PEDCo ENVIRONMENTAL

PEDCo-ENVIRONMENTAL
SUITE 13 • ATKINSON SQUARE
CINCINNATI, OHIO 45246
513/771-4330

AREA SOURCE EMISSION INVENTORY
HAMILTON COUNTY, TENNESSEE, AND
WALKER AND CATOOSA COUNTIES, GEORGIA

Volume I

Contract No. 68-02-1375
Task Order No. 9
PEDCo P.N. 3155-I

Prepared by

PEDCo-Environmental Specialists, Inc.
Suite 13, Atkinson Square
Cincinnati, Ohio 45246

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Region IV, Atlanta, Georgia

October, 1975

BRANCH OFFICES

Suite 110, Crown Center
Kansas City, Mo. 64108

Suite 104-A, Professional Village
Chapel Hill, N C. 27514

This report was furnished to the U.S. Environmental Protection Agency by PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio, in fulfillment of Contract No. 68-02-1375 (Task Order No. 9). The contents of this report are reproduced herein as received from the contractor. The opinions, findings, and conclusions expressed are those of the author and not necessarily those of the Environmental Protection Agency.

ACKNOWLEDGEMENT

This report was prepared for the U.S. Environmental Protection Agency by PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio. Mr. Edwin Pfetzing was the PEDCo Project Manager. The principal author of the report was Mr. Leslie J. Ungers.

Mr. Winston Smith was the Project Office for the U.S. Environmental Protection Agency. The Project team is appreciative of the additional assistance and cooperation extended by the following individuals and agencies:

Mr. Archie Lee and Mr. Randy Mayfield
Region IV, U.S. Environmental Protection Agency.

Mr. James Mullins
Georgia Department of Natural Resources

Mr. Herb Panr and Dr. James Lents
Hamilton County Air Pollution Control Bureau

TABLE OF CONTENTS

* Appended in Volume II of this report.

LIST OF FIGURES

LIST OF TABLES

1. SUMMARY AND GENERAL METHODOLOGY

SUMMARY

This project was undertaken to prepare an inventory of area sources of air pollutant (particulate, SO_x, CO, HC, NO_x) emissions in three counties in the Chattanooga area (Hamilton County, Tennessee; Walker, Catoosa County, Georgia) for use in analysis and modeling of air quality in this designated Air Quality Maintenance Area (AQMA) for the period 1975 to 1985. A base year of 1973 was specified for the inventory because this is the most recent year for which much of the published national, state, and local data were available.

The base year area source emissions are projected to three different future years--1975, 1980, and 1985--as part of this project. These analysis years are specified in the EPA regulations on preparation of AQMA plans.

The area source categories included in the inventory are shown in Tables 1-1, 1-2, 1-3, 1-4, with the category descriptor codes summarized in Table 1-5. This list of categories was compiled at the initial project meeting of the participants (EPA - Region IV, Georgia DNR, and PEDCo). It is conventional except for the four fugitive dust source categories.

Total pollutant emissions are summarized by category for the base year and three projection years in Tables 1-1, 1-2, 1-3, and 1-4. Survey data, emission estimating procedures,

Table 1-1. TOTAL EMISSIONS FROM AREA SOURCES - 1973 ton/yr[a,d]

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
RESCOAL	24999.0	TON/YR	188.7	390.0	625.0	143.7	56.2
RESFOIL	3462.0	10**3 GAL/YR	17.3	107.1	8.7	5.2	20.8
RESNGAS	2892.0	10**6 CU FT/YR	15.3	0.9	28.9	11.6	115.7
RESLPG	5829.0	10**3 GAL/YR	5.2	0.0	5.5	2.3	21.9
COMCOAL	0.0	TON/YR	0.0	0.0	0.0	0.0	0.0
COMROIL	2281.0	10**3 GAL/YR	26.2	340.9	4.6	3.4	68.4
COMDOIL	11879.0	10**3 GAL/YR	89.1	367.7	23.8	17.8	356.4
COMNGAS	2718.0	10**6 CU FT/YR	13.6	0.8	27.2	10.9	163.1
COMLPG	6555.0	10**3 GAL/YR	6.3	0.0	6.6	2.8	40.0
INDCOAL	60000.0	TON/YR	4485.0	1767.0	60.0	30.0	450.0
INDROIL	0.0	10**3 GAL/YR	0.0	0.0	0.0	0.0	0.0
INDDOIL	2929.0	10**3 GAL/YR	22.0	172.8	5.9	4.4	87.9
INDNGAS	11453.2	10**6 CU FT/YR	57.3	3.4	97.4	17.2	1002.2
INDLPG	511.0	10**3 GAL/YR	0.5	0.0	0.4	0.1	3.0
WOOD	6401.0	TON/YR	54.4	0.0	160.0	12.8	6.4
GASMVEH	2027.6	10**6 VMT/YR	1519.7	335.4	194701.9	26824.6	10506.3
DIEMVEH	47.6	10**6 VMT/YR	97.0	146.9	451.1	120.6	1316.5
RAILLOC	8740.8	10**3 GAL/YR	109.3	249.1	568.2	410.8	1617.0
VESSELS	2909.3	10**3 GAL/YR	0.0	23.9	1687.0	567.2	222.3
OFHIVEH	12042.0	10**3 GAL/YR	98.7	131.3	4607.3	670.1	1324.6
OPENBUR	9605.0	TON/YR	80.2	1.0	298.7	74.0	14.4
FFBURN	9153.0	TON/YR	77.8	0.0	457.6	91.5	9.2
EVAPLOS	536163.0	TON/YR	0.0	0.0	0.0	3645.9	0.0
FUUNPRD	34299.4	10**3 VMT/YR	5813.8	0.0	0.0	0.0	0.0
FUPAVRD	2041.5	10**6 VMT/YR	2428.0	0.0	0.0	0.0	0.0

Table 1-1 (continued). TOTAL EMISSIONS FROM AREA SOURCES - 1973 ton/yr[a,d]

SOURCE CATEGORY		INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
AIRCRAFT	105,114	Engine LTO's	5.3	19.9	647.2	77.6	105.5
INCINERA	4,136	Tons Burned	25.6	11.9	71.3	0.0	120.6
FDAGTIL	88,585	Acres Arable Land	268.2	0.0	0.0	0.0	0.0
FDCONST	663	Acres Exposed	928.3	0.0	0.0	0.0	0.0
Subtotal[b]			14,004.8				
FDPAVRD			2,428.0				
Total			16,432.8	4,070.0	204,544.3	32,744.5	17,628.4
EMISSION CONTRIBUTIONS BY STATE (ton/yr)[c]							
Tenn.			10,864.5	3,663.7	160,943.0	25,852.0	14,372.8
Ga.			5,568.3	406.3	43,601.3	6,892.5	3,255.6

[a]Totals respective to entire study area.

[b]Does not include FDPAVRD category.

[c]Tennessee emissions are contributed by grids 1-73, Georgia emissions by grids 74-107.

[d]The percent sulfur and percent ash content of specific fuels can be found in Table A-5 of Appendix A.

Table 1-2. TOTAL EMISSIONS FROM AREA SOURCES - 1975 ton/yr[a,d]

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
RESCOAL	20134.0	TON/YR	152.0	314.1	503.3	115.8	45.3
RESFOIL	3266.0	10**3 GAL/YR	16.3	101.1	8.2	4.9	19.6
RESNGAS	3033.8	10**6 CU FT/YR	16.1	0.9	30.3	12.1	121.4
RESLPG	6234.0	10**3 GAL/YR	5.6	0.0	5.9	2.5	23.4
COMCOAL	0.0	TON/YR	0.0	0.0	0.0	0.0	0.0
COMROIL	2363.0	10**3 GAL/YR	27.2	353.2	4.7	3.5	70.9
COMDOIL	12101.0	10**3 GAL/YR	90.8	374.5	24.2	18.2	363.0
COMNGAS	2843.7	10**6 CU FT/YR	14.2	0.9	28.4	11.4	170.6
COMLPG	7305.0	10**3 GAL/YR	6.6	0.0	6.9	2.9	42.0
INDCOAL	81000.0	TON/YR	6034.5	2385.4	81.0	40.5	607.5
INDROIL	0.0	10**3 GAL/YR	0.0	0.0	0.0	0.0	0.0
INDDOIL	2994.0	10**3 GAL/YR	22.5	176.6	6.0	4.5	89.8
INDNGAS	14385.0	10**6 CU FT/YR	71.9	4.3	122.3	21.6	1258.7
INDLPG	607.0	10**3 GAL/YR	0.5	0.0	0.5	0.1	3.6
WOOD	5883.0	TON/YR	50.0	0.0	147.1	11.8	5.9
GASMVEH	2115.2	10**6 VMT/YR	1585.3	349.9	142251.6	24019.6	10260.8
DIEMVEH	53.9	10**6 VMT/YR	109.8	166.2	510.6	136.6	1496.2
RAILLOC	7604.5	10**3 GAL/YR	95.1	216.7	494.3	357.4	1406.8
VESSELS	2908.3	10**3 GAL/YR	0.0	23.8	1686.4	567.0	222.2
OFHIVEH	12403.0	10**3 GAL/YR	101.7	135.2	4745.4	690.2	1364.3
OPENBUR	9413.6	TON/YR	78.6	0.9	292.8	72.5	14.1
FFBURN	9061.0	TON/YR	77.0	0.0	453.0	90.6	9.1
EVAPLOS	552249.0	TON/YR	0.0	0.0	0.0	3755.3	0.0
FDUNPRD	34299.4	10**3 VMT/YR	5813.8	0.0	0.0	0.0	0.0
FDPAVRD	2134.8	10**6 VMT/YR	2539.0	0.0	0.0	0.0	0.0

Table 1-2 (continued). TOTAL EMISSIONS FROM AREA SOURCES - 1975 ton/yr[a,d]

SOURCE CATEGORY		INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
AIRCRAFT	113,299	Engine LTO's	6.2	12.6	797.9	99.6	118.5
INCINERA	4,136	Tons Burned	63.6	12.4	70.7	0.1	121.2
FUAGTIL	139,060	Acres Arable Land	411.1	0.0	0.0	0.0	0.0
FUCCNST	802	Acres Exposed	1151.8	0.0	0.0	0.0	0.0
Subtotal[b]			16,002.2				
FDPAVRD			2,539.0				
Total			18,541.2	4,628.7	152,271.5	30,038.7	17,834.9
EMISSION CONTRIBUTIONS BY STATE (ton/yr)[c]							
Tenn.			13,008.9	4,266.8	120,826.7	24,336.0	14,886.0
Ga.			5,532.3	361.9	31,444.8	5,702.7	2,948.9

[a]Totals respective to entire study area.

[b]Does not include FDPAVRD category.

[c]Tennessee emissions are contributed by grids 1-73, Georgia emissions by grids 74-107.

[d]The percent sulfur and percent ash content of specific fuels can be found in Table A-5 of Appendix A.

Table 1-3. TOTAL EMISSIONS FROM AREA SOURCES - 1980 ton/yr[a,d]

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
RESCOAL	11660.0	TON/YR	88.0	181.9	291.5	67.0	26.2
RESFOIL	2824.0	10**3 GAL/YR	14.1	87.4	7.1	4.2	16.9
RESNGAS	3409.3	10**6 CU FT/YR	18.1	1.0	34.1	13.6	136.4
RESLPG	6657.2	10**3 GAL/YR	6.0	0.0	6.3	2.7	25.0
COMCOAL	0.0	TON/YR	0.0	0.0	0.0	0.0	0.0
COMROIL	2547.0	10**3 GAL/YR	29.3	380.6	5.1	3.8	76.4
COMDOIL	12968.0	10**3 GAL/YR	57.3	401.4	25.9	19.5	389.0
COMNGAS	3214.6	10**6 CU FT/YR	16.1	1.0	32.1	12.9	192.9
COMLPG	7792.6	10**3 GAL/YR	7.0	0.0	7.4	3.1	44.8
INDCOAL	82000.0	TON/YR	6129.5	2414.9	82.0	41.0	615.0
INDROIL	0.0	10**3 GAL/YR	0.0	0.0	0.0	0.0	0.0
INDDOIL	3097.0	10**3 GAL/YR	23.2	182.7	6.2	4.6	92.9
INDNGAS	14358.1	10**6 CU FT/YR	71.8	4.3	122.0	21.5	1256.3
INDLPG	622.0	10**3 GAL/YR	0.6	0.0	0.5	0.1	3.6
WOOD	4758.0	TON/YR	40.4	0.0	118.9	9.5	4.8
GASMVEH	2331.7	10**6 VMT/YR	1747.6	385.7	105655.7	15809.8	8740.4
DIEMVEH	65.1	10**6 VMT/YR	132.9	201.1	617.6	165.2	1738.0
RAILLOC	9177.8	10**3 GAL/YR	114.7	261.6	596.6	431.4	1697.9
VESSELS	2905.2	10**3 GAL/YR	0.0	23.8	1684.6	566.4	222.0
OFHIVEH	13969.0	10**3 GAL/YR	114.5	152.3	5344.5	777.4	1536.6
OPENBUR	9029.0	TON/YR	75.4	0.9	280.8	69.5	13.5
FFBURN	8878.0	TON/YR	75.5	0.0	443.9	88.8	8.9
EVAPLOS	568333.0	TON/YR	0.0	0.0	0.0	3864.7	0.0
FUUNPRD	34299.4	10**3 VMT/YR	5813.8	0.0	0.0	0.0	0.0
FUPAVRD	2362.5	10**6 VMT/YR	2809.8	0.0	0.0	0.0	0.0

Table 1-3 (continued). TOTAL EMISSIONS FROM AREA SOURCES - 1980 ton/yr[a,d]

SOURCE CATEGORY		INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
AIRCRAFT	141,450	Engine LTO's	8.2	86.0	817.0	114.1	162.5
INCINERA	4,136	Tons Burned	60.9	11.9	71.5	0.9	121.8
FDAGTIL	92,949	Acres Arable Land	298.5	0.0	0.0	0.0	0.0
FDCONST	2,202	Acres Exposed	3082.3	0.0	0.0	0.0	0.0
Subtotal[b]			18,065.7				
FDPAVRD			2,809.8				
Total			20,875.5	4,778.5	116,251.3	22,091.7	17,121.5
EMISSION CONTRIBUTIONS BY STATE (ton/yr)[c]							
Tenn.			14,496.2	4,380.7	91,272.0	17,546.7	14,070.4
Ga.			6,379.2	397.8	24,979.3	4,545.0	3,051.1

[a]Totals respective to entire study area.

[b]Does not include FDPAVRD category.

[c]Tennessee emissions are contributed by grids 1-73, Georgia emissions by grids 74-107.

[d]The percent sulfur and percent ash content of specific fuels can be found in Table A-5 of Appendix A.

Table 1-4. TOTAL EMISSIONS FROM AREA SOURCES - 1985 ton/yr[a,d]

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
RESCOAL	6762.0	TON/YR	51.1	105.5	169.0	38.9	15.2
RESFOIL	2447.0	10**3 GAL/YR	12.2	75.7	6.1	3.7	14.7
RESNGAS	3814.0	10**6 CU FT/YR	20.2	1.1	38.1	15.3	152.6
RESLPG	8289.0	10**3 GAL/YR	7.5	0.0	7.9	3.3	31.1
COMCOAL	0.0	TON/YR	0.0	0.0	0.0	0.0	0.0
COMROIL	2747.0	10**3 GAL/YR	31.6	410.5	5.5	4.1	82.4
COMDOIL	13906.0	10**3 GAL/YR	104.3	430.4	27.8	20.9	417.2
COMNGAS	3731.7	10**6 CU FT/YR	18.7	1.1	37.3	14.9	223.9
COMLPG	9821.0	10**3 GAL/YR	8.8	0.0	9.3	3.9	56.5
INDCOAL	83000.0	TON/YR	6204.3	2444.3	83.0	41.5	622.5
INDROIL	0.0	10**3 GAL/YR	0.0	0.0	0.0	0.0	0.0
INDDOIL	3221.0	10**3 GAL/YR	24.2	190.0	6.4	4.8	96.6
INDNGAS	14380.6	10**6 CU FT/YR	71.9	4.3	122.2	21.6	1258.3
INDLPG	645.0	10**3 GAL/YR	0.6	0.0	0.5	0.1	3.8
WOOD	3859.0	TON/YR	32.8	0.0	96.5	7.7	3.9
GASMVEH	2575.0	10**6 VMT/YR	1930.0	425.9	59050.6	7665.4	5394.0
DIEMVEH	71.3	10**6 VMT/YR	145.4	220.1	675.9	180.8	1972.6
RAILLOC	10139.3	10**3 GAL/YR	126.7	289.0	659.1	476.5	1875.8
VESSELS	2904.0	10**3 GAL/YR	0.0	23.8	1683.9	566.1	221.9
OFHIVEH	15293.0	10**3 GAL/YR	125.4	166.7	5851.1	851.1	1682.2
OPENBUR	8741.0	TON/YR	73.0	0.9	271.8	67.3	13.1
FFBURN	8695.0	TON/YR	73.9	0.0	434.8	86.9	8.7
EVAPLOS	589779.0	TON/YR	0.0	0.0	0.0	4010.5	0.0
FDUNPRD	34299.4	10**3 VMT/YR	5813.8	0.0	0.0	0.0	0.0
FDPAVRD	2610.1	10**6 VMT/YR	3104.3	0.0	0.0	0.0	0.0

Table 1-4 (continued). TOTAL EMISSIONS FROM AREA SOURCES - 1985 ton/yr[a,d]

SOURCE CATEGORY		INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
AIRCRAFT	151,564	Engine LTO's	9.2	19.1	1117.3	133.6	181.6
INCINERA	4,136	Tons Burned	25.7	12.0	71.7	0.0	122.9
FDAGTIL	85,074	Acres Arable Land	256.3	0.0	0.0	0.0	0.0
FDCONST	2,272	Acres Exposed	3180.7	0.0	0.0	0.0	0.0
Subtotal[b]			18,350.3				
FDPAVRD			3,104.3				
Total			21,454.6	4,820.4	70,425.8	14,218.9	14,451.4
EMISSION CONTRIBUTIONS BY STATE (ton/yr)[c]							
Tenn.			15,159.0	4,413.3	56,019.9	11,287.8	12,021.2
Ga.			6,295.6	407.1	14,405.9	2,931.1	2,430.2

[a]Totals respective to entire study area.

[b]Does not include FDPAVRD category.

[c]Tennessee emissions are contributed by grids 1-73, Georgia emissions by grids 74-107.

[d]The percent sulfur and percent ash content of specific fuels can be found in Table A-5 of Appendix A.

Table 1-5. SOURCE CATEGORY DESCRIPTOR CODES

Code	Source category
RESCOAL	Residential coal
RESFOIL	Residential fuel oil
RESNGAS	Residential natural gas
RESLPG	Residential LPG
COMCOAL	Commercial-Institutional coal
COMROIL	Commercial-Institutional residual oil
COMDOIL	Commercial-Institutional distillate oil
COMNGAS	Commercial-Institutional natural gas
COMLPG	Commercial-Institutional LPG
INDCOAL	Industrial coal
INDROIL	Industrial residual oil
INDDOIL	Industrial distillate oil
INDNGAS	Industrial natural gas
INDLPG	Industrial LPG
WOOD	Residential wood
GASMVEH	Gasoline motor vehicles
DIEMVEH	Diesel motor vehicles
RAILLOC	Rail locomotive
VESSELS	Vessels
OFHIVEH	Off-highway vehicles
OPENBUR	Open burning
FFBUR	Forest fire burn
EVAPLOS	Evaporative loss sources
FDUNPRD	Fugitive dust - unpaved roads
FDPAVRD	Fugitive dust - paved roads
AIRCRAFT	Aircraft
INCINERA	Incineration
FGDAGTIL	Fugitive dust - agricultural tilling
FGDCONST	Fugitive dust - construction

and projection techniques that were used to calculate these values for each source category are documented in detail in Chapters 1 through 5 of this report.

The estimated total area source emissions of the air pollutants - particulates, SO_x, CO, HC, NO_x - in 1973 are about 10.2, 18.5, 99.2, 90.3, and 40.6 percent, respectively, of the total point source emissions for the same year. This does not include the category of dust from paved roads. Thus, area sources are a significant component of overall emissions in the AQMA and should have a major impact on air quality. It also appears that this impact may become proportionately larger in the future because emissions from most area source categories do not exhibit a downward trend in 1975 and beyond as point source emissions would be expected to exhibit.

A source category not originally intended for inclusion herein, but which is receiving increased attention, is fugitive dust from paved roads. An accurate quantification of the contribution from this source was difficult. It has, however, been evaluated for its estimated impact on air quality and is discussed as an additional fugitive dust source in Chapter 5. Summary Tables 1-1, -2, 1-3, 1-4 include this source as an additional category after subtotalling all other area source emissions.

The procedures used to allocate emissions for each area source category to the grid cells are also explained in detail in subsequent sections. The resulting total emissions by grid for 1973, 1975, and 1980, and 1985 are presented in the Appendices (appended in Volume II). This data can be used directly in the AQMA modeling effort for air quality in the Chattanooga region.

The accuracy of the data used in compiling this area source inventory has been estimated based upon the level of accuracy and reliability of the contacts made and sources used.

Table 1-6 shows PEDCo's assessment of the accuracy (Order 3, highest accuracy) of data used in computing the area-wide emissions, projections, and subarea distribution for each source category. PEDCo has attempted to use the best available data and methods in compiling this area source emission inventory for the Chattanooga region.

Table 1-6. DATA ACCURACY* OF SOURCE CATEGORIES

Chapter	Source category	Area-wide emissions	Projections	Subarea distribution
2	Bituminous coal			
	Residential coal	1	2	3
	Commercial coal	2	2	3
	Industrial coal	2	2	3
2	Fuel oil			
	Residential fuel oil	1	2	3
	Commercial dist. oil	2	2	3
	Industrial dist. oil	2	2	3
	Commercial resid. oil	2	2	3
	Industrial resid. oil	2	-	-
2	Natural gas			
	Residential nat. gas	3	2	3
	Commercial nat. gas	3	2	3
	Industrial nat. gas	3	2	3
2	LPG			
	Residential LPG	2	2	3
	Commercial LPG	2	2	3
	Industrial LPG	2	2	3
2	Wood	1	1	3
3	Gasoline motor vehicles	3	3	3
3	Diesel motor vehicles	3	3	3
3	Aircraft	2	3	3
3	Rail locomotive	2	2	3
3	Vessels	2	2	3
3	Off-highway vehicles	1	1	1
4	Open burning	3	1	2
4	Incineration	3	2	3
4	Forest fires	3	1	2

Table 1-6 (continued). DATA ACCURACY* OF SOURCE CATEGORIES

Chapter	Source category	Area-wide emissions	Projections	Subarea distribution
5	Evaporative loss sources	1	1	1
5	Fugitive dust - unpaved roads	2	2	2
5	Fugitive dust - paved roads	1	1	1
5	Fugitive dust - agricultural tilling	3	2	2
5	Fugitive dust - construction	3	2	1

*Order 1 least detail and accuracy
2 moderate detail and accuracy
3 most detail and accuracy

GENERAL METHODOLOGY

The following describes the data, references, assumptions, and calculations used to estimate area source pollutant emissions for each of the 30 categories in the inventory. A separate subsection is provided for each source category. For each source category, the text is divided into three parts:

1. estimating area-wide base year emissions,
2. projecting base year emissions to the three future years,
3. allocating emissions to subarea grid cells.

Difficulties were experienced in attempting to project fuel usage, particularly fuel oil and natural gas, because of the many uncertainties at this time surrounding the future availabilities and costs of alternate fuels in the Chattanooga area. The intermediate-term impacts of energy conservation programs and the current economic recession further clouded the data available for making assumptions and projections. Overall, the increase in total energy consumption represented by the fuel usage increases shown in this report have been estimated in order to, insofar as possible, keep pace with the population and industrial-commercial growth expected in the Metropolitan area, and maintain a "worst case" analysis. However, expected reductions in per capita consumption of energy may account for future differences.

In order to input area source emissions into the atmospheric dispersion model for AQMA analysis, the distribution of these emissions within the study area must be determined. This was accomplished by allocating the total emissions for each category into grid squares covering the entire area, as shown in Figure 1-1. Four grid sizes are used: 2,4,6 and 8 km. The grid system has 107 grids, and Table 1-7 summarizes the geographical data pertinent to each.

The "Area-2 Program," originally developed by EPA, was employed to enable rapid, accurate calculation and allocation of emissions. Required input data are fuel usage totals, emission factors, and pertinent grid information. The program was modified by PEDCo to accept data input from up to 25 source categories requiring emission calculation and apportioning and 10 categories which are best treated as "point sources." Additionally, the data output now assumes a completely versatile and informative format, suitable for direct inclusion in this report.

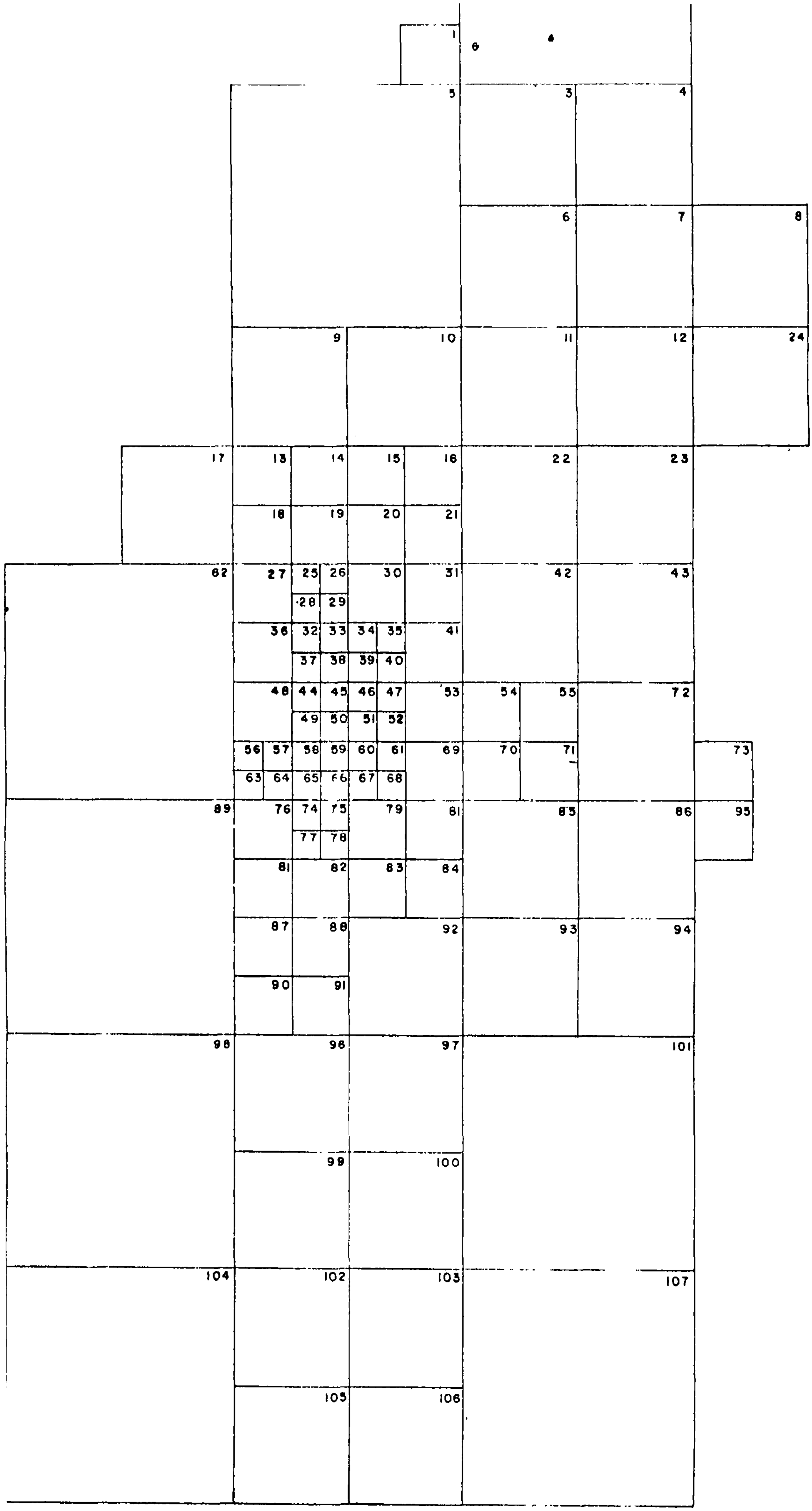
1
5
3
4
6
7
8
9
10
11
12
24
17
13
14
15
16
22
23
18
19
20
21
62
27
25
26
30
31
42
43
28
29
36
32
33
34
35
41
37
38
39
40
48
44
45
46
47
53
54
55
72
49
50
51
52
56
57
58
59
60
61
69
70
71
73
63
64
65
66
67
68
89
76
74
75
79
81
85
86
95
77
78
81
82
83
84
87
88
92
93
94
90
91
98
96
97
101
99
100
104
102
103
107
105
106

Figure 1-1. Hamilton Co., Tenn., Walker and Catoosa Co., Ga.

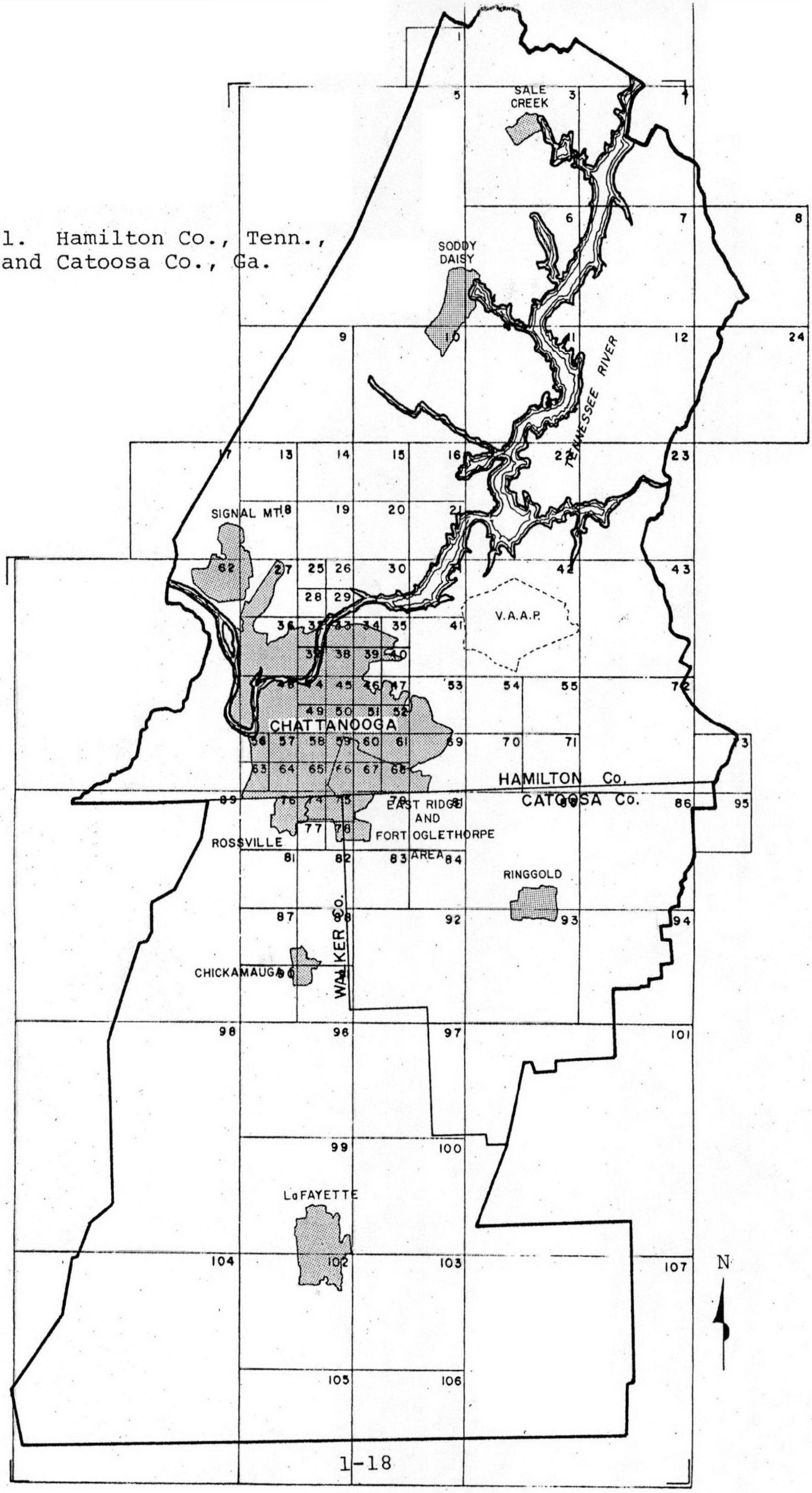

Figure 1-1. Hamilton Co., Tenn.,
Walker and Catoosa Co., Ga.

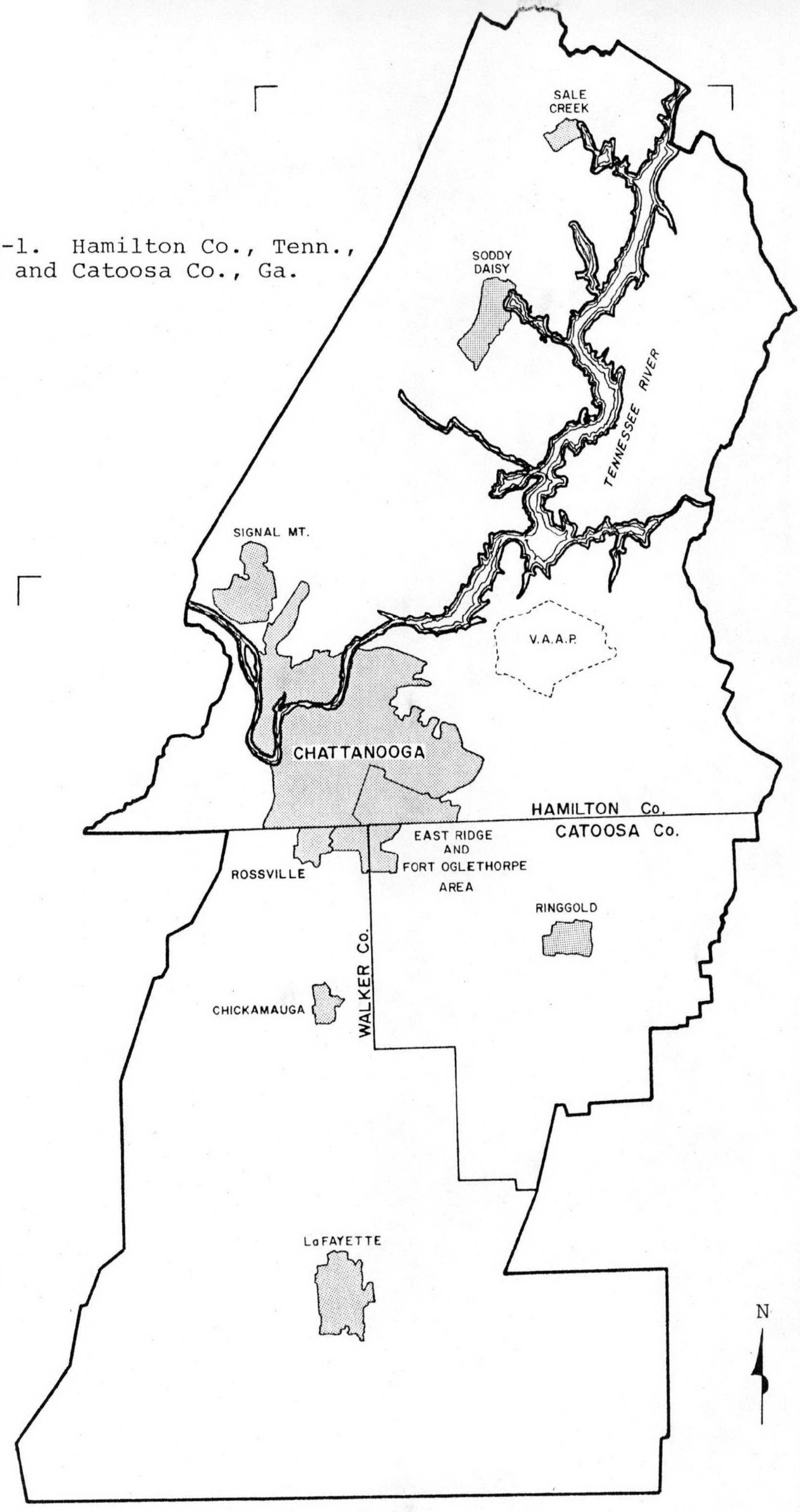

Table 1-7. GEOGRAPHICAL DATA - 1973

GRID NUMBER	REGION	POLITICAL JURISDICTION	COUNTY	UTM COORDINATES X(KM)	UTM COORDINATES Y(KM)	AREA (KM**2)	STACK HEIGHT (FT)
1	55	0	HAMILTON	663.0	3921.0	16.0	30.0
2	55	0	HAMILTON	667.0	3921.0	64.0	30.0
3	55	0	HAMILTON	667.0	3913.0	64.0	30.0
4	55	0	HAMILTON	675.0	3913.0	64.0	30.0
5	55	0	HAMILTON	651.0	3905.0	256.0	30.0
6	55	0	HAMILTON	667.0	3905.0	64.0	30.0
7	55	0	HAMILTON	675.0	3905.0	64.0	30.0
8	55	0	HAMILTON	683.0	3905.0	64.0	30.0
9	55	0	HAMILTON	651.0	3897.0	64.0	30.0
10	55	0	HAMILTON	659.0	3897.0	64.0	30.0
11	55	0	HAMILTON	667.0	3897.0	64.0	30.0
12	55	0	HAMILTON	675.0	3897.0	64.0	30.0
13	55	0	HAMILTON	651.0	3893.0	16.0	30.0
14	55	0	HAMILTON	655.0	3893.0	16.0	30.0
15	55	0	HAMILTON	659.0	3893.0	16.0	30.0
16	55	0	HAMILTON	663.0	3893.0	16.0	30.0
17	55	0	HAMILTON	643.0	3889.0	64.0	30.0
18	55	0	HAMILTON	651.0	3889.0	16.0	30.0
19	55	0	HAMILTON	655.0	3889.0	16.0	30.0
20	55	0	HAMILTON	659.0	3889.0	16.0	30.0
21	55	0	HAMILTON	663.0	3889.0	16.0	30.0
22	55	0	HAMILTON	667.0	3889.0	64.0	30.0
23	55	0	HAMILTON	675.0	3889.0	64.0	30.0
24	55	0	HAMILTON	683.0	3897.0	64.0	30.0
25	55	0	HAMILTON	655.0	3887.0	4.0	30.0
26	55	0	HAMILTON	657.0	3887.0	4.0	30.0
27	55	0	HAMILTON	651.0	3885.0	16.0	30.0
28	55	0	HAMILTON	655.0	3885.0	4.0	30.0
29	55	0	HAMILTON	657.0	3885.0	4.0	30.0
30	55	0	HAMILTON	659.0	3885.0	16.0	30.0
31	55	0	HAMILTON	663.0	3885.0	16.0	30.0
32	55	0	HAMILTON	655.0	3883.0	4.0	30.0
33	55	0	HAMILTON	657.0	3883.0	4.0	30.0
34	55	0	HAMILTON	659.0	3883.0	4.0	30.0
35	55	0	HAMILTON	661.0	3883.0	4.0	30.0
36	55	0	HAMILTON	651.0	3881.0	16.0	30.0
37	55	0	HAMILTON	655.0	3881.0	4.0	30.0
38	55	0	HAMILTON	657.0	3881.0	4.0	30.0
39	55	0	HAMILTON	659.0	3881.0	4.0	30.0
40	55	0	HAMILTON	661.0	3881.0	4.0	30.0
41	55	0	HAMILTON	663.0	3881.0	16.0	30.0
42	55	0	HAMILTON	667.0	3881.0	64.0	30.0
43	55	0	HAMILTON	675.0	3881.0	64.0	30.0
44	55	0	HAMILTON	655.0	3879.0	4.0	30.0
45	55	0	HAMILTON	657.0	3879.0	4.0	30.0
46	55	0	HAMILTON	659.0	3879.0	4.0	30.0
47	55	0	HAMILTON	661.0	3879.0	4.0	30.0
48	55	0	HAMILTON	651.0	3877.0	16.0	30.0

Table 1-7 (continued). GEOGRAPHICAL DATA - 1973

GRID NUMBER	REGION	POLITICAL JURISDICTION	COUNTY	UTM COORDINATES X(KM)	UTM COORDINATES Y(KM)	AREA (KM**2)	STACK HEIGHT (FT)
49	55	0	HAMILTON	655.0	3877.0	4.0	30.0
50	55	0	HAMILTON	657.0	3877.0	4.0	30.0
51	55	0	HAMILTON	659.0	3877.0	4.0	30.0
52	55	0	HAMILTON	661.0	3877.0	4.0	30.0
53	55	0	HAMILTON	663.0	3877.0	16.0	30.0
54	55	0	HAMILTON	667.0	3877.0	16.0	30.0
55	55	0	HAMILTON	671.0	3877.0	16.0	30.0
56	55	0	HAMILTON	651.0	3875.0	4.0	30.0
57	55	0	HAMILTON	653.0	3675.0	4.0	30.0
58	55	0	HAMILTON	655.0	3875.0	4.0	30.0
59	55	0	HAMILTON	657.0	3875.0	4.0	30.0
60	55	0	HAMILTON	659.0	3875.0	4.0	30.0
61	55	0	HAMILTON	661.0	3875.0	4.0	30.0
62	55	0	HAMILTON	635.0	3873.0	256.0	30.0
63	55	0	HAMILTON	651.0	3873.0	4.0	30.0
64	55	0	HAMILTON	653.0	3873.0	4.0	30.0
65	55	0	HAMILTON	655.0	3873.0	4.0	30.0
66	55	0	HAMILTON	657.0	3873.0	4.0	30.0
67	55	0	HAMILTON	659.0	3873.0	4.0	30.0
68	55	0	HAMILTON	661.0	3873.0	4.0	30.0
69	55	0	HAMILTON	663.0	3873.0	16.0	30.0
70	55	0	HAMILTON	667.0	3873.0	16.0	30.0
71	55	0	HAMILTON	671.0	3873.0	16.0	30.0
72	55	0	HAMILTON	675.0	3873.0	64.0	30.0
73	55	0	HAMILTON	683.0	3873.0	16.0	30.0
74	55	0	WALKER	655.0	3871.0	4.0	30.0
75	55	0	WALKER	657.0	3871.0	4.0	30.0
76	55	0	WALKER	651.0	3869.0	16.0	30.0
77	55	0	WALKER	655.0	3869.0	4.0	30.0
78	55	0	WALKER	657.0	3869.0	4.0	30.0
79	55	0	CATOOSA	659.0	3869.0	16.0	30.0
80	55	0	CATOOSA	663.0	3869.0	16.0	30.0
81	55	0	WALKER	651.0	3865.0	16.0	30.0
82	55	0	WALKER	655.0	3865.0	16.0	30.0
83	55	0	CATOOSA	659.0	3865.0	16.0	30.0
84	55	0	CATOOSA	663.0	3865.0	16.0	30.0
85	55	0	CATOOSA	667.0	3865.0	64.0	30.0
86	55	0	CATOOSA	675.0	3865.0	64.0	30.0
87	55	0	WALKER	651.0	3861.0	16.0	30.0
88	55	0	WALKER	655.0	3861.0	16.0	30.0
89	55	0	WALKER	635.0	3857.0	256.0	30.0
90	55	0	WALKER	651.0	3857.0	16.0	30.0
91	55	0	WALKER	655.0	3857.0	16.0	30.0
92	55	0	CATOOSA	659.0	3857.0	64.0	30.0
93	55	0	CATOOSA	667.0	3857.0	64.0	30.0
94	55	0	CATOOSA	675.0	3857.0	64.0	30.0
95	55	0	CATOOSA	651.0	3873.0	16.0	30.0
96	55	0	WALKER	651.0	3849.0	64.0	30.0
97	55	0	WALKER	659.0	3849.0	64.0	30.0

Table 1-7 (continued). GEOGRAPHICAL DATA - 1973

GRID NUMBER	REGION	POLITICAL JURISDICTION	COUNTY	UTM COORDINATES X(KM)	UTM COORDINATES Y(KM)	AREA (KM**2)	STACK HEIGHT (FT)
98	55	0	WALKER	635.0	3841.0	256.0	30.0
99	55	0	WALKER	651.0	3841.0	64.0	30.0
100	55	0	WALKER	659.0	3841.0	64.0	30.0
101	55	0	CATOOSA	667.0	3841.0	256.0	30.0
102	55	0	WALKER	651.0	3833.0	64.0	30.0
103	55	0	WALKER	659.0	3833.0	64.0	30.0
104	55	0	WALKER	635.0	3825.0	256.0	30.0
105	55	0	WALKER	651.0	3825.0	64.0	30.0
106	55	0	WALKER	659.0	3825.0	64.0	30.0
107	55	0	WALKER	667.0	3825.0	256.0	30.0

2. STATIONARY SOURCE FUEL COMBUSTION

BITUMINOUS COAL

Area-wide Emissions

An effort was made to determine coal consumption in the three-county area through contacts with the local coal distributors. Of the companies contacted, only a few were able to provide what they felt was complete and reliably accurate data. Many were unable to provide the data requested because their sales figures were not computed in coincidence with the geographic boundaries of this study. Some were unwilling to cooperate in providing the requested information.

The methods used to compute coal consumption involved following the procedures outlined in APTD-1135 (Ref. 1).

Residential (RESCOAL):

Residential coal consumption was calculated by the "degree day method," computed as follows:

$$\text{Area total} = (\text{Dwelling units using coal})(\text{Heating requirement factor})(\text{No. degree days/yr})\left(\frac{\text{Rooms/dwelling unit - study year}}{\text{5 avg. room/dwelling unit - U.S.}}\right)$$

The calculations are summarized by county for 1973 in the following table.

The total study area residential coal consumption is then, 24,999 tons/year in 1973.

Table 2-1. RESIDENTIAL COAL CONSUMPTION - 1973

County	Dwelling units using coal x	Heating requirement factor[a] x	Degree days per year[b] x	$\frac{\text{Rooms}}{\text{D.U.}}$ $\frac{1}{5}$ =	Coal usage (ton/yr)
Hamilton, Tennessee	5,008	.0012	3,254	$\frac{5.0}{5}$	19,555
Walker, & Catoosa, Georgia	1,136	.0012	3,254	$\frac{4.9}{5}$	4,347
Totals	6,425				24,999
References	9,10	1	12	10	

[a] (Tons coal/dwelling unit - degree day)

[b] (The sum of the negative departures of average daily temperature from 65°F)

Commercial-Institutional (COMCOAL)

Tennessee state retail bituminous coal usage	358.0×10^3 ton/yr[2]
- 1973 residential total (degree-day method)	(-) 378.2×10^3 ton/yr
Total commercial-institutional bituminous coal usage	=(-)20.2×10^3 ton/yr

Since commercial-institutional bituminous is a negative value, it is assumed that all establishments using coal would be included in the State point source inventory.

Georgia state retail bituminous coal usage	72.0×10^3 ton/yr[2]
- 1973 residential total (degree day method)	(-) 42,538 ton/yr
Total commercial-institutional usage	29,462 ton/yr
- 1973 state commercial-institutional point source usage	(-) 3,208 ton/yr[3]
Georgia state commercial-institutional area source usage	= 26,254 ton/yr

Because of the very rural nature of Walker and Catoosa counties, GA., it is assumed that any commercial-institutional establishments using coal would be included in point source inventory. It is indeed questionable as to whether or not any coal burning commercial-institutional facility would exist in such an area.

Industrial (INDCOAL)

Tenn. industrial coal usage	$2,292 \times 10^3$ ton/yr[2]
- 1973 point sources total	$3,014 \times 10^3$ ton/yr[4]

Subtracting the state industrial point source usage from the published state industrial coal usage total yields a state area source consumption of (-)722×10^3 ton.

Further investigation found that although the majority of industrial coal usage is included in point source inventories, some emissions may result from resent convertions to coal fired equipment because of the present energy situation. Industry in the Chattanooga area has begun a slow conversion from natural gas to coal fired equipment thus producing an approximate yearly decrease in new natural gas sales of about 5 percent.[5,6] This conversion is expected to continue at approximately the same rate, in the future. The result can be seen as a possible source of emissions which because of its perrennial occurance would most likely not be included in a point source inventory i.e., any point source inventory update would incompass the previous year's conversion but not the upcoming years "expected" change. Therefore in order to accomodate its situation for the Chattanooga area, the perennial change is included as the area source for industrial coal usage.

Total natural gas consumption[6] Hamilton Co., Tenn.	$24,519 \times 10^6 ft^3$
x .05 (the percentage reduction due to switch from natural gas to coal)	= $1,225 \times 10^6 ft^3$

x 1,050 Btu/ft^3 = 1.28×10^{12} Btu[7]

In order to determine an equivalent amount of coal which would provide the same amount of thermal energy 1.28×10^{12} Btu is divided by 21.0×10^6 Btu/ton of coal to yield[7] approximately 60.0×10^3 tons of bituminous coal. It is felt that this value would not show-up in the point sources and is used for area source combustion of bituminous coal.

Total (GA and FLA) "all other"
bituminous coal sales - 1973 388,000 ton/yr[2]

equals:

GA coal usage = 388,000 ton/yr[2]
less, GA state industrial
point source coal usage = (-) 261,765 ton/yr[3]

Total state industrial
bituminous coal area source usage
= 126,235 ton/yr

Georgia is provided with a significant area source for coal consumption, but because of the very rural nature of both Walker and Catoosa counties it was assumed that all existing industries using coal would be included in the point sources. Those few small enough to be missed would be lost in the retail category.[2]

The total area source bituminous coal consumption for the three-county region is the sum of the RESCOAL, COMCOAL and INDCOAL categories:

$$24{,}999 + 0.0 + 60{,}000 = 84{,}999 \text{ ton/yr}$$

for total three-county region.

Emission factors for the three categories were derived from AP-42[7] and are summarized by source category in Appendix A.*

Total emissions from these categories in 1973 are presented below.

Source category	Total emissions -1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
RESCOAL	188.7	390.0	625.0	143.7	56.2
COMCOAL	0.0	0.0	0.0	0.0	0.0
INDCOAL	4485.0	1767.0	60.0	30.0	450.0
Totals	4673.7	2157.0	685.0	173.7	506.2

Projections

Residential coal usage is steadily declining due to home heating conversions to natural gas and electricity. New homes that use coal as a heating fuel are not being built. Also, coal heated buildings are often quite old and subject to demolition in urban renewal and highway projects. Projections, therefore, were based upon the estimated number of dwelling units using coal in the projections years, derived by the exponential extrapolation method:

$$N_t = N_o e^{rt} \qquad (8)$$

where: N_o = number of units at time o,
N_t = number of units at time t,
r = rate of change
t = time in years

* Values for % sulfur and % ash content are given in Appendix A, Table A-5.

In arriving at these values, it was assumed that the number of houses using coal would continue to decline at the same rate/year as was consistent with the 1960-1970 trend, (Appendix B).

Year	1973	1975	1980	1985
No. houses using coal	6,425	5,167	2,997	1,738
Growth factor	base	0.80	0.47	0.27
RESCOAL consumption	24,999	20,134	11,660	6,762

RESCOAL emissions for the projection years are presented in Tables 2, 3, 4.

Commercial-institutional coal usage may increase due to the increase cost of alternative fuels. This increase will most likely be picked-up in future point source inventories. A very real alternative to individual coal burning facilities will be that of considering electricity as perhaps a more expensive, but because of its conveniences, more desirable energy source. In either event commercial-institutional emissions under a coal usage category should be neglegible as an area source consideration.

Industrial area source coal consumption was projected as being that amount which is equal in thermal value to five percent of the yearly industrial natural gas usage. Method for determination previously described.

Year	1973	1975	1980	1985
INDCOAL usage (ton/yr)	60,000	81,000	82,000	83,000
Growth factor[a]	base	1.36	1.37	1.38

[a] Factor determined by conversion from natural gas to coal-fired equipment, represents approximately 5 percent of years natural gas sales to customers.

Subarea Distribution

Apportioning of pollutant emissions from the three-county area source bituminous coal combustion to grid cells was based on the following factors for each source category:

RESCOAL - No. houses in each grid using coal[9,10]
COMCOAL - N.A.
INDCOAL - Industrial land use map

Allocated emissions for these categories for all study years are presented in Appendices G through J.

FUEL OIL

Distillate Oil

Area-Wide Emissions

A survey of several retail fuel oil dealers in the Chattanooga region yielded much the same vague data as determined from contacts with local coal distributors. Since the lack of data from any one of the dealers would render the total fuel oil sales total invalid, this method of computation of fuel oil sales was discontinued.

Residential (RESFOIL):

Consumption of distillate fuel oil in the three-county region was calculated by the degree-day method previously described for coal.

The calculations are summarized by county for 1973:

Table 2-2. RESIDENTIAL DISTILLATE OIL CONSUMPTION - 1973

County	Dwelling units using fuel oil x	Heating requirement factor[a] x	Degree days[b] per year x	$\frac{\text{Rooms}}{\text{D.U.}}$ $\frac{1}{5}$ =	
Hamilton	4,266	0.18	3,254	$\frac{5.0}{5.0}$	$2{,}498.7 \times 10^3$ gal
Walker	1,118	0.18	3,254	$\frac{4.9}{5.0}$	648.3×10^3 gal
Catoosa	543	0.18	3,254	$\frac{4.9}{5.0}$	315.0×10^3 gal
Total	5,932				$3{,}462 \times 10^3$ gal

[a] (Gallons/dwelling unit - degree day)

[b] (The sum of the negative departures of average daily temperature from 65°F)

Commercial-Institutional (COMDOIL):

To obtain the commercial-institutional area source distillate oil usage, the following state data were used:[13]

Tennessee -

Kerosene used for heating	=	2958×10^3 bbl
Distillate type heating oils	=	1871×10^3 bbl
Distillate used by military	=	156×10^3 bbl
		4985×10^3 bbl
		x 42 gal/bbl
Tennessee total commercial-institutional and residential distillate oil consumption	=	$209,370 \times 10^3$ gal

Georgia -

Kerosene used for heating	=	121×10^3 bbl
Distillate type heating oils	=	$2,984 \times 10^3$ bbl
Distillate used by military	=	95×10^3 bbl
Total		$3,200 \times 10^3$ bbl
		x 42 gal/bbl
Georgia total commercial-institutional and residential distillate oil consumption	=	$134,400 \times 10^3$ gal

The state residential distillate oil usage must be subtracted from the above,

Total state dwelling units using distillate oil in 1970	=	67,956 (Georgia)[10]
	=	76,397 (Tennessee)

Total state dwelling units using distillate oil in 1960 = 106,117 (Georgia)[9]
= 75,750 (Tennessee)

Using an exponential extrapolation ($S = Pe^{nr}$) to 1973, where $4 = \frac{\ell n\ S/P}{n}$ = 4.450% usage decrease/year. (Georgia)
1.001% usage increase/year (Tennessee)

Therefore,
Total estimated state dwelling units using distillate oil in 1973 = 59,451 (Georgia)
= 76,592 (Tennessee)

Average annual heating degree-days = 3,254[12]

Total state residential distillate oil consumption = $(59,451)(3,254)(0.18)(\frac{5}{5})$ (Georgia)
= $34,822 \times 10^3$ gal

= $(76,592)(3,254)(0.18)(\frac{5}{5})$ (Tennessee)
= $44,862 \times 10^3$ gal

Total state commercial-institutional and residential, less residential usage, less commercial-institutional point source distillate oil usage.

(Tennessee) $209,370 \times 10^3$ gal - [($44,862 \times 10^3$ gal) + (726×10^3)] = $190,996.8 \times 10^3$ gal (4)
(Georgia) $134,400 \times 10^3$ gal - [($34,821.8 \times 10^3$ gal) + ($8,102 \times 10^3$ gal)] = $91,476.2 \times 10^3$ gal (3)

Apportioning to the separate counties by population[9,10]

(Tennessee) Hamilton Co. $190{,}996.8 \times 10^3$ gal x .0622* =
$11{,}880.3 \times 10^3$

(Georgia) Walker Co. $99{,}578 \times 10^3$ gal x .0109* =
$1{,}085 \times 10^3$ gal

Catoosa Co. $99{,}578 \times 10^3$ gal x .0061* =
607×10^3 gal

Total three-county commercial-institutional area source distillate oil consumption = $13{,}572 \times 10^3$ gal/yr

* It should be noted at this point, the factors so designated are a ratio of county to state populations and will be seen frequently in the body of this text.

Industrial (INDDOIL)

Industrial consumption of distillate oil was determined using the following state data from Reference 13:

State industrial distillate oil sales:

(Tennessee) 1,661 x 10^3 bbl

(Georgia) 1,584 x 10^3 bbl

Conversion to gallons (x 42 gal/bbl)

(Tennessee) 69,762 x 10^3 gal

(Georgia) 66,528 x 10^3 gal

Subtract state point source totals[3,4]

(Tennessee) 69,762 x 10^3 gal - 34,766 x 10^3 gal = 34,996 x 10^3 gal

(Georgia) 66,528 x 10^3 gal - 22,331 x 10^3 gal = 44,197 x 10^3 gal

Apportioned to separate counties

(Tennessee) Hamilton Co. 34,996 x 10^3 gal · .0622 = 2176.7 x 10^3 gal/yr

(Georgia) Walker Co. 44,197 x 10^3 gal · .0109 = 482·10^3 gal/yr

Catoosa Co. 44,197 x 10^3 gal · .0061 = 270·10^3 gal/yr

Total industrial distillate oil consumption for study area

2929 x 10^3 gal/yr

The total area source distillate oil consumption for the three-county region is,

Residential	$3,462 \times 10^3$ gal/yr
Commercial-institutional	$11,879 \times 10^3$ gal/yr
Industrial	$2,929 \times 10^3$ gal/yr
Total distillate oil consumption	$18,270 \times 10^3$ gal/yr

Emission factors derived from AP-42 were applied to the fuel totals to calculate emission totals and are summarized in Table A-1 (Appendix A), values for % sulfur and % ash content are given in Appendix A, Table A-5.

The three-county area source pollutant emissions resulting from combustion of distillate oil are:

Source category	Total emissions -1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
RESFOIL	17.3	107.1	8.7	5.2	20.8
COMDOIL	89.1	367.7	23.8	17.8	356.4
INDDOIL	22.0	172.8	5.9	4.4	87.9
Totals	128.4	647.6	38.4	27.4	465.1

Projections

Distillate fuel oil consumption by the residential sector for the future study years was based on the estimated number of dwelling units using fuel oil for heating. In determining these estimates, it was assumed that the counties usage rate through 1985 was consistent with the 1960-1970 trend (Appendix B).

Year	1973	1975	1980	1985
No. houses using fuel oil	5,932	5,596	4,838	4,190
Growth factor	base	0.94	0.81	0.71
Fuel oil consumption (10^3 gal/yr)	3,462	3,266	2,824	2,447

Future RESFOIL pollutant emissions are presented in Tables 2, 3, 4.

The majority of emissions from this category will result from the commercial-institutional and industrial sectors where increased fuel oil usage is entirely probable, since natural gas in the Chattanooga region will be restricted to these users.[5,6]

For this reason, commercial-institution and industrial growth projections were developed from community population trends for the specific counties.[11] Projections were kept consistent with 1960-1970 trends extrapolated at an exponential rate of change.

Year	1973	1975	1980	1985
COMDOIL	11,879	12,101	12,968	13,906
INDDOIL usage (10^3 gal/yr)	2,929	2,994	3,097	3,221
Growth factor	base	1.02	1.09	1.17

Subarea Distribution

Pollutant emissions resulting from area source distillate fuel oil combustion were distributed to all grid cells based upon:

RESFOIL = No. houses in each grid using fuel oil[9,10]
COMDOIL = Commercial/institutional land use[11,14]
INDDOIL = Industrial land use[11,14]

Computer allocated emissions are tabulated in Appendices G through J.

FUEL OIL - RESIDUAL

Area-wide Emissions

Data for total state consumption of residual fuel oil were obtained from Bureau of Mines data[13] and the computation methods described in Reference 1 were followed.

Residential (RESROIL):

Contact with several major local fuel oil distributors indicated that there was no residential usage of residual oil in the Chattanooga Region.

Commercial-Institutional (COMROIL):

Tennessee residual type heating oils = 202×10^3 bbl (13)
$\times$ 42 gal/bbl

Total state commercial-institutional residual oil consumption = $8,484 \times 10^3$ gal

Subtracting the state commercial-institutional point source usage of 253×10^3 gal/yr from this total[4] gives the commercial-institutional area source residual oil consumption of $8,231 \times 10^3$ gal in Tennessee.

Georgia residual type heating oils = $2,492 \times 10^3$ bbl (13)

Total state commercial-institutional residual oil consumption $\times$ 42 gal/bbl = $104,664 \times 10^3$ gal

Subtracting the state commercial-institutional point source usage[3] of 620 x 10^3 gal/yr from this total gives the commercial-institutional area source residual oil consumption of 104,044 x 10^3 gal/year in Georgia.

Total three-county commercial-institutional area source residual oil consumption

Tennessee (8,231 x 10^3 gal)(.0622)*
= 512 x 10^3 gal
Georgia (104,044 x 10^3 gal)(.017)*
= 1,769 x 10^3 gal

Total residual oil total for study area = 2,281 x 10^3 gal

Industrial (INDROIL):

The state industrial residual oil consumption in 1973 is a combination of:

Tennessee state industrial residual oil sales (plus)	=	264 x 10^3 bbl	(13)
Tennessee state oil company sales	=	45 x 10^3 bbl	(13)
		309 x 10^3 bbl	
		x 42 gal/bbl	
Tennessee state industrial residual oil usage		12,978 x 10^3 gal/yr	

Subtracting the Tennessee State industrial point source usage of 23,726 x 10^3 gal/yr from this amount[4] gives a state area source residual oil consumption of (-)10,748 x 10^3 gal.

---

* Population factors for study area, county population/state population.

Georgia state industrial residual oil sales	=	$7{,}114 \times 10^3$ bbl	(13)
Georgia state oil company sales	=	152×10^3 bbl	
		$7{,}266 \times 10^3$ bbl	
Total Georgia State industrial		x 42 gal/bbl	
residual oil usage	=	$305{,}172 \times 10^3$ gal/yr	

Subtracting the Georgia State industrial point source usage of $324{,}786 \times 10^3$ gal/yr (Reference 3) from this amount, gives a state area source residual oil consumption of (-) $19{,}614 \times 10^3$ gal. Therefore, it is concluded that there is no industrial area source combustion of residual oil in the 3-county region, this is in agreement with the findings of GA. DNR in their treatment of 1972 data, and 1973 NEDS annual fuel summary report.

The total area source residual oil consumption for the study area is the commercial-institutional total $2{,}281 \times 10^3$ gal/yr.

Emission factors were determined from AP-42 as in preceeding sections (Table A-1).

The 3-county area source pollutant emissions resulting from combustion of residual oil are:

Source category	Total emissions -1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
COMROIL	26.2	340.9	4.6	3.4	68.4

Projections

The most complete data available for making projections were the population trends for the three specific counties.

Growth rate factors were determined in relation to total area population growth.

Year	1973	1975	1980	1985
COMROIL usage (10^3 gal/yr)	2,281	2,363	2,547	2,747
Growth factor	base	1.04	1.12	1.20

Subarea Distribution

Allocation of total emissions were performed using land use planning information.[11,14]

NATURAL GAS

Area-wide Emissions

Information on natural gas usage for the entire study area was available from the following distributors:

Chattanooga Natural Gas Company[9]
Atlanta Gas Light Company[15]
Lafayette Municipal Gas[16]

Residential (RESNGAS)

		1973
Tenn.	Chattanooga - Hamilton Co.	$2,060.2 \times 10^6 ft^3$
Ga.	Rossville - Lafayette - Walker Co.	$819.1 \times 10^6 ft^3$
	Ft. Oglethorpe - Catoosa Co.	$12.7 \times 10^6 ft^3$

Total residential natural gas in 3-county area, 1973. $2,891.9 \times 10^6 ft^3$

Commercial-Institutional (COMNGAS)

Tenn.	Chattanooga - Hamilton Co.	$2,507.7 \times 10^6 ft^3$
Ga.	Rossville - Lafayette - Walker Co.	$172.6 \times 10^6 ft^3$
	Ft. Oglethorpe - Catoosa Co.	$37.7 \times 10^6 ft^3$

Total commercial-institutional natural gas in 3-county area, 1973 $2,718.0 \times 10^6 ft^3$

Industrial (INDNGAS)

		1973	
Tenn.	Chattanooga - Hamilton Co.	$37,470 \times 10^6 ft^3$*	(Ref. 4)

* Apportioned by population from NEDS annual fuel summary for Tennessee.

(less) Industrial point source usage	(-)19,388 x $10^6 ft^3$
(less) C.F. Industries (direct pipeline service)	(-) 7,000 x $10^6 ft^3$
(equals) Chattanooga-hamilton Co. area source usage	11,082 x $10^6 ft^3$
Ga. Rossville - Lafayette - Walker Co	371 x $10^6 ft^3$
Ft. Oglethorpe - Catoosa Co.	-
Total industrial natural gas in 3-county area, 1973	11,453 x $10^6 ft^3$

The total area source consumption of natural gas in 1973 in the study area:

Residential	2,891.9 x $10^6 ft^3$
Commercial-Institutional	2,718.0 x $10^6 ft^3$
Industrial	11,453.0 x $10^6 ft^3$
	17,062.9 x $10^6 ft^3$

Emission factors input to the area 2 program with the above fuel totals were from AP-42 and are summarized in Table A-1. The total area source pollutant emissions resulting from the combustion of natural gas follow:

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
RESNGAS	15.3	0.9	28.9	11.6	115.7
COMNGAS	13.6	0.8	27.2	10.9	163.1
INDNGAS	57.3	3.4	97.4	17.2	1002.2
Totals	86.2	5.1	153.5	39.7	1281.0

Projections

The availability and supply of natural gas is unique to each region of the country. Future trends will be affected by so many socio-economical and geo-resource factors as to make a concrete prediction near impossible.

Pipeline supplies should remain relatively constant in the future, hovering around the 1975 figure. Any new sales will most likely take advantage of the more lucrative residential-commercial market.

In Chattanooga this is expected to result in a five percent annual reduction of availability in new sales of natural gas to industry which will inturn be made available to residential-commercial customers.[5,6] Therefore, residential and commercial categories were each increased by annual rates of 2.5 percent, industry remained about level at the 1975 value.

PROJECTED NATURAL GAS USAGE BY COUNTY

	1973	1975	1980	1985
Hamilton County area				
RESNGAS	2,060	2,164	2,449	2,771
COMNGAS	2,508	2,634	2,981	3,373
Growth factor[a]	given	base	1.13	1.28
INDNGAS	11,082	14,067	14,067	14,067
Growth factor	given	base	1.00	1.00
Walker County area				
RESNGAS	819	857	947	1,028
COMNGAS	173	173	193	313
INDNGAS	372	318	291	313
Growth factor[b]	given	base	1.06	1.23

Catoosa County area				
RESNGAS	13	12	14	15
COMNGAS	38	36	40	45
INDNGAS[c]	-	-	-	-
Growth factor[a]	given	base	1.13	1.28

[a] Growth factors at a 5% rate of annual increase, determined from base year.[5,6]

[b] Growth factors, determined as an average value from decreasing natural gas sales by Chattanooga Gas Co., and increasing sales from Lafayette Municipal Gas.[5,6]

[c] Industrial usage in Catoosa County non-existent as area source.[15]

Subarea Distribution

Emissions resulting from natural gas combustion in the study area were distributed separately by subcategory.

Residential - No. of houses used natural gas[12,13]

Commercial-institutional - commercial-institutional land use[7,8]

Industrial - industrial land use[7,8]

LPG

Area-wide Emissions

Contact with local distributors of LPG could not produce a complete set of information for the base year. Base year values were extrapolated from 1971 and 1972 figures for LPG.[17]

Tennessee residential-commercial LPG	$146,955 \times 10^3$ gal	
(less) commercial point sources	(-) 36×10^3 gal	(4)

Tennessee residential-commercial LPG consumption - area source	= $146,919 \times 10^3$ gal
(times) population factor Hamilton Co./Tenn.	(x) .062
Hamilton Co. total residential-commercial LPG	$9,109 \times 10^3$ gal
(times) percent residential (natural gas ratio)	(x) .442
Residential LPG, Hamilton Co.	= $3,844 \times 10^3$ gal

Georgia residential-commercial LPG	$216,233 \times 10^3$ gal	
(less) commercial point sources	(-) 7×10^3 gal	(4)

Georgia residential-commercial LPG consumption - area source	$216,226 \times 10^3$ gal
(times) population factor, Walker and Catoosa Co./Georgia	(x) .017

Walker - Catoosa residential-commercial-institutional, LPG consumption	$3,675 \times 10^3$ gal
(times) percent residential (natural gas ratio)	(x) .540

Residential LPG Walker-Catoosa Co. $\underline{1,985 \times 10^3 \text{ gal}}$

Total residential usage of LPG for study area equals:

$3844 + 1985 = \underline{5829 \times 10^3 \text{ gal}}$

Commercial-institutional (COMLPG)

Hamilton Co. residential-commercial-institutional LPG		$9,109 \times 10^3$ gal
(less) residential usage for Hamilton Co.	(-)	$3,844 \times 10^3$ gal
Hamilton Co. commercial institutional LPG	=	$\underline{5,265 \times 10^3 \text{ gal}}$
Walker-Catoosa residential-commercial-institutional LPG		$3,675 \times 10^3$ gal
(less) Walker-Catoosa residential LPG	(-)	$1,985 \times 10^3$ gal
Walker-Catoosa commercial-institutional LPG	=	$\underline{1,690 \times 10^3 \text{ gal}}$

Total commercial-institutional usage of LPG for study area equals:

$5265 + 1690 = \underline{6955 \times 10^3 \text{ gal}}$

Industrial (INDLPG)

Tennessee Industrial LPG state total		$5,483 \times 10^3$ gal
(less) Tennessee industrial point source usage of LPG[2]	(-)	161×10^3 gal

Tennessee industrial area source usage of LPG		$5,322 \times 10^3$ gal
(times) population factor Hamilton Co./Tenn.	(x)	.062
Hamilton Co. industrial area source usage of LPG	=	$\underline{330 \times 10^3 \text{ gal}}$
Georgia industrial LPG state total		$11,924 \times 10^3$ gal
(less) Georgia industrial point source usage of LPG	(-)	$1,302 \times 10^3$ gal
Georgia industrial area source usage of LPG		$10,622 \times 10^3$ gal
(times) population factor Walker-Catoosa/Georgia		.017
Walker-Catoosa industrial area source usage of LPG		$\underline{181 \times 10^3 \text{ gal}}$

Total industrial area source usage of LPG for study area equals:

$330 + 181 = \underline{511 \times 10^3 \text{ gal}}$

Projections

Projections from 1975 to 1985 were made parallel to those used for natural gas consumption the same rate of increase developed for natural gas is used for development of LPG growth factors.

Source category	Total emissions - 1973 (ton/yr)				
	Part.	SO_x	CO	HC	NO_x
RESLPG	5.2	0.0	5.5	2.3	21.9
COMLPG	6.3	0.0	6.6	2.8	40.0
INDLPG	0.5	0.0	0.4	0.1	3.0
Total	12.0	0.0	12.5	5.2	64.9

Year	1973	1975	1980	1985
Hamilton Co. RESLPG gal/yr	3,844	4,036	4,803	5,151
COMLPG gal/yr	5,265	5,528	6,265	7,055
Growth factor	base	1.05	1.19	1.34
INDLPG gal/yr	330	419	419	419
Growth factor	base	1.27	1.27	1.27

Year	1973	1975	1980	1985
Walker and Catoosa RESLPG gal/yr	1,985	2,064	2,223	2,488
COMLPG gal/yr	1,690	1,758	1,893	2,112
Growth factor	base	1.04	1.12	1.25
INDLPG gal/yr	181	188	203	226
Growth factor	base	1.04	1.14	1.25

Subarea Distribution

LPG consumption for the 3-county area was allocated using the same methods as described for natural gas.

WOOD

Area-wide Emissions

Residential wood combustion was calculated according to the degree-day method described in Reference 1 and previously detailed.

The calculations are summarized by county for 1973:

Table 2-3. RESIDENTIAL WOOD CONSUMPTION - 1973

County	State	Dwelling units using wood x	Heating requirement factor[a] x	Degree days per year x	Rooms/D.U. =	Wood usage (tons/year)
Hamilton	Tenn.	795	0.0017	3,254	$\frac{5.0}{5.0}$	4,398
Walker	Ga.	290	0.0017	3,254	$\frac{4.9}{5.0}$	1,572
Catoosa	Ga.	78	0.0017	3,254	$\frac{5.0}{5.0}$	431
Total		1,163				6,401

[a] (Tons wood/dwelling unit - degree day)

Commercial-institutional and Industrial:

There were no data available to indicate the use of wood fuel by commercial-institutional area sources. It is expected to be quite minimal. Wood burning by industrial sources is only done as wood waste burning by the wood industry and these are included as point sources. Therefore, commercial-institutional and industrial area source emissions from wood combustion were considered to be negligible.

The emission factors applied to the residential wood fuel total to calculate emissions are included in Table A-1. Pollutant emissions in the 3 county region are:

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
Wood	54.4	0.0	160.0	12.8	6.4

Projections

Wood as a home heating fuel is definitely declining, especially in the urban area. This is due to home heating conversions and the renovating of older neighborhoods for various urban projects. Therefore, projections of future residential wood usage were based on the 1960-1970 rate of decrease in number of dwelling units using wood, an exponential rate as previously decribed (Table B-1).

Year	1973	1975	1980	1985
No. houses using wood	6,401	5,883	4,758	3,859
Growth factor	base	0.92	0.74	0.60
Wood usage (ton/yr)	6,401	5,883	4,758	3,859

Subarea Distribution

Allocation of emissions from wood combustion to grid cells was by the number of houses in each grid cell using wood as a heating fuel[9,10]. Grid emissions for all study years are tabulated in Appendices G through J.

3. MOBILE SOURCES

GASOLINE HIGHWAY MOTOR VEHICLES (GASMVEH)

Area-Wide Emissions

This category is broken down into 2 subcategories; gasoline powered automobiles and small trucks (LDMV) and gasoline powered large trucks (HDMV). Two methods were employed to determine the vehicle miles traveled (VMT) by these categories in the study area.

The first method involved breaking down the fuel sales totals obtained from the State Department of Revenue.[39,40]

	Tennessee	Georgia
State gasoline sales	$2,171.9 \times 10^6$ gal	$2,114.0 \times 10^6$ gal
Ratio of county to state population	.062	.017
County gasoline sales	134.7×10^6 gal	35.9×10^6 gal
(less) off-highway[a] fuel usage	3.75×10^6 gal	$- 1.56 \times 10^6$ gal
Area on-highway gasoline sales	130.95×10^6	34.33×10^6 gal

[a]See section of off-highway fuel usage

Total gasoline on-highway sales for study area	165.28×10^6 gal/yr

If 11[24,25] percent of the total VMT traveled is assumed to have been consumed by heavy duty gasoline powered trucks and LDMV's get 13.6 mi/gal and HDMV's 8.4 mi/gal, then:

Total gasoline on-highway usage		165.28×10^6 gal/yr
Percent of total that is heavy duty.		.11
Total gasoline for HDMV		18.18×10^6 gal/yr

then:

Total gasoline on-highway usage (less) total HDMV usage		165.28×10^6
	(-)	18.18×10^6
Total LDMV fuel usage		147.10×10^6

Calculation of VMT:

Total HDMV gasoline usage (times) miles per gallon factor for HDMV		18.18×10^6 gal/yr
	(x)	8.4
Total VMT's traveled by HDMV in study area		$\underline{152.71 \times 10^6 \text{ VMT}}$

Total LDMV gasoline usage (times) miles per gallon factor for LDMV		147.10×10^6 gal/yr
	(x)	13.6
Total VMT's traveled by LDMV in study area		1000.6×10^6 gal/yr

DIESEL SALES

		Tennessee	Georgia
Total diesel fuel[39] sales by state		289.1×10^6 gal	
(times) ratio of study area to state population	(x)	.062	
Area diesel sales[40]		17.92×10^6 gal	3.99×10^6 gal
Hamilton Co., Tenn. diesel usage		17.92×10^6 gal	(continued on following page)

(less)

Tennessee off-highway sales[39] 30.9×10^6 gal
(government, farm, etc.)
(times) Hamilton Co./
Tenn. population factor (x) .062

Hamilton Co. off-highway sales = 1.92×10^6 gal

(less)

All other diesel fuel usage[1]
[(7.4 gal/capita)(256,770 Hamilton Co. pop.)] = 1.90×10^6 gal

Hamilton County total on-highway diesel fuel usage = $\underline{14.10 \times 10^6 \text{ gal}}$

Walker - Catoosa Co., GA. diesel usage 3.99×10^6 gal
(less)

County off-highway sales
(government, farm, etc.)
[295 tractors using diesel fuel (Walker)[32]
no value available (Catoosa)][33]

$(295)(1000 \text{ gal/tractor yr}) = .295 \times 10^6$ gal
3.70×10^6 gal

(less)

All other off-highway diesel fuel use[1] = $.601 \times 10^6$ gal
[(7.4 gal/capita)(82,170 Walker-Catoosa, pop)]

Total Walker-Catoosa on-highway diesel fuel sales = $\underline{3.09 \times 10^6 \text{ gal}}$

The total on-highway diesel fuel usage (Hamilton and Walker-Catoosa) times 5.1 miles/gal[1] will yield total diesel VMT in study area

$(14.1 + 3.09)(5.1) = \underline{87.68 \times 10^6 \text{ VMT}}$

The second method was chosen for use in this report. It was assumed that county or small area gasoline sales could in no way reflect accurately the actual VMT's traveled since much of the gasoline sold could have been consumed outside of the study area. This is particularly true to the

Chattanooga study, because of its proximity to interstate I-75, a very major artery of north-south traffic in the eastern part of the country. The second method uses state DOT traffic survey data which is derived from direct traffic count measurements.

County	Paved roads	Unpaved roads	Total	Ref.
Hamilton	1,563.46	4.73	1,568.19	24
Walker	235.71	19.79	255.50	25
Catoosa	241.74	9.77	251.51	25
Area total	2,040.91	34.29	2,075.20	

Total VMT for study area $\quad 2,075.2 \times 10^6$ VMT

In order to determine those VMT generated by light-duty gasoline vehicles, heavy-duty gasoline vehicles and diesel vehicles, methods were developed for each specific county:

Hamilton Co., Tenn.

It was assumed that 13 percent of the traffic in Hamilton Co. was generated by heavy-duty gasoline - diesel trucks.[24] Heavy-duty gasoline vehicles contributing 80 percent of this figure, while diesel powered vehicles produce the remaining 20 percent.[43]

Hamilton County		$1,568.19 \times 10^6$ VMT
(times) HDGV - D truck factor	(x)	.13
Total HDGV - D truck VMT's	=	205.35×10^6 VMT

(times) .80, equals HDGV VMT's = $\underline{164.28 \times 10^6 \text{ VMT}}$ (Ref. 1)
(times) .20, equals diesel truck VMT's = $\underline{41.07 \times 10^6 \text{ VMT}}$ (Ref. 1)

Walker County, Georgia

Walker County's rural nature and lack of interstate highways causes heavy-duty gasoline - diesel trucks to contribute only 6.68 percent of the total VMT's[25] this value was determined using the following equation:

$$\frac{\Sigma\ (\text{Daily VMT})(\%\ \text{trucks})}{\Sigma(\text{Daily VMT})} = \frac{1,327}{19,867} = 6.68\%$$

It was assumed that 80 percent of this value was contributed by heavy-duty gasoline vehicles and 20 percent by diesel powered vehicles.

Walker County 255.5×10^6 VMT
(times) HDGV - D truck factor (x) .0668

Total HDGV - D truck VMT's = 17.07×10^6 VMT

(times) .80, equals HDGV VMT's = $\underline{13.65 \times 10^6 \text{ VMT}}$

(times) .20, equals diesel truck VMT's = $\underline{3.41 \times 10^6 \text{ VMT}}$

Catoosa County, Georgia

The percentage of the county VMT's contributed by heavy-duty gasoline-diesel trucks was calculated to be 6.2 percent, using the following equation:

$$\frac{[(\text{interstate VMT daily})(\%\ \text{trucks})] + [(\text{rural VMT daily})(\%\ \text{trucks})]}{2}$$

$$\frac{[(375{,}397.0)(.16)] + [(611{,}477 - 375{,}397)(.0608)]}{2} \qquad (25)$$

$$\frac{(60{,}063.52) + (15{,}770.1)}{2} = \frac{37{,}916.83}{611{,}477} = 6.2\%$$

daily Catoosa VMT

It was assumed that 80 percent of this value was contributed by heavy-duty gasoline vehicles and 20 percent by diesel powered vehicles.

Catoosa County		251.51×10^6 VMT
(times) HDGV - D trucks factor	(x)	.062
Total HDGV - D truck VMT's	=	15.59×10^6 VMT
(times) .80, equals HDGV VMT's	=	12.48×10^6 VMT
(times) .20, equals D truck VMT's	=	3.12×10^6 VMT

County	Gasoline		Diesel	Total*
	LDMV*	HDMV*	DMV*	
Hamilton	1,317.28	209.84	41.07	1,568.19
Walker	238.44	13.65	3.41	255.50
Catoosa	235.91	12.48	3.12	251.51
Area total	1,791.63	235.97	47.60	2,075.20

Emission factors for use with this category were derived from AP-42, Supplement 5, April 1975, incorporating the

[a] all values given as 1.0×10^6 VMT.

latest revisions and application of Federal Test Procedure data for EF calculations. The new methodology employed will not be discussed as the procedural changes are too numerous and the calculations too involved for inclusion herein (the reader is referred to Supplement 5, which should be readily available). In order to account for the combination of LDMV (gasoline) and HDMV (gasoline) VMT, weighted emission factors were computed. The assumptions used in computing the emission factors for each category will be listed and a brief explanation offered for each pollutant EF calculation.

LDMV

The emission factor for particulates is composed of the following components:

exhaust	0.34 gm/mi	
tire wear	0.20 gm/mi	
brake wear	0.02 gm/mi	(Ref. 44)
Particulate emission factor for light duty motor vehicles =	0.56 gm/mi	

The factors for emissions and tire wear are published figures from AP-42. The brake wear factor is unpublished but based upon 2 lb worn off per set of brake shoes each 45,000 miles.

Street dust is often times a significant factor in total particulate emissions from vehicle travel. An attempt to quantify this component is presented in Chapter 5, where dust from paved streets has been treated as a separate fugitive dust category.

The above EF for particulates and that for SO_x (0.13 gm/mi) are assumed to remain constant through 1985.

The crux of the new procedures involves calculation of composite emission factors for each calender year under consideration for CO, HC, and NO_x. The assumptions made follow:

1. Typical urban patterns of vehicle operation apply.
2. Average route speed equals 19.6 mph.
3. 20% cold engine operation.
4. Ambient temperature[12] = 58.6.
5. Nationwide statistics for vehicle mix apply.
6. The hot start-up phase for catalyst controlled vehicles is 27% of the operating time.
7. Vehicles are catalyst controlled from 1975-1977.

Then, the composite emission factors are calculated by:

$$e_{npstw} = \sum_{i=n-12}^{n} c_{ipn}\ m_{in}\ v_{ips}\ z_{ipt}\ r_{iptw},$$ and the resultants

shown below.

Year	Composite emission factors (gm/mi)				
	Part.	SO_x	CO	HC	NO_x
1973	0.56	0.13	77.1	10.3	4.4
1975	0.56	0.13	65.7	8.8	4.0
1980	0.56	0.13	30.5	5.1	2.8
1985	0.56	0.13	11.9	2.0	1.13

HDMV(gasoline)

The emission factor for particulates is composed of the following components:

exhaust	0.91 gm/mi
tire wear	0.30 gm/mi
brake wear	0.03 gm/mi

Particulate emission factor for HDMV (gasoline) = 1.24 gm/mi

The factors for emissions and tire wear are published figures from AP-42. The brake wear factor is unpublished, but based upon 3 lb worn off per set of brake shoes per 45,000 miles. Again, street dust is a factor in vehicle traffic and a rough quantification of this component is shown in Chapter 5.

The emission factor for SO_x is 0.36 gm/mi. Both these factors are projected (AP-42) to remain constant through 1985.

The calculation of the composite emission factors for CO, HC, and NO_x for HDMV (gasoline) and the assumptions made follow:

1. Vehicle operation is entirely warmed up condition.
2. The vehicle mix is based on nationwide statistics.
3. Average route speed equals 18 mph.
4. The speed correction factor is based on LDMV data.
5. There exists an average of 6 tires per vehicle.

Then, the composite emission factors are calculated by:

$$e_{nps} = \sum_{i=n-12}^{n} c_{ipn} m_{in} v_{ips}.$$

They are as follows:

Year	Composite emission factors(gm/mi)				
	Part.	SO_x	CO	HC	NO_x
1973	1.24	0.36	217.36	34.62	9.20
1975	1.24	0.36	204.90	30.20	10.20
1980	1.24	0.36	181.32	20.14	11.42
1985	1.24	0.36	138.90	12.23	12.32

The weighted emission factors incorporating those of both subcategories.

The following summarizes the weighted EF's computed:

Year	Composite emission factors (gm/mi)				
	Part.	SO_x	CO	HC	NO_x
1973	0.61	0.15	87.1	12.0	4.7
1975	0.61	0.15	61.0	10.3	4.4
1980	0.61	0.15	41.1	6.15	3.4
1985	0.61	0.15	20.8	2.7	1.9

The above EF's were input with the total VMT for LDMV and HDMV (gasoline) vehicles in the study area in 1973 (10,997 x 10^6 VMT/yr) to the Area 2 program to calculate total and apportioned emissions. Prior to this, however, the EF's were converted to lb/10^6 VMT to ensure compatability with the fuel total units (Table A-1). The resultant total emissions are:

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
GASMVEH	1,519.7	335.4	194,701.9	26,824.6	10,506.3

Projections

Emission factor development for succeeding study years has already been treated. Projections of annual VMT for gasoline motor vehicles are derived from data acquired from the Ga. and Tenn. State DOT's.[24,25] Estimated VMT projection factors by county, based on factors pertaining to vehicle registrations, annual vehicle-miles, population and licensed driver distributions, and roads in service were obtained. Using these county growth factors and estimating annual VMT by county then summing to get annual VMT in the study area, an overall weighted growth factor for the entire study area evolved. The same ratio of LDMV VMT and HDMV VMT to Total VMT was assumed to prevail through 1985. The projections are:

Year	1973	1975	1980	1985
VMT growth factor	base	1.04	1.15	1.27
GASMVEH VMT (10^6 VMT/yr)	2,027.6	2,115.2	2,331.7	2,575.0

Projecting vehicular travel at this time, given the following uncertain trends:

1. federal motor vehicle control programs,
2. average new vehicle gas mileage,
3. federal regulations governing gasoline lead content,
4. number of people buying new cars,

is a matter to be approached with extreme caution. All aspects of the current energy market must be brought to bear. Although the above issues all generally suggest declining VMT in the future, other considerations and trends suggest that because of increases in population and probable increases in fuel economy in future motor vehicles, some upward trend in VMT could be expected over the next ten years. The major point to be impressed here is that, although the VMT projection factors probably represent the best available estimates, they should not be regarded as absolute inviolate prophecies of future activity.

Subarea Distribution

Allocation of emissions from all motor vehicle sources was based upon the distribution of total county measured VMT by functional classification (freeway, rural, urban) in each grid cell as determined from traffic count maps. This total was, of course, composed of gasoline motor vehicles and diesel motor vehicles (truck) traffic. Using the truck traffic percentage factors as previously described, the total was broken into GASMVEH VMT/grid and DIEMVEH VMT/ grid (grid apportioning factors). Apportioning factors for future years were projected using the growth factors outlined above.

DIESEL HIGHWAY MOTOR VEHICLES (DIEMVEH)

Area-Wide Emissions

This category includes buses and heavy duty trucks using diesel fuel. Since measured VMT data was used to determine the emissions from gasoline motor vehicles, the same VMT data was also used for this category. However, to maintain consistency, both methods of fuel totals computations are presented for comparison.

The emission factor for particulates is composed of the following components:

exhaust	1.3 gm/mi
tire wear	0.50 gm/mi
brake wear	0.05 gm/mi

Emission factor for heavy duty diesel powered motor vehicles
= 1.85 gm/mi

The factors for emissions and tire wear are published figures from AP-42. The brake wear factor is unpublished, but based upon 3 lb worn off per set of brake shoes per 45,000 miles. Again, street dust is a factor in vehicle traffic and a rough quantification of this component is shown in Chapter 5.

The EF for SO_x is 2.8 gm/mi and it, along with that for particulates, remains constant through 1985 (Tables A-2, A-3, A-4).

The assumptions made for calculation of the composite emission factors for CO, HC, and NO_x are:

1. Average route speed equals 45 mph (due to large amount of interstate truck traffic in metropolitan Atlanta).

2. All engine operation is in warmed up condition.

3. Vehicle mix is based upon nationwide statistics.

4. There exists an average of 10 tires per vehicle.

Then, the composite emission factors are calculated by:

$$e_{nps} = \sum_{i = n-12}^{n} c_{ipn} \, m_{in} \, v_{ips},$$ and the resultants shown below:

Year	Composite emission factors (gm/mi)				
	Part.	SO_x	CO	HC	NO_x
1973	1.85	2.8	8.6	2.3	25.1
1975	1.85	2.8	8.6	2.3	25.1
1980	1.85	2.8	8.6	2.3	24.2
1985	1.85	2.8	8.6	2.3	25.2

After converting the emission factors to a $lb/10^6$ VMT basis, they were input, with the DIEMVEH VMT total, to the Area 2 Program for total and apportioned emissions calculations. The EF's in appropriate input form are presented in Table A-1. The resultant emissions for 1973 are:

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
DIEMVEH	96.9	146.9	451.1	120.6	1,617.0

Projections

Projections of future VMT for diesel motor vehicle is just as subjective an operation as it was for gasoline vehicles. Data was taken from Ga. and Tenn. State DOT's.[24,25]

Again, the same vehicle mix and ratio of DIEMVEH VMT/total VMT were assumed to apply through 1985. These projections should be viewed with the same astute awareness as those for gasoline motor vehicles.

Year	1973	1975	1980	1985
VMT growth factor	base	1.13	1.37	1.50
Total VMT (10^6 VMT/yr)	2,027.6	2,115.2	2,331.7	2,575.0
DIEMVEH VMT (10^6 VMT/yr)	47.6	53.9	65.1	71.3

Subarea Distribution

Allocation of emissions from this category was performed exactly as that for gasoline motor vehicles. They are tabulated in Appendices G through J.

AIRCRAFT (AIRCRAFT)

Area-Wide Emissions

The effects aircraft upon air quality are attributable to four airports of significant size in the study area. The number of operations by aircraft category were obtained by several means, and formed the basis for emissions calculations.

It was desired to obtain FAA Master Records for each airport in the study area. However, personnel at the FAA Regional Office in Atlanta indicated that, due to workload, these would have to be extracted from their files personally by the requester. Therefore, other sources of more readily available published data were consulted to obtain the required information.

Aircraft operations at Lovell Field, Chattanooga, Tennessee, were obtained through FAA Air Traffic Activity Report.[37] Data pertaining to the smaller fields was collected through contacts with their respective managers or individuals in charge of flight operations.

Emission factors were obtained directly from AP-42. The number of engines for each category is directly obvious except for the air carrier category. Contact with Lovell Field[38] showed that the vast majority of jet air carrier flights in and out of Chattanooga were by medium-range jet aircraft. The medium range jet emission factor was used along with the following estimated total engine LTO's for air carrier flights:

EMISSION FACTORS (lb/eng - LTO)[a]

Aircraft category	Part.	SO_2	CO	HC	NO_x
Air carrier[1]	.41	1.01	17.0	4.9	10.2
Air taxi turboprop[2]	.65	.29	4.85	2.0	1.85
General aviation	.02	.01	12.2	.4	.047
Military[3]	.29	.45	84	15	1.7

[1] Medium range jet aircraft value AP-42.

[2] Average value (air carrier and general aviation turboprop) AP-42

[3] Average value (jet and piston military aircraft) AP-42

[a] Emission factors for each class of aircraft are based upon LTO operations by mode (e.g. taxi - idle, take-off, etc.) AP-42.

TOTAL ENGINE LTO FOR AIR CARRIERS, LOVELL FIELD - 1973

	Number of yearly operations	Percent total operations by aircraft	Aircraft type	Number and type engine	Total operations ÷ 2	Total engine LTO
		.76	McDonald Douglas DC-9	2 Pratt & Whitney JT-8D	13,680	
Air carrier	18,000	.21	Boeing 727	3 Pratt & Whitney JT-8D	5,670	
		.03	Boeing 737	2 Pratt & Whitney JT-8D	540	19,890

TOTAL EMISSIONS FOR 1973 ARE SHOWN IN TABLE 3-1.

Table 3-1. TOTAL EMISSIONS - 1973 (ton/yr)

Airport	Aircraft category	Total eng - LTO	Part.	SO_x	CO	HC	NO_x
Lovell Field (Grid 53)	Air carrier	19,890	4.08	10.04	169.1	48.7	101.44
	Air taxi turboprop	1,000	.32	.14	2.4	1.0	.92
	General aviation	47,200	.47	.24	287.9	9.4	1.11
	Military	2,000	.29	.45	84.0	15.0	1.70
	Total		5.16	11.00	543.4	74.1	105.20
Collegedale (Grid 72)	Air taxi turboprop	18,061	.00	.00	.03	.01	.01
	S/E General aviation	8,580	.09	.04	52.34	1.72	.20
	M/E General aviation	890	.01	.01	5.43	.18	.02
	Total		.10	.05	57.80	1.91	.23
Dallas Bay (Grid 16)	S/E General aviation	4,236	.04	.02	25.84	.85	.10
	M/E General aviation	737	.01	.00	4.49	.14	.02
	Total		.05	.02	30.33	.99	.12
Barwick-Lafayette (Grid 102)	Business jet[1]	50	.00	.01	.40	.09	.04
	S/E General aviation	1,330	.02	.01	8.11	.27	.03
	M/E General aviation	1,140	.01	.00	6.95	.23	.03
	Total		.03	.02	15.46	.49	.10

[1] Business jet, used emission factors: Part., .11, SO_x .37, CO 15.8, HC 3.6, NO_x 1.6, AP-42.

SMALL FIELD TOTAL LTO PROJECTIONS

	1973	1975	1980	1985
College Dale				
Service area population	9,485	9,974	11,325	12,787
Growth factor	base	1.05	1.19	1.35
Projected total LTO's	9,031	9,496	10,782	12,174
Dallas Bay				
Service area population	26,753	27,885	30,875	33,888
Growth factor	base	1.04	1.15	1.27
Projected total LTO's	9,210	9,600	10,628	11,667
Barwick-Lafayette				
Service area population	54,790	57,600	62,700	68,200
Growth factor	base	1.05	1.14	1.24
Projected total LTO's	3,800	4,000	4,363	4,758

Projections

Air carrier traffic is expected to increase through 1985. Projections were based on estimates in daily flight totals expected.[38]

INCREASE IN TOTAL ENGINE LTO FOR AIR CARRIERS LOVELL FIELD

Year	1973	1975	1980	1985
Estimated daily flight totals	25	27	38	42
Growth factor	base	1.11	1.52	1.73
Resulting increase in air carrier engine LTO per year	19,890	22,100	30,653	34,255

Projections for the three other air fields were based on population increases in the area which they serve.

Subarea Distribution

Aircraft air considered area sources and the emissions from them are applied to the grids at the airport locations. For purposes of computation then, aircraft emissions were input to the Area 2 Program as "hand calculated emissions" and added to the apportioned emissions of the appropriate grid cells (Appendices G through J).

RAIL LOCOMOTIVE (RAILLOC)

Area-wide Emissions

Emission as a result of railroad activity in the 3-county study area were computed from reported state railroad fuel usage.[22,23]

Tennessee total distillate fuel[22] oil usage (1973)		$2{,}215 \times 10^3$ bbl
(times) track mileage ratio[22] Hamilton Co./Tennessee	(x)	423/5791
Hamilton Co. railroad distillate oil usage	=	$\underline{161.8 \times 10^3 \text{ bbl}}$
Georgia total distillate fuel[23] oil usage (1973)		$2{,}845 \times 10^3$ bbl
(times) track mileage ratio[23] Walker-Catoosa Co./Georgia	(x)	88.3/5417
Walker and Catoosa area railroad distillate oil usage	=	$\underline{46.4 \times 10^3 \text{ bbl}}$
Total distillate oil usage for study area $[(161.8 \times 10^3)+(46.4 \times 10^3)]$	=	208.2×10^3 bbl
(times) barrel to gallons, conversion factor	(x)	42 gal/bbl
Total distillate oil usage by railroads for study area	=	8740.8×10^3 gal

Emission factors, based on average locomotive statistics (Table A-1), were applied to the above fuel consumption to yield total pollutant emissions for this category:

Source category	Part.	SO_x	CO	HC	NO_x
RAILLOC (ton/yr)	109.3	249.1	568.2	410.8	1617.0

Projections

The railroad industry in general has shown a decrease in activity in the past several decades. However, at least one factor can be cited to indicate a possible growth trend in railroad activity. Although no quantitative measure of this factor was obtained, it remains that the hauling of coal by the railroads is likely to increase as dwindling supplies of cleaner fuels place more importance on coal as an energy source. A subjective indication of railroad activity was translated into a 5 percent increase from 1973 to 1980 and 10 percent increase for the period 1980 to 1985. These percentages were used as the basis for projecting emissions for this category.

	1973	1975	1980	1985
RAILLOC 10^3 gal	8,740.8	7,604.5	9,177.8	10,139.3
Growth factor	given	base	1.21	1.33

Subarea Distribution

The miles of railroad track in each grid were measured from USGS topographic maps of the study area. The total measured mileage was 511.3. Since the area contains 212.6 miles of mainline track,[22,23] the difference was attributed to grids where major track or yard facilities were noted. Thus, allocating proportionately to the measured track mileage rather than the mainline mileage will more heavily weight the grids containing greater railyard activity.

Switch engine activity in the yards was assumed to be included in the emissions from this category were then distributed to each grid on the basis of track mileage contained in the grid.

VESSELS (VESSELS)

Area-Wide Emissions

Estimation of pollutant emissions attributable to vessel traffic in the study area included both pleasure boats and river barge tow boats. The major aquatic surface area in the study region is that of the Tennessee River system; a series of artificial lakes connected by locks and navigable routes of the Tennessee River.

Pleasure Boats

The total aquatic surface area for both Tennessee and Georgia is 916 + 803 = 1719 sq miles.[19]

The surface area of the Tennessee River System located within the study region equals 35 sq miles[a] thus;

35/1719 = percentage of total aquatic surface area within study region
= .02

The total number of pleasure boats registered for the two states[20,21] (174,729 Tenn. + 115,000 Ga. = 289,729).

Then:

289,729 x .02 = 5795 pleasure boats in study area

5795 pleasure boats x 160 gal/vessel-year
equals $\underline{927.2 \times 10^3 \text{ gal/yr}}$

---

[a] Determined from USGS maps of study area.

Towboats

Information on barge towboat movement on the Tennessee River System was acquired for traffic between river miles 452-499.[18]

It was determined that approximately 2033 towboats passed through the study area in 1973. In order to determine how many vessels stopped in port at Chattanooga, the tonnage receipts and shipments in the port of Chattanooga, were divided by the total tonnage passing between Nichajack locks down river (1255th mile) and Chichamauga lock upriver (778th mile).

1,355,172 short tons/2,109,097 short tons = .642

Total number of towboats passing through study area	(x)	2033
Number of towboats entering Chattanooga port	=	1306
(times) (14 hours average[18] travel time within study region + 2 hours lay-over inport)	(x)	16
Hours of on-board power plant operation	=	20896 hr/yr
(times) nautical speed (47 miles traveled/14 hours)	(x)	3.36 mph
Equivalent nautical miles traveled	=	70,210.6 nautical miles

(times) 19 gallons of fuel[1] per nautical mile	(x)	19
Total usage of fuel by vessels using Chattanooga port facilities		$\underline{1334 \times 10^3 \text{ gal/yr}}$
Number of towboats traveling river but not entering Chattanooga port facilities.		727
(times)(14 hours average travel time within study region)	(x)	14
Hours of on-board power plant operation		10,178 hr/year
(times) nautical speed (47 miles traveled/14 hours)	(x)	3.36 mph
Nautical miles traveled		34,198.1
(times) 19 gallons of fuel per nautical mile	(x)	19
Total usage of fuel by vessels passing Chattanooga port facilities	=	$\underline{649.8 \times 10^3 \text{ gal/yr}}$
Total usage of fuel by river towboat vessels in study area $[(1334.0 \times 10^3) + (649.8 \times 10^3)]$	=	$\underline{1983.8 \times 10^3 \text{ gal/yr}}$

Emissions factors for vessels in the Chattanooga area were calculated as a weighted average between three sub-categories, inboard, inboard/outboard, outboard, and diesel powered towboats.

Pleasure crafts included all inboard, inboard/outboard, and outboard engines. Emission factors were taken directly from AP-42 and assuming seventy percent outboard motor usage against thirty percent inboard - inboard/outboard usage the emission factor value for each class of pleasure boat were weighed accordingly.

Type	Emission factors, lb/10^3 gal				
	Part.	SO_x	CO	HC	NO_x
Pleasure boats	0.0	4.7	2354.7	773.1	9.3

Emission factors for diesel powered towboats were taken directly from AP-42.

Diesel towboat	0.0	27.0	100.0	50.0	280.0

weighted average between diesel powered towboats and pleasure crafts determined according to percentage of total fuel usage for 1973.

Fifty-three percent of the fuel is consumed by towboats and 47 percent by pleasure boats. Resulting emission factors are:

	Part.	Weighted emission factors, lb/10^3 gal			
		SO_x	CO	HC	NO_x
Vessels	0.0	16.4	1159.7	389.9	152.8

Input into Area 2 program resulted in emissions for 1973 of:

Source category	Emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
Vessels	0.0	23.9	1,687.0	567.2	222.3

<u>Projections</u>

In today's conservation intensive fuel market, predicting future fuel use trends is difficult, to say the least. However, if one will accept a few basic assumptions the elucidation of future trends clears considerably.

1. The increase in overland movement of freight will continue thus the contemporary rate of decline in commercial river traffic should remain about the same.[18]

2. Continued increases in leisure time and general enthusiasm in pleasure boating should cause some increase in fuel usage.

Projections were calculated by extrapolating the 1970 to 1973 rate of change for both gasoline and diesel fuels.

	Vessel fuel consumption 10^3 gal/yr			
	1973	1975	1980	1985
Gasoline	927.2	937.8	965.0	992.9
Diesel	1,982.1	1,970.5	1,940.2	1,911.0
Total	2,909.3	2,908.3	2,905.2	2,903.9

Sub-Area Distribution

Pollutant emissions were allocated to grid cells in proportion to the inland water area present therein, determined from USGS maps.

OFF-HIGHWAY VEHICLES (OFHIVEH)

Area-wide Emissions

This category includes off-highway vehicles using diesel and gasoline fuels. Typical gasoline fuel users are farm tractors, lawnmowers, compressors, pumps, and small electric generators. Typical diesel fuel users are farm tractors, construction equipment, emergency generator power units, and compressor engines. Of the farm tractors, approximately 60 percent are assumed to be gasoline powered.[1]

In attempts to collect all the necessary data for determination of off-highway vehicle fuel usage it was found that there would be a variety of deletion in the information for each county. Although these deletions may cause the total off-highway fuel consumption value to be underestimated, it was the only data and method available.

1. Gasoline:

Gasoline farm equipment refund[39]		\$467,288.00
for Tenn. (times 0.07 dollars/gal)	=	$6{,}676 \times 10^3$ gal

Off-highway tractor usage for Tenn. (x)		.062
(times) population factor for		
Hamilton County	=	413,884 gal

13 gallons/capita[1] times population of Hamilton County (256,770) equals total "all other" off-highway gasoline 3,338,010 gal/yr.

Total off-highway gasoline usage in Hamilton County (413,884 + 3,338,010) = 3,751,894 gal/yr

Number of tractors for[40] study area in Georgia		842
(times) % using gasoline	(x)	.60
(times) 1000 gal/tractor/yr		1,000
Off-highway tractor usage for Georgia	=	505,200 gal/yr

Thirteen gallons/capita[1] times population of Walker and Catoosa Counties (82,170) equals total "all other" off-highway gasoline 1,068,210 gal/yr.

Total off-highway gasoline usage in Walker and Catoosa (505,200 + 1,068,210) = 1,573,410 gal/yr

Total off-highway gasoline usage for study area (3,751,894 + 1,573,410) = 5,325,304 gal/yr.

2. Diesel:

State total off-highway fuel[39] sales, farm tractor, construction equipment, etc.		30,932,392
(times) population factor for Hamilton Co. area	(x)	.062
Total off-highway diesel fuel sales (farm tractor, construction, etc)		1,917,808 gal/yr

7.4 gallons/capita[1] times population of Hamilton County (256,770) equals total "all other" off-highway diesel fuel sales 1,900,098 gal/yr

Total off-highway diesel usage of Hamilton Co.
(1,917,808 + 1,900,098) = 3,817,906 gal/yr

Number of tractors for study area in Georgia	842
(times) % using diesel	.35
(times) 1000 gal/tractor/yr	1,000
Off-highway diesel tractor usage for Georgia	294,700 gal/yr
Number of construction equipment using diesel in Walker and Catoosa	149
(times) 5000 gal/tractor/yr[1]	(x)5,000
Total off-highway diesel usage by construction equipment	745,000 gal/yr

7.4 gallons/capita[1] times population of Walker and Catoosa Counties (83,170) equals total "all other" off-highway diesel fuel usage 608,058 gal/yr

Total off-highway diesel usage in Georgia sector of study area (294,700 + 745,000 + 608,058) = 1,647,758 gal/yr

Total off-highway diesel usage for
study area (3,817,906 + 1,647,758) = 5,465,664 gal/yr

LPG fuel sales (LPG Section) allocates approximately 1,251,000 gal/yr for off-highway usage

Total fuel usage for off-highway category in study area [5,325,304 (gasoline) + 5,465,664 (diesel) + 1,251,000 (LPG)] = 12,041,968 gal/yr

There are no directly applicable emission factors for off-highway sources. A composite emission factor, based upon a weighted average of light duty motor vehicle emission factors and diesel motor vehicle emission factors, was applied to the composite fuel total. Since smaller engines are probably not as efficient as larger engines, this was felt to be a reasonable approach. The derivation follows in Table 3-2.

Total estimated emissions for the off-highway vehicles category, including both gasoline and diesel fuel users, are as shown:

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
OFHIVEH	98.7	131.3	4,607.3	670.1	1,324.6

Projections

Although unobtainable, State projections of fuel consumption for this category would depict the most accurate usage. Therefore, they were based on population growth projections.

Table 3-2. EMISSIONS FACTOR DERIVATION-OFF-HIGHWAY VEHICLES

Emission factor	Partic.		SO_x		CO		HC		NO_x	
	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel
gm/mi (1)	0.56	1.53	0.13	2.8	75.9	8.6	10.2	2.3	4.4	25.1
mi/gal (2)	12.2	5.1	12.2	5.1	12.2	5.1	12.2	5.1	12.2	5.1
gm/gal (=1x2)	6.83	7.8	1.59	14.3	926	43.9	124.4	11.7	53.7	128
wt'd avg. (gas & diesel)	$\frac{(20,796)(6.83)+(39,618)(7.8)}{60,414}$		$\frac{(20,796)(1.59)+(39,618)(14.3)}{60,414}$		$\frac{(20,796)(926)+(39,618)(43.9)}{60,414}$		$\frac{(20,796)(124.4)+(39,618)(11.7)}{60,414}$		$\frac{(20,796)(53.7)+(39,618)(128)}{60,414}$	
gm/gal	7.47		9.9		347.4		50.5		102.4	
$lb/10^3$ gal [a]	16.4		21.8		765.2		111.3		220	

[a]Input to Area 2 Program/presented in Table A-1.

Year	1973	1975	1980	1985
Total population	337,074	353,928	391,006	428,084
Growth factor	base	1.05	1.16	1.27
OFHIVEH fuel usage (10^3 gal/yr)	12,042	12,403	13,969	15,293

It is to be noted that, since off-highway vehicles are essentially uncontrolled, the 1973 emission factors have been assumed to apply through 1985 (Tables A-2, A-3, A-4).

Subarea Distribution

The calculation of emissions from this category is based almost entirely on population. The allocation of emissions to each grid were, therefore, distributed proportionately to the grid population of each study year. These distributions are shown in Appendices G through J.

4. COMBUSTION OF SOLID WASTES
(Controlled and Uncontrolled)

OPEN BURNING (OPENBUR)

Area-Wide Emissions

There are four classifications that have been given consideration under this category: a) agricultural burning, b) leaf burning, c) residential on-site burning and d) unintentional structural fires.

Contact with the Hamilton County Air Pollution produced some very useful and extensive data concerning open burning in the study region. A value of 1.25×10^{-3} ton/yr/km^2 was discerned as a viable estimate of unauthorized burning in Hamilton Co., (because of the parity between Hamilton Co. and the rest of the study area this value was used for the entire 3-county area).

Area of study region		4256 km^2
(times) unauthorized burning factor	(x)	1.25×10^{-3} ton/yr/km^2
Total tonnage of material burned of unauthorized nature	=	5.32 ton/yr

The number of structural fires in the study area for 1973 was calculated at 1914 fires. In the metropolitan Chattanooga area, there were 245 building fires and 725 dwelling fires, totalling a reported 970 structural fires.[36] In order to determine structural fires for the rest of the study area attempts were made at contacting other local fire departments, however, because many of these departments are composed of volunteers yearly records are not kept. The number of structural fires for these areas was determined as follows:

Population of area outside metropolitan Chattanooga (times)		236,134
structural fires per[7] 1000 persons	(x)	4/1000
Total number of structural fires outside Chattanooga area	=	944 fires
Total structural fires in study region	=	(970 + 944) 1,914
(times) fuel consumed per structural fire		5 ton/fire
Total fuel consumed during structural fires in study area	=	9570 ton/yr

Permitted burning within the study area was determined using values supplied by the Hamilton County Air Pollution Bureau, value derived for municipalities in Hamilton County were used for similarly populated areas in the other counties.

Total tonnage permitted burnings	30.0 ton/yr
Total tonnage of material consumed by open burning (5.32 + 9570 + 30.0)	= 9605.3 ton/yr

Emission factors for this subcategory were derived from the wood refuse table in AP-42 and an overall weighted EF for both subcategories of this source was computed (Table A-1), since it was desired that they be combined as an entity for calculation purposes.

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
OPENBUR	80.2	1.0	298.7	74.0	14.4

Projections

Leaf burning is expected to remain a negligible factor in open burning outside the urban services area. There are a number of theories that could be postulated to project residential on-site burning emissions. One seemingly obvious one is that as population increases, open burning increases by the same percentage. The assumption made in this study was that as population increases, emissions from this category will decrease by the same percentage.

The reasoning follows: 1) air pollution control regulations will become more stringent in the future and enforcement policies stricter, 2) more refined methods of solid waste disposal and recycling will be utilized making solid waste less economically feasible to dispose of in a wasteful fashion, 3) urban development and the trend toward multi-family dwellings indicates that less space per capita will be available where burning could occur.

Subjective indications from personnel associated with the various fire bureaus contacted are that unintentional structural fires indicate a decreasing trend, probably due to upgrading of the downtown sections of the city and tearing down of many older fire-prone residences. For similar reasons as above, the number of fires burned for each projection year was adjusted downward by the same percentage as the total population increased.

Year	1973	1975	1980	1985
Total population	328,872	337,074	347,824	360,026
Growth factor	base	1.02	1.06	1.10
Adjusted growth factor	base	.98	.94	.91
OPENBUR fuel (ton/yr)	9,605	9,413	9,029	8,741

OPENBUR emissions for future years are presented in Tables 2, 3, and 4, assuming that the same emission factors prevail as in 1973 (Tables A-2, A-3 and A-4).

Subarea Distribution

Computed emissions were allocated to grid cells proportional to each grid's study year population and are tabulated in Appendices G through J.

INCINERATION (INCINERA)

Area-Wide Emissions

A listing of all known non-point source incinerators in the study area was compiled from information supplied by the Hamilton County Air Pollution Bureau and the Georgia DNR. This listing is shown in Table 4-1. While the data are representative of 1975, not the base year 1973, they probably provide the best available estimate of the 1973 refuse burning rates for the incinerators still in operation. However, the total emission could be low because several incinerators may have been shut down during 1973 and 1974. Nevertheless, in the absence of more detailed information, it was assumed that the total emissions from incinerators in 1973 equalled that presented for 1975.

Total emissions of each pollutant in tons per year was determined for each incinerator in the Hamilton County area.[41] Emissions from incinerators located in Catoosa and Walker counties were determined using the tons of refuse burned per year times an emission factor from AP-42.

Incinerator emissions (ton/yr) = (lb. refuse burned/day)(days operated/yr)(ton/2000 lb) (lb pollutant emitted/ton refuse burned)(ton/2000 lb)

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
INCINERATOR	25.6	11.9	71.3	0.0	120.6

Table 4-1. LIST OF INCINERATORS AND EMISSIONS - 1973

(ton/yr)

Incinerator/location	Grid	Refuse burned (tons/year)	Days operated per year	Particulate	SO_x	CO	HC	NO_x
HOSPITAL								
Baroness-Erlanger 261 Wiehl Street Chattanooga, Tenn.	44			1.0	0.7	4.4	0.0	7.6
East-Ridge Community 941 Spring Creek Rd. Chattanooga, Tenn.				0.0	0.0	0.0	0.0	0.0
Memorial Hospital 2500 Citico Avenue Chattanooga, Tenn.	66			1.6	0.0	11.6		0.0
T.C. Thompson's Children's Hospital 1001 Glenwood Drive Chattanooga, Tenn.	45	34.2		0.1	0.0	0.0		0.0
Parkridge Hospital Post Office Box 3133 Chattanooga, Tenn.	50			0.0	0.0	0.0		0.0
J.L. Hutchenson Memorial 100 Gross Cresent Ft. Oglethorpe, Ga.	83	37.0		0.1	0.1	0.2		0.1

Table 4-1 (continued). LIST OF INCINERATORS AND EMISSIONS - 1973 (ton/yr)

Incinerator/location	Grid	Refuse burned (tons/year)	Days operated per year	Particulate	SO_x	CO	HC	NO_x
COMMERCIAL								
By-Rite Stores 8101 E. Brainerd Rd.	70			2.8	0.4	1.5		6.7
2029 Dodson Avenue	45			0.4	0.1	0.4		0.9
1302 Dorchester	74			0.5	0.4	4.1		4.6
7158 Lee Hwy.	54			0.3	0.1	0.7		0.5
Gibson Discount Centers 5615 Lee Hwy	69			0.1	0.1	0.8		1.8
3636 Ringgold Rd.	66			0.4	0.9	4.3		12.5
2398 Rossville Blvd.	57			3.7	0.4	0.7		14.9
Goodlets Supermarket 3603 Rossville Blvd. Chattanooga, Tenn.	62			0.1	0.1	0.4		0.4
M & J Supermarket 3956 Brainerd Rd.	60			0.7	0.2	1.1		1.7
3315 S. Broad St.	57			0.7	0.2	1.1		1.7
4355 Hwy. 58	41			0.7	0.2	1.1		1.7
4001 Hixson Pike	29			0.7	0.2	1.1		1.7
325 East Main St.	49			0.7	0.2	1.1		1.7
1308 E. Main St.	49			0.7	0.2	1.1		1.7
41022 Ringgold Rd.	57			0.7	0.2	1.1		1.7

Table 4-1 (continued). LIST OF INCINERATORS AND EMISSIONS - 1973 (ton/yr)

Incinerator/location	Grid	Refuse burned (tons/year)	Days operated per year	Particulate	SO_x	CO	HC	NO_x
804 Scenic Hwy.	62			0.7	0.2	1.1		1.7
1210 Taft Hwy.	62			0.7	0.2	1.1		1.7
Piggly Wiggly 850 E. Brainerd Rd.	70			0.1	0.1	0.6		1.2
Pruett's Food Town 427 Cherokee Blvd.	36			0.1	0.2	1.0		4.2
Hwy. 27 Daisy, Tenn.	10			0.2	0.3	1.0		4.2
Hwy. 58	41			0.1	0.2	1.0		4.2
5738 Ringgold Rd.	68			0.1	0.2	1.0		4.2
4816 Rossville Rd.	74			0.1	0.2	1.0		4.2
2108 East 3rd Street	50			0.1	0.2	1.0		4.2
Red Food Store 7804 E. Brainerd	72			0.1	0.1	0.1		0.9
3415 S. Broad St.	56			0.1	0.1	0.1		0.8
1744 Dayton Blvd. 37405	34			0.1	0.1	0.4		0.8
4016 Dayton Blvd. 37415	25			0.1	0.1	0.4		0.7
9362 Dayton Blvd. 37406	10			0.1	0.1	0.4		0.8
2300 Dodson Ave. 37406	39			0.1	0.1	0.4		0.8
2555 4th Ave. 37407	58			0.1	0.1	0.4		0.8

Table 4-1 (continued). LIST OF INCINERATORS AND EMISSIONS - 1973
(ton/yr)

Incinerator/location	Grid	Refuse burned (tons/year)	Days operated per year	Particulate	SO_x	CO	HC	NO_x
3504 Hixson Pike 37415	24			0.1	0.1	0.4		0.8
5414 Hixson Pike 37343	20			0.1	0.1	0.4		0.8
6951 Lee Hwy. 37421	54			0.1	0.1	0.6		1.2
401 W. 9th St. 37402	48			0.2	0.1	0.1		1.0
3715 Ringgold Rd. 37412	67			0.1	0.1	0.4		0.8
5901 Shallowford Rd. 37421	53			0.1	0.1	0.6		1.2
2300 E. 3rd St. 37404	50			0.1	0.1	0.4		0.8
Shop Rite Post Office Box 806 Lafayette, Georgia	102			0.0	0.0	0.0		0.0
730 Dallas Rd. Chattanooga, Tenn.	22			0.1	0.1	0.6		0.1
1910 Dayton Blvd. Chatt., Tenn. 37415	27			0.1	0.1	0.3		0.9
3921 Hixson Pike Chatt., Tenn. 37405	29			0.1	0.1	0.6		1.2
Tote-A-Poke 425 Signal Mt. Chatt., Tenn. 37405	36			0.3	0.1	0.2		1.1
Willes Supermarket 1909 S. Broad St. Chatt., Tenn. 37408	48			0.6	0.3	3.2		3.4

Table 4-1 (continued). LIST OF INCINERATORS AND EMISSIONS - 1973
(ton/yr)

Incinerator/location	Grid	Refuse burned (tons/year)	Days operated per year	Particulate	SO_x	CO	HC	NO_x
4350 Ringgold Rd. Chatt., Tenn. 37412	68			0.6	0.3	3.2		3.4
5013 Rossville Blvd. Chatt., Tenn. 37407	65			0.6	0.3	3.2		3.4
Alton Box Board Co. Dry Valley Rd. Rossville, Ga.	74	1,800	365	6.3	2.2	9.0		2.7
Pruetts Foodtown 315 Patton Avenue Lafayette, Ga.	102	156		0.6	0.2	0.7		0.2
Shop Rite Hwy. 27 Ft. Oglethorpe, Ga.	83	37		0.1	0.1	0.2		0.1

Projections

There has existed a recent trend to shut down on-site incinerators and use compactors or dumpsters for commercial, institutional, and industrial solid waste disposal. However, this trend probably will moderate because all of the remaining incinerators are expected to become in compliance with air pollution control regulations and will not require expensive upgrading. Most incinerator operators probably will not change their means of waste disposal unless the economics of an alternate disposal method change or the facility moves or is renovated. Also, the possibility of new on-site incinerators exists. Therefore, it has been assumed that solid waste disposal in and emissions from on-site incinerators will remain almost constant over the next ten years at the estimated 1973 level.

Subarea Distribution

The street addresses of all the on-site incinerators are known (Table 4-1). Therefore, emissions for 1973 and succeeding projection years have been allocated directly to the appropriate grids by totaling the amount of refuse burned and resulting emissions in each grid. Thus, emissions are summarized as "additional emissions" under the INCINERA category in the Area 2 Program printouts (Appendices G through J) and total emission summaries (Tables 1, 2, 3 and 4).

FOREST BURNING (FFBUR)

Area-wide Emissions

In 1973, 250 unintentional forest fires burned 1016.4 acres in the 3-county region.[34,35] The majority of fires which caused extensive burns were located in the less populated regions of each county. The table below summarizes pertinent data. An estimate obtained for fuel consumed per forested acre under fire is 9 tons wood/acre.[7]

County	No. forest fires[a]	Acres burned[a]	Conversion factor	Tons burned
Hamilton	135	171	9 tons/acre	1539
Walker	63	143	9 tons/acre	1287
Catoosa	52	703	9 tons/acre	6327
Study area total	250	1017	@ 9 tons/acre	9153

[a] This value constitutes a 5 year average for each specific county.

Emission factors for this category[7] were input to the Area 2 Program along with the above fuel totals to calculate total and apportioned emissions.

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
Forest fire (FFBUR)	77.8	0.0	457.7	91.6	9.1

Subarea Distribution

Allocation of emissions from FFBUR in unincorporated areas of the counties to grid cells was done by the Area 2 Program proportional to the forested acreage per grid. The total forested watershed acreage per county, exclusive of cropland, populated, or highway acreage, was estimated from USGS maps.

Projections

Climatic factors will heavily influence the occurrence of unintentional forest and field fires on a year to year basis and predicting future trends is quite difficult. Emissions from this category, however, may decline as suburban development encroaches on heretofore undeveloped forested land. Based upon total land use increases in the unincorporated areas of the counties containing grids with forested acreage, the acreage burned for each projected year was adjusted downward by a factor equal to the decrease in total acreage of forested area, this was determined using USGS and land use planning maps.

	1973	1975	1980	1985
Forested area (acres)	46,603	46,200	45,317	44,293
Adjusted growth factor	base	0.99	0.97	0.95
Forest fire (ton/burned)	9,153	9,061	8,878	8,695

Due to the mountainous nature of the terrain in the unincorporated areas of the county it was felt that any future development or urban sprawl would take place along the already agriculturally developed valleys. Thus future growth in the area would affect forested areas to a lesser degree than it would agricultural land.

5. OTHER SOURCES

EVAPORATIVE LOSS SOURCES (EVAPLOS)

Area-wide Emissions

This category considers emissions from gasoline handling losses, dry cleaning losses, and surface coating and miscellaneous solvent-use operations. No local survey data was available to estimate HC losses from these sources; therefore, procedures outlined in Reference 1 were employed.

1. Solvent Use:

Emissions were computed under this subcategory for dry cleaning operations only. From the per-capita emission factor given in Reference 1 and the per ton emission factor presented in Reference 42, a per-capita use factor was developed, due to the necessity, when using the Area 2 Program, to enter the fuel usage total and emission factor in compatible units.

$$\text{Per capita use factor} = \frac{\dfrac{2\ \text{lb HC emitted}}{\text{capita-year}}}{257.5\ \dfrac{\text{lb HC emitted}}{\text{ton solvent used}}} = 15.5\ \frac{\text{lb solvent used}}{\text{capita-year}}$$

Solvent use emissions for the 3 county region in 1973 are:

Solvent used (ton/yr) =

$$\frac{(328{,}875)\left(\frac{15.5 \text{ lb solvent}}{\text{cap.-yr}}\right)}{2{,}000 \text{ lb/t}} = \underline{2{,}549 \text{ ton/yr}}$$

The emission factor for this subcategory is the average of the published (AP-42) factors for petroleum and synthetic solvents - 257.5 lb/t.

2. Surface Coating Operations:

The per-capita solvent use factor - 28 $\frac{\text{lb solvent used}}{\text{capita-year}}$ (42)

was used to calculate total solvent use:

$$\text{Solvent used (ton/yr)} = \frac{(328{,}872)\left(28\ \frac{\text{lb solvent used}}{\text{capita-year}}\right)}{2{,}000 \text{ lb/ton}}$$

$$= \underline{4{,}604 \text{ ton/yr}}$$

The emission factor for this subcategory is the average of the factors for 5 surface coatings - 1,164 lb/ton (AP-42).

3. Gasoline Handling Losses:

The splash filling and liquid spillage losses associated with the filling of motor vehicle gas tanks were the only emission sources considered under this subcategory. Emissions from petroleum storage tanks were assumed to have been accounted for by point source inventories.

From county fuel sales reports for 1973[39,40] gasoline usage is:

Total gasoline usage in study area = $171{,}478 \times 10^3$ gal/yr

$$= \frac{(171,478 \times 10^3 \text{ gal/yr})(6.17 \text{ lb/gal})}{(2,000 \text{ lb/t})}$$

$$= \underline{529,010 \text{ ton/yr}}$$

It is assumed that all the gasoline sold in the area but not consumed there equals that sold elsewhere but consumed in the area.

The emission factor for this subcategory equals:

$$\begin{aligned} EF &= 11.0 \text{ lb}/10^3 \text{ gal pumped (vapor displacement loss)} \\ &\quad \underline{+0.67 \text{ lb}/10^3 \text{ gal pumped}} \text{ (liquid spillage loss)} \\ &= 11.67 \text{ lb}/10^3 \text{ gal pumped} \end{aligned}$$

Converting units:

$$EF = (11.67 \text{ lb}/10^3 \text{ gal})\left(\frac{10^3 \text{ gal}}{3.1 \text{ T}}\right) = \underline{3.8 \frac{\text{lb HC emitted}}{\text{ton gas pumped}}}$$

The overall emission factor for this category is a weighted average of the factors for the above 3 subcategories, since a combined input to the Area 2 Program was desirable. Its derivation follows:

$$\overline{EF} = \frac{(11,802)(257.5)+(21,319)(1,164)+(2,797,595)(3.8)}{(11,802 + 21,319 + 2,797,595)}$$

$$= \underline{13.6 \frac{\text{lb HC emitted}}{\text{T solvent used}}}$$

Total hydrocarbon emissions from evaporative loss sources equal:

Source category	HC emissions - 1973, ton/yr
Solvent use	328
Surface coating	2,680
Gasoline handling	3,597
Total	6,605

Projections

It is not anticipated that solvent usage rates will fluctuate greatly during the period of accountability of this study. It always remains a possibility, however, that more refined control measures will be implemented for this essentially uncontrolled category. In the absence of more sophisticated estimation techniques, projections for all evaporative loss sources are based solely on the total population increase in the 3 county study area. Projected solvent/gas usage and corresponding EVAPLOS emissions are:

Year	1973	1975	1980	1985
Total population	328,872	337,074	347,824	360,026
Growth factor	base	1.03	1.06	1.10
Solvent/gas usage (ton/yr)	536,163	552,248	568,333	589,779
Total HC emissions (ton/yr)	6,605	6,803	7,001	7,266

Subarea Distribution

Emissions were distributed to grid cells proportional to the total population of the cells during the respective study year (Appendices G through J).

FUGITIVE DUST-UNPAVED ROADS (FDUNPRD)

Area-wide Emissions

There are 469 miles of unpaved roads in the 3 county region. Walker County contained the greatest number with 241, Catoosa has 119 and Hamilton 109, however from official highway maps and USGS topographic maps, the location of 431 miles of these roads was determined. It is highly probable that the DOT inventory is accurate and the balance of the mileage is not accounted for on USGS maps, because the most recent survey data has not yet been incorporated thereon. Also unaccounted for may be city alleys and roads in outlying residential developments that are not paved until construction is complete. For apportioning purposes it was assumed that the actual complement of unpaved road mileage per grid was in the same proportion to those values actually determined from USGS maps.

State Departments of Transportation provided estimates of total VMT's traveled on unpaved roads for each county.

County	Miles of unpaved roads	10^3 VMT/year	
Hamilton	109	4,734.0	(24)
Walker	241	19,792.0	(25)
Catoosa	119	9,773.0	(25)
Area total	469	34,299.0	

The emission factor for unpaved roads was obtained from the EPA report, Development of Emission Factors for Fugitive Dust Sources,[26] a gravel roadbase with an average silt content of 12 percent, and an average speed of 30 mph on the roads.

$$\begin{aligned} \text{EF (unpaved roads)} &= 0.81\ s\left(\frac{S}{30}\right) = 0.81(12)\left(\frac{30}{30}\right) \\ &= 9.72\ \text{lb/VMT} \end{aligned}$$

This value was corrected downward to account for the relative climatic factors between the area in which the factor was developed the Chattanooga study area, and by the annual percentage of time during which no emissions would occur because of rainfall, to yield a revised emission factor of 39.9 lb/vehicle-mile traveled.

The correction factor derivations are:

Climatic factor:

C_1 (Franklin County, Kansas)	= 0.1	(43, p.47)
C_2 (Chattanooga)	= 0.007	(43, p.47)
C (relative) = C_2/C_1	= 0.1	

Surface moisture:

No. days with >0.01 in. precipitation = 140 (26, p.132)

$$\begin{aligned} \text{EF (unpaved roads)}_{\text{corrected}} &= (9.72\ \text{lb/VMT})(0.07)\left(\frac{365-145}{365}\right) \\ &\ 399\ \text{lb/VMT} \\ &\ \underline{399\ \text{lb}/10^3\ \text{VMT}} \end{aligned}$$

The resulting area-wide emissions were then calculated and apportioned by the Area 2 Program.

$$\text{FDUNPRD Emissions} = (34{,}299.4 \times 10^3 \text{ VMT/yr})(399 \text{ lb}/10^3 \text{ VMT})\left(\frac{\text{ton}}{2000 \text{ lb}}\right)$$

$$= \underline{6{,}843 \text{ ton/yr}}$$

Projections

There is almost no information available on discernible trends toward increased or reduced traffic volumes for unpaved roads. Nevertheless, observations can be made regarding certain classifications of unsurfaced roads, leading to the conclusion that the total VMT may remain constant over the next 10 years.

First, most of the county maintained unpaved roads lead to rural residences, farming districts, or recreational areas and forested land. Therefore, volume on these roadways is unlikely to increase proportionately with total traffic volume for the counties. Secondly, if traffic on a road were to increase significantly as a result of a new trip generator along the road, the road would probably be paved at that time. Thirdly, roads in new residential areas that are to be paved by developers when building construction phases are completed will be replaced by similar under-construction developments in future years.

For lack of any definitive information, it has been assumed that traffic volume on unpaved roads will remain constant over the next 10 years, with no increase or decrease of total mileage.

Subarea Distribution

All fugitive dust emissions from unpaved roads were allocated directly to grid cells based on the measured mileage of unpaved roads contained in each.

FUGITIVE DUST - PAVED ROADS (FDPAVRD)

Area-wide Emissions

Initially, inclusion of this source category in the area source inventory was not intended, due to the paucity of available data and procedures on which to base emission estimates. However, this source is becoming recognized as a significant contributor to the total particulate loading in many areas, and it was concluded that some quantitative estimate should be included, in spite of the paucity of pertinent data.

It must be emphasized that the derivations presented below do not have the same accuracy as calculations in other sections of this report, and the resulting emission estimates are only order-of-magnitude values. In recognition of this and in anticipation of future refinements of these estimates, this source category has been separated from the remainder of the categories in all data summaries.

Seattle Study - Only one study was found in which any pertinent data have been published.[27,28] From a single test of a paved road that was flushed and swept regularly, field sampling showed an emission rate of 0.14 lb/VMT, with 0.0055 lb/VMT (2.5 grams/VMT) below 10 micrometers in size. Three tests of dusty paved roads, in areas with construction projects or near unpaved roads where dirt was tracked onto the pavement, indicated an average emission factor of 0.83 lb/VMT with 0.17 lb/VMT (77 grams/VMT) under 10 micrometers.

A major concern with these reported values is the sampling method used--impaction samplers were mounted in an array on a trailer towed behind the test vehicle. Most of the resuspended material collected in the area of turbulence on the roadway would have an impact on air quality only in this limited area and not on a regional scale. This sampling method does not allow for settling and, more importantly, it may pick up particulate matter generated by many preceding vehicles, not just the test vehicle.

Example emission calculations presented in Appendix 4 to the publication[27] show substantial reductions from the emission rates cited above, although these reductions are not made for the purpose of compensating for the sampling method. In calculating annual emissions, the authors assume that:

1. dust is emitted from the road 200 days/year (in Seattle);
2. the "dry emission factor" is 30% less than the values presented;
3. average dusty paved roads emit at only 50% of the rate for the three roads tested; and
4. the sample of under 10 microns is comparable to the suspended particulate emitted.

No data are presented to support any of these assumptions.

If the emission factors and assumptions from this study are applied to Chattanooga data, and it is additionally assumed that roads in Chattanooga would be similar to the tested street that was cleaned regularly, the following results are obtained:

$$\text{EF (corrected)} = (0.0055 \text{ lb/VMT})(0.7)\left(\frac{225}{365} - \begin{matrix}\text{days with}\\ \text{no rain}\end{matrix}\right)\left(\frac{10^6}{10^6}\right)$$

$$= \underline{2{,}373 \text{ lb}/10^6 \text{ VMT}}$$

The 50 percent correction factor was not used, since it applied specifically to uncleaned streets.

Thus, total emissions are:

$$\text{FDUNPRD Emissions} = (2{,}041 \times 10^6 \text{ VMT/yr})(2{,}373 \text{ lb}/10^6 \text{ VMT})\left(\frac{\text{ton}}{2{,}000 \text{ lb}}\right)$$

$$= \frac{\text{ton/yr}}{2{,}422}$$

Of course, the total VMT traveled and the EF were input to the Area 2 Program to calculate apportioned emissions (Appendices D through P).

<u>Chicago Study</u> - The American Public Works Association (APWA) is presently conducting a study to determine the environmental benefits of improved street cleaning. In conjunction with the Chicago Department of Environmental Control and IIT Research, they are microscopically examining hi-vol filters from street canyon exposures in an attempt to determine the origin of the particulate matter. They have not yet reached final conclusions, but preliminary indications[29] are that auto exhaust accounts for only 25 percent of motor vehicle impact, with the remainder from resuspended dust and tire wear. Using this 25 percent factor and particulate emission factors from Chapter 3, an average emission factor for the road dust portion can be approximated:

(0.25)(TMVPEF)*	=	0.34 grams/VMT
TMVPEF	=	1.36 grams/VMT
FDPAVRD	=	TMVPEF - exhaust - tire wear - brake wear
	=	1.36 - 0.34 - 0.20 - 0.02
	=	0.8 grams/VMT

* Total motor vehicle particulate emission factor.

With this factor, fugitive dust from paved roads in Chattanooga area would equal 775 ton/year. For an initial estimate, it is proposed that the value from the Seattle Study be used in order to pressure the "worst case" analysis.

Projections

At this point, it cannot even be established that VMT is the best indicator of dust emissions from paved roads. Emissions are possibly more closely related to miles of road surface or some other parameter. However, since the current emission estimates are based on VMT, future emissions can reasonably be assumed to increase proportionately to VMT. These emissions are:

Year	1973	1975	1980	1985
Estimated total VMT ($x10^6$)	2,041	2,135	2,362	2,610
Growth factor	base	1.05	1.16	1.28
FDPAVRD emissions (ton/year)	2,422	2,533	2,803	3,099

Subcounty Distribution

To maintain consistency, dust emissions from paved roads have been allocated based upon the total VMT in each grid for the study years. The distributions of estimated emissions from dust on paved roads are shown in Appendices G through J.

FUGITIVE DUST - AGRICULTURAL TILLING (FGDAGTIL)

Area-Wide Emissions

Windblown dust from tilled fields was estimated by use of the wind erosion equation, a procedure explained in detail in Reference 26. Briefly, a separate emission factor is established for each crop type in an area as a function of resistance to wind erosion provided by that crop and plowing methods normally used with it. The emission factors also vary according to the common soil types found in agricultural land in an area and its climate. The fugitive dust component generated by the actual implement tilling operation has also been estimated.

Emission calculations for tillage operations account for the limited periods when the farming equipment is actually used in the fields; they do not account for the lower level emissions that occur periodically as a result of wind erosion across the fields. Annual emissions from tilling may be quite small in comparison with suspended particulate emissions generated by wind erosion.

In order to simplify the calculations involved and to account for gaps in the available data on crop types, three main categories were created:

1. Pasture - acreage lying in fallow, and that used for grazing, e.g. alfalfa, timothy, rye, safflower, grasses.
2. Harvest - barely, corn, cotton, grain, hay, oats, sorghum, soybeans, sugar beets, wheat.
3. Truck - Beans, peanuts, potatoes, vegetables.

The modified form of the wind erosion equation is:

$$E_w \text{ (tons/acre/year)} = aICKL'V' (\pm 5\%) \qquad (26)$$

where,

a, I, C, K, L', V' are quantities and factors defined in Table 5-2, in which windblown dust emissions from the tilled acreage in the 3-counties are presented in tabular form. The total particulate emissions from the windblown component are seen to be 55.97 ton/year.

The emission factor for tillage operations is estimated by the following equation:

$$E_t \text{(lb/acre)} = \frac{1.4s(S/5.5)}{(PE/50)^2} \quad (\pm 15\%) \qquad (26)$$

where,

S = implement speed (mi/hr) - assumed to be 5.5 mph

s = silt content of soil (%) - assumed to be 18%

PE = thornthwaite's precipitation-evaporation index

= 116 for the study area (26)

The calculated tillage EF then, was 4.7 lb/acre. Fugitive dust emissions by county are given in Table 5-1.

The total fugitive dust emissions from agricultural activity are presented in Table 5-3 by county.

Subarea Distribution

From information contained in USGS quadrangle maps, the grid cells most likely to contain agricultural activity were estimated to be numbers: 1,2,3,4,5,6, 7,8,10,11,12,23,24, 43,48,55,71,72,73,76,79,80,81,82, 83, 84,85,86,87,88,89,90,

Table 5-2. FUGITIVE DUST EMISSIONS FROM AGRICULTURAL FIELDS DUE TO WIND EROSION - 1973

County	Source category	A, acres	L, field length	V, vegetative cover	I(T/ac-yr) based on soil type	C, climatic factor	K' surface roughness	L' length factor	V' vegetative factor	E=AaICKL'V'* windblown dust (TPY)
Hamil-ton	Pasture	3,756	667	2,000	47	.02	1.0	.66	Neg.	.00
	Harvest	9,968	667	780	47	.02	.6	.45	.09	5.69
	Truck	722	167	100	47	.02	.6	.20	.82	1.67
Walker	Pasture	19,064	667	2,000	86	.02	1.0	.66	Neg.	.00
	Harvest	3,177	667	780	86	.02	.6	.45	.09	3.32
	Truck	454	167	100	86	.02	.6	.20	.82	1.92
Catoosa	Pasture	31,895	667	2,000	86	.02	1.0	.66	Neg.	.00
	Harvest	12,346	667	780	86	.02	.6	.45	.09	12.90
	Truck	7,202	167	100	86	.02	.6	.20	.82	30.47
										55.97

* Where a = portion of total wind erosion losses that would be measured as suspended particulate estimated to be 0.025.

Table 5-1. FUGITIVE DUST FROM AGRICULTURAL TILLING - 1973

County	Acres tilled x	EF (lb/acre) x	No. tillings per year x	T/2000 lb =	FD emissions (tons/year)
Hamilton	14,447	4.7	3	T/2000 lb	33.95
Walker	22,695	4.7	3	T/2000 lb	53.33
Catoosa	51,443	4.7	3	T/2000 lb	120.89
Study area total	88,585				208.17

Table 5-3. TOTAL FUGITIVE DUST EMISSIONS FROM AGRICULTURAL ACTIVITY - 1973

County	Acres tilled	Emissions from implement tilling operations (tons/year)	Emissions from wind erosion from Table 5-2 (tons/year)	Total agricultural associated emissions (tons/year)
Hamilton	14,447	33.95	7.36	41.31
Walker	22,695	53.33	5.24	58.57
Catoosa	51,443	120.89	43.37	164.26
Totals	88,585	208.17	55.97	264.14

92,93,94,96,97,98,100,101,102,104,105, 106,107. Emissions were allocated into each grid as the percentage of agricultural acreage, and then added to Area 2 program as "Additional Emissions."

Projections

Contact with county agricultural extension agents produced values for both 1973 and 1975.[31,32,33] Projections were made for 1980 and 1985 based on the percent reduction in agricultural land due to residential, commercial and industrial growth.[11,14,30] It was assumed that new additions to the total agricultural acreage would be minor, this being due to the unsuitable nature of the terrain, in the Chattanooga area, i.e. the majority of good agricultural land will by 1975 be either under till or in the category of "pasture".

	1973	1975	1980	1985
Agriculture (acres) land	88,585	139,060	92,949	85,094
Land-use factor	base	given	0.67	0.61
Total emission of fugitive dust (tons/year)	264.1	414.6	277.8	252.9

FUGITIVE DUST CONSTRUCTION

Area-wide Emissions

Acreage exposed to construction was determined through contact with regional governmental agencies[11,30] and State Department of Transportation.[24,25] Attempts were made to compile actual surface area exposed to construction, however it was found that for practical purposes most building permit records were in dollar value figures and not surface area. Because of these limitations in data, it was necessary to develop factors to convert 1973 dollar values into surface area exposed to construction.

The industrial construction, conversion factor was computed as an average of both the suggested value of 3.0 acres/10^6 dollars[26] a value specific for the Chattanooga area, 4.3 acres/10^6 dollars. The Chattanooga area value was calculated by summing the total acreage exposed to construction over the sum of its known cost in 10^6 dollars. The final conversion factor:

$$\frac{3.0\text{ (suggested factor)} + 4.3\text{ (Chattanooga area factor)}}{2}$$

Industrial conversion factor = 3.65 acres/10^6 dollars

Dollar cost (10^6) for industrial construction[11,30]		6.3
(times) conversion factor for industrial construction	(x)	3.65

Total acreage determined from dollar value figures	22.99
(plus) actual acreage values accorded by permits[11,30]	(+)30.34
Total acreage exposed to industrial construction	53.34

In determining a dollar value to acreage conversion factor for commercial high rise construction the same method was used as previously described for industrial construction. A value of .36 acres/10^6 dollars was calculated from permits providing both dollar values and area exposed to construction. This value was averaged with the suggested conversion factor of 2.5 acres/10^6 dollars[26] for commercial construction projects, producing a value of 1.548 acres/10^6 dollars.

Dollar cost (10^6) for commercial high rise consturction[30]	34.82
(times) conversion factor for commercial high rise construction	(x) 1.548
Total acreage determined from dollar value figures	= 53.87
(plus) actual acreage values accorded by permits[30]	(+) .93
Total acreage exposed to commercial high rise construction	= 54.83 acres

The conversion factor for commercial low rise construction was calculated as being an average of 2.5 acres/10^6 dollars and 17.18 acres/10^6 dollars[26] a value specific to Chattanooga area building permits. The calculated conversion factor is 9.84 acres/10^6 dollars.

Dollar cost (10^6) for commercial low rise construction[30]	16.89
(times) conversion factor for commercial low rise construction	(x) 9.84
Total acreage determined from dollar value figures	= 166.21 acres
(plus) actual acreage values accorded by permits[30]	(+) 26.84
Total acreage exposed to commercial low rise construction	= 193.05 acres

Dollar value to acreage conversion factor for both residential high and low rise construction was assumed to be the suggested value of 8.0 acres/10^6 dollars.[26]

Dollar cost (10^6) for residential construction[30]	34.97
(times) conversion factor for residential construction	(x) 8.0
Total acreage exposed to residential construction	= 279.77 acres

The actual locations of the construction projects were available in only a few cases, it was more common to receive data according to large areas such as municipalities, villages, townships, etc. for this reason total acreage exposed to construction is listed by grid cell in Table 5-5.

Highway construction data was collected through contact with local, regional and State highway departments. In most cases, county road departments were unable to supply the needed data due to the nature of their records. Information herein was received from state and regional governments and will reflect only major highway construction projects.

Highway projects for 1973 and 1975 are given in Table 5-4, and their approximate locations are shown on Figure 5-1, in solid line. Projected highway projects for 1980 and 1985 are shown in double line in Figure 5.1, and are included in Table 5-4. It should be noted that 1980 and 1985 highway project locations are subject to change.[11]

The average emission factor for construction was derived from Reference 26 by adjusting the base emission rate of 1.2 tons/acre/month by a correction factor to reflect difference in soil type and climate between the test sites and the Chattanooga area. This factor was:

$\frac{(30)^2}{(116)^2}$ = 0.067, and the resulting emission factor (Ref. 44) was 0.965 tons/acre/year

Derivation: 1.2 tons/acre/month x 12 months/year
x (.067) = 1.4 tons/acre/year

Total emissions produced as cause of construction are 928.3 tons/year 1973.

Table 5-5. FUGITIVE DUST EMISSIONS FROM ALL TYPES OF CONSTRUCTION - 1973 (ton/yr)

Grid No.	Industrial	Commercial	Residential	Highway	Total
1					
2					
3	0.84	1.63	4.03		6.50
4					
5					
6	1.14	2.94	7.27		11.35
7					
8					
9					
10	0.93	2.94	7.27		11.14
11	0.47	1.41	3.49		5.37
12	0.70	1.41	3.49		5.60
13	0.05	1.41	3.49		4.95
14	0.05	1.63	4.03		5.71
15	0.33	1.63	4.03		5.99
16		1.63	4.03		5.66
17		1.63	4.03		5.66
18	0.33	2.94	7.27		10.54
19		5.00	12.36		17.36
20	0.47	4.35	10.76		15.58
21		1.63	4.03		5.66
22		2.28	5.64		7.92
23					
24					
25	0.16	4.35	10.76		15.27
26		0.87	2.15		3.02
27		2.28	5.64		7.92
28	0.16	2.94	7.27		10.37
29	0.61	5.65	13.97		20.23
30	1.98	4.67	11.55		18.20
31		0.87	2.15		3.02
32		0.87	2.15		3.02
33	3.27				3.27
34	3.27	0.87	2.15		6.29
35		0.87	2.15		3.02
36	3.04	11.09	27.42		41.55
37		0.87	2.15		3.02
38	2.90	2.39	5.91		11.20
39	0.33	2.28	5.64		8.25
40	0.61	1.63	4.03		6.27
41	2.17	5.33	13.18		20.68
42	2.34	2.28	5.64		10.26
43		1.63	4.03		5.66
44	0.47	2.28	5.64	9.90	18.29
45	0.58	1.63	4.03		6.24

Table 5-5 (continued). FUGITIVE DUST EMISSIONS FROM ALL TYPES OF CONSTRUCTION - 1973 (ton/yr)

Grid No.	Industrial	Commercial	Residential	Highway	Total
46		1.63	4.03		5.66
47					
48	7.48	34.79	86.03	9.90	138.20
49	2.34	10.87	26.88		40.09
50	0.14	0.65	1.61		2.40
51					
52					
53	2.24	10.44	25.82		38.50
54					
55	0.33	1.52	3.76		5.61
56	0.47	2.94	7.27		10.68
57	0.98	2.94	7.27		11.19
58	0.89	8.37	20.70		29.96
59	0.44	4.35	10.76		15.55
60		3.59	8.88	2.90	15.37
61		6.52	16.12		22.64
62		8.37	20.70		29.07
63		1.63	4.03		5.66
64	2.01	1.63	4.03		7.67
65	1.24	7.72	19.09		28.05
66					
67					
68					
69					
70					
71					
72					
73					
74	1.24	8.70	21.51		31.45
75	1.24	8.70	21.51		31.45
76	0.47	4.35	10.76		15.58
77	0.47	4.35	10.76		15.58
78	0.47	4.35	10.76		15.58
79	0.47	4.35	10.76		15.58
80					
81					
82					
83	0.19	4.13	10.21		14.53
84					
85					
86					
87					
88	0.14	1.09	2.70		3.93
89					
90					
91	0.14	1.09	2.70		3.93

Table 5-5 (continued). FUGITIVE DUST EMISSIONS FROM ALL TYPES OF CONSTRUCTION - 1973 (ton/yr)

Grid No.	Industrial	Commercial	Residential	Highway	Total
92					
93	0.14	1.20	2.97		4.31
94	0.14	1.20	2.97		4.31
95					
96					
97					
98					
99	0.14	1.09	2.70		3.93
100	0.14	1.09	2.70		3.93
101					
102	0.14	1.09	2.70		3.93
103	0.14	1.09	2.70		3.93
104					
105					
106					
107					
Total					938.39

Figure 5-1. Highway projects.

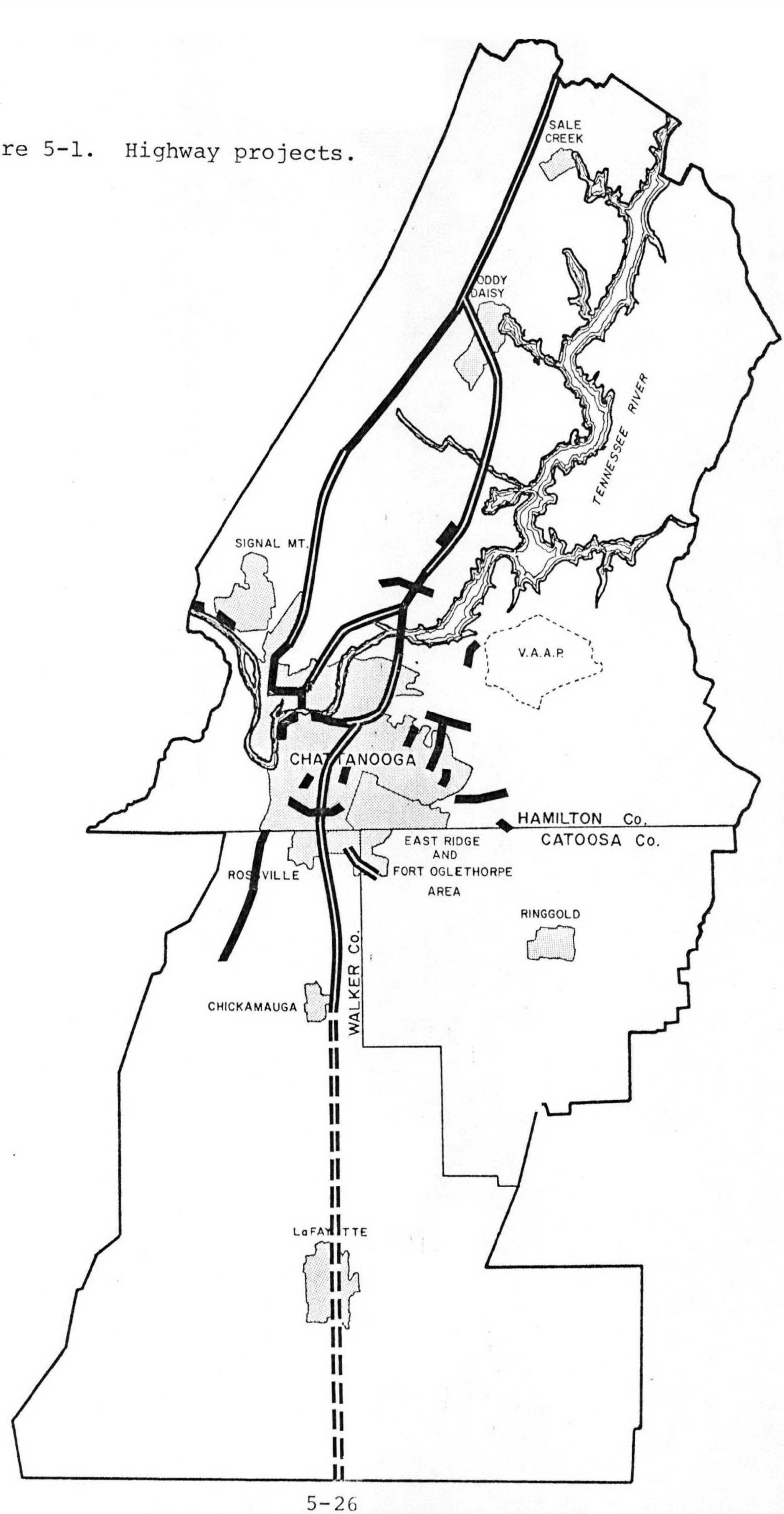

Table 5-4. HIGHWAY CONSTRUCTION ACTIVITY - PRESENT AND PROPOSED - 1973 THRU 1985

Project	Grid	Approx. mileage length of site	Conversion factor	Total acreage exposed
1973				
Riverfront Parkway	44	.85	12.138	10.3
Citico to Broad	48	.85	12.138	10.3
Riverfront Parkway	48	1.00	12.138	12.1
Broad to 9th St.				
New connection	60	.25	12.138	3.0
Germantown - tunnes blvd.				
1975				
Holtzclaw Ave.	59	.12	7.283	.9
13th to Main St.				
Intersection	60	.12	12.138	1.5
Brainerd Rd. - Germantown Rd.				
New connection	26	.12	18.207	2.2
Access Rd. to Ashland Terrace	29	.12	18.207	2.2
Bridge Chickmamauga	69	.10	2.0	.2
U.S. 41 - North				
Bridge	62	.10	2.0	.2
S.R. 27 - Shoal Creek				
Bridge	30	.66	2.0	.2
Amnicola Hwy. -	33	.66	2.0	.2
Hixson Pike	39	.66	2.0	.2
East Branard Rd.	69	1.6	12.138	19.4
Lee Hwy - I-75				
Eastgate access	46	.5	12.138	6.1
Brrds Mill Rd. - Eastgate				
State Route 29	10	3.75	18.207	68.3
Lovell - Pitts Branch	15	3.75	18.207	68.3
Georgia Route 193				
Stateline - Nicaataca Road	76	4.25	24.276	103.2

Table 5-4 (continued). HIGHWAY CONSTRUCTION ACTIVITY - PRESENT AND PROPOSED - 1973 THRU 1985

1980-1985

Project	Grid	Approx. mileage length of site	Conversion factor	Total acreage exposed
Dayton Freeway	2	3.0	24.276	72.83
	3	5.0	24.276	121.38
	6	5.5	24.276	133.52
	10	1.2	24.276	29.13
	11	5.0	24.276	121.38
	15	2.5	24.276	60.69
	19	3.0	24.276	72.83
	25	1.0	24.276	24.28
	27	2.0	24.276	48.55
Central-Dayton Loop	29	1.8	24.276	43.70
	30	1.0	24.276	24.28
	32	1.0	24.276	24.28
	36	1.0	24.276	24.28
	37	1.2	24.276	29.13
Central Freeway	6	1.0	24.276	24.28
	11	5.0	24.276	116.90
	22	1.0	24.276	24.28
	16	1.0	24.276	24.28
	21	2.0	24.276	48.55
	20	1.0	24.276	24.28
	30	3.0	24.276	92.83
	33	1.0	24.276	24.28
	38	1.0	24.276	24.28
	44	1.0	24.276	24.28
	45	0.5	24.276	12.14
	49	1.0	24.276	24.28
	58	1.0	24.276	24.28
	65	1.0	24.276	24.28

Table 5-4 (continued). HIGHWAY CONSTRUCTION ACTIVITY - PRESENT AND PROPOSED - 1973 THRU 1985

1980-1985

Project	Grid	Approx. mileage length of site	Conversion factor	Total acreage exposed
Central - State Route 2 Connection	74	1.0	24.276	24.28
	75	1.2	24.276	29.13
	79	2.0	24.276	48.55
Central - Georgia Toll	74	1.2	24.276	29.13
	77	1.2	24.276	29.13
	82	2.4	24.276	58.26
	88	2.4	24.276	58.26
	91	2.4	24.276	58.26
	96	4.8	24.276	116.50
	99	4.8	24.276	116.50
	102	4.8	24.276	116.50
	105	3.5	24.276	84.97

Projections

Projections were based on increases in residential-commercial and industrial land use in the study area.[11,14,30]

Subarea Distribution

Distribution was performed using locations provided by building permits per municipality and actual or proposed locations of highway projects.

	1973	1975	1980	1985
Residential commercial [30]	815.1	845.9	928.2	1015.4
Growth factor	base	1.04	1.14	98.1
Industrial[30]	51.4	64.9	83.8	98.1
Growth factor	base	1.26	1.63	1.91
Highway development	61.8	212.5	2070.3	2067.2
Total const. emissions	928.3	1123.3	3082.3	3180.7

It has been assumed that all constructions projects last the full year, and that projected highway construction projects will be at maxiumum state of activity in both 1980-1985.

REFERENCES

1. Guide for Compiling a Comprehensive Emission Inventory. U.S. Environmental Protection Agency. Government Publication No. APTD-1135.

2. Mineral Industry Surveys. Bituminous Coal and Lignite Distribution. Calendar Year 1973. U.S. Department of the Interior, Bureau of Mines, Washington, D.C., June 1974.

3. Georgia State Point Source Inventory. Region IV, EPA. Atlanta, Georgia.

4. Tennessee State Point Source Inventory. Region IV, EPA, Atlanta, Georgia.

5. Federal Energy Administration. Personal Communications, Bob Bickum, FEA Regional Office. Atlanta, Georgia, and Mr. Leslie Ungers, PEDCo-Environmental Specialists, 1975.

6. Chattanooga Natural Gas Company. Personal Communication, Mr. H. Royce, Chattanooga, Tennessee.

7. Compilation of Air Pollutant Emission Factors. U.S. Environmental Protection Agency. Government Publication No. AP-42.

8. Population, Resources, Environmental. Issues in Human Ecology. P.R. Ehrlich, A. H. Ehrlich, W.H. Freeman and Co., San Francisco.

9. 1960 Census of Population. "Small Area Statistics" Bureau of the Census. U.S. Department of Commerce.

10. 1970 Census of Population. "Housing Characteristics" Bureau of the Census. U.S. Department of Commerce.

11. Chattanooga Area Regional Council of Governments, CARCOG Chattanooga, Tennessee.

12. Information Office. National Climatic Center. Federal Building, Asheville, North Carolina.

13. Mineral Industry Surveys, Sales of Fuel Oil and Kerosene: 1973, U.S. Department of the Interior, Bureau of Mines, Washington, D.C. 1974.

14. COOSA Valley Regional Study. COOSA Valley Planning and Development Commission.

15. Personal Communication: Mr. James Tate, Atlanta Gas and Light Co. - Public Relations Department, and N.S. Walsh, PEDCo-Environmental Specialists, Inc.

16. LaFayette Municipal Gas, G. McCalmon City Manager, LaFayette, Georgia.

17. Mineral Industry Surveys, Sales of Liquified Petroleum Gases and Ethane: 1972, U.S. Department of the Interior, Bureau of Mines, Washington, D.C., 1974.

18. Tennessee Valley Authority, Navigation Economics Branch, George B. Tully, Chief, Knoxville, Tennessee.

19. Statistical Abstract of the United States 1972. Bureau of the Census. U.S. Department of Commerce.

20. Tennessee Department of Natural Resources. Office of Fishing and Wildlife. Boat Registration. Knoxville, Tennessee.

21. Personal Communication: Mrs. Christine Hull, Georgia Department of Natural Resources, Boat Registration Division, and Mr. N.S. Walsh, PEDCo-Environmental Specialists, Inc. 1975.

22. Tennessee Department of Transportation. Office of Railroad Administration. P. Edens.

23. Personal Communication: Mr. David Benson, Georgia Public Service Commission, Office of Planning, and Mr. L.J. Ungers, PEDCo-Environmental Specialists, Inc. 1975.

24. Tennessee Department of Transportation. Bureau of Planning and Programming. Office of Research and Planning.

25. Personal Communication: Mr. Joe Lindsay, Georgia Department of Transportation - Road Life Division, and Mr. N.S. Walsh, PEDCo-Environmental Specialists, Inc.

26. Development of Emission Factors for Fugitive Dust Sources, U.S. Environmental Protection Agency, Publication No. 450/3-74-037, Research Triangle Park, North Carolina, June, 1974.

27. Roberts, J.W. et al, "The Measurement, Cost and Control of Traffic Dust in Seattle's Duwamish Valley," Paper No. AP-72-5, Presented at the APCA Pacific Northwest International Section Annual Meeting, Eugene, Oregon.

28. Roberts, J.W. and H. A. Watters, "Cost and Benefits of Road Dust Control in Seattle's Industrial Valley," Presented at the 67th Annual Meeting of APCA, Denver, Colorado, June, 1974.

29. Personal Communication: Mr. Ken Axetell, PEDCo-Environmental Specialists, Inc., and Mr. William J. Murphy, APWA, March 19, 1975.

30. "Chattanooga Area Economic Data," Great Chattanooga Area Chamber of Commerce, Chattanooga, Tennessee.

31. Personal Communication: R.L. Barger, Office of A.S.C.A. Hamilton County, Tennessee.

32. Personal Communication: C. Benton, Walker County Agricultural Extension Agent.

33. Georgia Agricultural Facts: 1964-1972, U.S. Department of Agriculture, Statistical Reporting Service; Georgia Crop Reporting Service, Athens, Georgia, September, 1973.

34. Personal Communication; J. Connelly, Forest Fire Chief, Department of Forestry, Nashville, Tennessee.

35. Personal Communication; H. Long, Fire Protection Bureau, Department of Natural Resources, Macon, Georgia.

REFERENCES (continued)

36. Office of Fire Prevention Chief, Chattanooga Fire Department, Chattanooga, Tennessee.

37. FAA Air Traffic Activity, U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C. 1973.

38. Lovell Field: Office of the Manager, Chattanooga, Tennessee, 1975.

39. Personal Communication: R. Toilett, Department of Revenue, Nashville, Tennessee, August 6, 1975.

40. G. Madden, Georgia Department of Transportation, Georgia Department of Revenue, Atlanta, Georgia.

41. Personal Communication: J. Lents, Ph.D., Air Pollution Control Bureau, Chattanooga, Tennessee.

42. Compilation of Air Pollutant Emission Factors, (incorporating revisions through Supplement 5), U.S. Environmental Protection Agency, Publication No. AP-42, Research Triangle Park, North Carolina, April 1975.

43. "Particulate Area Source Emission Inventory for Nashville - Davidson County, Tennessee. PEDCo-Environmental Specialists, Inc.

44. Walsh, Steve. PEDCo-Environmental Specialists, Inc., Kansas City, Kansas.