphenyls quaterphenyls, biphenylene dibenzofurans, chloro-methoxybiphenyls	hexane and methanol
2,2',4,4',5,5'-hexachlorobiphenyl	dechlorinated products chlorinated quaterphenyls	hexane and methanol
2,2',3,3',4,4',5,5'-octachloro-biphenyl	dechlorinated products	
Aroclor 1254	dechlorinated, hydroxylated and hydrated photoproducts	dioxane-water

When the rate of polychlorinated biphenyls photolysis in oxygen-saturated solutions is compared with the rate in anoxic solutions, it is evident that oxygen supresses photolysis, apparently by acting as a free radical quencher. This supports the contention that an intermediate triplet excited state is involved in the photolytic reaction (Safe et al. 1976). Since in natural waters the photic zone corresponds to the most oxygen-rich zone (due to photosynthesis), dissolved oxygen is an inherent limitation on the rate of aqueous polychlorinated biphenyl photodegradation.

Bunce and Kumar (1978) measured photolysis of several polychlorinated biphenyl species in a 4:1 acetonitrile-water solution and calculated the approximate rate of dechlorination under environmental conditions. For shallow waters and typical environmental PCB concentrations, they predicted that up to 5% of the lightly chlorinated polychlorinated biphenyls molecules might lose a chlorine atom in one year, but that at least one chlorine atom should be lost from each highly chlorinated molecule annually. The authors stress the limitations of the assumptions made in this calculation, but if accurate, it is very significant since the less-chlorinated species can be biodegraded while the heavier species cannot. Furthermore, Bunce and Kumar point out the fact that if polychlorinated biphenyls concentrate heavily in the surface film, the photolytic rates would be much higher than those calculated.

Thus it is possible that photolysis results in the breakdown of the more highly-chlorinated polychlorinated biphenyl species. Even though the rate of such breakdown is slow, it is significant since none of the other fate processes result in degradation of the heavier species.

36.4.2 Oxidation

Polychlorinated biphenyls are extremely resistant to oxidation (Hutzinger et al. 1974). Gustafson (1970) cites a Monsanto technical bulletin that "they can be heated to 140°C under 260 p.s.i. of oxygen pressure without showing any evidence of oxidation as judged by development of acidity or formation of sludge." Thus chemical oxidation is not important as an environmental fate process.

36.4.3 Hydrolysis

Polychlorinated biphenyls are strongly resistant to both acidic and basic hydrolysis (Gustafson 1970; Hutzinger et al. 1974). Hydrolysis does not appear to be important in terms of environmental fate.

36.4.4 Volatilization

Volatilization and/or aerosol dispersion of polychlorinated biphenyls is thought to account for their ubiquitous distribution. Atmospheric transport followed by fallout with dust or rain is largely responsible for the fact that polychlorinated biphenyls have been detected in air over Baltimore, Maryland (Paris, et al. 1978) in "rainwater in England, brown seals off the coast of Scotland, white-tailed eagles in Sweden, cod in the Baltic Sea, mussels in the Netherlands, Adelie penguins in the Antarctica, brown pelican eggs in Panama, Arctic terns, shrimp in Florida, river water in Japan (and) waters in the Great Lakes" (Gustafson 1970). Although these compounds have a fairly high molecular weight and low vapor pressure, they have a remarkably high activity coefficient in water which causes a high equilibrium vapor partial pressure (Mackay and Wolkoff 1973). As a result, the rate of volatilization is somewhat higher than might be expected.

Mackay and Wolkoff (1973), and later Mackay and Leinonen (1975) calculated the evaporative half-life of Aroclors 1242, 1248, 1254, and 1260 in a water column 1 meter deep on the basis of an approach assuming thermodynamic equilibrium. The estimated half-lives for the Aroclors published by Mackay and Leinonen range from 9.5 hours for Aroclor 1248 to 12.1 hours for Aroclor 1242 (see Table 36-4). The Mackay and Wolkoff (1973) model suggests that volatilization results from the entrainment of solute molecules in the stream of evaporating water molecules. The rate at which the solute molecules are so carried off is determined by the effective surface concentration of the solute and by the evaporative rate of the water. The model proposed by Mackay and Leinonen (1975) is based on the assertion that equilibrium will be reached when the chemical potential for the solute in the air and in the aqueous phases are equal; the driving force is the actual inequality of these chemical potentials. Here, again, the controlling concentration is that of the solute at the surface. Neither of these models are directly concerned with those processes that act in the aqueous phase to control the surface concentration and thus are based on the assumption of sufficiently perfect mixing within the aqueous phase so that the surface phenonmena are rate-controlling in the volatilization process. Since the Mackay and Leinonen (1975) model has a more acceptable thermodynamic basis, the results presented herein are calculated from this model rather than from Mackay and Wolkoff (1973).

It should be noted that, even though the Aroclor mixtures 1016, 1221 and 1232 have larger proportions of the more volatile (i.e., higher vapor pressure) mono-, di- and trichloro species that does 1242, they also exhibit higher ultimate aqueous solubility so that, without a direct measure of the Henry constant, it is not possible to assert that these species will volatilize more rapidly than does Aroclor 1242.

Table 36-4

Calculated Volatilization Half-Life at 25°C, in 1 m^3 water, 1 m deep

Preparation	Henry Law Constant [Atmos m^3/mole]	$t_{1/2}$ (hrs)
Aroclor 1242[a]	5.7×10^{-4}	12.1
Aroclor 1248[a]	3.5×10^{-3}	9.5
Aroclor 1254[a]	2.8×10^{-3}	10.3
Aroclor 1260[a]	7.1×10^{-3}	10.2
Aroclor 1016[b]	-	9.9

[a]MacKay and Leinonen 1975.

[b]Paris *et al*. 1978.

Haque et al. (1974) demonstrated that volatilization of Aroclor 1254 is much slower from soil than from sand or unadulterated PCB solution. Apparently adsorption by organic materials in the soil greatly reduces the concentration of "free" PCB's in solution which can evaporate.

The reduction of volatilization by adsorption may explain the fact that polychlorinated biphenyls in most natural water samples evaporate at a much slower rate than that predicted by Mackay and Wolkoff (1973) or Mackay and Leinonen (1975). Oloffs et al. (1972) showed that volatilization loss of Aroclor 1260 from solutions of 100 μg/l in river water was only 67% after 12 weeks. When sediment was added to the system maximum loss was only 34% after 12 weeks (Oloffs et al. 1973). Tucker et al. (1975) demonstrated volatilization rates of 4.2 and 3.6% for Aroclor, 1221 and 1016, respectively over a 24-hour period in aerated samples exposed to activated sludge.

All of the above measurements indicate volatilization half-lives considerably longer than those estimated by Mackay and Wolkoff (1973) and Mackay and Leinonen (1975). The estimated half-life resulting from the Oloffs et al. (1973) experiment would be of the order of 1260 hours, which is to be compared to the Mackay and Leinonen (1975) estimate of 10.2 hours.

Although empirical evidence shows that volatilization is slow under natural conditions, the lack of destructive processes for the more highly chlorinated polychlorinated biphenyls indicates that volatilization is an important transport process. The persistence of these compounds, along with the transport afforded them by volatilization, is probably the major factor in their widespread distribution.

36.4.5 Sorption

Adsorption to sediments is the major non-destructive process affecting polychlorinated biphenyls after introduction to the aquatic environment. The combination of low water solubility (.0027-15 mg/l) and high octanol/water partition coefficient (2.8-7.4) (also see Table 36-2) indicates that polychlorinated biphenyls will have a high affinity for suspended solids, especially those high in organic carbon (Hamelink et al. 1971). This has been confirmed by a number of experiments which have shown that polychlorinated biphenyls are quickly adsorbed and that the greatest amount is usually associated with sediments or soils in soil-water systems (Oloffs et al. 1973; Haque et al. 1974; Hetling et al. 1978; Moein 1976; Moein et al. 1976; Paris et al. (1978). Paris et al. (1978) found the partition coefficients for polychlorinated biphenyl between water and a variety of bacteria, seston, and sediments to be only an order of magnitude less than the corresponding octanol/water partition coefficient.

When contamination becomes sufficiently high, sediments may serve as a reservoir for re-solution of polychlorinated biphenyls (Veith and Comstock 1975). This fact has important ramifications for areas where polychlorinated biphenyls are spilled; even after the initial degradation in water quality, release of these compounds by sediments can cause long-term pollution. For example, Wilson and Forester (1978) report that for 7 years following a spill, oyster tissue (Crassostrea virginica) still contained measurable quantities of Aroclor 1254 even though the amount in water was below detectable levels.

Polychlorinated biphenyls have an even greater affinity for oil than for sediments (Sayler and Colwell 1976). In areas polluted by both oil and polychlorinated biphenyls, microbes capable of degrading each of the pollutants separately appear to be inhibited by the high concentrations in combination.

The preferential sorption of polychlorinated biphenyls on the organic fraction of the suspended solids coupled with the entrance of these suspended solids into the sediments is thought to be a major mechanism for the immobilization in aquatic systems. The persistance of these chemicals, however, makes re-solution a possibility for years after they have entered the sediments.

36.4.6 Bioaccumulation

Since polychlorinated biphenyls are adsorbed strongly to organic sediments, it is not surprising to find that they are also strongly bioaccumulated. Their resistance to biodegradation implies that they will be quite persistent in organisms. This is indeed the case.

The potential for bioaccumulation of polychlorinated biphenyls species is directly related to the number of chlorines for two reasons: first, the more highly chlorinated species have a greater octanol/water partition coefficient, and secondly, the heavier polychlorinated biphenyls species are more resistant to biodegradation (Metcalf et al. 1975; EPA 1977).

Numerous authors have published the concentrations of polychlorinated biphenyls in various aquatic and terrestrial organisms. Although the ambient concentrations are not often reported along with the in vivo concentrations, it is suggested that bioaccumulation factors are usually on the order of 10^4 -10^6. Although these factors are very high, it is probable that the total reservoir of polychlorinated biphenyls in the oceanic water column is higher than the total reservoir in oceanic biota (Clayton et al. 1977).

Polychlorinated biphenyls can be passed along a food chain; however, biomangification is apparently not a controlling factor in attaining the levels found in aquatic organisms (Metcalf et al. 1975; Clayton et al. 1977). Scura and Theilacker (1977) found that the partition coefficient for each organism in an aquatic food chain determined the ultimate level and not the food chain itself.

36.4.7 Biotransformation and Biodegradation

Individual polychlorinated biphenyl species vary widely in their susceptibility to biodegradation. The mono-, di-, and tri-chlorinated species can be degraded by an array of organisms ranging from bacteria to man. Polychlorinated biphenyls with five or more chlorines per molecule are quite resistant to biodegradation.

The mechanism of polychlorinated biphenyl biodegradation has been investigated thoroughly (Hutzinger et al. 1972; Metcalf et al. 1975; Branson et al. 1975; Berlin et al. 1975; Kaiser and Wong 1974; Wong and Kaiser 1976; Furakawa et al. 1978). For the purposes of this study, it suffices to say that biodegradability of these compounds is a function of the number of C-H bonds available for hydroxylation by microsomal oxidation. Adjacent unchlorinated carbons allow the formation of arene oxide intermediates and thus facilitate metabolism. There are exceptions to this simple rule however. For example, in a study of the biodegradation of 31 isomers of polychlorinated biphenyls by Alcaligenes and Actinobacter, chlorinated biphenyl containing two chlorines on either the ortho position of a single ring (i.e., 2.6-) or both rings (i.e., 2,2'-) showed very poor degradability (Furakawa et al. 1978). Whether this will be a general phenomenon for all organisms is yet to be determined.

Rates of biodegradation vary widely, depending on the composition and distribution of biota, concentration of polychlorinated biphenyls, availability of other nutrients, temperature, and other factors. Tucker et al. (1975) reported the rates listed below for degradation of mixtures of polychlorinated biphenyls in an acclimated semi-continuous activated sludge experiment with 48-hour exposure:

Aroclor	% Degradation
1221	81 ± 6
1016	33 ± 14
1242	26 ± 16
1254	19 ± 38

Tulp et al. 1978, in contrast, found that the metabolism of th single compound 4,4'-dichlorobiphenyl by a mixed culture of bacteria lated from activated sludge was almost totally suppressed by alte-

carbon sources such as glucose, glycerol, peptone, yeast extract, humic acid or activated sludge. Though the interpretation of the latter result is trivial it points out the difficulty in extrapolating conclusions drawn from laboratory studies to the environment.

Wong and Kaiser (1976) published data on the degradation of 2-mono-chlorobiphenyl (0.05%) and 4-monochlorobiphenyl (0.05%) by a mixed culture of bacteria (predominately Achromobacter sp) isolated from lake waters. Interpolating from a graph presented in their paper, the half-life of the former was about 100 hours and the latter was 175 hours.

Metcalf and co-workers (1975) studied the behavior of 2,5,2'-trichlorobiphenyl; 2,5,2',5'-tetrachlorobiphenyl; and 2,4,5,2',5',-pentachlorobiphenyl in a model ecosystem. After 33 days, the concentrations of the parent materials and metabolites in the water column and organisms were measured. The trichlorobiphenyl species was degraded considerably, but the tetra- and penta-chlorinated forms were, for the most part, unchanged and were strongly bioaccumulated.

The polychlorinated biphenyl species composing the heavier Aroclor mixtures are essentially non-biodegradable. Oloffs et al. (1972) showed that there was no degradation of the polychlorinated biphenyls in Aroclor 1260 over 12 weeks in natural water samples. In a study of the distribution and fate of Aroclor 1254 after a spill of transformer fluid, Moein et al. (1976) concluded that "no detectable reduction in the concentration of this mixture in the soil has occurred as the result of chemical transformation or biodegradation". This study compared the polychlorinated biphenyls found in soil samples in 1975 to those found in mixtures (askarels) used in the transformer in 1973.

To summarize, biodegradation is very likely to be an important fate process for the mono-, di-, and tri-chlorinated biphenyls, but does not have a signficant effect on polychlorinated biphenyls with five or more chlorines. The tetra-chlorinated biphenyls are intermediate in their susceptibility to biodegradation.

36.5 Data Summary

Biodegradation is the only process known to transform polychlorinated biphenyls under environmental conditions, and only the lighter compounds are measurably biodegraded. There is experimental evidence that the heavier polychlorinated biphenyls (five chlorines or more per molecule) can be photolyzed by ultraviolet light, but there are no data to indicate that this process is operative in the environment.

Volatilization is probably responsible for the global disperson of polychlorinated biphenyls, but on the basis of mass, aqueous transport (either adsorbed to suspended solids or in "solution") is probably the more significant process.

Polychlorinated biphenyls are strongly partitioned to organic solids and biota. Their incorporation into deep sediments is an important sink resulting in immobilization. However, resuspension of these sediments could cause them to be released back into the water column.

The fate of polychlorinated biphenyls is summarized in Table 36-5.

Table 36-5

Summary of Aquatic Fate of Polychlorinated Biphenyls

Environmental Process[a]	Summary Statement	Rate	Half-Life ($t_{1/2}$)	Confidence of Data
Photolysis	May result in destruction of heavier PCBs.	-	-	Low
Oxidation	PCBs are stable to oxidation.	-	-	High
Hydrolysis	PCBs are stable to hydrolysis	-	-	High
Volatilization	Important mechanism for transport. Volatility depressed by presence of organic solids.	Varies widely	Varies widely	Medium
Sorption	PCBs strongly adsorbed by solids, especially with high organic content.	Typically rapid	-	High
Bioaccumulation	Bioaccumulation factors range from about 10^4 - 10^6 .	Typically rapid	-	High
Biotransformation/ Biodegradation	The only proven mode of destruction of PCBs, but only important for those with fewer than 4 chlorines per molecule.	Varies widely	-	High

a. There is insufficient information in the reviewed literature to permit assessment of a most probable fate.

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Reference 47

Dangerous Properties of Industrial Materials

Seventh Edition

Volume III

N. IRVING SAX

and

RICHARD J. LEWIS, SR.

VAN NOSTRAND REINHOLD
NEW YORK

THR: Moderately toxic by ingestion. An allergen. Habitual users develop, "absinthism" with tremors, vertigo, vomiting and hallucinations. May cause a contact dermititis. When heated to decomposition it emits acrid smoke and irritating fumes.

ARL375 *HR: 2*
ARTEMISINE
CAS: 63968-64-9 NIOSH: KD 4170000
mf: $C_{15}H_{22}O_5$ mw: 282.37

PROP: Needles. Mp: 156-157°. Sol in most aprotic solvents. Sltly sol in oil.

SYNS:
ARTEANNUIN
ARTEMISININ
OCTAHYDRO-3,6,9-TRIMETHYL-3,12-EPOXY-12H-PYRANO(4,3-j)-1,2-BENZODIOXEPIN-10(3H)-ONE
QINGHAOSU (CHINESE)
QING HAU SAU (CHINESE)

TOXICITY DATA:	CODEN:
orl-mus LD50:5105 mg/kg	CMJODS 92,811,79
ipr-mus LD50:1558 mg/kg	CMJODS 92,811,79
ims-mus LD50:2800 mg/kg	CMJODS 92,811,79

THR: Moderately toxic by ingestion, intramuscular, and intraperitoneal routes. When heated to decomposition it emits acrid smoke and fumes.

ARL500 *HR: 3*
d-ARTERENOL
CAS: 149-95-1 NIOSH: DN 6125000
mf: $C_8H_{11}NO_3$ mw: 169.20

SYN: α-(AMINOMETHYL)-3,4-DIHYDROXYBENZYL ALCOHOL

TOXICITY DATA:	CODEN:
ivn-rat LD50:1400 μg/kg	JPETAB 95,502,49
ivn-mus LD50:18 mg/kg	JPETAB 95,502,49

THR: Poison by intravenous route. When heated to decomposition it emits toxic fumes of NO_x.

ARL750 *HR: 3*
dl-ARTERENOL
CAS: 138-65-8 NIOSH: DN 6300000
mf: $C_8H_{11}NO_3$ mw: 169.20

SYN: α-(AMINOMETHYL)-3,4-DIHYDROXYBENZYL ALCOHOL

TOXICITY DATA:	CODEN:
ivn-rat LD50:130 μg/kg	JPETAB 95,502,49
ivn-mus LD50:4700 μg/kg	JPETAB 95,502,49

THR: Poison by intravenous route. When heated to decomposition it emits toxic fumes of NO_x.

ARL875 *HR: 2*
ARYL ALKYL POLYETHER ALCOHOL
NIOSH: TQ 4150000

SYNS:
ALKYL ARYL POLYETHER ALCOHOLS
ALKYLARYLPOLYGLYKOLA-ETHER (GERMAN)
ALKYL PHENOL POLYGLYCOL ETHERS
ALKYL PHENOXY POLYETHOXY ETHANOLS
ARYL ALKYL POLYETHER ALCOHOL

TOXICITY DATA:	CODEN:
orl-rat LD50:3200 mg/kg	85GYAZ -,144,71
ipr-mus LD50:3100 mg/kg	PSTGAW 3,1,45
orl-rbt LD50:3 g/kg	85GYAZ -,144,71

THR: Moderately toxic by ingestion and other routes.

ARM000 *HR: 3*
ASALIN
CAS: 13425-94-0 NIOSH: YV 9365000

SYN: ETHYL ESTER OF N-ACETYL-dl-SARCOSYLYL-dl-VALINE

TOXICITY DATA:	CODEN:
orl-rat LD50:59 mg/kg	FATOAO 33,472,70
ipr-rat LD50:187 mg/kg	PCJOAU 12,25,78
ims-rat LD50:17 mg/kg	FATOAO 33,472,70
rec-rat LD50:40 mg/kg	FATOAO 33,472,70

THR: Poison by ingestion, intramuscular, rectal, and intraperitoneal routes. See also ESTERS.

ARM250 *HR: 3*
ASBESTOS
CAS: 1332-21-4 NIOSH: CI 6475000
DOT: 2212/2590

SYNS:
AMIANTHUS
AMOSITE (OBS.)
AMPHIBOLE
ASBEST (GERMAN)
ASBESTOS FIBER
FIBROUS GRUNERITE
NCI C08991
SERPENTINE

TOXICITY DATA:	CODEN:
ipl-rat TDLo:100 mg/kg:ETA	BJCAAI 41,918,80
itr-rat TDLo:50 mg/kg:ETA	STRHAV 39,386,79
ihl-hmn TCLo:1.2 fibers/cc/19Y-C:PUL	ARDSBL 104,576,71

IARC Cancer Review: Human Sufficient Evidence IMEMDT 2,17,73; IMEMDT 14,11,77; Animal Sufficient Evidence IMEMDT 2,17,73; IMEMDT 14,11,77. Reported in EPA TSCA Inventory. On Community Right To Know List. EPA Genetic Toxicology Program.

OSHA PEL: TWA 2 million fb/m^3; CL 10 million fb/m^3
ACGIH TLV: Human Carcinogen, TWA 2 fb/cc
DFG TRK: (Fine dust particles which are able to reach the alveolar area of the lung) 0.05 resp. 1 × 10^6 fibers/m^3 (definition of fiber: length greater than 5 μm; diameter less than 3 μm; length/diameter greater than 3:1, equivalent to 1 fiber/cc); 2.0 mg/m^3 applicable when there is less than or equal to 2.5 wt % asbestos in fine dust (additionally to TRK value).
NIOSH REL: TWA 100,000 fb/m^3 over 5 μm in length

DOT Classification: ORM-C

THR: A human carcinogen. An experimental tumorigen. Human pulmonary system effects by inhalation. Usually at least 4 to 7 years of exposure are required before serious lung damage (fibrosis) results. A common air contaminant. For further information, see Vol. 1, No. 1 of *DPIM Report*.

ARM260 *HR: 3*

ASBESTOS, ACTINOLITE

CAS: 77536-66-4 NIOSH: CI 6476000

SYNS:

ASBESTOS (ACGIH)
ACTINOLITE ASBESTOS

IARC Cancer Review: Animal Sufficient Evidence (IMEMDT 14,11,77)

OSHA PEL: TWA 2 million fb/m^3; CL 10 million fb/m^3
ACGIH TLV: Human Carcinogen, TWA 2 fb/cc
NIOSH REL: TWA 100,000 fb/m^3 over 5 μm in length

THR: A human carcinogen. See also other asbestos entries.

ARM262 *HR: 3*

ASBESTOS, AMOSITE

CAS: 12172-73-5 NIOSH: CI 6477000

SYNS:

AMOSITE ASBESTOS
ASBESTOS (ACGIH)
MYSORITE
NCI C60253A

TOXICITY DATA:	CODEN:
cyt-ham:ovr 10 mg/L	CSHCAL 4,941,77
sce-ham:ovr 10 mg/L	JEPTDQ 4(2-3),373,80
msc-ham:lng 10 mg/L	MUREAV 68,265,79
ihl-rat TCLo:11 mg/m^3/2Y-I: CAR	BJCAAI 29,252,74
ipl-rat TDLo:80 mg/kg:CAR	TOLED5 13,143,82
itr-rat TDLo:12 mg/kg/12W-I: ETA	TOLED5 13,143,82
imp-rat TDLo:200 mg/kg:NEO	JJIND8 67,965,81
ipr-mus TDLo:80 mg/kg:CAR	ENVRAL 35,277,84
scu-mus TDLo:2400 mg/kg/ 13W-I:CAR	FCTXAV 6,566,68
mul-ham TDLo:290 g/kg/35W-C:ETA	ANYAA9 132,456,65
ipl-rat TD :200 mg/kg:NEO	BJCAAI 28,173,73
ihl-rat TC :12 mg/m^3/13W-I: NEO	RRCRBU 39,37,72
ipl-rat TD :200 mg/kg:NEO	JNCIAM 48,797,72
ipl-rat TD :100 mg/kg:CAR	BJCAAI 23,567,69
ihl-rat TC :10 mg/m^3/52W-C: ETA	IAPUDO 30,285,80

IARC Cancer Review: Animal Sufficient Evidence IMEMDT 2,17,73; IMEMDT 14,11,77; Human Sufficient Evidence IMEMDT 2,17,73; IMEMDT 14,11,77. NTP Carcinogenesis Studies (feed); No Evidence: hamster NTPTR* NTP-TR-249,83. EPA Genetic Toxicology Program.

OSHA PEL: TWA 2 million fb/m^3; CL 10 million fb/m^3
ACGIH TLV: Human Carcinogen, TWA 0.5 fb/cc
NIOSH REL: TWA 100,000 fb/m^3 over 5 μm in length

THR: A human carcinogen. An experimental carcinogen, neoplastigen and tumorigen by inhalation and most other routes. Mutagenic data.

ARM264 *HR: 3*

ASBESTOS, ANTHOPHYLITE

CAS: 77536-67-5 NIOSH: CI 6478000

SYNS:

ANTHOPHYLITE
ASBESTOS (ACGIH)
AZBOLEN ASBESTOS
FERROANTHOPHYLLITE

TOXICITY DATA:	CODEN:
cyt-ham:ovr 10 mg/L	CSHCAL 4,941,77
ihl-rat TCLo:11 mg/m^3/1Y-I: CAR	BJCAAI 29,252,74
ipl-rat TDLo:200 mg/kg:NEO	BJCAAI 28,173,73
ipl-ham TDLo:83 mg/kg:NEO	31BYAP -,92,74
ipl-rat TD :2400 mg/kg/34W-I: ETA	IAPUDO 30,343,80

IARC Cancer Review: Animal Sufficient Evidence IMEMDT 2,17,73; IMEMDT 14,11,77; Human Sufficient Evidence IMEMDT 14,11,77 EPA Genetic Toxicology Program.

OSHA PEL: TWA 2 million fb/m^3; CL 10 million fb/m^3
ACGIH TLV: Human Carcinogen, TWA 2 fb/cc
NIOSH REL: TWA 100,000 fb/m^3 over 5 μm in length

THR: A human carcinogen. An experimental carcinogen, neoplastigen and tumorigen. Mutagenic data.

ARM268 *HR: 3*

ASBESTOS, CHRYSOTILE

CAS: 12001-29-5 NIOSH: CI 6478500
DOT: 2590

SYNS:

7-45 ASBESTOS
ASBESTOS (ACGIH)
ASBESTOS, WHITE (DOT)
AVIBEST C
CALIDRIA RG 100
CALIDRIA RG 144
CALIDRIA RG 600
CASSIAR AK
CHRYSOTILE ASBESTOS
CHRYSOTILE (DOT)
HOOKER NO. 1 CHRYSOTILE ASBESTOS
METAXITE
NCI C61223A
PLASTIBEST 20
SERPENTINE
SERPENTINE CHRYSOTILE
SYLODEX
WHITE ASBESTOS

TOXICITY DATA:	CODEN:
oms-hmn:fbr 10 mg/L	MUREAV 116,369,83
otr-rat:oth 400 ng/cm^2	CRNGDP 6,523,85
cyt-rat:oth 7 mg/L	MUREAV 169,141,86
otr-ham:emb 250 ng/cm^2	PAACA3 24,96,83
dns-ham:oth 130 ng/cm^2	CNREA8 42,3669,82
oms-ham:ovr 10 mg/L	MUREAV 116,369,83
cyt-ham:emb 100 μg/L	ENVRAL 10,165,75
cyt-ham:ovr 10 mg/μmol	CSHCAL 4,941,77
sce-ham:ovr 100 μg/L	ENVRAL 24,325,81
msc-ham:lng 10 mg/L	MUREAV 68,265,79
ihl-man TCLo:400 mppcf/1Y-C: CAR,PUL	AEHLAU 28,61,74
orl-rat TDLo:7100 mg/kg/39W-C:CAR	ARGEAR 46,437,76

OSHA PEL: TWA 0.2 mg/m^3
NIOSH REL: (To Coal Tar Products) TWA 0.1 mg/m^3

DOT Classification: Flammable or Combustible; Label Flammable Liquid

THR: An experimental carcinogen and tumorigen. Mutagenic data. A human and experimental skin irritant. When heated to decomposition it emits acrid smoke and irritating fumes.

LCC000 *HR: 1*
LAVENDER ABSOLUTE
CAS: 8000-28-0 NIOSH: OF 6100000

PROP: Found in the flowers of *Lavandula officinalis chaix.* The main constituent is linalyl acetate. A dark green liquid prepared from alcoholic extract of a residue which is extracted from plant material using an organic solvent.

TOXICITY DATA:	CODEN:
skn-rbt 500 mg/24H MLD	FCTXAV 14,449,76
orl-rat LD50:4250 mg/kg	FCTXAV 14,449,76

THR: Mildly toxic by ingestion. A skin irritant. When heated to decomposition it emits acrid smoke and irritating fumes. See also 3,7-DIMETHYL-1,6-OCTADIEN-3-OL ACETATE.

LCD000 *HR: 1*
LAVENDER OIL
CAS: 8000-28-0 NIOSH: OF 6110000

PROP: Main constituent is linalyl acetate. Found in the plant *Lavandulaofficinalif choix (Fam. Labiate).* Prepared by steam distillation of the flowering stalks of the plant.

SYNS:
LAVENDEL OEL (GERMAN) OIL OF LAVENDER

TOXICITY DATA:	CODEN:
skn-rbt 500 mg/24H MLD	FCTXAV 14,451,76
orl-rat LD50:9040 mg/kg	PHARAT 14,435,59

Reported in EPA TSCA Inventory.

THR: Mildly toxic by ingestion. A skin irritant. When heated to decomposition it emits acrid smoke and irritating fumes. See also 3,7-DIMETHYL-1,6-OCTADIEN-3-OL ACETATE.

LCE000 *HR: 3*
LD-813
CAS: 64083-05-2 NIOSH: OF 6730000

PROP: Commercial mixture of aromatic amines containing approx 40% MOCA.

TOXICITY DATA:	CODEN:
orl-rat TDLo:37 g/kg/2Y-C:CAR	TXAPA9 31,159,75

THR: An experimental carcinogen. When heated to decomposition it emits toxic fumes of NO_x. See also AROMATIC AMINES.

LCF000 *HR: 3*
LEAD
CAS: 7439-92-1 NIOSH: OF 7525000
af: Pb aw: 207.19

PROP: Bluish-gray, soft metal. Mp: 327.43°, bp: 1740°, d: 11.34 @ 20°/4°. vap press: 1 mm @ 973°.

SYNS:

C.I. 77575	OLOW (POLISH)
C.I. PIGMENT METAL 4	OMAHA
GLOVER	OMAHA & GRANT
LEAD FLAKE	SI
LEAD S2	SO

TOXICITY DATA:	CODEN:
cyt-hmn-unr 50 μg/m^3	MUREAV 147,301,85
cyt-rat-ihl 23 μg/m^3/16W	GTPZAB 26(10),38,82
cyt-mky-orl 42 mg/kg/30W	TOLED5 8,165,81
orl-rat TDLo:790 mg/kg (MGN):REP	AEHLAU 23,102,71
orl-rat TDLo:1140 mg/kg (14D pre-21D post):REP	PHMCAA 20,201,78
orl-rat TDLo:1100 mg/kg (1-22D preg):TER	FEPRA7 37,895,78
ihl-rat TCLo:10 mg/m^3/24H (1-21D preg):TER	ZHPMAT 165,294,77
orl-wmn TDLo:450 mg/kg/6Y: PNS:CNS	JAMAAP 237,2627,77
ihl-hmn TCLo:10 μg/m^3:GIT: LIV	VRDEA5 (5),107,81
ipr-rat LDLo:1000 mg/kg	EQSSDX 1,1,75
orl-pgn LDLo:160 mg/kg	HBAMAK 4,1289,35

IARC Cancer Review: Animal Inadequate Evidence IMEMDT 23,325,80. Lead and its compounds are on the Community Right To Know List. Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program.

OSHA PEL: TWA 0.05 mg(Pb)/m^3
ACGIH TLV: TWA 0.15 mg(Pb)/m^3
NIOSH REL: TWA (Inorganic Lead) 0.10 mg(Pb)/m^3

THR: Poison by ingestion. Moderately toxic by intraperitoneal route. It is a suspected carcinogen of the lungs and kidneys. Human systemic effects by ingestion and inhalation: loss of appetite, anemia, malaise, insomnia, headache, irritability, muscle and joint pains, tremors, flaccid paralysis without anesthesia, hallucinations and distorted perceptions, muscle weakness, gastritis and liver changes. The major organ systems affected are the nervous system, blood system, and kidneys. 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. Experimental evidence now suggests that blood levels of lead below 10 μg/dl can have the effect of dimin-

ishing the IQ scores of children. Low levels of lead impair neurotransmission and immune system function and may increase systolic blood pressure. Reversible kidney damage can occur from acute exposure. Chronic exposure can lead to irreversible vascular schlerosis, tubular cell atrophy, interstitial fibrosis, and glomerular sclerosis. Severe toxicity can cause sterility, abortion and neonatal mortality and morbidity. An experimental teratogen. Experimental reproductive effects. Human mutagenic data. Very heavy intoxication can sometimes be detected by formation of a dark line on the gum margins, the so-called "lead line."

When lead is ingested, much of it passes through the body unabsorbed, and is eliminated in the feces. The greater portion of the lead that is absorbed is caught by the liver and excreted, in part, in the bile. For this reason, larger amounts of lead are necessary to cause toxic effects by this route, and a longer period of exposure is usually necessary to produce symptoms. On the other hand, upon inhalation, absorption takes place easily from the respiratory tract and symptoms tend to develop more quickly. For industry, inhalation is much more important than is ingestion. For the general population, exposure to lead occurs from inhaled air, dust of various types, and food and water with an approximate 50/50 division between inhalation and ingestion routes. Lead occurs in water in either dissolved or particulate form. At low pH, lead is more easily dissolved. Chemical treatment to soften water increases the solubility of lead. Adults absorb about 5-15% of ingested lead and retain less than 5%. Children absorb about 50% and retain about 30%.

Lead produces a brittleness of the red blood cells so that they hemolyze with but slight trauma; the hemoglobin is not affected. Due to their increased fragility, the red cells are destroyed more rapidly in the body than is normal, producing an anemia which is rarely severe. The loss of circulating red cells stimulates the production of new young cells which, on entering the blood stream, are acted upon by the circulating lead, with resultant coagulation of their basophilic material. These cells after suitable staining, are recognized as "stippled cells." There is no uniformity of opinion regarding the effect of lead on the white blood cells.

In addition to its effect on the red blood cells, lead produces a damaging effect on the organs or tissues with which it comes in contact. No specific or characteristic lesion is produced. Autopsies in deaths attributed to lead poisoning and experimental work on animals have shown pathological lesions of the kidneys, liver, male gonads, nervous system, blood vessels and other tissues. None of these changes, however, has been found consistently. In cases of severe lead poisoning, the amount of lead found in the blood is frequently in excess of 0.07 mg per 100 cc of whole blood. The urinary lead excretion generally exceeds 0.1 mg per liter of urine.

Flammable in the form of dust when exposed to heat or flame. Moderately explosive in the form of dust when exposed to heat or flame. Mixtures of hydrogen peroxide + trioxane explode on contact with lead. Rubber gloves containing lead may ignite in nitric acid. Violent reaction on ignition with chlorine trifluoride; concentrated hydrogen peroxide; ammonium nitrate (below 200°C with powdered lead); sodium acetylide (with powdered lead). Incompatible with NaN_3; Zr; disodium acetylide; oxidants. Can react vigorously with oxidizing materials. A common air contaminant. When heated to decomposition it emits highly toxic fumes of Pb. See also LEAD COMPOUNDS. For further information, see Vol. 1, No. 1 of *DPIM Report*.

LCG000 *HR: 3*

LEAD ACETATE

CAS: 301-04-2 NIOSH: AI 5250000

DOT: 1616

mf: $C_4H_6O_4 \cdot Pb$ mw: 325.29

PROP: Trihydrate: colorless crystals or white granules or powder. Sltly acetic odor, slowly effloresces. D: 2.55, mp: 75° (when rapidly heated), decomp above 200°. Very sol in glycerol.

SYNS:

ACETATE de PLOMB (FRENCH)
ACETIC ACID LEAD (2+) SALT
BLEIACETAT (GERMAN)
DIBASIC LEAD ACETATE
LEAD (2+) ACETATE
LEAD(II) ACETATE
LEAD DIACETATE
LEAD DIBASIC ACETATE
NORMAL LEAD ACETATE
PLUMBOUS ACETATE
RCRA WASTE NUMBER U144
SALT OF SATURN
SUGAR OF LEAD

TOXICITY DATA:	CODEN:
sln-smc 250 μmol/L	MUTAEX 1,21,86
cyt-hmn:lym 1 mmol/L/24H	TXCYAC 10,67,78
mnt-rat-ipr 51800 μg/kg	AEHLAU 40,144,85
otr-rat:emb 200 mg/L	JJIND8 67,1303,81
oms-rat-ipr 10400 μg/kg	AEHLAU 40,144,85
cyt-rat-unr 9 mg/kg/26W-C	GISAAA 49(3),15,84
cyt-rat-ipr 51800 μg/kg	AEHLAU 40,144,85
orl-rat TDLo:600 μg/kg (30D male):REP	AJOGAH 115,1058,73
orl-rat TDLo:1413 mg/kg (1-18D preg):TER	ENVRAL 30,152,83
orl-mus TDLo:236 mg/kg (7-16D preg):TER	ARTODN 41,125,78
orl-rat TDLo:900 mg/kg/60D-C: NEO	ENVRAL 24,391,81
orl-rat TD :250 g/kg/47W-C: ETA	BJCAAI 16,283,62
orl-rat TD :2430 mg/kg/23W-C: ETA	ENVRAL 24,391,81
orl-rat TD :4605 mg/kg/44W-C: ETA	ENVRAL 24,391,81
orl-rat TD :7560 mg/kg/72W-C: NEO	ENVRAL 24,391,81
orl-rat TD :9150 mg/kg/44W-C: NEO	AJPAA4 50,571,67
orl-rat TD :218 g/kg/1Y-C:ETA	BECTA6 23,464,79
orl-rat TD :138 g/kg/76W-C: ETA	TOPADD 13,50,85

Arsenic and its compounds are on the Community Right To Know List.

THR: Poison by most routes. See also ARSENIC COMPOUNDS and SULFIDES. Dangerous fire hazard when exposed to heat or by spontaneous chemical reaction, i.e., in air. Vigorous reaction with oxidizing materials. When heated to decomposition it emits toxic fumes of As.

CAC500 *HR: 3*
CADIA DEL PERRO
NIOSH: EU 9500000

PROP: Aqueous extract from the dried leaves of the plant (JNCIAM 46,1131,71).

SYNS:
K. IXINA KRAMERIA IXINA

TOXICITY DATA:	CODEN:
scu-rat TDLo:300 mg/kg/1Y-I: NEO	JNCIAM 46,1131,71
ims-rat TDLo:45 g/kg/1Y-I:ETA	JNCIAM 46,1131,71
skn-ham TDLo:53950 mg/kg/65W-I:CAR	JNCIAM 53,1259,74
scu-rat TD :990 mg/kg/55W-I: NEO	JNCIAM 52,1579,74

THR: An experimental carcinogen, tumorigen and neoplastigen. When heated to decomposition it emits acrid smoke and fumes.

CAD000 *HR: 3*
CADMIUM
CAS: 7440-43-9 NIOSH: EU 9800000
mf: Cd mw: 112.40

PROP: Hexagonal crystals, silver-white, malleable metal. Mp: 320.9°, bp: 767 ± 2°, d: 8.642, vap press: 1 mm @ 394°.

SYNS:
C.I. 77180 KADMIUM (GERMAN)
COLLOIDAL CADMIUM

TOXICITY DATA:	CODEN:
cyt-ham:ovr 1 µmol/L	CGCGBR 26,251,80
orl-rat TDLo:220 mg/kg (1-22D preg):REP,TER	TOLED5 11,233,82
orl-rat TDLo:23 mg/kg (1-22D preg):REP,TER	PSEBAA 158,614,78
ivn-rat TDLo:1250 µg/kg (14D preg):REP,TER	JJATDK 1,264,81
ims-rat TDLo:40 mg/kg/4W-I: CAR	JEPTDQ 1(1),51,77
ims-rat TD :70 mg/kg:ETA	BJCAAI 18,124,64
ims-rat TD :63 mg/kg:ETA	NATUAS 193,592,62
ims-rat TD :45 mg/kg/4W-I: NEO	NCIUS* PH-43-64-886,SEPT,71
ihl-man TCLo:88 µg/m³/8.6Y: KID	AEHLAU 28,147,74
ihl-hmn LCLo:39 mg/m³/20M	AIHAAP 31,180,70
unk-man LDLo:15 mg/kg	85DCAI 2,73,70
orl-rat LD50:225 mg/kg	TXAPA9 41,667,77
ipr-rat LD50:4 mg/kg	TXAPA9 41,667,77
scu-rat LD50:9 mg/kg	TXAPA9 41,667,77
ivn-rat LD50:1800 µg/kg	JJATDK 1,264,81
unr-rat LD50:1140 mg/kg	GTPZAB 22(5),6,78
orl-mus LD50:890 mg/kg	41HTAH -,14,78
ihl-mus LCLo:170 mg/m³	NTIS** PB158-508
unr-mus LD50:890 mg/kg	GTPZAB 22(5),6,78
orl-rbt LDLo:70 mg/kg	AMPMAR 34,127,73
scu-rbt LDLo:6 mg/kg	PROTA* -,-,55
ivn-rbt LDLo:5 mg/kg	JOGBAS 35,693,28
ims-ham LDLo:25 mg/kg	NCIUS* PH-43-64-886

IARC Cancer Review: Animal Sufficient Evidence IMEMDT 11,39,76; IMEMDT 2,74,73. Cadmium and its compounds are on the Community Right To Know List. Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program.

OSHA PEL: TWA 0.1 mg(Cd)/m³; CL 0.6 mg(Cd)/m³ (fume)
ACGIH TLV: TWA 0.01 mg(Cd)/m³ (dust), Human carcinogen
DFG BAT: Blood 1.5 µg/dL; Urine 15 µg/dL
NIOSH REL: (Cadmium) Reduce to lowest feasible level

THR: A human poison by inhalation and possibly other routes. Poison experimentally by ingestion, inhalation, intraperitoneal, subcutaneous, intramuscular, and intravenous routes. In humans inhalation causes an excess of protein in the urine. An experimental carcinogen, tumorigen, neoplastigen, and teratogen. Experimental reproductive effects. Mutagenic data. The dust ignites spontaneously in air and is flammable and explosive when exposed to heat, flame, or by chemical reaction with oxidizing agents; metals; HN_3; Zn; Se; and Te. Explodes on contact with hydrazoic acid. Violent or explosive reaction when heated with ammonium nitrate. Vigorous reaction when heated with nitryl fluoride. When heated strongly it emits toxic fumes of Cd. See also CADMIUM COMPOUNDS. For further information, see Vol. 3, No. 5 of *DPIM Report*.

CAD250 *HR: 3*
CADMIUM(II) ACETATE
CAS: 543-90-8 NIOSH: EU 9810000
DOT: 2570
mf: $C_2H_4O_2 \cdot 1/2Cd$ mw: 116.25

PROP: Monoclinic, colorless crystals; odor of acetic acid. Mp: 256°, bp: decomp, d: 2.341.

SYNS:
ACETIC ACID, CADMIUM SALT CADMIUM DIACETATE
BIS(ACETOXY)CADMIUM C.I. 77185
CADMIUM ACETATE (DOT)

TOXICITY DATA:	CODEN:
cyt-hmn:lym 10 nmol/L	MUREAV 85,236,81
otr-ham:emb 1 µmol/L	CNREA8 39,193,79
dnd-ham:emb 1 µmol/L	CNREA8 39,193,79

THR: A poison by ingestion, skin contact and intraperitoneal routes. Vigorous reaction with indium at 350°C. Incompatible with sodium and potassium. When heated to decomposition it emits very toxic fumes of Br^- and Hg. See also MERCURY COMPOUNDS and BROMIDES.

MCY250 *HR: 3*

MERCURY(II) BROMIDE COMPLEX WITH TRIS(2-ETHYLHEXYL) PHOSPHITE

CAS: 64011-37-6 NIOSH: TH 2275000

mf: $C_{24}H_{51}O_3P{\cdot}Br_2Hg$ mw: 779.13

SYN: PHOSPHOROUS ACID, TRIS(2-ETHYLHEXYL) ESTER, COMPLEX WITH MERCURY(II) BROMIDE (1:1)

TOXICITY DATA:	CODEN:
ipr-mus LDLo:31 mg/kg	CBCCT* 7,790,55

Mercury and its compounds are on the Community Right To Know List.

ACGIH TLV: TWA 0.1 mg(Hg)/m^3 (skin)

NIOSH REL: (To Inorganic Mercury) TWA 0.05 mg(Hg)/m^3

THR: Poison by intraperitoneal route. When heated to decomposition it emits very toxic fumes of PO_x, Br^- and Hg. See also individual components.

MCY475 *HR: 3*

MERCURY(II) CHLORIDE

CAS: 7487-94-7 NIOSH: OV 9100000

DOT: 1624

mf: Cl_2Hg mw: 271.50

SYNS:

BICHLORIDE OF MERCURY
BICHLORURE de MERCURE (FRENCH)
CALOCHLOR
CHLORID RTUTNATY (CZECH)
CHLORURE MERCURIQUE (FRENCH)
CLORURO di MERCURIO (ITALIAN)
CORROSIVE MERCURY CHLORIDE
MERCURIC CHLORIDE (DOT)
MERCURY BICHLORIDE
MERCURY PERCHLORIDE
NCI-C60173
QUECKSILBER CHLORID (GERMAN)
PERCHLORIDE OF MERCURY
SULEMA (RUSSIAN)
SUBLIMAT (CZECH)
TL 898

TOXICITY DATA:	CODEN:
skn-rbt 500 mg/24H SEV	28ZPAK -,12,72
eye-rbt 50 µg/24H SEV	28ZPAK -,12,72
cyt-ham-scu 6400 µg/kg	TJADAB 25,381,82
cyt-hmn:hla 10 mg/L	JJEMAG 39,47,69
cyt-hmn:lym 5 µmol/L	MUREAV 157,221,85
dnd-ham:ovr 2500 nmol/L/1H-C	PAACA3 24,74,83
dnr-rat:ast 500 µmol/L	JBCHA3 261,3370,86
orl-wmn TDLo:50 µg/kg (10W preg):REP	AJOGAH 80,145,60
orl-rat TDLo:240 mg/kg (6-15D preg):TER	TJADAB 25(1),26A,82
orl-rat TDLo:120 mg/kg (6-15D preg):TER	TJADAB 25(1),26A,82
orl-man TDLo:21 mg/kg: PUL,GIT,KID	MJAUAJ 2,125,78
orl-wmn TDLo:50 mg/kg: GIT,KID	AJOGAH 80,145,60
orl-hmn LDLo:29 mg/kg	NEJMAG 244,459,51
unr-man LDLo:7253 µg/kg	85DCAI 2,73,70
scu-mus LD50:4500 µg/kg	NEZAAQ 34,193,79
skn-rat LD50:41 mg/kg	GTPZAB 25(7),27,81

Mercury and its compounds are on the Community Right To Know List. EPA Genetic Toxicology Program. Reported in EPA TSCA Inventory.

ACGIH TLV: TWA 0.1 mg(Hg)/m^3 (skin)

NIOSH REL: (To Inorganic Mercury) TWA 0.05 mg(Hg)/m^3

DOT Classification: Poison B; Label: Poison

THR: A human poison by ingestion and possibly other routes. Poison experimentally by skin contact and subcutaneous routes. Human systemic effects by ingestion: respiratory obstruction, nausea or vomiting, urine volume decreased or anuria. Human reproductive effects by ingestion: terminates pregnancy. Experimental teratogenic and reproductive effects. Human mutagenic data. A severe eye and skin irritant. Reaction with sodium aci-nitromethanide + acids forms the explosive mercury fulminate. When heated to decomposition it emits toxic fumes of Hg. See also MERCURY COMPOUNDS and CHLORIDES.

MCY500 *HR: 3*

MERCURY(II) CHLORIDE COMPLEX WITH TRIS(2-ETHYLHEXYL) PHOSPHITE

CAS: 63981-49-7 NIOSH: TH 2450000

mf: $C_{24}H_{51}O_3P{\cdot}Cl_2Hg$ mw: 690.21

SYN: PHOSPHOROUS ACID, TRIS(2-ETHYLHEXYL) ESTER, COMPLEX WITH MERCURY(II) CHLORIDE (1:1)

TOXICITY DATA:	CODEN:
ipr-mus LDLo:63 mg/kg	CBCCT* 7,791,55

Mercury and its compounds are on the Community Right To Know List.

NIOSH REL: (To Inorganic Mercury) TWA 0.05 mg(Hg)/m^3

THR: Poison by intraperitoneal route. When heated to decomposition it emits very toxic fumes of Hg, Cl^- and PO_x. See also individual components.

MCY750 *HR: 3*

MERCURY(I) CHLORITE

mf: $Cl_2Hg_2O_4$ mw: 536.08

Mercury and its compounds are on the Community Right To Know List.

THR: A poison. The dry chlorite is spontaneously explosive. Upon decomposition it emits very toxic fumes of Cl^- and Hg. See also MERCURY COMPOUNDS and CHLORITES.

Mercury and its compounds are on the Community Right To Know List.

NIOSH REL: (To Inorganic Mercury) TWA 0.05 mg(Hg)/m^3

THR: Poison by intravenous and intramuscular routes. When heated to decomposition it emits very toxic fumes of NO_x, Na_2O and Hg vapors. See also MERCURY COMPOUNDS.

MCV750 *HR: 3*

MERCUROPHYLLINE

CAS: 8012-34-8 NIOSH: OV 8650000

SYNS:

MERCUPURIN
MERCUZANTHIN

TOXICITY DATA:	CODEN:
ivn-hmn TDLo:28 mg/kg:CVS	JAMAAP 117,1806,41
ipr-rat LD50:121 mg/kg	THERAP 10,936,55
scu-mus LD50:163 mg(Hg)/kg	JPETAB 105,336,52
ivn-mus LD50:1410 mg/kg	JPETAB 99,149,50
ivn-cat LDLo:250 mg/kg	JPETAB 99,149,50
ivn-rbt LDLo:177 mg/kg	JPETAB 99,149,50

Mercury and its compounds are on the Community Right To Know List.

ACGIH TLV: TWA 0.1 mg(Hg)/m^3 (skin)
NIOSH REL: (To Inorganic Mercury) TWA 0.05 mg(Hg)/m^3

THR: Poison by subcutaneous, intraperitoneal and intravenous routes. Human systemic effects by intravenous route: cardiac arrythmias. When heated to decomposition it emits toxic fumes of Hg. See also MERCURY COMPOUNDS.

MCW000 *HR: 3*

MERCUROUS CHLORIDE

CAS: 7546-30-7 NIOSH: OV 8750000

mf: Cl_2Hg_2 mw: 472.09

PROP: White, odorless, tasteless, heavy powder or crystals. Sublimes @ 400°, d: 7.150. Insol in H_2O, alc and ether. Protect from light. Sunlight causes it to decomp into mercuric chloride and metallic Hg.

SYNS:

CALOGREEN
CALOMEL
CALOMELANO (ITALIAN)
CALOSAN
CHLORURE MERCUREUX (FRENCH)
C.I. 77764
CLORURO MERCUROSO (ITALIAN)
CYCLOSAN
KALOMEL (GERMAN)
MERCUROCHLORIDE (DUTCH)
MERCURY(I) CHLORIDE
MERCURY MONOCHLORIDE
MERCURY PROTOCHLORIDE
MILD MERCURY CHLORIDE
PRECIPITE BLANC
QUECKSILBER(I)-CHLORID (GERMAN)
QUECKSILBER CHLORUER (GERMAN)
SUBCHLORIDE OF MERCURY

TOXICITY DATA:	CODEN:
mrc-bcs 50 mmol/L	MUREAV 77,109,80
sce-ham:ovr 3200 nmol/L	ENMUDM 7,381,85
orl-rat LD50:166 mg/kg	GTPZAB 25(7),27,81
skn-rat LD50:1500 mg/kg	GTPZAB 25(7),27,81
orl-mus LD50:180 mg/kg	GTPZAB 25(7),27,81
ipr-mus LD50:10 mg/kg	GTPZAB 25(7),27,81

Mercury and its compounds are on the Community Right To Know List. EPA Genetic Toxicology Program. Reported in EPA TSCA Inventory.

ACGIH TLV: TWA 0.1 mg(Hg)/m^3 (skin)
NIOSH REL: (To Inorganic Mercury) TWA 0.05 mg(Hg)/m^3

THR: Poison by ingestion and intraperitoneal routes. Moderately toxic by skin contact. Mutagenic data. A fungicide. An FDA over-the-counter drug. Incompatible with bromides; iodides; alkali chlorides; sulfates; sulfites; carbonates; hydroxides; lime water; ammonia; golden antimony sulfide; cyanides; copper salts; hydrogen peroxide; iodine; iodoform; lead salts; silver salts; sulfides. When heated to decomposition it emits very toxic fumes of Cl^- and Hg. See also MERCURY COMPOUNDS.

MCW250 *HR: 3*

MERCURY

CAS: 7439-97-6 NIOSH: OV 4550000

DOT: 2809

af: Hg aw: 200.59

PROP: Silvery, heavy, mobile liquid. A liquid metallic element. Mp: −38.89°, bp: 356.9°, d: 13.534 @ 25°, vap press: 2×10^{-3} mm @ 25°. Solid: tin-white, ductile, malleable mass which can be cut with a knife.

SYNS:

COLLOIDAL MERCURY
KWIK (DUTCH)
MERCURE (FRENCH)
MERCURIO (ITALIAN)
MERCURY, METALLIC (DOT)
NCI-C60399
QUECKSILBER (GERMAN)
QUICK SILVER
RCRA WASTE NUMBER U151
RTEC (POLISH)

TOXICITY DATA:	CODEN:
cyt-man-unr 150 µg/m^3	AEHLAU 34,461,79
ihl-rat TCLo:890 ng/m^3/24H (16W male):REP	GISAAA 45(3),72,80
ihl-rat TCLo:7440 ng/m^3/24H (16W male):REP	GISAAA 45(3),72,80
ipr-rat TDLo:400 mg/kg/14D-I: ETA	ZEKBAI 61,511,57
ihl-man TDLo:44300 µg/m^3/8H: CNS,LIV,MET	JOCMA7 20,532,78
ihl-wmn TCLo:150 µg/m^3/46D: CNS,GIT	AEHLAU 33,186,78
skn-man TDLo:129 mg/kg/5H-C:EAR,CNS,SKN	DERAAC 172,48,86
ihl-rbt LCLo:29 mg/m^3/30H	AMIHBC 7,19,53

Mercury and its compounds are on the Community Right To Know List.

OSHA PEL: CL 0.1 mg/m^3
ACGIH TLV: TWA 0.05 mg(Hg)/m^3 (vapor, skin)
DFG MAK: 0.01 ppm (0.1 mg/m^3)
NIOSH REL: (To Inorganic Mercury) TWA 0.05 mg(Hg)/m^3

THR: An experimental carcinogen and neoplastigen. Very powerful oxidizer. See also CHROMIUM COMPOUNDS.

CMI500 *HR: 3*
CHROMITE (MINERAL)
CAS: 1308-31-2 NIOSH: GB 4000000
mf: Cr_2FeO_4 mw: 223.85

SYNS:
CHROME ORE
CHROMITE
CHROMITE ORE
IRON CHROMITE

TOXICITY DATA:	CODEN:
mma-sat 2 mg/plate	CRNGDP 3,1331,82
cyt-hmn:oth 500 mg/L	BJCAAI 44,219,81
dni-ham:kdy 500 mg/L	BJCAAI 44,219,81
oms-ham:kdy 500 mg/L	BJCAAI 44,219,81
cyt-ham:ovr 5 mg/L	BJCAAI 44,219,81
sce-ham:ovr 10 mg/L	CRNGDP 3,1331,82

IARC Cancer Review: Animal Inadequate Evidence IMEMDT 23,205,80. Chromium and its compounds are on the Community Right To Know List.

OSHA PEL: CL 0.5 mg(Cr)/m^3
ACGIH TLV: TWA 0.05 mg/m^3 (ore processing); Human Carcinogen (ore processing)

THR: A human carcinogen. Human mutagenic data. See also CHROMIUM COMPOUNDS and IRON.

CMI750 *HR: 3*
CHROMIUM
CAS: 7440-47-3 NIOSH: GB 4200000
mf: Cr mw: 52.00

SYN: CHROME

TOXICITY DATA:	CODEN:
ivn-rat TDLo:2160 µg/kg/6W-I: ETA	JNCIAM 16,447,55
imp-rat TDLo:1200 µg/kg/6W-I: ETA	JNCIAM 16,447,55
imp-rbt TDLo:75 mg/kg:ETA	ZEKBAI 52,425,42
orl-hmn LDLo:71 mg/kg:GIT	34ZIAG -,176,69

IARC Cancer Review: Animal Inadequate Evidence IMEMDT 23,205,80. Reported in EPA TSCA Inventory. Chromium and its compounds are on the Community Right To Know List.

OSHA PEL: TWA 1 mg/m^3
ACGIH TLV: TWA 0.5 mg/m^3

THR: Human poison by ingestion with gastrointestinal effects. An experimental tumorigen and suspected carcinogen. Powder will explode spontaneously in air. Ignites and is potentially explosive in atmospheres of carbon dioxide. Violent or explosive reaction when heated with ammonium nitrate. May ignite or react violently with bromine pentafluoride. Incandescent reaction with nitrogen oxide; sulfur dioxide. Incompatible with oxidants. See also CHROMIUM COMPOUNDS. For further information, see Vol. 3, No. 3 of *DPIM Report*.

CMJ000 *HR: 3*
CHROMIUM ACETATE HYDRATE
CAS: 628-52-4 NIOSH: AG 3000000
mf: $C_4H_6O_4 \cdot Cr \cdot H_2O$ mw: 188.12

PROP: Red crystals.

SYNS:
ACETIC ACID, CHROMIUM (2+) SALT (8CI, 9CI)
CHROMIUM(2+) ACETATE
CHROMIUM(II) ACETATE
CHROMIUM DIACETATE
CHROMOUS ACETATE
CHROMOUS ACETATE MONOHYDRATE

TOXICITY DATA:	CODEN:
orl-rat LD50:11260 mg/kg	AIHAAP 30,470,69

Reported in EPA TSCA Inventory. Chromium and its compounds are on the Community Right To Know List.

OSHA PEL: CL 0.5 mg(Cr)/m^3
ACGIH TLV: TWA 0.5 mg(Cr)/m^3

THR: Mildly toxic by ingestion. The anhydrous acetate ignites spontaneously in air. See also CHROMIUM COMPOUNDS. When heated to decomposition it emits acrid smoke and irritating fumes.

CMJ250 *HR: 3*
CHROMIUM CHLORIDE
CAS: 10025-73-7 NIOSH: GB 5425000
mf: Cl_3Cr mw: 158.35

PROP: Bp: 1300° (subl).

SYNS:
CHROMIC CHLORIDE
CHROMIUM(III) CHLORIDE (1:3)
CHROMIUM CHLORIDE, ANHYDROUS
CHROMIUM TRICHLORIDE
C.I. 77295
PURATRONIC CHROMIUM CHLORIDE
TRICHLOROCHROMIUM

TOXICITY DATA:	CODEN:
pic-esc 500 µmol/L	ENMDUM 6,59,84
cyt-hmn:oth 500 mg/L	BJCAAI 44,219,81
dnd-rat-ipr 80 mg/kg	CNREA8 45,1146,85
dni-mus:fbr 300 µmol/L	JTEHD6 15,237,85
sce-ham:lng 39 mg/L	CRNGDP 4,605,83
ipr-mus TDLo:44600 µg/kg (8D preg):TER	JTSCDR 1,1,76
ipr-mus TDLo:59500 µg/kg (9D preg):REP	JTSCDR 1,1,76
scu-mus TDLo:450 mg/kg (1-17D preg):TER	TJADAB 12,198,75
skn-rat LDLo:2 g/kg	85GMAT -,39,82
ihl-mus LC50:31500 µg/m^3/2H	85GMAT -,39,82
ipr-mus LD50:434 mg/kg	COREAF 256,1043,63
scu-mus LDLo:800 mg/kg	AQMOAC #70-15,70
ivn-mus LDLo:400 mg/kg	AQMOAC #70-15,70
ivn-mus LD50:40 mg/kg	85GMAT -,39,82
skn-rbt LDLo:1 g/kg	85GMAT -,39,82

ivn-hmn TDLo:7 mg/kg: GIT,KID	CTRRDO 62,1449,78
ivn-hmn TDLo:144 mg/kg:BLD	CTRRDO 62,1449,78
ipr-rat LD50:67500 μg/kg	EQSSDX 1,1,75
scu-rat LDLo:72 mg/kg	INMEAF 12,7,43
orl-mus LD50:4360 mg/kg	GISAAA 45(10),13,80
ipr-mus LD50:80 mg/kg	EQSSDX 1,1,75
scu-mus LD50:600 mg/kg	GISAAA 45(10),13,80

Reported in EPA TSCA Inventory.

THR: Poison by intraperitoneal and subcutaneous routes. Moderately toxic by ingestion. Human systemic effects by intravenous route: nausea or vomiting, renal function changes, proteinuria, normocytic anemia and thrombocytopenia. A severe skin irritant. Mutagenic data. When heated to decomposition it emits toxic fumes of NO_x. See also GALLIUM COMPOUNDS and NITRATES.

GBU000 *HR: 1*
GALOXOLIDE
CAS: 1222-05-5 NIOSH: GY 0790000
mf: $C_{18}H_{26}O$ mw: 258.44

SYN: 1,3,4,6,7,8-HEXAHYDRO-4,6,6,7,8,8-HEXAMETHYL-CYCLOPENTA-γ-2-BENZOPYRAN

TOXICITY DATA:	CODEN:
skn-rbt 500 mg/24H MOD	FCTXAV 14,793,76

Reported in EPA TSCA Inventory.

THR: A skin irritant. When heated to decomposition it emits acrid smoke and irritating fumes.

GBU600 *HR: 2*
GANCIDIN (unpurified)
NIOSH: LX 1756000

PROP: Produced by the strain *Streptomyces sp.* AAK-84 (85ERAY 2,1354,78)

TOXICITY DATA:	CODEN:
ipr-mus LD50:1500 mg/kg	85ERAY 2,1354,78
scu-mus LD50:2800 mg/kg	85ERAY 2,1354,78
ivn-mus LD50:700 mg/kg	85ERAY 2,1354,78

THR: Moderately toxic by intravenous, intraperitoneal and subcutaneous routes.

GBW000 *HR: 2*
GAS OIL

PROP: Yellow liquid. Flash p: 150°F, d: 1, lel: 6.0%, uel: 13.5%, autoign temp: 640°F, boiling range: 230°-250°.
THR: Combustible when exposed to heat or flame; can react vigorously with oxidizing materials. A moderate explosion hazard when exposed to heat or flame. To fight fire use foam, CO_2, dry chemical. See also KEROSENE.

GBY000 *HR: 3*
GASOLINE
CAS: 8006-61-9 NIOSH: LX 3300000
DOT: 1203/1257

PROP: Clear, aromatic, volatile liquid; a mixture of aliphatic HC. Flash p: −50°F, d: <1.0, vap d: 3.0-4.0, ulc: 95-100, lel: 1.3%, uel: 6.0%, autoign temp: 536-853°F, bp: Initially 39°, after 10% distilled = 60°, after 50% = 110°, after 90% = 170°, final bp: 204°. Insol in H_2O, freely sol in absolute alc, ether, chloroform, benzene.

SYNS:
CASING HEAD GASOLINE (DOT) NATURAL GASOLINE (DOT)
MOTOR FUEL (DOT) PETROL (DOT)
MOTOR SPIRIT (DOT)

TOXICITY DATA:	CODEN:
eye-man 500 ppm/1H MOD	AEHLAU 1,548,60
eye-hmn 140 ppm/8H MLD	JIHTAB 25,225,43
ihl-man TCLo:900 ppm/1H: EYE,CNS,PUL	JIHTAB 25,225,43
ihl-rat LC50:300 g/m³/5M	NTIS** PB158-508
ihl-mus LC50:300 g/m³/5M	NTIS** PB158-508
ihl-gpg LC50:300 g/m³/5M	NTIS** PB158-508
ihl-mam LCLo:30000 ppm/5M	AEPPAE 138,65,28

Reported in EPA TSCA Inventory.

ACGIH TLV: TWA 300 ppm; STEL 500 ppm

DOT Classification: Flammable Liquid; Label: Flammable Liquid

THR: Mildly toxic by inhalation. Human systemic effects by inhalation: cough, conjunctiva irritation, hallucinations or distorted perceptions. Repeated or prolonged dermal exposure causes dermatitis. Can cause blistering of skin. Inhalation or ingestion can cause central nervous system depression. Pulmonary aspiration can cause severe pneumonitis. Some addiction has been reported from inhalation of fumes. Even brief inhalations of high concentrations can cause a fatal pulmonary edema. The vapors are considered to be moderately poisonous. If its concentration in air is sufficiently high to reduce the oxygen content below that needed to maintain life, it acts as a simple asphyxiant. A human eye irritant. Gasoline is a common air contaminant. A very dangerous fire and explosion hazard when exposed to heat or flame; can react vigorously with oxidizing materials. To fight fire use foam, CO_2, dry chemical.

GCA000 *HR: 3*
GASOLINE (100-130 octane)

PROP: Flash p: −50°F, autoign temp: 824°F, lel: 1.3%, uel: 7.1%.
THR: Moderately toxic by inhalation. A very dangerous fire and explosion hazard when exposed to heat, flame or oxidizers. To fight fire use water spray or mist, CO_2, dry chemical. See also GASOLINE.

TIM000 *HR: 1*

1,1,2-TRICHLORO-2,2-DIFLUOROETHANE

CAS: 354-21-2 NIOSH: KI 1435000

mf: $CHCl_3F_2$ mw: 157.37

SYNS:

1,1-DIFLUORO-1,2,2-TRICHLOROETHANE
UCON FLUOROCARBON 122

TOXICITY DATA:	CODEN:
orl-rat LDLo:7500 mg/kg	HXPHAU 20(Pt 1),-459,66
ihl-rat LCLo:4000 ppm/4H	UCMH** 15NOV62

THR: Mildly toxic by ingestion and inhalation. When heated to decomposition it emits very toxic fumes of F^- and Cl^-. See also CHLORINATED HYDROCARBONS, ALIPHATIC and FLUORIDES.

TIM500 *HR: 1*

TRICHLORO ESTERTIN

NIOSH: WH 8240000

SYN: ESTERTRICHLOROSTANNANE

TOXICITY DATA:	CODEN:
unr-rat LD50:5500 mg/kg	TIUSAD 107,1,76

OSHA PEL: TWA 0.1 mg(Sn)/m^3
ACGIH TLV: TWA 0.1 mg(Sn)/m^3 (skin)
NIOSH REL: (Organotin Compounds) TWA 0.1 mg(Sn)/m^3

THR: When heated to decomposition it emits toxic fumes of Cl^-. See also TIN COMPOUNDS and ESTERS.

TIM750 *HR: 3*

1,1,1-TRICHLOROETHANE

CAS: 71-55-6 NIOSH: KJ 2975000

DOT: 2831

mf: $C_2H_3Cl_3$ mw: 133.40

PROP: Colorless liquid. Bp: 74.1°, fp: −32.5°, flash p: none, d: 1.3376 @ 20°/4°, vap press: 100 mm @ 20.0°. Insol in water; sol in acetone, benzene, carbon tetrachloride, methanol, ether.

SYNS:

AEROTHENE TT
CHLOROETENE
CHLOROETHENE
CHLOROTHANE NU
CHLOROTHENE
CHLOROTHENE (INHIBITED)
CHLOROTHENE NU
CHLOROTHENE VG
CHLORTEN
INHIBISOL
METHYLCHLOROFORM
METHYL CHLOROFORM (ACGIH, DOT)
METHYLTRICHLOROMETHANE
NCI-C04626
RCRA WASTE NUMBER U226
SOLVENT 111
STROBANE
α-T
1,1,1-TCE
1,1,1-TRICHLOORETHAAN (DUTCH)
1,1,1-TRICHLORAETHAN (GERMAN)
TRICHLORO-1,1,1-ETHANE (FRENCH)
α-TRICHLOROETHANE
1,1,1-TRICLOROETANO (ITALIAN)
TRI-ETHANE

TOXICITY DATA:	CODEN:
eye-man 450 ppm/8H	BJIMAG 28,286,71
skn-rbt 5 g/12D-I MLD	AIHAAP 19,353,58
skn-rbt 500 mg/24H MOD	28ZPAK -,28,72
eye-rbt 100 mg MLD	AIHAAP 19,353,58
eye-rbt 2 mg/24H SEV	28ZPAK -,28,72
dnr-esc 500 mg/L	PMRSDJ 1,195,81
otr-mus:emb 20 mg/L	CALEDQ 28,85,85
orl-rat TDLo:43 mg/kg (1-22D preg/21D post):TER	TJADAB 29(2),25A,84
ihl-rat TCLo:2100 ppm/24H (14D pre/1-20D preg):TER	TOXID9 1,28,81
ihl-man LCLo:27 g/m^3/10M	JOCMA7 8,358,66
ihl-man TCLo:350 ppm:CNS	WEHSAL 10,82,73
orl-hmn TDLo:670 mg/kg:GIT	NTIS** PB257-185
ihl-hmn TCLo:920 ppm/70M: EYE,CNS	AIHAAP 19,353,58
ihl-man TCLo:200 ppm/4H:CNS	ATSUDG 5,96,82
orl-rat LD50:10300 mg/kg	NTIS** PB257-185
ihl-rat LC50:18000 ppm/4H	28ZPAK -,28,72
ipr-rat LD50:5100 mg/kg	NTIS** PB257-185
orl-mus LD50:11240 mg/kg	NTIS** PB257-185
ihl-mus LC50:3911 ppm/2H	SAIGBL 13,226,71
ipr-mus LD50:4700 mg/kg	TXAPA9 13,287,68
orl-dog LD50:750 mg/kg	FMCHA2 -,C242,83
ipr-dog LD50:3100 mg/kg	TXAPA9 10,119,67
ivn-dog LDLo:95 mg/kg	HBTXAC 5,72,59
ihl-cat LCLo:600 mg/m^3/4H	85GMAT -,38,82
orl-rbt LD50:5660 mg/kg	AIHAAP 19,353,58
skn-rbt LDLo:1 g/kg	85GMAT -,38,82
scu-rbt LDLo:500 mg/kg	HBTXAC 5,72,59
orl-gpg LD50:9470 mg/kg	AIHAAP 19,353,58

IARC Cancer Review: Animal Inadequate Evidence IMEMDT 20,515,79. NCI Carcinogenesis Bioassay (gavage); Inadequate Studies: mouse, rat NCITR* NCI-CG-TR-3,77. Community Right To Know List. Reported in EPA TSCA Inventory. EPA Genetic Toxicology Program:

OSHA PEL: TWA 350 ppm
ACGIH TLV: TWA 350 ppm; STEL 450 ppm
DFG MAK: 200 ppm (2080 mg/m^3); BAT: blood 55 μg/dl
NIOSH REL: (1,1,1-Trichloroethane) CL 350 ppm/15M

DOT Classification: ORM-A; Label: None; Poison B; Label: St Andrews Cross

THR: Poison by intravenous route. Moderately toxic by ingestion, inhalation, skin contact, subcutaneous and intraperitoneal routes. An experimental teratogen. Human systemic effects by ingestion and inhalation: conjunctiva irritation, hallucinations or distorted perceptions, motor activity changes, irritability, aggression, hypermotility, diarrhea, nausea or vomiting and other gastrointestinal changes. Experimental reproductive effects. Mutagenic data. A human skin irritant. An experimental skin and severe eye irritant. Narcotic in high concentrations. Causes a proarrhythmic activity which sensitizes the heart to epinephrine-induced arrhythmias. This sometimes will cause cardiac arrest, particularly when this material is massively inhaled as in drug abuse for euphoria.

Under the proper conditions it can undergo hazardous reactions with aluminum oxide + heavy metals; dinitrogen tetraoxide; inhibitors; metals (e.g., magnesium; aluminum; potassium; potassium-sodium alloy); sodium hydroxide; N_2O_4; oxygen. When heated to decomposition it emits toxic fumes of Cl^-. Used as a cleaning solvent, a chemical intermediate to produce vinylidene chloride, and as a propellant in aerosol cans. See also CHLORINATED HYDROCARBONS, ALIPHATIC. For further information see methyl chloroform, Vol. 2, No. 5 of *DPIM Report*.

TIN000 *HR: 3*

1,1,2-TRICHLOROETHANE

CAS: 79-00-5 NIOSH: KJ 3150000

mf: $C_2H_3Cl_3$ mw: 133.40

PROP: Liquid; pleasant odor. Bp: 114°, fp: −35°, d: 1.4416 @ 20°/4°, vap press: 40 mm @ 35.2°.

SYNS:

ETHANE TRICHLORIDE
NCI-C04579
RCRA WASTE NUMBER U227
β-T
1,1,2-TRICHLORETHANE
β-TRICHLOROETHANE
1,2,2-TRICHLOROETHANE
TROJCHLOROETAN(1,1,2) (POLISH)
VINYL TRICHLORIDE

TOXICITY DATA:	CODEN:
skn-rbt 500 mg open MLD	UCDS** 6/28/72
skn-rbt 810 mg/24H SEV	JETOAS 9,171,76
eye-rbt 162 mg MLD	JETOAS 9,171,76
skn-gpg 1440 mg/15M	APTOA6 41,298,77
otr-mus:emb 25 mg/L	CALEDQ 28,85,85
cyt-gpg-skn 2880 μg/kg	APTOA6 41,298,77
dnd-mam:lym 1 mmol/L	TODED5 11,243,82
orl-mus TDLo:532 mg/kg (14D male):REP	DCTODJ 8,333,85
orl-mus TDLo:76 g/kg/78W-I:CAR	NCITR* NCI-CG-TR-74,78
orl-mus TD :152 g/kg/78W-I:CAR	NCITR* NCI-CG-TR-74,78
orl-rat LD50:580 mg/kg	AIHAAP 30,470,69
ihl-rat LCLo:500 ppm/8H	AIHAAP 30,470,69
orl-mus LD50:378 mg/kg	DCTODJ 8,333,85
ipr-mus LD50:494 mg/kg	TXAPA9 9,139,66
scu-mus LD50:227 mg/kg	JPETAB 123,224,58
orl-dog LDLo:500 mg/kg	AJHYA2 16,325,32
ipr-dog LD50:450 mg/kg	TXAPA9 10,119,67
ivn-dog LDLo:95 mg/kg	QJPPAL 7,205,34
ihl-cat LCLo:13100 mg/m³/4.5H	AHBAAM 116,131,36
skn-rbt LD50:3730 mg/kg	AIHAAP 30,470,69
scu-rbt LDLo:500 mg/kg	QJPPAL 7,205,34

IARC Cancer Review: Animal Limited Evidence IMEMDT 20,533,79. NCI Carcinogenesis Bioassay (gavage); No Evidence: rat NCITR* NCI-CG-TR-74,78; (gavage); Clear Evidence: mouse NCITR* NCI-CG-TR-74,78. Community Right To Know List. Reported in EPA TSCA Inventory.

OSHA PEL: TWA 10 ppm (skin)
ACGIH TLV: TWA 10 ppm (skin)
DFG MAK: 10 ppm (55 mg/m³)

THR: Poison by ingestion, intravenous and subcutaneous routes. Moderately toxic by inhalation, skin contact, and intraperitoneal routes. An experimental carcinogen. Experimental reproductive effects. Mutagenic data. An eye and severe skin irritant. Has narcotic properties and acts as a local irritant to the eyes, nose and lungs. It may also be injurious to the liver and kidneys. Incompatible with potassium. When heated to decomposition it emits toxic fumes of Cl^-. A priority pollutant associated with EPA superfund sites. See also CHLORINATED HYDROCARBONS, ALIPHATIC and other trichloroethane entries. For further information, see Vol. 5, No. 3 of *DPIM Report*.

TIN500 *HR: 3*

TRICHLOROETHANOL

CAS: 115-20-8 NIOSH: KM 3850000

mf: $C_2H_3Cl_3O$ mw: 149.40

PROP: Liquid. Mp: 17.8°, bp: 150° @ 765 mm, d: 1.54 @ 25/4°, vap press: 1 mm @ 20°, vap d: 5.16.

SYNS:

TRICHLORETHANOL
2,2,2-TRICHLOROETHANOL
TRICHLOROETHYL ALCOHOL
2,2,2-TRICHLOROETHYL ALCOHOL

TOXICITY DATA:	CODEN:
mmo-asn 5 μL/plate/2H	CBINA8 30,9,80
sln-asn 10240 μmol/L	MUREAV 155,105,85
sce-hmn:lym 178 g/L	TOERD9 3,63,81
orl-rat LDLo:500 mg/kg	CRAA7 17,258,38
ipr-rat LDLo:300 mg/kg	JPETAB 63,453,38
orl-mus LDLo:500 mg/kg	CRAAA7 17,258,38
ivn-mus LD50:201 mg/kg	28ZPAK -,78,72
ivn-rbt LDLo:50 mg/kg	JPETAB 63,453,38
rec-rbt LDLo:500 mg/kg	CRAA7 17,258,38

EPA Genetic Toxicology Program. Reported in EPA TSCA Inventory.

THR: Poison by intravenous and intraperitoneal routes. Moderately toxic by ingestion and rectal routes. Human mutagenic data. Explosive reaction with concentrated sodium hydroxide solutions. When heated to decomposition it emits toxic fumes of Cl^-. Used as an hypnotic and anesthetic. See also CHLORINATED HYDROCARBONS, ALIPHATIC.

TIN750 *HR: 3*

TRICHLOROETHENYLSILANE

CAS: 75-94-5 NIOSH: VV 6125000

DOT: 1305

mf: $C_2H_3Cl_3Si$ mw: 161.49

PROP: Fuming liquid. Bp: 90.6°, d: 1.265 @ 25/25°, flash p: 16°F.

SYNS:

SILANE, VINYL TRICHLORO 1-150
TRICHLORO(VINYL)SILANE
TRICHLOROVINYL SILICANE
UNION CARBIDE A-150
VINYLSILICON TRICHLORIDE
VINYL TRICHLOROSILANE (DOT)
VINYL TRICHLOROSILANE, INHIBITED (DOT)

PJL335 *HR: 3*
POLYBROMINATED BIPHENYLS

PROP: A class of aromatic compounds, related to polychlorinated biphenyls, containing two benzene nuclei with two or more substituent bromine atoms. Typically they are inert solids and thus have been used in industry as flame retardants. They do not occur as natural products, but are persistent in the environment and are concentrated in body fat.

SYN: PBB

Community Right To Know list.

THR: The major isomer in production, hexabromobiphenyl, was involved in a large-scale poisoning of dairy cattle in Michigan in 1973.

Generally acute LD_{50} doses are very high but in experimental animals subchronic poisoning may cause body-weight decrease, liver hypertrophy, chloracne-like lesions, suppression of immune response, neuromuscular dysfunction, teratogenic and embryotoxic effects. In humans they cross the placental barrier and are concentrated and secreted in mothers' milk. When heated to decomposition it emits toxic fumes of Br^-. See also HEXABROMOBIPHENYL and OCTABROMODIPHENYL.

PJL350 *HR: 3*
cis-POLY(BUTADIENE)
CAS: 9003-17-2
mf: $(C_4H_6)_n$

$$(CH_2CH{=}CHCH_2)_n$$

THR: May explode when heated above 337°C. When heated to decomposition it emits acrid smoke and irritating fumes. See also BUTADIENE.

PJL375 *HR: 3*
POLY(1,3-BUTADIENE PEROXIDE)
mf: $(C_4H_6O_2)_n$

THR: A powerful explosive very sensitive to shock. Formed by the reaction of butadiene with air. When heated to decomposition it emits acrid smoke and irritating fumes. See also PEROXIDES.

PJL500 *HR: 1*
β-POLY(1,3-BUTADIENE)STYRENE, COPOLYMER
CAS: 9003-55-8 NIOSH: WL 6000000

SYN: KOPOLYMER BUTADIEN STYRENOVY (CZECH)

TOXICITY DATA:	CODEN:
eye-rbt 500 mg/24H MOD	28ZPAK -,257,72

Reported in EPA TSCA Inventory.

THR: An eye irritant. When heated to decomposition it emits acrid smoke and irritating fumes.

PJL600 *HR: 3*
POLY(CARBON MONOFLUORIDE)
CAS: 25136-85-0
mf: $(CF)_n$

THR: Explodes when heated to 500°C in inert atmospheres. Ignites when heated to 400°C in hydrogen atmospheres. When heated to decomposition it emits toxic fumes of F^-. See also FLUORIDES.

PJL750 *HR: 3*
POLYCHLORINATED BIPHENYLS
CAS: 1336-36-3 NIOSH: TQ 1350000
DOT: 2315

PROP: Bp: 340-375°, flash p: 383°F (COC), d: 1.44 @ 30°. A series of technical mixtures consisting of many isomers and compounds that vary from mobile oily liquids to white crystalline solids and hard noncrystalline resins. Technical products vary in composition, in the degree of chlorination and possibly according to batch (IARC** 7,262,74).

SYNS:

AROCLOR	KANECHLOR
CHLOPHEN	MONTAR
CHLOREXTOL	NOFLAMOL
CHLORINATED BIPHENYL	PCB (DOT)
CHLORINATED DIPHENYL	PHENOCHLOR
CHLORINATED DIPHENYLENE	POLYCHLORINATED BIPHENYL
CHLORO BIPHENYL	POLYCHLOROBIPHENYL
CHLORO-1,1-BIPHENYL	PYRALENE
CLOPHEN	PYRANOL
DYKANOL	SANTOTHERM
FENCLOR	SOVOL
INERTEEN	THERMINOL FR-1

TOXICITY DATA:	CODEN:
orl-mam TDLo:325 mg/kg (30D pre/1-36D preg):REP	AMBOCZ 6,239,77
orl-rat TDLo:16800 mg/kg/2Y-C:ETA	TOERD9 1,159,78
orl-mus TDLo:1250 mg/kg/25W-I:CAR	FCTOD7 21,688,83
orl-rat TD :1250 mg/kg/25W-I:CAR	FCTOD7 21,688,83
orl-mus LD50:1900 mg/kg	FKIZA4 60,544,69

IARC Cancer Review: Human Limited Evidence IMEMDT 18,43,78. EPA Extremely Hazardous Substances List. Reported in EPA TSCA Inventory.

NIOSH REL: TWA (Polychlorinated Biphenyls) 0.001 mg/m^3

DOT Classification: ORM-E; Label: None

THR: Moderately toxic by ingestion. Some are poisons by other routes. Suspected human carcinogens. Experimen-

tal carcinogens and tumorigens. Experimental reproductive effects. Like the chlorinated naphthalenes, the chlorinated diphenyls have two distinct actions on the body, namely, a skin effect and a toxic action on the liver. This hepatotoxic action of the chlorinated diphenyls appears to be increased if there is exposure to carbon tetrachloride at the same time. The higher the chlorine content of the diphenyl compound, the more toxic is it liable to be. Oxides of chlorinated diphenyls are more toxic than the unoxidized materials. In persons who have suffered systemic intoxication, the usual signs and symptoms are nausea, vomiting, loss of weight, jaundice, edema and abdominal pain. Where the liver damage has been severe the patient may pass into coma and die. Combustible when exposed to heat or flame. When heated to decomposition they emit highly toxic fumes of Cl^-. Used in heat transfer, hydraulic fluids, lubricants, and insecticides. See also specific compounds. For further information, see PCB's, Vol. 3, No. 4 of *DPIM Report*.

PJM000 *HR: 2*

POLYCHLORINATED BIPHENYL (AROCLOR 1221)

CAS: 11104-28-2 NIOSH: TQ 1352000

SYNS:

AROCHLOR 1221 CHLORODIPHENYL (21% Cl)

TOXICITY DATA:	CODEN:
scu-rat TDLo:1 g/kg (1D pre): REP	ENVRAL 16,123,78
orl-rbt TDLo:28 mg/kg (1-28D preg):REP	BECTA6 6,120,71
orl-rat LD50:3980 mg/kg	ARVPAX 14,139,74
skn-rbt LDLo:3169 mg/kg	ARVPAX 14,139,74

IARC Cancer Review: Human Limited Evidence IMEMDT 18,43,78.

NIOSH REL: TWA (Polychlorinated Biphenyls) 0.001 mg/m^3

THR: Moderately toxic by ingestion and skin contact. Suspected human carcinogen. Experimental reproductive effects. When heated to decomposition it emits toxic fumes of Cl^-. Used in heat transfer, hydraulic fluids, lubricants, and insecticides. See also POLYCHLORINATED BIPHENYLS.

PJM250 *HR: 2*

POLYCHLORINATED BIPHENYL (AROCLOR 1232)

CAS: 11141-16-5 NIOSH: TQ 1354000

SYNS:

AROCLOR 1232 CHLORODIPHENYL (32% Cl)

TOXICITY DATA:	CODEN:
orl-rat LD50:4470 mg/kg	ARVPAX 14,139,74
skn-rbt LDLo:2000 mg/kg	ARVPAX 14,139,74

IARC Cancer Review: Human Limited Evidence IMEMDT 18,43,78.

NIOSH REL: TWA (Polychlorinated Biphenyls) 0.001 mg/m^3

THR: Moderately toxic by skin contact. Mildly toxic by ingestion. Suspected human carcinogen. When heated to decomposition it emits toxic fumes of Cl^-. Used in heat transfer, hydraulic fluids, lubricants, and insecticides. See also POLYCHLORINATED BIPHENYLS.

PJM500 *HR: 3*

POLYCHLORINATED BIPHENYL (AROCLOR 1242)

CAS: 53469-21-9 NIOSH: TQ 1356000

SYNS:

AROCHLOR 1242
AROCLOR 1242
CHLORIERTE BIPHENYLE, CHLORGEHALT 42% (GERMAN)
CHLORODIPHENYL (42% Cl)
CLORODIFENILI, CLORO 42% (ITALIAN)
DIPHENYLE CHLORE, 42% de CHLORE (FRENCH)
GECHLOREERDEDIFENYL (DUTCH)

TOXICITY DATA:	CODEN:
oms-mus:oth 25 ppm/4H	EESADV 3,10,79
orl-rat TDLo:945 mg/kg (36W pre):REP	AECTCV 3,479,75/76
orl-pig TDLo:93 mg/kg (1-16W preg):REP	AJVRAH 36,23,75
ihl-hmn TCLo:10 mg/m^3: PUL,LIV	85CYAB 2,153,59
orl-rat LD50:4250 mg/kg	TXAPA9 24,434,73
scu-gpg LDLo:345 mg/kg	PHRPA6 59,1085,44

IARC Cancer Review: Human Limited Evidence IMEMDT 18,43,78. EPA Genetic Toxicology Program.

OSHA PEL: TWA 1 mg/m^3 (skin)
ACGIH TLV: TWA 1 mg/m^3 (skin)
NIOSH REL: TWA (Polychlorinated Biphenyls) 0.001 mg/m^3

THR: Poison by subcutaneous route. Mildly toxic by ingestion. Human systemic effects by inhalation: pulmonary and liver effects. Suspected human carcinogen. Moderately toxic by ingestion. Experimental reproductive effects. Mutagenic data. When heated to decomposition it emits toxic fumes of Cl^-. Used in heat transfer, hydraulic fluids, lubricants, and insecticides. See also POLYCHLORINATED BIPHENYLS. For further information, see Chlorinated Diphenyls, Vol. 1, No. 3 of *DPIM Report*.

PJM750 *HR: 3*

POLYCHLORINATED BIPHENYL (AROCLOR 1248)

CAS: 12672-29-6 NIOSH: TQ 1358000

SYNS:

AROCLOR 1248 CHLORODIPHENYL (48% Cl)

PROP: Mixture of propane, isobutane, isobutylene and other hydrocarbons (FEREAC 41,15972,76).

SYN: LIQUEFIED PETROLEUM GAS (DOT)

Reported in EPA TSCA Inventory.

DOT Classification: Label: Flammable Gas

THR: A very dangerous fire and explosion hazard when exposed to heat or flame; can react vigorously with oxidizing materials. When heated to decomposition it emits acrid smoke and irritating fumes. See also individual components.

PCS750 *HR: 2*
PETROLEUM 60 SOLVENT
NIOSH: SE 7551000

PROP: Consists of a mixture of hydrocarbons from C_5-C_{10}, chiefly of paraffins, cycloparaffins, alkyl benzenes and benzene (TXAPA9 34,374,75).

TOXICITY DATA:	CODEN:
ihl-hmn TCLo:550 ppm/15M: EYE	TXAPA9 34,374,75
ihl-rat LC50:4900 ppm/4H	TXAPA9 34,374,75
ihl-cat LCLo:4100 ppm/4H	TXAPA9 34,374,75

NIOSH REL: TWA 350 mg/m^3; CL 1800 mg/m^3/15M

THR: Mildly toxic by inhalation. Human systemic effects by inhalation: change in sense of smell and taste, conjunctiva irritation. When heated to decomposition it emits acrid smoke and irritating fumes. See also individual components.

PCT000 *HR: 2*
PETROLEUM 70 SOLVENT
NIOSH: SE 7552000

PROP: Consists of a mixture of hydrocarbons from C_5-C_{10}, chiefly of paraffins, monocycloparaffins, and alkyl benzenes (TXAPA9 34,395,75)

TOXICITY DATA:	CODEN:
ihl-hmn TCLo:180 ppm/15M: EYE	TXAPA9 34,395,75
ihl-dog LCLo:930 ppm/4H	TXAPA9 34,395,75

NIOSH REL: TWA 350 mg/m^3; CL 1800 mg/m^3/15M

THR: Mildly toxic by inhalation. Human systemic effects by inhalation: lacrimation. When heated to decomposition it emits acrid smoke and irritating fumes. See also OLEFINS.

PCT250 *HR: 3*
PETROLEUM SPIRITS
CAS: 64475-85-0 NIOSH: PY 8240000
DOT: 1115

PROP: Volatile, clear, colorless and non-fluorescent liquid. Mp: <−73°, bp: 40-80°, ulc: 95-100, lel: 1.1%, uel: 5.9%, flash p: <0°F, d: 0.635-0.660, autoign temp: 550°F, vap d: 2.50.

SYNS:

BENZINE	SKELLY-SOLVE S
BENZOLINE	SOLVENT NAPHTHA
CANADOL	STODDARD SOLVENT
HERBITOX	VARNISH MAKERS' NAPHTHA
LIGROIN	VARNISH MAKERS' AND PAINTERS' NAPHTHA
MINERAL SPIRITS	VARSOL
MINERAL THINNER	V.M. AND P. NAPHTHA
MINERAL TURPENTINE	WHITE SPIRITS
PAINTERS' NAPHTHA	
REFINED SOLVENT NAPHTHA	

TOXICITY DATA:	CODEN:
eye-hmn 880 ppm/15M	TXAPA9 32,263,75
ihl-hmn TCLo:600 mg/m^3/8H: EYE,PUL,GIT	TPKVAL 10,116,68
unr-man LDLo:1470 mg/kg	85DCAI 2,73,70
ihl-rat LC50:3400 ppm/4H	TXAPA9 32,263,75
ipr-rat LDLo:8560 mg/kg	TXAPA9 1,156,59
ihl-mus LCLo:50000 mg/m^3	TPKVAL 10,116,68

Reported in EPA TSCA Inventory.

ACGIH TLV: TWA 300 ppm; STEL 400 PPM
NIOSH REL: TWA 350 mg/m^3; CL 1800 mg/m^3/15M

THR: Moderately toxic to humans by an unspecified route. Mildly toxic by inhalation and intraperitoneal routes. Ingestion can cause a burning sensation, vomiting, diarrhea, drowsiness, and, in severe cases, pulmonary edema. Inhalation of concentrated vapors can cause intoxication resembling that from alcohol, headache, nausea, coma, and hemorrhage to various vital organs. Highly dangerous fire hazard when exposed to heat, flame sparks, or oxidizing materials. Explosive in the form of vapor when exposed to heat or flame. Highly dangerous; keep away from heat or flame. To fight fire, use foam, CO_2, dry chemical. When heated to decomposition it emits acrid smoke and irritating fumes.

PCT500 *HR: 1*
PETROLEUM 50 THINNER
NIOSH: SE 7558000

PROP: A mixture of paraffins, monocycloparaffins, condensed cycloparaffins, benzene, toluene, and C_8 alkyl benzenes (TXAPA9 36,427,76).

SYN: 50 THINNER

TOXICITY DATA:	CODEN:
eye-hmn 530 ppm/30M MLD	TXAPA9 36,427,76
ihl-rat LC50:8300 ppm/4H	TXAPA9 36,427,76

THR: Mildly toxic by inhalation. A human eye irritant. When heated to decomposition it emits acrid smoke and

REFERENCE 48

SOURCE:

Hine J. and Mookerjee P.K. J. Organic Chemistry 40: 292-8. 1975.

Registry No.—1, 6159-17-7; 1 oxime (Z), 53369-67-6; 1 oxime (E), 53403-31-9; 2, 53369-68-9; 2 hydrochloride, 53403-32-0; 3, 10299-77-7; 4, 53369-69-0; 5, 53403-33-1; 6, 53403-34-2; 7, 53369-70-3; 2,2-dimethyl-3-dimethylaminopropanal, 15451-14-6; hydroxylamine hydrochloride, 5470-11-1; 2,2-dimethyl-3-dimethylaminopropanal oxime, 7405-24-5; 2,2-dimethyl-3-dimethylaminopropylamine, 53369-71-4; 2-(dimethylaminomethyl)cyclohexanone oxime, 53369-72-5; *cis*-2-(dimethylaminomethyl)cyclohexylamine, 53369-73-6; *trans*-2-(dimethylaminomethyl)cyclohexylamine, 53369-74-7; 2-methyl-3-dimethylaminopropylamine, 6105-72-2; 4-methyl-3,4-diazatricyclo[5.2.1.0^{2,6}]-2-decene, 53369-75-8; 3-methylene-2-norbornanone, 5597-27-3; methylhydrazine, 60-34-4; *o*-(dimethylaminomethyl)benzonitrile, 53369-76-9; *o*-cyanobenzyl bromide, 22115-41-9; dimethylamine, 124-40-3; *o*-(dimethylaminomethyl)benzylamine, 53369-77-0; *o*-(dimethylaminomethyl)benzylamine hydrochloride, 53369-78-1; *N,N,N',N'*,2,2-hexamethyl-1,3-propanediamine, 53369-79-2; *o*-bis(dimethylaminomethyl)benzene, 53369-80-5; *o*-bis(dimethylaminomethyl)benzene monoperchlorate, 53369-81-6.

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The Intrinsic Hydrophilic Character of Organic Compounds. Correlations in Terms of Structural Contributions[1]

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Log γ, where $\gamma = c_w/c_g$, with c_w being the concentration of a compound in dilute aqueous solution at 25° and c_g the concentration in the gas phase in equilibrium with the aqueous solution (both in moles per liter), is defined as the intrinsic hydrophilicity of a compound. Values for 292 compounds are listed, and parameters for a bond contribution correlation and a group contribution correlation are determined. Major deviations from the correlations arising from distant polar interactions (interactions between halogen, oxygen, nitrogen, or sulfur substituents separated by more than one carbon atom) are observed. The significance of such deviations and of the relative magnitudes of the group contributions is discussed.

The hydrophilic and hydrophobic character of compounds[2,3] is commonly discussed in terms of data on systems involving an aqueous phase and some other liquid phase. Such data, which include water solubilities and distribution coefficients between water and some other solvent,[4,5] have been quite useful. They depend on differences in free energy (or of enthalpy or some other property) of the molecules of a compound when they are surrounded by water molecules and when they are surrounded by molecules of the other solvent. Hence they depend not only on the nature of the compound in question and on the nature of water but also on the nature of the other solvent in the system in question. The interpretation of data may be simplified somewhat if we consider the difference in free energy of molecules of a given compound when they are surrounded by water and when they are surrounded by nothing, that is, when they are in the gas phase. We shall consider the tendency of a molecule to go from the gas phase to dilute aqueous solution to be a measure of its *intrinsic hydrophilic character.*

In order to discuss the relationship between molecular structure and the intrinsic hydrophilic character of compounds in quantitative terms we have carried out correlations in terms of structural additivity schemes. Such schemes have been used in correlations of enthalpies of formation, entropies, and other thermodynamic properties.[6-8] These correlations have been largely restricted to the properties of compounds in the gas phase. They would be more useful if they were extended to the common solvents in which most reactions are run. Such extensions would consist of correlations concerning transfer processes between the gas phase and the solvents of interest. Butler and coworkers pointed out long ago that the free energy of transfer of organic compounds from the gas phase to aqueous solution is an approximately additive function of the groups present in the compounds.[9-11] Pierotti, Deal, and Derr

treated about 340 cases, including 71 in which water was the solvent, by an empirical equation that may be applied to any compound in any solvent (when the appropriate parameters have been determined).[12] Although this equation is reasonably economical with parameters in its application to solvents, in general it is less so when applied to any one solvent. The 15 homologous series of compounds whose activity coefficients in water were correlated required 30 disposable parameters. A group contribution scheme of the Benson type[6,8] would cover all these compounds and many more with only 24 parameters. For this reason and because of the increased number of reliable data that have become available in recent years, we have correlated activity coefficients in the gas phase relative to aqueous solution using both a bond contribution and a group contribution scheme. Not only will such correlations aid in understanding hydrophobic bonding[2,3] and in predicting equilibrium constants for chemical reactions, they will also be useful in studies of the loss of flavor components from largely aqueous foods,[13] the transfer of pesticides and other compounds between various bodies of water and the atmosphere, and in other ways. In addition, when either the vapor pressure or the water solubility of a difficultly soluble organic compound is known, the other may be estimated from such correlations.

Results

We have tried to correlate values of log γ for various compounds, where γ is the activity coefficient in the ideal gas phase relative to infinitely dilute aqueous solution. As shown in eq 1, γ is taken to be equal to the concentration of

$$\gamma = c_w/c_g \qquad (1)$$

the compound in a dilute aqueous solution divided by its concentration in the gas phase that is in equilibrium with that solution. When the compound and water are not very soluble in each other, c_w may be taken as the water solubility and c_g as the vapor pressure of the compound. We have made γ dimensionless by expressing c_w and c_g in moles per liter. Data at 25° were used and water solubilities were used only for compounds whose water solubility is 1.0 M or less, except for ethyl formate (1.2 M).

The values of log γ, log c_w, log c_g, and P (where P is the vapor pressure in millimeters; log c_g = log P − 4.269) we used and the appropriate literature references are listed in Table IV.[14] The values of γ cover a range of about 10^{10}.

The bond contribution scheme used is similar to that of Benson and Buss, in which certain groups such as cyano, nitro, and carbonyl are treated as atoms. Thus the contribution of the C–CN bond includes implicitly the contribution of the carbon–nitrogen triple bond of the cyano group, and the H–CO bond contribution includes half the contribution of the carbon–oxygen double bond. Olefinic, acetylenic, and aromatic carbon are denoted C_d, C_t, and C_{ar}, respectively. The contribution for a C_d–H bond (or for any C_d–X bond) includes one-fourth of the contribution for the carbon–carbon double bond, and any C_t–X contribution contains half the triple bond contribution. However, the C_{ar}–H contribution does not include a C_{ar}=C_{ar} contribution. The latter was kept separate so as to simplify the treatment of data on nonbenzenoid aromatic compounds. For example, log γ for naphthalene is equal to eight times the C_{ar}–H contribution plus 11 times the C_{ar}=C_{ar} contribution, and log γ for pyridine is equal to five times the C_{ar}–H contribution plus four times the C_{ar}=C_{ar} and two times the C_{ar}=N_{ar} contribution. The 35 bond contributions obtained by least-squares treatment of data on 263 compounds are listed in Table I. The 263 values of log γ calculated from these contributions, which are listed in Table IV,[14] differed from the experimental values with a standard deviation of 0.41. The deviations from about 40 additional values of log γ, some of which had not been located when the parameters listed in Table I were calculated but some of which had been left out of the least-squares treatment because of their highly deviant nature, tended to be larger than this. Most of the larger deviations were of the types that will be rationalized in our discussion of the group contribution correlation.

Table I
Bond Contributions to the Logarithms of Activity Coefficients in the Gas Phase Referred to Aqueous Solution[a]

Bond[b]	Contribution	Bond	Contribution
C–H	−0.11	C_{ar}–Br	0.21
C–F	−0.50	C_{ar}–NO_2[c]	1.83
C–Cl	0.30	C_{ar}–O	−0.74
C–Br	0.87	C_{ar}–S	0.53
C–I	1.03	C_{ar}–CO[d]	1.14
C–CN[c]	2.28	C_{ar}==C_{ar}[e]	0.23
C–NO_2[c]	3.10	C_{ar}==N_{ar}[e]	1.64
C–O	1.00	C_d–H	−0.15[f]
C–S	1.11	C_d–Cl	0.16[f]
C–N	1.35	C_d–C_d	0.48[f]
C–C	0.04	C_d–CO[d]	2.42[f]
C–CO[d]	1.78	C_t–H[g]	0.00
C–C_d	0.15[f]	CO–H[d]	1.19
C–C_t[g]	0.64	CO–O[d]	0.28
C–C_{ar}	0.11	O–H	3.21
C_{ar}–H	−0.21	S–H	0.23
C_{ar}–Cl	−0.14	N–H	1.34

[a] At 25°. [b] C without a subscript refers to a carbon atom bound by single bonds to four other atoms except in CN. [c] The cyano and nitro groups are treated as univalent atoms. [d] The CO group is treated as a divalent atom. [e] The bond denoted == is the $\sigma + \pi$ bond in an aromatic ring. [f] This contribution includes one-fourth the contribution of the carbon–carbon double bond(s). [g] This contribution includes one-half the contribution of the carbon–carbon triple bond.

The group contribution scheme we used is similar to that of Benson and coworkers.[6,8] In most cases a group is taken to contain one polyvalent atom and the monovalent atoms bonded to it, but the group is *characterized* by the nature of the atoms to which it is attached as well as those it contains. Thus a methylene group attached to two oxygen atoms is different from one attached to a carbon and an oxygen atom. Our notation for group contributions, which is $[CH_2(O)_2]$ and $[CH_2(C)(O)]$ for the two groups just referred to, for example, differs from that of Benson and coworkers in that the atoms contained in the group are not parenthesized. We feel that the notation $[C(H)_2(O)_2]$ makes it less obvious that additional contributions are required for the oxygen atoms but not for the hydrogen atoms. The value of log γ for methyl ethyl ether, for example, is taken to be the sum of the four contributions $[CH_3(O)]$, $[O(C)_2]$, $[CH_2(C)(O)]$, and $[CH_3(C)]$. Instead of the symbol C_B for benzenoid carbon[6,8] we have used C_{ar} to include the carbon atoms in the rings of polynuclear aromatic and certain hetaromatic compounds as well. For example, log γ for pyridine is set equal to $3[C_{ar}H(C_{ar})_2] + 2[C_{ar}H(C_{ar})(N_{ar})] + [N_{ar}(C_{ar})_2]$. As in the case of the bond contribution scheme, C_d and C_t refer to olefinic and acetylenic carbon, respectively. Since any C_d must be attached to another C_d and any C_t to another C_t, the C_d or C_t at the other end of the multiple bond is not included in the nota-

Table II
Group Contributions to the Logarithms of Activity Coefficients in the Gas Phase Referred to Aqueous Solution[a]

Group	Contribution	Group	Contribution
$CH_3(X)$[b]	−0.62	$C(C)_3(O)$	0.78
$CH_2(C)_2$	−0.15	$CH_2(O)_2$	−2.54
$CH(C)_3$	0.24	$CH(C)(O)_2$	−1.35[c]
$C(C)_4$	0.71	$CH_2(C_d)(O)$	−0.57[c]
$CH_2(C)(C_{ar})$	−0.19	$CH_2(C)(CO)$	−0.15
$CH(C)_2(C_{ar})$	0.29	$C_{ar}(O)(C_{ar})_2$	−0.43
$C(C)_3(C_{ar})$	0.93	$C_{ar}(CO)(C_{ar})_2$	−0.84[c]
$CH_2(C)(C_d)$	−0.23	$C_dH(CO)$	0.28
$CH_2(C_d)_2$	−0.31[c]	$CHO(Y)$[f]	3.23
$CH_2(C)(C_t)$	−0.29[d]	$CO(C)_2$	4.03
C_dH_2	−0.41	$CO(C)(C_{ar})$	4.26[e]
$C_dH(C)$	0.22	$CO(C)(O)$	4.09
$C_d(C)_2$	0.67	$CO(C_{ar})(O)$	4.57[c]
$C_dH(C_d)$	0.18	$CH_2(C)(S)$	−0.02
$C_d(C)(C_d)$	0.86	$C_{ar}(S)(C_{ar})_2$	−0.25[c]
C_tH	0.00[d]	$CH_2(C)(N)$	−0.08
$C_t(C)$	0.96[d]	$CH_2CN(C)$[g]	3.43
$C_{ar}H(C_{ar})_2$	0.11	$CH_2NO_2(C)$[g]	3.27
$C_{ar}(C)(C_{ar})_2$	0.70	$CHNO_2(C)_2$[g]	3.53[c]
$C_{ar}(C_{ar})_3$[e]	0.47	$C_{ar}H(C_{ar})(N_{ar})$	0.11[h]
$CHF_2(C)$	0.70[c]	$C_{ar}(C)(C_{ar})(N_{ar})$	0.59
$CH_2Cl(C)$	1.05	$C_{ar}NO_2(C_{ar})_2$[g]	2.19
$CHCl_2(C)$	1.33	$OH(C)$	4.45
$CCl_3(C)$	0.80[c]	$OH(C_{ar})$	4.45[i]
$CHCl(C)_2$	1.46	$O(C)_2$	2.93
$CH_2Cl(C_d)$	0.61[c]	$O(C)(C_{ar})$	1.25[c]
C_dHCl	0.05[c]	$O(C)(CO)$	−0.53
$C_{ar}Cl(C_{ar})_2$	0.18[c]	$SH(C)$	1.56
$CH_2Br(C)$	1.10	$SH(C_{ar})$	1.56[j]
$CHBr(C)_2$	1.58[c]	$S(C)_2$	2.35
$C_{ar}Br(C_{ar})_2$	0.49	$S(C)(C_{ar})$	2.30[c]
$CH_2I(C)$	1.14	$NH_2(C)$	4.15
$CHI(C)_2$	1.57[c]	$NH(C)_2$	4.37
$CH_2(C)(O)$	−0.13	$N(C)_3$	4.14
$CH(C)_2(O)$	0.12	$N_{ar}(C_{ar})_2$	3.06

[a] At 25°. [b] X is C, O, N, CO, C_d, C_{ar}, C_t, or S. [c] Based on only one log γ value. [d] This is one of a set of contributions whose sum was determined by a considerably larger set of log γ values but for which only the minimum number of log γ values required for separation into individual contributions was available. [e] This refers to a carbon atom common to two fused aromatic rings, such as C-9 in naphthalene. It may not be applicable to the carbon atoms joined by single bonds in biphenyl, for example. [f] Y is C, O, C_d, or C_{ar}. [g] Nitro and cyano groups are treated as univalent atoms. [h] Assigned the same value as $[C_{ar}H(C_{ar})_2]$. [i] Assigned the same value as [OH(C)]. [j] Assigned the same value as [SH(C)].

tion for the group contribution. Thus the contribution of an olefinic methylene group is written $[C_dH_2]$ rather than $[C_dH_2(C_d)]$.

The values of certain group contributions must be assigned arbitrarily.[6,8] Most such assignments were made in the same way used by Benson and coworkers; *e.g.*, $[CH_3(O)]$, $[CH_3(CO)]$, $[CH_3(N)]$, etc., were all assigned the same value as $[CH_3(C)]$. We also followed their practice of treating certain groups, such as cyano, nitro, and carbonyl, as if they were atoms.

Many of the deviations observed in the bond contribution correlation may be thought of as arising from interactions between polar bonds. When the polar bonds involve a common atom, such interactions are included automatically in a group contribution. The interaction between the two carbon–oxygen bonds involving the central carbon atom of methylal, for example, is included in the $[CH_2(O)_2]$ group contribution. However, early regression analyses convinced us that interactions between more widely separated polar bonds were producing marked deviations from our group contribution correlation. To ignore such interactions would reduce the quality of our correlation and make the values of the parameters depend significantly on the particular set of compounds for which log γ values were available. We therefore decided to obtain contributions for such distant polar interactions or to neglect data upon which such interactions might have a significant effect. Most distant polar interactions of a given type appeared in only one of the 292 compounds for which we had log γ values. Also, a number of group contributions appeared in sets of compounds no larger than the number of parameters to be determined. Compounds of either of these types were deleted from the set before the regression analysis because the analysis would be trivial in such cases. Analysis of the remaining 212 log γ values gave two distant interaction parameters and 49 group contributions (not counting some assigned arbitrarily). From these parameters the log γ values may be calculated with a standard deviation of 0.12, which may not be very much larger than the average experimental uncertainty. The 49 group contributions are listed in Table II with the contributions assigned arbitrarily and 20 additional contributions calculated from data that had not been included in the least-squares treatment. Since these latter contributions are based on small sets of log γ values of the same size as the set of contributions being determined (the set size being 1.0 in most cases), they are less reliable than those obtained from the overdetermined system.

Table III
Distant Polar Interactions in Various Types of Compounds[a]

Compound(s)	Interaction	Compound	Interaction
Pyrazines	−2.26	*cis*-CHCl=CHCl	0.76
RO–C–C–OR	−1.58	$ClCH_2CH_2Br$	−0.72
$HOCH_2CH(OH)CH_2OH$	−7.05	$BrCH_2CH_2Br$	−0.66
$HOCH_2CH_2OH$	−3.02	$MeCHBrCH_2Br$	−0.65
$(ClCH_2CH_2)_2S$	−1.53	$BrCH_2CH_2CH_2Br$	−0.61
p-$HOC_6H_4NO_2$	1.12	$ClCH_2CH_2CH_2Cl$	−0.57
Cl_3CCHCl_2	−1.12	Cl_3CCCl_3	−0.56
$H_2NCH_2CH_2NH_2$	−1.00	*trans*-CHCl=CHCl	0.46
$MeCHClCH_2Cl$	−0.98	*p*-$C_6H_4Br_2$	0.27
Cl_2CHCH_2Cl	−0.95	*p*-HOC_6H_4Br	0.26
$Cl_2CHCHCl_2$	−0.92	*o*-$C_6H_4Cl_2$	0.19
p-HOC_6H_4CHO	0.83	*m*-$C_6H_4Cl_2$	−0.09
$ClCH_2CH_2Cl$	−0.83	*p*-$C_6H_4Cl_2$	−0.07

[a] Values of $(\log \gamma)_{obsd} - (\log \gamma)_{calcd}$, with the latter being obtained from the group contribution scheme.

The only distant polar interactions (numbers that must be added to the group contributions to obtain log γ values) that appeared in more than one compound, and hence the only ones calculated by a least-squares treatment, were the interaction of the two nitrogen atoms in a pyrazine ring and the interaction of two alkoxy groups attached to adjacent saturated carbon atoms. These are the first two entries in Table III. The other distant polar interactions or sets of distant polar interactions occurred in only one compound each and are therefore listed with the formula of the compound in Table III.

Most of the larger interactions seem qualitatively understandable in terms of the structures of the compounds involved. Glycerol and ethylene glycol are internally hydro-

do not gain as much hydrogen bonding on going into aqueous solution and their log γ values are smaller than would be expected from [OH(C)] and [CH_2(C)(O)] values derived from data on monohydroxylic alcohols, for which internal hydrogen bonding is impossible. The third largest interaction, that found in pyrazines, may also be explained in terms of hydrogen bonding, which we assume is the main reason that pyridine and most other azines are much more water soluble than benzene. That is, the large positive value of [$N_{ar}(C_{ar})_2$] listed in Table II, which arises from data on pyridine derivatives, is a reflection of the ability of the pyridine nitrogen atom to accept hydrogen bonds from water. The hydrogen-bonding ability of these nitrogen atoms, like that of other basic atoms of a given type, is known to be decreased by electron-withdrawing substituents.[15] The value of log K for hydrogen bonding of 3- and 4-substituted pyridines to p-fluorophenol in carbon tetrachloride at 25° decreases by 0.24 for each pK unit by which the basicity in water at 25° decreases.[15] Each nitrogen atom in pyrazine is about 4.8 pK units more weakly basic than the nitrogen atom in pyridine.[16] These numbers seem large enough to make it plausible that weak hydrogen bonding to the two nitrogen atoms of pyrazines (relative to hydrogen bonding to the nitrogen atom of pyridine) accounts for much of the distant polar interaction listed for pyrazines. A qualitatively similar effect would be expected for ethylenediamine, but since the amino groups in ethylenediamine are only about 1.0 pK unit weaker than the one in ethylamine[16] it is not surprising that the distant polar interaction is smaller than for pyrazines. The interactions for β-diethers and for the saturated polyhalides and 2,2'-dichlorodiethyl sulfide may be rationalized qualitatively in the same way. Interpretation of the relative magnitudes of these interactions is probably complicated by the following facts. (1) Some of the halides are probably of such low basicity that they are so little involved in hydrogen bonding with water that further decreases in basicity have little effect. (2) Some of the compounds, such as those with dichloromethyl groups, may be acidic as well as basic participants in hydrogen bonding. (3) The strength of hydrogen bonding depends on the polarity as well as the acidity and basicity of the interacting species. (4) Some of the interactions listed may contain major experimental errors.

The largest positive distant polar interaction, for p-nitrophenol, is probably also attributable largely to hydrogen-bonding effects. The nitro group probably interacts with water largely by acting as a base in hydrogen bonding. With the hydroxy group, however, hydrogen bonding to water with the group acting as an acid must be important. The p-hydroxy substituent acts as an electron donor and increases the basicity of the nitro group and the p-nitro substituent acts as an electron withdrawer and increases the acidity of the hydroxy group. Thus the nitro and hydroxy groups in p-nitrophenol may interact more strongly with water than do the nitro and hydroxy groups in nitrobenzene and phenol, respectively. The same argument explains the smaller but still positive interaction observed with p-hydroxybenzaldehyde.

We do not understand why the interactions listed for the 1,2-dichloroethylenes are positive (although the value for the more polar cis isomer would be expected to be more positive, as observed).

Intrinsic hydrophilic character is more simply understood in terms of molecular structure than is the hydrophilic character measured by water solubility or distribution coefficients. Since a hydroxy group can participate as both an acid and a base in hydrogen bonding whereas an ether should ordinarily be considerably more hydrophilic than isomeric ethers. In agreement with expectation γ for n-butyl alcohol is more than 100 times as large as γ for its isomer diethyl ether. In contrast, the solubilities of the two compounds differ by less than 20%; n-butyl alcohol is already so strongly hydrogen bonded in the organic phase that it does not gain as much hydrogen bonding on going into aqueous solution as it otherwise would.

Although the relative magnitudes of the group contributions in Table II tend to agree with common notions concerning structural effects on hydrophilic character, with the contributions for oxygen- and nitrogen-containing groups tending to be larger than those for hydrocarbon groups, it should be remembered that some of the numbers are the results of arbitrary assignments. In the following discussion we shall consider only points that are independent of such assignments. Some of the contributions reflect the kind of polar interactions already discussed in connection with Table III. For example, although [CH_2(C)(O)] is essentially equal to [$CH_2(C)_2$], [$CH_2(O)_2$] is more than two units smaller. Each of the two atoms lowers the basicity and, hence, the hydrogen-bonding ability of the other. Neither of the oxygen atoms is *in* the $CH_2(O)_2$ group, as the carbon and hydrogen atoms are, but since the $CH_2(O)_2$ is the only group uniquely characteristic of a compound with two oxygen atoms bonded to the same methylene group, the interaction appears in the [$CH_2(O)_2$] contribution.

The fact that [S(C)(C_{ar})] is about equal to [$S(C)_2$] whereas [O(C)(C_{ar})] is considerably smaller than [$O(C)_2$] reflects the much greater ability of a phenyl group to withdraw electrons, by a resonance interaction, from an oxygen atom to which it is bonded than from a sulfur atom. The fact that [O(C)(CO)] is still smaller than [O(C)(C_{ar})] reflects the greater electron-withdrawing power of a carbonyl group.

In applying the group contributions in Table II to compounds in which significant distant polar interactions seem possible, the magnitudes of such interactions may be estimated from the interactions listed in Table III. Although the group contribution scheme is to be preferred when the required group contributions have been (or can be) determined, the less precise bond contribution scheme presently covers a significantly larger number of possible compounds.

A brief and preliminary account of this investigation will appear in a forthcoming book.[17]

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Appendix

Table IV is arranged in the order: hydrocarbons, halohydrocarbons, ethers and sulfides, alcohols and mercaptans, phenols and thiophenols, aldehydes, ketones, carboxylic acids, esters, amines, nitriles, nitro compounds, pyridines, and pyrazines. The regression analyses were carried out using a computer program (BMDX 85).[16] In cases where there are no entries under P, log c_g, and log c_w, the values of log γ were obtained from data in the reference cited first.[1-15,17-35] In most cases the units had to be changed to obtain the values listed. Data on aldehydes in aqueous solution were not corrected to allow for the amount present as hydrate (1,1-diol). To permit a direct comparison of the correlating abilities of the group and bond contribution schemes, the latter was applied to the same 212 values of log γ that had been used for the group contribution correlation. The resulting standard deviation, 0.42, was essentially the same as that obtained in the bond correlation of 263 compounds that yielded the parameters in Table I and the calculated values of log γ in the last column of Table IV.

To help in assessing the quality of the correlations, a plot of log γ_{bond} *vs.* log γ_{expt} is shown in Figure 1. The quality of the group contribution correlation may be inferred from the fact that the standard deviation was only 29% as large as that in the bond contribution correlation.

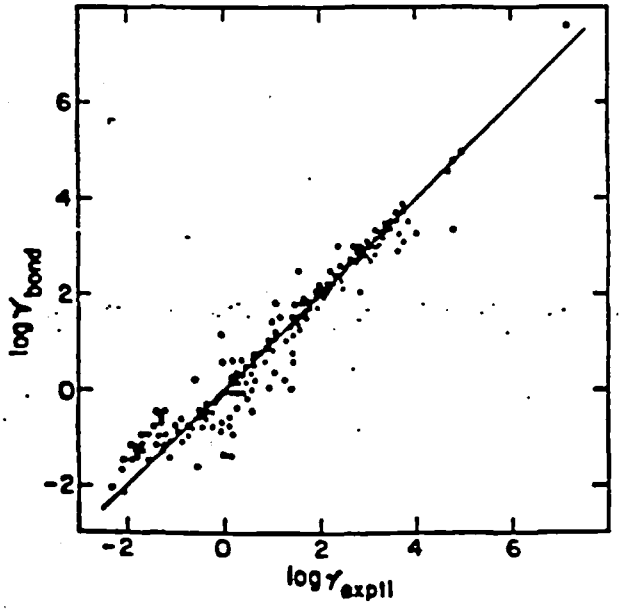

Figure 1. Plot of log γ_{bond} *vs.* log γ_{expt}.

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Ranking Strong Acids *via* a Selectivity Parameter. I

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The relative facility of an acid in catalyzing the isomerization of methylpentanes to 2,2-dimethylbutane and *n*-hexane and the simultaneous deprotonation of carbonium ion intermediates is used to define a selectivity parameter, $k_{iso}/k_{ex} \equiv I/E$, characteristic of the medium. I/E is used to rank Lewis acids in HBr, HCl, HF, HSO_3F, and CF_3SO_3H. Data for two I/E scales, one for exchange with isopentane and the other for exchange with methylcyclopentane, are reported.

The choice of an acid catalyst for a hydrocarbon reaction is to a large extent governed by qualitative observations rather than quantitative information about existing possibilities. This situation exists because the relative acid strength of important acids is often unknown and because firm information about the stability of ionic intermediates in most acids is virtually unavailable.

To help clarify the issues recent work, notably that of Professor R. J. Gillespie and his colleagues, has aimed at determining Hammett acidity function values, H_0, for systems employing SbF_5 as a Lewis acid.[1-3] Using nitro aromatics as indicators, he has shown that some acids have about 10^8 times the protonating ability of 100% H_2SO_4. Acids in this range are generally useful for paraffin–olefin alkylation, paraffin isomerization, and certain types of cracking reactions. Using similar techniques we are in the process of extending Gillespie's measurements to other acids, but of added importance, we have developed a new procedure to classify acids according to the manner in which they stabilize or interact with alkyl carbonium ions.

Our procedure is aimed at giving us quantitative information about the nucleophilicity of a given acid solution. Specifically it tells us if an alkyl cation can rearrange with or without deprotonating during its lifetime in the acid. It should be noted that the nucleophilicity of an acid system is not necessarily directly related to its acidity as a Bronsted acid, a property more properly evaluated by an H_0 type measurement.

This information is acquired by simultaneously reacting a hydrocarbon which contains an essentially uniform distribution of tritium around its skeleton with another molecular weight but unlabeled hydrocarbon over any acid catalyst. A "perfect" acid will allow all isomerizations to occur without hydrogen exchange while a "poor" acid, which is unable to stabilize the ion, will tend to induce faster exchange than isomerization. The ratio of isomerization to exchange rate constants, k_{iso}/k_{ex} or I/E, is defined as a selectivity parameter which permits the ranking of all strong acids. This parameter should be useful until alternate exchange mechanisms become important. At very high acidities direct protonation and displacement may become significant but it is not a serious factor through 2 *M* SbF_5–HSO_3F solutions which have H_0 values > −18.

Strategical Approach to the Problem

In order to obtain the selectivity parameter, it is first necessary to prepare a suitably labeled hydrocarbon. This was done by contacting 2- or 3-methylpentane with 98% H_2SO_4 containing tracer quantities of T_2O (1 mCi/ml) for several days. In this acid, the methylpentanes isomerize without undergoing chain branching rearrangements and exchange all protons except the tertiary hydrogen.[4-13] The labeled methylpentanes were diluted with unlabeled methylpentanes and mixed with isopentane (mixture 1) or methylcyclopentane (mixture 2).

Since it is known that during the isomerization of methylpentanes to an equilibrium mixture of all isomers there is a rapid equilibration of 2-methylpentane, 3-methylpentane, and 2,3-dimethylbutane which is followed by a slower conversion of this mixture to 2,2-dimethylbutane and *n*-hexane[4,14,15] we choose the rate of the latter process, k_{iso}, as a measure of the isomerization activity of the acid.

We also measure the rate of depletion of radioactivity in the total hexane fraction. The isomerization and overall exchange processes are both assumed to follow first-order kinetics and the rate constants are obtained from log concentration or radioactivity *vs.* time plots. In the more reactive acid systems there is substantial uncertainty in the rate

REFERENCE 49

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IRIS. Integrated Risk Information System. National Library of Medicine Database. Retrieved June 18, 1990.

1 - IRIS
NAME OF SUBSTANCE Asbestos
CAS REGISTRY NUMBER 1332-21-4
EVIDENCE FOR HUMAN CARCINOGENICITY

CLASSIFICATION: NOTE: The carcinogen assessment summary for asbestos may change in the near future pending the outcome of a further review now being conducted by the CRAVE Work Group. —— Classification -- A; human carcinogen Basis -- Observation of increased mortality and incidence of lung cancer, mesotheliomas and gastrointestinal cancer in exposed workers. Animal studies by inhalation in two strains of rats showed similar findings for lung cancer and mesotheliomas. Animal evidence for carcinogenicity via ingestion is limited (male rats fed intermediate-range chrysotile fibers; i.e., >10 um length, developed benign polyps), and epidemiologic data in this regard are inadequate.

HUMAN CARCINOGENICITY DATA:

Sufficient. Numerous epidemiologic studies have reported an increased incidence of deaths due to cancer, primarily lung cancer and mesotheliomas associated with exposure to inhaled asbestos. Among 170 asbestos insulation workers in North Ireland followed for up to 26 years, an increased incidence of death was seen due to all cancers (SMR=390), cancers of the lower respiratory tract and pleura (SMR=1760) (Elmes and Simpson, 1971) and mesothelioma (7 cases). Exposure was not quantified.

Selikoff (1976) reported 59 cases of lung cancer and 31 cases of mesothelioma among 1249 asbestos insulation workers followed prospectively for 11 years. Exposure was not quantified. A retrospective cohort mortality study (Selikoff et al., 1979) of 17,800 U.S. and Canadian asbestos insulation workers for a 10-year period using best available information (autopsy, surgical, clinical) reported an increased incidence of cancer at all sites (319.7 expected vs. 995 observed, SMR=311) and cancer of the lung (105.6 expected vs. 486 observed, SMR=460). A modest increase in deaths from gastrointestinal cancer was reported along with 175 deaths from mesothelioma (none expected). Years of exposure ranged from less than 10 to greater than or equal to 45. Levels of exposure were not quantified. In other epidemiologic studies, the increase for lung and pleural cancers has ranged from a low of 1.9 times the expected rate, in asbestos factory workers in England (Peto et al., 1977), to a high of 28 times the expected rate, in female asbestos textile workers in England (Newhouse et al., 1972). Other occupational studies have demonstrated asbestos exposure-related increases in lung cancer and mesothelioma in several industries including textile manufacturing, friction products manufacture, asbestos cement products, and in the mining and milling of asbestos. The studies used for the inhalation quantitative estimate of risk are listed in the table in CARI.

A case-control study (Newhouse and Thompson, 1965) of 83 patients with mesothelioma reported 52.6% had occupational exposure to asbestos or lived with asbestos workers compared with 11.8% of the controls. Of the remaining subjects, 30.6% of the mesothelioma cases lived within one-half mile of an asbestos factory compared with 7.6% of the controls.

The occurrence of pleural mesothelioma has been associated with the presence of asbestos fibers in water, fields and streets in a region of Turkey with very high environmental levels of naturally-occurring asbestos (Baris et al., 1979).

Kanarek et al. (1980) conducted an ecologic study of cancer deaths in 722 census tracts in the San Francisco Bay area, using cancer incidence data from the period of 1969-1971. Chrysotile asbestos concentrations in drinking water ranged from nondetectable to 3.6E+7 fibers/L. Statistically significant dose-related trends were reported for lung and peritoneal cancer in white males and for gall bladder, pancreatic and peritoneal cancer in white females. Weaker correlations were reported between asbestos levels and female esophageal, pleural and kidney cancer, and stomach cancer in both sexes. In an extension of this study, Conforti et al. (1981) included cancer incidence data from the period of 1969-1974. Statistically significant positive associations were found between asbestos concentration and cancer of the digestive organs in white females, cancers of the digestive tract in white males and esophageal, pancreatic and stomach cancer in both sexes. These associations appeared to be independent of socioeconomic status and occupational exposure to asbestos.

Marsh (1983) reviewed eight independent ecologic studies of asbestos in drinking water carried out in five geographic areas. It was concluded that even though one or more studies found an association between asbestos in water and cancer mortality (or incidence) due to neoplasms of various organs, no individual study or aggregation of studies exists that would establish risk levels from ingested asbestos. Factors confounding the results of these studies include the possible underestimates of occupational exposure to asbestos and the possible misclassification of peritioneal mesothelioma as GI cancer.

Polissar et al. (1984) carried out a case-control study which included better control for confounding variables at the individual level. The authors concluded that there was no convincing evidence for increased cancer risk from asbestos ingestion. At the present time, an important limitation of both the case-control and the ecologic studies is the short follow-up time relative to the long latent period for the appearance of tumors from asbestos exposure.

ANIMAL CARCINOGENICITY DATA:

Sufficient. There have been about 20 animal bioassays of asbestos. Gross et al. (1967) exposed 61 white male rats (strain not reported) to 86 mg chrysotile asbestos dust/cu.m for 30 hours/week for 16 months. Of the 41 animals that survived the exposure period, 10 had lung cancer. No lung cancer was observed in 25 controls.

Reeves (1976) exposed 60-77 rats/group for 4 hours/day, 4 days/week for 2 years to doses of 48.7-50.2 mg/cu.m crocidolite, 48.2-48.6 mg/cu.m amosite and 47.4-47.9 mg/cu.m chrysotile. A 5-14% incidence of lung cancer was observed among concentration groups and was concentration-dependent.

Wagner et al. (1974) exposed CD Wistar rats (19-52/group) to 9.7-14.7 mg/cu.m of several types of asbestos for 1 day to 24 months for 7 hours/day,

5 days/week. A duration-dependent increased incidence of lung carcinomas and mesotheliomas was seen for all types of asbestos after 3 months of exposure compared with controls.

F344 rats (88-250/group) were exposed to intermediate range chrysotile asbestos (1291E+8 f/g) in drinking water by gavage to dams during lactation and then in diet throughout their lifetime (NTP, 1985). A statistically significant increase in incidence of benign epithelial neoplasms (adenomatous polyps in the large intestine) was observed in male rats compared with pooled controls of all NTP oral lifetime studies (3/524). In the same study, rats exposed to short range chrysotile asbestos (6081E+9 f/g) showed no significant increase in tumor incidence.

Ward et al. (1980) administered 10 mg UICC amosite asbestos 3 times/week for 10 weeks by gavage to 50 male F344 rats. The animals were observed for an additional 78-79 weeks post-treatment. A total of 17 colon carcinomas were observed. This result was statistically significant compared with historical controls; no concurrent controls were maintained.

Syrian golden hamsters (126-253/group) were exposed to short and intermediate range chrysotile asbestos at a concentration of 1% in the diet for the lifetime of the animals (NTP, 1983). An increased incidence of neoplasia of the adrenal cortex was observed in both males and females exposed to intermediate range fibers and in males exposed to short range fibers. This increase was statistically significant by comparison to pooled controls but not by comparison to concurrent controls. NTP suggested that the biologic importance of adrenal tumors in the absence of target organ (GI tract) neoplasia was questionable.

SUPPORTING DATA:

Sincock (1977) reported an increased number of chromosomes and chromosome breaks after passive inclusion of asbestos with CHO-K1 cells. Chamberlain and Tarmy (1977) reported asbestos not to be mutagenic for E. coli or S. typhimurium. A positive response was unlikely, however, since prokaryotic cells do not phagocytize particles as do eukaryotic cells.

ORAL EXPOSURE ND
CARCINOGENICITY ASSESSME
INHALATION EXPOSURE
CARCINOGENICITY ASSESSME

CLASSIFICATION: NOTE: The carcinogen assessment summary for asbestos may change in the near future pending the outcome of a further review now being conducted by the CRAVE Work Group.
----- Classification -- A; human carcinogen Basis -- Observation of increased mortality and incidence of lung cancer, mesotheliomas and gastrointestinal cancer in exposed workers. Animal studies by inhalation in two strains of rats showed similar findings for lung cancer and mesotheliomas. Animal evidence for carcinogenicity via ingestion is limited (male rats fed intermediate-range chrysotile fibers; i.e., >10

um length, developed benign polyps), and epidemiologic data in this regard are inadequate.

RISK/AIR CONCENTRATIONS:

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	4E-4 f/mL
E-5 (1 in 100,000)	4E-5 f/mL
E-6 (1 in 1,000,000)	4E-6 f/mL

INHALATION DOSE-RESPONSE DATA:

Human Data Occupational Group	Fiber Type	Reported Average Exposure (fiber-yr/mL)	% Increase in Cancer per fiber-yr/mL	Reference
Lung Cancer:				
Textile Products	Predominantly Chrysotile	44	2.8	Dement et al., 1983b
Textile Products	Chrysotile	31	2.5	McDonald et al., 1983a
Textile Products	Chrysotile	200	1.1	Peto, 1980
Textile Products	Chrysotile	51	1.4	McDonald et al., 1983b
Friction Products	Chrysotile	32	0.058	Berry and Newhouse, 1983
Friction Products	Chrysotile	31	0.010	McDonald et al., 1984
Insulation Products	Amosite	67	4.3	Seidman, 1984
Insulation Workers	Mixed (Chrysotile, Crocidolite and Amosite)	300	0.75	Selikoff et al., 1979
Asbestos Products		374	0.49	Henderson and Enterline, 1979
Cement Products		89	0.53	Weill et al., 1979
		112	6.7	Finkelstein, 1983
Mesothelioma:				
Insulation workers	Mixed	375	1.5E-6	Selikoff et al., 1979; Peto et al., 1982

Insulation Products	Amosite	400	1.0E-6	Seidman et al., 1979
Textile Products Manufacturer	Chrysotile	67 -	3.2E-6	Peto, 1980; Peto et al., 1982
Cement Products	Mixed	108	1.2E-5	Finkelstein, 1983

ADDITIONAL COMMENTS:

Risks have been calculated for males and females according to smoking habits for a variety of exposure scenarios (U.S. EPA, 1986). The unit risk value is calculated for the additive combined risk of lung cancer and mesothelioma, and is calculated as a composite value for males and females. The epidemiological data show that cigarette smoking and asbestos exposure interact synergistically for production of lung cancer and do not interact with regard to mesothelioma. The unit risk value is based on risks calculated using U.S. general population cancer rates and mortality patterns without consideration of smoking habits. The risks associated with occupational exposure were adjusted to continuous exposure by applying a factor of 140 cu.m/50 cu.m based on the assumption of 20 cu.m/day for total ventilation and 10 cu.m/8-hour workday in the occupational setting.

The unit risk is based on fiber counts made by phase contrast microscopy (PCM) and should not be applied directly to measurements made by other analytical techniques. The unit risk uses PCM fibers because the measurements made in the occupational environment use this method. Many environmental monitoring measurements are reported in terms of fiber counts or mass as determined by transmission electron microscopy (TEM). PCM detects only fibers longer than 5 um and >0.4 um in diameter, while TEM can detect much smaller fibers. TEM mass units are derived from TEM fiber counts. The correlation between PCM fiber counts and TEM mass measurements is very poor. Six data sets which include both measurements show a conversion between TEM mass and PCM fiber count that range from 5-150 (ug/cu.m)/(f/mL). The geometric mean of these results, 30 (ug/cu.m)/(f/mL), was adopted as a conversion factor (U.S. EPA, 1986), but it should be realized that this value is highly uncertain. Likewise, the correlation between PCM fiber counts and TEM fiber counts is very uncertain and no generally applicable conversion factor exists for these two measurements.

In some cases TEM results are reported as numbers of fibers <5 um long and of fibers longer than 5 um. Comparison of PCM fiber counts and TEM counts of fibers >5 um show that the fraction of fibers detected by TEM that are also >0.4 um in diameter (and detectable by PCM) varies from 22-53% (U.S. EPA, 1986).

It should be understood that while TEM can be specific for asbestos, PCM is a nonspecific technique and will measure any fibrous material. Measurements by PCM which are made in conditions where other types of fibers may be present may not be reliable.

In addition to the studies cited above, there were three studies of asbestos workers in mining and milling which showed an increase in lung cancer (McDonald et al., 1980, Nicholson et al., 1979; Rubino et al., 1979).

The slope factor calculated from these studies was lower than the other studies, possibly because of a substantially different fiber size distribution, and they were not included in the calculation. The slope factor was calculated by life table methods for lung cancer using a relative risk model, and for mesothelioma using a absolute risk model. The final slope factor for lung cancer was calculated as the weighted geometric mean of estimates from the 11 studies cited in CARI. The final slope factor for mesothelioma is based on the calculated values from the studies of Selikoff et al. (1979), Peto et al. (1982), Seidman et al. (1979), Peto (1980) and Finkelstein (1983) adjusted for the mesothelioma incidence from several additional studies cited previously.

There is some evidence which suggests that the different types of asbestos fibers vary in carcinogenic potency relative to one another and site specificity. It appears, for example, that the risk of mesothelioma is greater with exposure to crocidolite than with amosite or chrysotile exposure alone. This evidence is limited by the lack of information on fiber exposure by mineral type. Other data indicates that differences in fiber size distribution and other process differences may contribute at least as much to the observed variation in risk as does the fiber type itself.

The unit risk should not be used if the air concentration exceeds 4E-2 ug/cu.m, since above this concentration the slope factor may differ from that stated.

DISCUSSION OF CONFIDENCE:

A large number of studies of occupationally-exposed workers have conclusively demonstrated the relationship between asbestos exposure and lung cancer or mesothelioma. These results have been corroborated by animal studies using adequate numbers of animals. The quantitative estimate is limited by uncertainty in the exposure estimates, which results from a lack of data on early exposure in the occupational studies and the uncertainty of conversions between various analytical measurements for asbestos.

CARCINOGENICITY
ASSESSMENT DOCUMENTATION
CARCINOGENICITY SOURCE DOCUMENT:

U.S. EPA. 1985. Drinking Water Criteria Document for Asbestos. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Drinking Water, Washington, DC.

U.S. EPA. 1986. Airborne Asbestos Health Assessment Update. Prepared by the Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA 600/8-84/003F.

The 1985 Drinking Water Criteria Document for Asbestos and the 1986 Airborne Asbestos Health Assessment Update have received Agency review.

REVIEW DATES: 09/15/87, 12/02/87
VERIFICATION DATE: 12/02/87
EPA CONTACTS:

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1 - IRIS

NAME OF SUBSTANCE Lead and compounds (inorganic)

CAS REGISTRY NUMBER 7439-92-1

EVIDENCE FOR HUMAN CARCINOGENICITY

CLASSIFICATION: B2; probable human carcinogen

BASIS FOR CLASSIFICATION: Sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short term studies show that lead affects gene expression. Human evidence is inadequate.

HUMAN CARCINOGENICITY DATA:

Inadequate. There are four epidemiologic studies in occupational cohorts exposed to lead and lead compounds. Two studies (Dingwall-Fordyce and Lane 1963, Nelson et al., 1982) did not find any association between exposure to lead and cancer mortality. Selevan et al. (1985) in their retrospective cohort mortality study of primary lead smelter workers found a slight decrease in the total cancer mortality (SMR=95). Apparent excesses were observed for respiratory cancer (SMR=111, obs=41, $p>0.05$) and kidney cancer (SMR=204, obs=6, $p>0.05$). Cooper and Gaffey (1975) and Cooper (1985 update) in their cohort mortality study of battery plant workers and lead smelter workers found statistically significant excesses for total cancer mortality (SMR=113, obs=344), stomach cancer (SMR=168, obs=34) and lung cancer (SMR=124, obs=109) in battery plant workers. Although similar excesses were observed in smelter workers, they were not statistically significant. Cooper and Gaffey (1975) felt it was possible that individual subjects were monitored primarily on the basis of obvious signs of lead exposure, while others who show no symptoms of lead poisoning would not be monitored.

All of the available studies lacked quantitative exposure information, as well as information on the possible contribution of smoking. All studies also had exposures to other metals such as arsenic, cadmium and zinc for which no adjustment was done. The cancer excesses observed in the lung and stomach were relatively small (<200). There was no consistency of site among the various studies, and no study showed any dose-response relationship. Thus, the available human evidence is considered to be inadequate to refute or demonstrate potential carcinogenicity for humans from lead exposure.

ANIMAL CARCINOGENICITY DATA:

Sufficient. The carcinogenic potential of lead salts, primarily phosphates and acetates, administered by the oral route, diet or by injection has been demonstrated in rats and mice by more than 10 investigators. The most characteristic cancer response is bilateral renal carcinoma. Rats given lead acetate or subacetate orally have developed gliomas, and lead subacetate also produced lung adenomas in mice after i.p. adminstration. Most of these investigations found a carcinogenic response only at the highest dose. The lead compounds tested in animals are almost all soluble salts. Metallic lead, lead oxide and lead tetralkyls have not been tested adequately. Studies with inhalation exposure have not been located in the literature.

Azar et al. (1973) administerd 10, 50, 100, and 500 ppm lead as lead acetate in dietary concentrations to fifty rats/sex/treatment group for 2 years. One hundred control rats of each sex received the basal laboratory diet. In a second 2-year feeding study, 20 rats/group were given diets containing 0, 1000, and 2000 ppm lead as lead acetate. No renal tumors were reported in the control groups or in treated animals of either sex receiving 10 to 100 ppm. Male rats fed 500, 1000, and 2000 ppm lead acetate had an increased renal tumor incidence of 5/50, 10/20, and 16/20, while 7/20 females in the 2000 ppm developed renal tumors.

The Azar et al. (1973) study is limited by the lack of experimental detail. The possibility of environmental contamination from lead in the air or drinking water was not mentioned. The strains of rats used were not specified in the study, but the Health Effects Assessment for Lead (U.S. EPA, 1984) indicated the rats were Wistar strain. The weight gain at 1000 and 2000 ppm was reported to be depressed, but details were not given.

Kasprzak et al. (1985), in investigating the interaction of dietary calcium on lead carcinogenicity, fed a diet with 1% lead subacetate (8500 ppm Pb) to male Sprague-Dawley rats for 79 weeks. Of the rats surviving (29/30) in this treatment group beyond 58 weeks, 44.8% had renal tumors. Four rats had adenocarcinomas; the remainaing nine had adenomas. Bilateral tumors were noted. No renal tumors were noted among the controls.

As part of a study to determine interactions between sodium nitrite, ethyl urea and lead, male Sprague-Dawley rats were given lead acetate in their drinking water for 76 weeks (Koller et al., 1986). The concentration of lead was 2600 ppm. No kidney tumors were detected among the 10 control rats. Thirteen of 16 (81%) lead-treated rats had renal tubular carcinoma, with three tumors detected at 72 weeks and the remainder detected at the termination of the study.

Van Esch and Kroes (1969) fed basic lead acetate at 0, 0.1%, and 1.0% in the diet to 25 Swiss mice/sex/treatment group for 2 years. No renal tumors developed in the control group, but 6/25 male mice of 0.1% basic lead acetate group had renal tumors (adenomas and carcinomas combined). In the 1.0% group, one female had a renal tumor. The authors felt that the low incidence in the 1.0% group was due to early mortality.

Hamsters given lead subacetate at 0.5% and 1% in the diet had no significant renal tumor response (Van Esch and Kroes, 1969).

SUPPORTING DATA:

Lead acetate induces cell transformation in Syrian hamster embryo cells (DiPaolo et al., 1978) as well as enhances the incidence of simian adenovirus induction. Lead oxide showed similar enhanced adenovirus induction (Casto et al., 1979).

Under certain conditions lead compounds are capable of inducing chromosomal aberrations in vivo and in tissue cultures. Grandjean et al. (1983) showed a relationship between SCE and lead exposure in exposed workers. Lead has been shown, in a number of DNA structure and function assays, to

affect the molecular processes associated with the regulation of gene expression (U.S. EPA, 1986).

ORAL EXPOSURE ND
CARCINOGENICITY ASSESSME
INHALATION EXPOSURE ND
CARCINOGENICITY ASSESSME
CARCINOGENICITY
ASSESSMENT DOCUMENTATION
CARCINOGENICITY SOURCE DOCUMENT:

U.S. EPA. 1984. Health Effects Assessment for Lead. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-86/055. NTIS PB85-163996/AS.

U.S. EPA. 1986. Air Quality Criteria Document for Lead. Volumes III, IV. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC, for the Office of Air Quality Planning and Standards. EPA-600/8-83/028dF.

U.S. EPA. 1987. Preliminary review of the carcinogenic potential of lead associated with oral exposure. Prepared by the Office of Health and Environmental Assessment, Carcinogenic Assessment Group, Washington DC, for the Office of Drinking Water, Office of Solid Waste and the Office of Emergency and Remedial Response (Superfund). OHEA-C-267. Internal Review Draft.

The review of the carcinogenic potential of lead associated with oral exposure has received Agency review.

The 1986 Air Quality Criteria Document for Lead has received Agency and External Review.

REVIEW DATES: 05/04/88
VERIFICATION DATE: 05/04/88
EPA CONTACTS:

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1 - IRIS
NAME OF SUBSTANCE 1,1,1-Trichloroethane
CAS REGISTRY NUMBER 71-55-6
EVIDENCE FOR HUMAN CARCINOGENICITY

CLASSIFICATION: D; not classifiable as to human carcinogenicity.
BASIS FOR CLASSIFICATION: There are no reported human data and animal studies (one lifetime gavage, one intermediate-term inhalation) have not demonstrated carcinogenicity. Technical grade 1,1,1-trichloroethane has been shown to be weakly mutagenic, although the contaminant, 1,4-dioxane, a known animal carcinogen, may be responsible for this response.
HUMAN CARCINOGENICITY DATA:

None.

ANIMAL CARCINOGENICITY DATA:

Inadequate. The NCI (1977) treated 50 male and 50 female Osborne-Mendel rats with 750 or 1500 mg/kg technical-grade 1,1,1-trichloroethane 5 times/week for 78 weeks by gavage. The rats were observed for an additional 32 weeks. Twenty rats of each sex served as untreated controls. Low survival of both male and female treated rats (3%) may have precluded significant development of tumors late in life. Although a variety of neoplasms was observed in both treated and matched control rats, they were common to aged rats and were not significantly related to dosage. Similar results were obtained when the NCI (1977) treated B6C3F1 hybrid mice with the time-weighted average doses of 2807 or 5615 mg/kg 1,1,1-trichloroethane by gavage 5 days/week for 78 weeks. The mice were observed for an additional 12 weeks. The control and treated groups had 20 and 50 animals of each sex, respectively. Only 25 to 45% of those treated survived until the time of terminal sacrifice. A variety of neoplasms were observed in treated groups but with an incidence not statistically different from matched controls.

Quast et al. (1978) exposed 96 Sprague-Dawley rats of both sexes to 875 or 1750 ppm 1,1,1-trichloroethane vapor for 6 hours/day, 5 days/week for 12 months, followed by an additional 19-month observation period. The only significant sign of toxicity was an increased incidence of focal hepatocellular alterations in female rats at the highest dosage. It was not evident that a maximum tolerated dose (MTD) was used nor was a range-finding study conducted. No significant dose-related neoplasms were reported, but these dose levels were below those used in the NCI study.

SUPPORTING DATA:

Mutagenicity testing of 1,1,1-trichloroethane has produced positive results in S. typhimurium strain TA100 (Simmon et al., 1977; Fishbein, 1979; Snow et al., 1979) as well as some negative results (Henschler et al., 1977; Taylor, 1978).

It was mutagenic for S. typhimurium strain TA1535 both with exogenous metabolic activation (Farber, 1977) and without activation (Nestmann et al., 1980). 1,1,1-Trichloroethane did not result in gene conversion or mitotic

recombination in Saccharomyces cerevisiae (Farber, 1977; Simmon et al., 1977) nor was it positive in a host-mediated forward mutation assay using Schizosaccharomyces pombe in mice. The chemical also failed to produce chromosomal aberrations in the bone marrow of cats (Rampy et al., 1977), but responded positively in a cell transformation test with rat embryo cells (Price et al., 1978).

An isomer, 1,1,2-trichloroethane, is carcinogenic in mice, inducing liver cancer and pheochromocytomas in both sexes. Dichloroethanes, tetrachloroethanes and hexachloroethanes also produced liver cancer in mice and other types of neoplasms in rats.

It should be noted that 1,4-dioxane, a known animal carcinogen, is a contaminant of technical-grade 1,1,1-trichlorethane. It causes liver and nasal tumors in more than one strain of rats and hepatocellular carcinomas in mice.

ORAL EXPOSURE ND
CARCINOGENICITY ASSESSME
INHALATION EXPOSURE ND
CARCINOGENICITY ASSESSME
CARCINOGENICITY
ASSESSMENT DOCUMENTATION
CARCINOGENICITY SOURCE DOCUMENT:

U.S. EPA. 1984a. Health Effects Assessment for 1,1,1-Trichloroethane. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Emergency and Remedial Response, Washington, DC.

U.S. EPA. 1984b. Health Assessment Document for 1,1,1-Trichloroethane. Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA-600/8-82-003F.

The 1984 Health Effects Assessment for 1,1,1-Trichloroethane has received limited Agency review. The values in the 1984 Health Assessment Document for 1,1,1-Trichloroethane have received both Agency and public review.

REVIEW DATES: 08/05/87
VERIFICATION DATE: 08/05/87
EPA CONTACTS:

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1 - IRIS
NAME OF SUBSTANCE Chromium(VI)
CAS REGISTRY NUMBER 7440-47-3
EVIDENCE FOR HUMAN CARCINOGENICITY

CLASSIFICATION: A; human carcinogen by the inhalation route
BASIS FOR CLASSIFICATION: Results of epidemiologic studies are consistent across investigators and locations. Dose-response relationships for lung tumors have been established.
HUMAN CARCINOGENICITY DATA:

Sufficient. Epidemiologic studies of chromate production facilities in the United States (Machle and Gregorius, 1948; Brinton et al., 1952; Mancuso and Hueper, 1951, Mancuso, 1975; Baetjer, 1950; Taylor, 1966; Enterline, 1974; Hayes et al., 1979; Hill and Ferguson, 1979), Great Britain (Bidstrup, 1951; Bidstrup and Case, 1956; Alderson et al., 1981), Japan (Watanabe and Fukuchi, 1975; Ohsaki et al., 1978; Sano and Mitohara, 1978; Satoh et al., 1981) and West Germany (Korallus et al., 1982; Bittersohl, 1971) have established an association between chromium (Cr) exposure and lung cancer. Most of these studies did not attempt to determine whether Cr III or Cr VI compounds were the etiologic agents.

Three studies of the chrome pigment industry, one in Norway (Langard and Norseth, 1975), one in England (Davies, 1978, 1979), and the third in the Netherlands and Germany (Frentzel-Beyme, 1983) also found an association between occupational chromium exposure (predominantly to Cr VI) and lung cancer.

Results of two studies of the chromium plating industry (Royle, 1975; Silverstein et al., 1981) were inconclusive, while the findings of a Japanese study of chrome platers were negative (Okubo and Tsuchiya, 1979). The results of studies of ferrochromium workers (Pokrovskaya and Shabynina, 1973; Langard et al., 1980; Axelsson et al., 1980) were inconclusive as to lung cancer risk.

ANIMAL CARCINOGENICITY DATA:

Sufficient. Hexavalent chromium compounds were carcinogenic in animal assays producing the following tumor types: intramuscular injection site tumors in Fischer 344 and Bethesda Black rats and in C57BL mice (Furst et al., 1976; Maltoni, 1974, 1976; Payne, 1960; Heuper and Payne, 1959); intraplural implant site tumors for various chromium VI compounds in Sprague-Dawley and Bethesda Black rats (Payne, 1960; Heuper 1961; Heuper and Payne, 1962); intrabronchial implantation site tumors for various Cr VI compounds in Wistar rats (Levy and Martin, 1983; Laskin et al., 1970; Levy as quoted in NIOSH, 1975); and subcutaneous injection site sarcomas in Sprague-Dawley rats (Maltoni, 1974, 1976).

SUPPORTING DATA:

A large number of chromium compounds have been assayed in in vitro genetic toxicology assays. In general, hexavalent chromium is mutagenic in bacterial assays whereas trivalent chromium is not (Lofroth, 1978; Petrellie and Flora, 1977, 1978). Likewise Cr VI but not Cr III was mutagenic in yeasts (Bonatti et al., 1976) and in V79 cells (Newbold et al., 1979). Chromium III and VI compounds decrease the fidelity of DNA synthesis in vitro (Loeb et al., 1977), while Cr VI compounds inhibit replicative DNA synthesis in mammalian cells (Levis et al., 1978) and produce unscheduled DNA synthesis, presumably repair synthesis, as a consequence of DNA damage (Raffetto, 1977). Chromate has been shown to transform both primary cells and cell lines (Fradkin et al., 1975; Tsuda and Kato, 1977; Casto et al., 1979). Chromosomal effects produced by treatment with chromium compounds have been reported by a number of authors; for example, both Cr VI and Cr III salts were clastogenic for cultured human leukocytes (Nakamuro et al., 1978).

ORAL EXPOSURE ND
CARCINOGENICITY ASSESSME
INHALATION EXPOSURE
CARCINOGENICITY ASSESSME

CLASSIFICATION: A; human carcinogen by the inhalation route
INHALATION UNIT RISK: 1.2E-2/ug/cu.m
DOSE EXTRAPOLATION METHOD: Multistage, extra risk
RISK/AIR CONCENTRATIONS:

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	8E-3 ug/cu.m
E-5 (1 in 100,000)	8E-4 ug/cu.m
E-6 (1 in 1,000,000)	8E-5 ug/cu.m

INHALATION DOSE-RESPONSE DATA:

Species/Strain Tumor Type	Dose	Tumor Incidence		Reference
human	Route: Occupational exposure (inhalation)			
Age (years)	Midrange (ug/cu.m)	Deaths from Lung Cancer	Person Years	
50	5.66	3	1345	Mancuso, 1975
	25.27	6	931	
	46.83	6	299	
60	4.68	4	1063	

	20.79	5	712
	39.08	5	211
70	4.41	2	401
	21.29	4	345

ADDITIONAL COMMENTS:

The cancer mortality in Mancuso (1975) was assumed to be due to Cr VI, which was further assumed to be no less than one-seventh of total chromium. It was also assumed that the smoking habits of chromate workers were similar to those of the U.S. white male population. Slope factors based on Langard et al. (1980), Axelsson et al. (1980), and Pokrovskaya and Shabynina (1973) result in air unit risk estimates of 1.3E-1, 3.5E-2 and 9.2E-2 ug/cu.m, respectively.

Hexavalent chromium compounds have not produced lung tumors in animals by inhalation. Trivalent chromium compounds have not been reported as carcinogenic by any route of administration.

The unit risk should not be used if the air concentration exceeds 8E-1 ug/cu.m, since above this concentration the slope factor may differ from that stated.

DISCUSSION OF CONFIDENCE:

Results of studies of chromium exposure are consistent across investigators and countries. A dose-relationship for lung tumors has been established. The assumption that the ratio of Cr III to Cr VI is 6:1 may lead to a 7-fold underestimation of risk. The use of 1949 hygiene data, which may underestimate worker exposure, may result in an overestimation of risk. Further overestimation of risk may be due to the implicit assumption that the smoking habits of chromate workers were similar to those of the general white male population, since it is generally accepted that the proportion of smokers is higher for industrial workers than for the general population.

CARCINOGENICITY
ASSESSMENT DOCUMENTATION

CARCINOGENICITY SOURCE DOCUMENT:

Mancuso, T.F. 1975. International Conference on Heavy Metals in the Environment. Toronto, Ontario, Canada.

U.S. EPA. 1984. Health Assessment Document for Chromium. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH. EPA 600/8-83-014F.

The quantification of cancer risk in the 1984 Health Assessment Document has received peer review in public sessions of the Environmental Health Com-

mittee of the U.S. EPA's Science Advisory Board.

REVIEW DATES: 06/26/86
VERIFICATION DATE: 06/26/86
EPA CONTACTS:

Herman J. Gibb / ORD -- (202)382-5898 / FTS 382-5898

Chao W. Chen / ORD -- (202)382-5719 / FTS 382-5719

Selenium

SEARCH IN PROGRESS
NP (7782-49-2 (IRIS))
*NONE-

1 - IRIS
NAME OF SUBSTANCE Cadmium
CAS REGISTRY NUMBER 7440-43-9
EVIDENCE FOR HUMAN CARCINOGENICITY

CLASSIFICATION: B1; probable human carcinogen by inhalation
BASIS FOR CLASSIFICATION: Limited evidence from epidemiologic studies and sufficient evidence of carcinogenicity in rats and mice by two routes
HUMAN CARCINOGENICITY DATA:

Limited. A 2-fold excess risk of lung cancer was observed in cadmium smelter workers. The cohort consisted of 602 white males who had been employed in production work a minimum of 6 months during the years 1940-1969. The population was followed to the end of 1978. Urine cadmium data available for 261 workers employed after 1960 suggested a highly exposed population. The authors were able to ascertain that of these possible confounding factors the increased lung cancer risk was probably not due to the presence of arsenic or to smoking (Thun et al., 1985). An evaluation by the Carcinogen Assessment Group of these possible confounding factors has indicated that the assumptions and methods used in accounting for them may not be valid. As the SMRs observed were low and there is a lack of clear cut evidence of a causal relationship of the cadmium exposure only, this study is considered to supply only limited evidence of human carcinogenicity.

An excess lung cancer risk was also observed in three other studies which were, however, compromised by the presence of other carcinogens (arsenic, smoking) in the exposure or by a small population (Varner, 1983; Sorahan and Waterhouse, 1983; Armstrong and Kazantzis, 1983).

Four studies of workers exposed to cadmium dust or fumes provided evidence of a statistically significant positive association with prostate cancer (Kipling and Waterhouse, 1967; Lemen et al., 1976; Holden, 1980; Sorahan and Waterhouse, 1983), but the total number of cases was small in each study. The Thun et al. (1985) study is an update of an earlier study (Lemen et al., 1976) and does not show excess prostate cancer risk in these workers. Studies of human ingestion of cadmium are inadequate to assess carcinogenicity.

ANIMAL CARCINOGENICITY DATA:

Exposure of Wistar rats to cadmium as cadmium chloride at concentrations of 12.5, 25 and 50 ug/cu.m for 18 months, with an additional 13-month observation period, resulted in significant increases in lung tumors (Takenaka et al., 1983). Intratracheal instillation of cadmium oxide did not produce lung tumors in Fischer 344 rats but rather mammary tumors in females and tumors at multiple sites in males (Sanders and Mahaffey, 1984). Injection site tumors and distant site tumors (for example, testicular) have been reported by a

number of authors as a consequence of intramuscular or subcutaneous administration of cadmium metal and chloride, sulfate, oxide and sulfide compounds of cadmium to rats and mice (U.S. EPA, 1985). Seven studies in rats and mice where cadmium salts (acetate, sulfate, chloride) were administered orally have shown no evidence of a carcinogenic response.

SUPPORTING DATA:

Results of mutagenicity tests in bacteria and yeast have been inconclusive. Positive responses have been obtained in mutation assays in Chinese hamster cells (Dom and V79 lines) and in mouse lymphoma cells (Casto, 1976; Ochi and Ohsawa, 1983; Oberly et al., 1982).

Conflicting results have been obtained in assays of chromosomal aberrations in human lymphocytes treated in vitro or obtained from exposed workers. Cadmium treatment in vivo or in vitro appears to interfere with spindle formation and to result in aneuploidy in germ cells of mice and hamsters (Shimada et al., 1976; Watanabe et al., 1979; Gilliavod and Leonard, 1975).

ORAL EXPOSURE ND
CARCINOGENICITY ASSESSME
INHALATION EXPOSURE
CARCINOGENICITY ASSESSME

CLASSIFICATION: B1; probable human carcinogen by inhalation
BASIS FOR CLASSIFICATION: Limited evidence from epidemiologic studies and sufficient evidence of carcinogenicity in rats and mice by two routes
INHALATION UNIT RISK: 1.8E-3/ug/cu.m
DOSE EXTRAPOLATION METHOD: Two stage; only first affected by exposure; extra risk
RISK/AIR CONCENTRATIONS:

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	6E-2 ug/cu.m
E-5 (1 in 100,000)	6E-3 ug/cu.m
E-6 (1 in 1,000,000)	6E-4 ug/cu.m

INHALATION DOSE-RESPONSE DATA:

Species/Strain Tumor Type	Dose Administered	Tumor Human Equivalent	Reference Incidence
Human/white male; lung, trachea, bronchus cancer deaths	Route: Inhalation exposure in the workplace		Thun et al., 1985

Cumulative Exposure (mg/day/cu.m)	Median Observation	24 hour/ ug/cu.m Equivalent	No. of Expected Lung, Trachea and Bronchus Cancers Assuming No Cadmium Effect	Observed No. of Deaths (lung, trachea, bronchus cancers)
less than or equal to 584	280	168	3.77	2
585-2920	1210	727	4.61	7
greater than or equal to 2921	4200	2522	2.50	7

The 24-hour equivalent = median observation x 10E-3 x 8/24 x 1/365 x 240/365.

ADDITIONAL COMMENTS:

The unit risk should not be used if the air concentration exceeds 6 ug/cu.m, since above this concentration the slope factor may differ from that stated.

DISCUSSION OF CONFIDENCE:

The data were derived from a relatively large cohort. Effects of arsenic and smoking were accounted for in the quantitative analysis for cadmium effects.

A slope factor derived from cadmium chloride inhalation assay data in rats (Takenaka et al., 1983) equals 3.4E-1/ug/kg/day for elemental cadmium or 2.1E-1/ug/kg/day for cadmium chloride. An inhalation unit risk for cadmium based on this analysis is 9.2E-2/ug/cu.m. While this estimate is higher than that derived from human data (1.8E-3/ug/cu.m) and thus more conservative, it was felt that the use of available human data was more reliable because of species variations in response and the type of exposure (cadmium salt vs.

cadmium fume and cadmium oxide).

CARCINOGENICITY
ASSESSMENT DOCUMENTATION
CARCINOGENICITY SOURCE DOCUMENT:

U.S. EPA. 1985. Updated Mutagenicity and Carcinogenicity Assessment of Cadmium: Addendum to the Health Assessment Document for Cadmium (May 1981, EPA 600/B-Bl-023). EPA 600/B-83-025F.

The Addendum to the Cadmium Health Assessment has received both Agency and external review.

REVIEW DATES: 11/12/86
VERIFICATION DATE: 11/12/86
EPA CONTACTS:

William E. Pepelko / ORD -- (202)382-5904 / FTS 382-5904

David Bayliss / ORD -- (202)382-5726 / FTS 382-5726

REFERENCE 50

DRAFT

TOXICOLOGICAL PROFILE FOR SELECTED PCBs (Aroclor-1260, -1254, -1248, -1242, -1232, -1221, and -1016)

Date Published — November 1987

Prepared by:

Syracuse Research Corporation
under Contract No. 68-03-3228

for

Agency for Toxic Substances and Disease Registry (ATSDR)
U.S. Public Health Service

in collaboration with

U.S. Environmental Protection Agency (EPA)

Published by:

Oak Ridge National Laboratory
under
DOE Interagency Agreement No. 1425-1425-A1

Aroclor 1016

EPA Longer-term health advisory (HA) (adult)--0.0035 mg/L (EPA 1987a)
Longer-term HA (child)--0.001 mg/L (EPA 1987a)

9.2.2.3 Soil

AGENCY	ADVISORY
EPA	Permissible PCB soil contamination levels corresponding to: Noncancer 10-day HA (adult)--700 μg/day Noncancer 10-day HA (child)--100 μg/day Cancer risk specific doses: 1.75 to 0.00175 μg/day at 10^{-4} to 10^{-7} risk levels (EPA 1986d)

9.2.2.4 Others

AGENCY	ADVISORY
EPA	Reportable quantity (RQ) (statutory) - 10 lb (EPA 1985d) RQ (proposed) - 1 lb (EPA 1987d)

9.2.3 Data Analysis

Reference dose. The EPA (1987a) derived an oral reference dose (RfD) of 0.0001 mg/kg/day for Aroclor 1016 based on the study by Barsotti and Van Miller (1984) using an uncertainty factor of 100. This RfD was used to calculate longer-term HAs for adults and children. In this study, rhesus monkeys were maintained on diets containing Aroclor 1016 at 0.025, 0.25, and 1.0 ppm for approximately 7 months prior to mating and during gestation. The offspring of the 1.0-ppm group were significantly smaller than the controls. No effects were observed at 0.25 ppm, which was considered a NOAEL and is equivalent to a dose of 0.0105 mg/kg/day, assuming that a monkey consumes a daily amount of food equal to 4.2% of its body weight. The RfD was calculated according to methods outlined in Barnes et al. (1987) as follows:

$$RfD = (0.01 \text{ mg/kg/day})/(100) = 0.0001 \text{ mg/kg/day},$$

where: 0.01 mg/kg/day = NOAEL

100 = uncertainty factor for interspecies (10) and intraspecies (10) extrapolation, appropriate for use with an animal NOAEL.

Carcinogenic potency. EPA (1987a) determined that the positive evidence for carcinogenicity of Aroclor 1254, Aroclor 1260, Kaneclor 500, and Clophen A-30 and A-60 in animals, along with inadequate evidence in humans places these PCBs in category B2, probable human carcinogens. Because any PCB mixture that contains appreciable amounts of the components in Aroclors 1254 and 1260, Kaneclor 500, and Clophen A-30 and A-60 are likely to present a carcinogenic risk and because of the variety and variability of PCB mixtures, EPA (1987a) recommended that all commercial PCB mixtures be considered to have a similar carcinogenic potential and classified all PCB mixtures in category B2.

REFERENCE 51

GREENHORNE & O'MARA, INC.

TELEPHONE CONTACT REPORT

G&O Personnel: Larry Ramsey Project No.: 5035 - W.R - 126

Project Title: North Carolina Pre-Remedial Investigation

Contact: Dario A Sena Title:

Organization: Eveready/Union Carbide Location: Asheboro NC.

Date: 7 / 5 / 90 Phone Number: (919) 625-3836

Time: 14:00

Subject: Verification of unknown or questionable data.

Items Discussed: Primary process waste waters are treated by primary removal followed by sand filtration and carbon absorption. Sludges have been non-hazardous and landfilled.

Mercury containers are now lined with PVA soluble bags so containers are not hazardous.

Company is a small quantity generator.

Recycle system on waste waters began in 1979.

Prior to 1970 company put waste in City of Asheboro landfill. Now uses Randolf County landfill.

Hazardous wastes are removed by GSX and treated of landfill in Pinewood SC

Source of TCE in tank unknown. Should be one time event. Culprit may have been wastes removed from plant II

Comments or Actions Required:

Appendix C

APPENDIX C
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	D003216462

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site)	02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER
Union Carbide Corporation, Inc.	800 Albemarle Road

03 CITY	04 STATE	05 ZIP CODE	06 COUNTY	07 COUNTY CODE	08 CONG DIST
Asheboro	NC	27204	Randolph	76	4

09 COORDINATES LATITUDE	LONGITUDE	10 TYPE OF OWNERSHIP (Check one)
35°41'25.0	079°49'34.0	☒ A. PRIVATE ☐ B. FEDERAL ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL ☐ F. OTHER ☐ G. UNKNOWN

III. INSPECTION INFORMATION

01 DATE OF INSPECTION	02 SITE STATUS	03 YEARS OF OPERATION
05 / 25 / 90 (MONTH DAY YEAR)	☒ ACTIVE ☐ INACTIVE	1945 / ____ (BEGINNING YEAR / ENDING YEAR) ____ UNKNOWN

04 AGENCY PERFORMING INSPECTION (Check all that apply)

☐ A. EPA ☐ B. EPA CONTRACTOR _____ (Name of firm) ☐ C. MUNICIPAL ☐ D. MUNICIPAL CONTRACTOR _____ (Name of firm)
☐ E. STATE ☒ F. STATE CONTRACTOR Greenhorne & O'Mara, Inc. (Name of firm) ☐ G. OTHER _____ (Specify)

05 CHIEF INSPECTOR	06 TITLE	07 ORGANIZATION	08 TELEPHONE NO
Hunter Loftin	Hazardous Waste Engineer	Greenhorne & O'Mara, Inc.	(301) 220-2594

09 OTHER INSPECTORS	10 TITLE	11 ORGANIZATION	12 TELEPHONE NO
			( )
			( )
			( )
			( )
			( )

13 SITE REPRESENTATIVES INTERVIEWED	14 TITLE	15 ADDRESS	16 TELEPHONE NO
Dario Sena	Environmental Coordinator	P. O. Box 3209, 800 Albermarle Rd., Asheboro, NC	(919) 672-3500
Guy McClanahan	Plant Manager	P.O.Box 3209, 800 Albermarle Rd., Asheboro, NC	(919 672-3500
Bob Behr	Quality Control Mgr.	P.O.Box 3209, 800 Albermarle Rd., Asheboro, NC	(919) 672-3500
			( )
			( )
			( )

17 ACCESS GAINED BY (Check one)	18 TIME OF INSPECTION	19 WEATHER CONDITIONS
☒ PERMISSION ☐ WARRANT		

IV. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF (Agency/Organization)	03 TELEPHONE NO.
Dario Sena	Union Carbide Corporation, Inc.	(919)672-3500

04 PERSON RESPONSIBLE FOR SITE INSPECTION FORM	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NO.	08 DATE
Hunter Loftin		Greenhorne & O'Mara, Inc.	(301)220-2594	7 / 25 / 90 (MONTH DAY YEAR)

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	D003216462

II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS

01 PHYSICAL STATES (Check all that apply)

- [ ] A SOLID
- [X] B POWDER, FINES
- [X] 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 Unknown

CUBIC YARDS _____

NO. OF DRUMS _____

03 WASTE CHARACTERISTICS (Check all that apply)

- [X] A TOXIC
- [X] B CORROSIVE
- [ ] C RADIOACTIVE
- [ ] D PERSISTENT
- [ ] E SOLUBLE
- [ ] F INFECTIOUS
- [X] G FLAMMABLE
- [ ] H IGNITABLE
- [ ] I HIGHLY VOLATILE
- [ ] J EXPLOSIVE
- [ ] K REACTIVE
- [ ] L INCOMPATIBLE
- [ ] M NOT APPLICABLE

III. WASTE TYPE

CATEGORY	SUBSTANCE NAME	01 GROSS AMOUNT	02 UNIT OF MEASURE	03 COMMENTS
SLU	SLUDGE	Unknown		Non-hazardous, landfilled.
OLW	OILY WASTE	Unknown		Waste oils are recycled.
SOL	SOLVENTS	Unknown		Waste recycled.
PSD	PESTICIDES			
OCC	OTHER ORGANIC CHEMICALS			
IOC	INORGANIC CHEMICALS			
ACD	ACIDS			
BAS	BASES			
MES	HEAVY METALS	0.0014	Tons	Air emission/yr, landfill amt. unknown

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
SOL	1,1,1-Trichloroethane	71-55-6	Drums,UST/drum recycled		
MES	Chromium	7440-47-3	Metals: drum/		
MES	Lead	7439-92-1	Landfill		
MES	Mercury	7439-97-6			
MES	Cadmium	7440-66-6			
MES	Zinc	7440-66-6			
SOL	Desolv-it(Mineral Spirits)	64475-85-0	Drums/Recycled		

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. NC Department of Environment, Health and Natural Resources.
2. USGS Maps.
3. Eveready Battery Company.

EPA

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

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216462

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 ☒ A. GROUNDWATER CONTAMINATION — 02 ☒ OBSERVED (DATE: 1/8/86) — ☐ POTENTIAL — ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: 7,623
04 NARRATIVE DESCRIPTION

Pollution Incident Report #3155 was issued on January 8, 1986 for a leaking UST. The UST has been removed. The population potentially affected is for a 3-mile radius.

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

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

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

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

01 ☒ F. CONTAMINATION OF SOIL — 02 ☒ OBSERVED (DATE: 1/8/86) — ☐ POTENTIAL — ☐ ALLEGED
03 AREA POTENTIALLY AFFECTED: Unknown (Acres)
04 NARRATIVE DESCRIPTION

Pollution Incident Report #3155 for a leaking UST.

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

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

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

EPA

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

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216462

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: 7,623 (3-Mile radius)

IV. COMMENTS

Groundwater is currently being monitored in response to the leaking UST (Pollution Incident Report #3155).

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

1. NC Department of Environment, Health and Natural Resources
2. EPA
3. Eveready Battery Company

EPA

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

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D003216462

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				
X C. AIR	5035R3	10/23/87	10/1/92	
X D. RCRA		8/10/83		Small quantity generator
☐ E. RCRA INTERIM STATUS				
☐ F. SPCC PLAN				
☐ G. STATE (Specify)				
X H. LOCAL (Specify)	4036	7/1/87	7/1/92	Discharge pretreated
☐ I. OTHER (Specify)				wastewater
☐ J. NONE				

III. SITE DESCRIPTION

01 STORAGE/DISPOSAL (Check all that apply)	02 AMOUNT	03 UNIT OF MEASURE
☐ A. SURFACE IMPOUNDMENT		
☐ B. PILES		
X C. DRUMS, ABOVE GROUND		
☐ D. TANK, ABOVE GROUND		
X E. TANK, BELOW GROUND	500	Gal
☐ 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
- X F. SOLVENT RECOVERY
- ☐ G. OTHER RECYCLING/RECOVERY
- X H. OTHER (Specify) Wastewater Pretreatment

05 OTHER
- X A. BUILDINGS ON SITE

06 AREA OF SITE: 24.4 (Acres)

07 COMMENTS

Leaking UST removed in January 1986.

IV. CONTAINMENT

01 CONTAINMENT OF WASTES (Check one)

X A. ADEQUATE, SECURE ☐ B. MODERATE ☐ C. INADEQUATE, POOR ☐ D. INSECURE, UNSOUND, DANGEROUS

02 DESCRIPTION OF DRUMS, DIKING, LINERS, BARRIERS, ETC.

Leaking UST removed in January 1986.
Current practices are to store hazardous substances and wastes under roof inside containment and inside a locked chainlink fence.

V. ACCESSIBILITY

01 WASTE EASILY ACCESSIBLE: ☐ YES X NO

02 COMMENTS

Waste storage areas are fenced.

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

1. NC Department of Environment, Health and Natural Resources.
2. Eveready Battery Company.
3. EPA.

EPA

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

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D003216462

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. 0.9 (mi)
B. 0.7 (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 7,623 (3-Mile radius) 03 DISTANCE TO NEAREST DRINKING WATER WELL 0.7 (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
(ft)		(ft)	(gpd)	☐ YES ☐ NO

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

Population served by groundwater includes both community and private wells.

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
Cedar Fork Creek	☐	0.2 (mi)
Back Creek	☐	5.7 (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. 2,371 NO. OF PERSONS	B. 7,371 NO. OF PERSONS	C. 12,625 NO. OF PERSONS

02 DISTANCE TO NEAREST POPULATION: 0.11 (mi)

03 NUMBER OF BUILDINGS WITHIN TWO (2) MILES OF SITE: _____

04 DISTANCE TO NEAREST OFF-SITE BUILDING: _____ (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)

The site is located in an industrial and commercial zone. An urban residential area surrounds the site.

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

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
NC	D003216462

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
_____ (ft)	_____ (ft)	_____

06 NET PRECIPITATION	07 ONE YEAR 24 HOUR RAINFALL	08 SLOPE: SITE SLOPE	DIRECTION OF SITE SLOPE	TERRAIN AVERAGE SLOPE
6.5 (in)	2.9 (in)	6 %	NW	6 %

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. > 1 (mi)

12 DISTANCE TO CRITICAL HABITAT (of endangered species)

> 1 (mi)

ENDANGERED SPECIES: N/A

13 LAND USE IN VICINITY

DISTANCE TO:

COMMERCIAL/INDUSTRIAL	RESIDENTIAL AREAS; NATIONAL/STATE PARKS, FORESTS, OR WILDLIFE RESERVES	AGRICULTURAL LANDS: PRIME AG LAND	AGRICULTURAL LANDS: AG LAND
A. < 0.01 (mi)	B. 0.09 (mi)	C. > 2 (mi)	D. > 1 (mi)

14 DESCRIPTION OF SITE IN RELATION TO SURROUNDING TOPOGRAPHY

The site not completely surrounded by areas by higher elevation. The site drains to the headwaters of Cedar Fork Creek.

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

1. NC Department of Environmental, Health and Natural Resources
2. USGS Maps
3. EPA

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

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216462

II. SAMPLES TAKEN

SAMPLE TYPE	01 NUMBER OF SAMPLES TAKEN	02 SAMPLES SENT TO	03 ESTIMATED DATE RESULTS AVAILABLE
GROUNDWATER		NO SAMPLES TAKEN	
SURFACE WATER			
WASTE			
AIR			
RUNOFF			
SPILL			
SOIL			
VEGETATION			
OTHER			

III. FIELD MEASUREMENTS TAKEN

01 TYPE	02 COMMENTS
	NO MEASUREMENTS TAKEN

IV. PHOTOGRAPHS AND MAPS

01 TYPE ☐ GROUND ☐ AERIAL

02 IN CUSTODY OF _____ (Name of organization or individual)

03 MAPS ☒ YES ☐ NO

04 LOCATION OF MAPS Greenhorne & O'Mara, Inc.

V. OTHER FIELD DATA COLLECTED (Provide narrative description)

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

1. NC Department of Environment, Health and Natural Resources
2. USGS Maps
3. NC Department of Transportation, Randolph County Map

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

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216462

II. CURRENT OWNER(S)

01 NAME	02 D+B NUMBER	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	05 CITY	06 STATE	07 ZIP CODE
Eveready Battery Company, Inc.		P.O. Box 3209 800 Albermarle Road		Asheboro	NC	27204

PARENT COMPANY (If applicable)

08 NAME	09 D+B NUMBER	10 STREET ADDRESS (P.O. Box, RFD #, etc.)	11 SIC CODE	12 CITY	13 STATE	14 ZIP CODE
Ralston Purina Company		Checkerboard Square		St. Louis	MO	63164

III. PREVIOUS OWNER(S) (List most recent first)

01 NAME	02 D+B NUMBER	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	05 CITY	06 STATE	07 ZIP CODE
Union Carbide Corp., Inc.		P.O. Box 3209 800 Albemarle Road		Asheboro	NC	27204
National Carbon Company		800 Albemarle Road		Asheboro	NC	27204

IV. REALTY OWNER(S) (If applicable; list most recent first)

01 NAME	02 D+B NUMBER	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	05 CITY	06 STATE	07 ZIP CODE

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

1. NC Department of Environment, Health and Natural Resources
2. City of Asheboro Tax and Records offices

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

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216462

CURRENT OPERATOR (Provide if different from owner)			OPERATOR'S PARENT COMPANY (If applicable)		
01 NAME	02 D+B NUMBER		10 NAME	11 D+B NUMBER	
03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE		12 STREET ADDRESS (P.O. Box, RFD #, etc.)	13 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE	14 CITY	15 STATE	16 ZIP CODE
08 YEARS OF OPERATION	09 NAME OF OWNER				

PREVIOUS OPERATOR(S) (List most recent first; provide only if different from owner)			PREVIOUS OPERATORS' PARENT COMPANIES (If applicable)		
01 NAME	02 D+B NUMBER		10 NAME	11 D+B NUMBER	
03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE		12 STREET ADDRESS (P.O. Box, RFD #, etc.)	13 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE	14 CITY	15 STATE	16 ZIP CODE
08 YEARS OF OPERATION	09 NAME OF OWNER DURING THIS PERIOD				
01 NAME	02 D+B NUMBER		10 NAME	11 D+B NUMBER	
03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE		12 STREET ADDRESS (P.O. Box, RFD #, etc.)	13 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE	14 CITY	15 STATE	16 ZIP CODE
08 YEARS OF OPERATION	09 NAME OF OWNER DURING THIS PERIOD				
01 NAME	02 D+B NUMBER		10 NAME	11 D+B NUMBER	
03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE		12 STREET ADDRESS (P.O. Box, RFD #, etc.)	13 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE	14 CITY	15 STATE	16 ZIP CODE
08 YEARS OF OPERATION	09 NAME OF OWNER DURING THIS PERIOD				

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

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 9 - GENERATOR/TRANSPORTER INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216462

II. ON-SITE GENERATOR

01 NAME	02 D+B NUMBER
Eveready Battery Company, Inc.	

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

05 CITY	06 STATE	07 ZIP CODE
Asheboro	NC	27204

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)

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 10 - PAST RESPONSE ACTIVITIES

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216462

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

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 10 - PAST RESPONSE ACTIVITIES

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216462

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)*

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 11 - ENFORCEMENT INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
NC	D003216462

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)*