SIOUX FALLS, SOUTH DAKOTA METROPOLITAN AREA AIR POLLUTION EMISSION INVENTORY

U. S. ENVIRONMENTAL PROTECTION AGENCY
Air Pollution Control Office

The APTD (Air Pollution Technical Data) series of reports is issued by the Office of Air Programs, Environmental Protection Agency, to report Technical data of interest to a limited number of readers. Copies of APTD reports are available free of charge to Federal employees, current contractors and grantees, and nonprofit organizations - as supplies permit - from the Office of Technical Information and Publications, Environmental Protection Agency, Research Triangle Park, North Carolina 27711 or from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151.

Office of Air Programs Publication No. APTD-0832

SIOUX FALLS, SOUTH DAKOTA METROPOLITAN AREA

AIR POLLUTION EMISSION INVENTORY

Prepared by

Carl V. Spangler

and

George M. Duggan

ENVIRONMENTAL PROTECTION AGENCY
Air Pollution Control Office
Division of Air Quality and Emission Data
Durham, North Carolina
January 1971

ACKNOWLEDGMENTS

Sincere gratitude is extended by the Air Pollution Control Office to the many individuals and companies who contributed to this study.

Special thanks are due to Mr. Charles E. Carl, Director, Mr. Donald C. Kurvink, Chief, Radiological and Occupational Health Section, Mr. Perry Van Beek, Chief, Solid Wastes Section, all of the Division of Sanitary Engineering of the South Dakota Department of Health at Pierre. Thanks are also due to Mr. Adolph R. Zulk, Public Health Director, to Mr. Gordon Aasen, Sanitarian, to the Health Officer Dr. N. E. Wessman, and to David A. Witte, Commissioner, at the City of Sioux Falls.

PREFACE

This report, which presents the emission inventory for the Sioux Falls, South Dakota Area, is another in a series of surveys outlining the sources and emissions of air pollutants for major metropolitan areas in the country. These surveys, conducted by the National Inventory of Air Pollutant Emissions and Control Branch of the Air Pollution Control Office, provide estimates of the present levels of air pollutant emissions and status of their control. The pollutants which include sulfur oxides, particulates, carbon monoxide, hydrocarbons and nitrogen oxides, are delineated with respect to source type, season of the year and geographical distribution within the area. The general procedure for the surveys is based upon the rapid survey technique for estimating air pollutant emissions.[1] These reports are intended to serve as aids in the proposing of boundaries of Air Quality Control Regions, as directed by the Air Quality Act of 1967.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

This report is a summary of the Sioux Falls, South Dakota air pollutant emission inventory conducted in June 1970. Since all inventories are based upon a calendar year, the data and emission estimates presented are representative of 1969 and should be considered as indicating the conditions as existed during that year.

The Study Area, which was chosen on the basis of the distribution of population and air pollution sources, consists of six counties surrounding Sioux Falls. This area covers approximately 5,560 square miles and had a 1969 population of 149,000.

The grid coordinate system was used to show the geographical distribution of emissions within counties. The Study Area was subdivided into 18 grid zones ranging in size from 25 square kilometers in the heavily populated and industrialized areas to 1,600 square kilometers in the rural areas.

All sources of emissions were classified into five categories--transportation, stationary fuel combustion, solid-waste disposal, industrial processes and evaporative losses. Each of these source categories was divided into two subgroups--point sources and area sources. Facilities, which emit large quantities of air pollutants, were considered individually as point sources, while the many remaining contributors such as motor vehicles, residential and commercial fuel users, small industries and on-site refuse burning equipment, were considered collectively as area sources. For this report, five individual sources, which have emissions greater than 0.5 tons per average annual day for any pollutant, were classified as point sources.

Emissions were estimated by using various indicators such as fuel consumption, refuse burning rates, vehicle-miles, production data, and control efficiencies and emission factors relating these indicators

to emission rates.[2] These factors represent average emission rates for a particular source category. Since individual sources have inherent differences that cannot always be taken into consideration, discrepancies between the actual and estimated emissions are more likely in individual sources than in the total emissions for a source category.

As in all emission surveys, the data presented are estimates and should not be interpreted as absolute values. The estimates are, in some cases, partial totals due to the lack of emission factors and production or consumption data. Despite these limitations, these estimates are of sufficient accuracy and validity to define the extent and distribution of air pollutant emissions in the Study Area.

SUMMARY

The annual emissions as estimated by the Sioux Falls, South Dakota Area Air Pollutant Emission Inventory are:

Sulfur Oxides	3,700 tons
Particulates	4,800 tons
Carbon Monoxide	97,200 tons
Hydrocarbons	20,700 tons
Nitrogen Oxides	10,100 tons

The following is a brief description of the air pollutant emissions as presented in Table 1 and Table 2.

Sulfur Oxides: The largest portion of the sulfur oxides emitted came from the two steam-electric plants located in the Study Area. Together these plants accounted for 62 percent of total sulfur oxides. The combustion of fossil fuels by other stationary sources accounted for 20 percent of the sulfur oxides emitted. There was 16 percent origination from motor vehicles, and 1 percent from refuse disposal.

Particulates: The majority of the particulate emissions, 52 percent, came from the combustion of coal at the two power plants in the Study Area. The next largest source of particulates, 24 percent, came from transportation. Open burning of refuse accounted for 16 percent of the particulate, and other stationary combustion sources for 7 percent.

Carbon Monoxide: In most metropolitan areas the largest source of carbon monoxide emissions is from automobiles and other vehicles. This is also true in the Sioux Falls area as motor vehicles contributed 90 percent of the carbon monoxide emitted annually.

TABLE 1 SUMMARY OF AIR POLLUTANT EMISSIONS IN SIOUX FALLS STUDY AREA, 1969

(Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Motor Vehicles	480	820	87,600	7,200	5,650
Other	100	360	400	400	630
Subtotal	580	1,180	88,000	7,600	6,280
Stationary Fuel Combustion					
Industry	440	180	4	2	230
Steam-Electric	2,280	2,500	6	6	780
Residential	290	140	19	27	500
Commercial and Institutional	30	40	2	2	190
Subtotal	3,040	2,860	30	40	1,700
Refuse Disposal					
Incineration	0	0	0	0	0
Open Burning	50	770	9,100	8,000	2,100
Subtotal	50	770	9,100	8,000	2,100
Industrial Processes	0	0	0	0	0
Evaporative Losses				5,160	
GRAND TOTAL	3,680	4,800	97,100	20,800	10,100

All values have been rounded.

TABLE 1A SUMMARY OF AIR POLLUTANT EMISSIONS IN SIOUX FALLS STUDY AREA, 1969

(1000 kg/year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Motor Vehicles	430	730	78,800	6,400	5,100
Other	91	320	380	360	560
Subtotal	520	1,050	79,180	6,760	5,660
Stationary Fuel Combustion					
Industrial	390	160	4	2	210
Steam-Electric	2,000	2,290	5	5	700
Residential	260	120	17	24	450
Commercial and Institutional	26	31	2	2	170
Subtotal	2,700	2,600	30	34	1,530
Refuse Disposal					
Incineration	0	0	0	0	0
Open Burning	40	690	8,190	7,100	1,900
Subtotal	40	690	8,190	7,100	1,900
Industrial Processes	0	0	0	0	0
Evaporative Losses				4,600	
GRAND TOTAL	3,260	4,340	87,400	18,500	9,100

All values have been rounded

TABLE 2 PERCENTAGE CONTRIBUTION OF EACH SOURCE CATEGORY TO TOTAL EMISSIONS IN THE SIOUX FALLS STUDY AREA

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Motor Vehicles	13.0	17.0	90.1	34.6	56.0
Other	2.8	7.5	0.5	2.0	6.3
Subtotal	15.8	24.5	90.6	36.6	62.3
Stationary Fuel Combustion					
Industry	12.1	3.7	0.0	0.0	2.3
Steam-Electric	62.2	52.3	0.0	0.0	7.8
Residential	7.9	2.8	0.0	0.1	5.0
Commercial and Institutional	0.8	0.7	0.0	0.0	1.9
Subtotal	83.0	59.5	0.0	0.1	17.0
Refuse Disposal					
Incineration	0.0	0.0	0.0	0.0	0.0
Open Burning	1.2	16.0	9.4	38.4	20.7
Subtotal	1.2	16.0	9.4	38.4	20.7
Process Losses	0.0	0.0	0.0	0.0	0.0
Evaporative Losses	--	--	--	24.9	--
TOTAL	100	100	100	100	100

The only other significant source of carbon monoxide was from the inefficient combustion of refuse at open burning dumps. This category accounted for about 9 percent of the total emissions.

Hydrocarbons: Exhaust gases from motor vehicles are a primary area type source of hydrocarbon emissions, accounting for over 34 percent of the total. Evaporative losses from motor vehicles which include losses from the gas tank, carburetor, and engine crankcase accounted for about 25 percent of total hydrocarbon emissions. Other smaller evaporative loss sources are from gasoline storage and handling, industrial solvent usage, dry cleaning plants, and miscellaneous solvent usage. Other sources included the open burning of solid waste, which accounted for 38 percent of total emissions, railroad and aircraft operations, and stationary fuel combustion.

Nitrogen Oxides: The largest source of nitrogen oxides were the road vehicles, amounting to 56 percent of the total. The combustion of coal, oil, and gas at stationary sources accounted for 17 percent of total emissions.

The second largest source of nitrogen oxides was the open burning refuse disposal in the Study Area, which contributed 21 percent of the total.

DESCRIPTION OF STUDY AREA

The Study Area for the emission survey of the Sioux Falls, South Dakota Area consists of six counties--Lincoln, McCook, Minnehaha, and Turner Counties all in South Dakota, plus Rock County in Minnesota, and Lyon County in Iowa. The six county area is located in the southeastern part of South Dakota and extends into the other two states.

Figure 1 is an outline map of the Sioux Falls Study Area. The Study Area occupies 5,560 square miles and contained an estimated 1970 population of 149,000[3]. The city of Sioux Falls has gained approximately 10 percent in population during the last 10 year period, whereas the surrounding rural areas are declining in population at about the same rate. The preliminary population figure for Sioux Falls for 1970 is 72,500.

TOPOGRAPHY

The Sioux Falls Study Area is located in the north central prairie area of the United States, and is centralized about the city of Sioux Falls, South Dakota, which is in the southeastern corner of that state. The Big Sioux River and its tributaries run directly through the center of the Study Area. The land is generally flat with minor hills of erosion offering some relief. The elevations above sea level are between 1,400 and 1,500 feet. There are no local geographic features to influence the winds. The Big Sioux River flows south to the Missouri.[4]

CLIMATOLOGY

Sioux Falls has a moderate climate, but is characterized by extremely cold winters and quite warm summers. Prevailing strong summer winds are from the south. The prevailing winds in winter are normally out of the northwest averaging around 10 mph. In general, the climatological and topographical conditions in the Sioux Falls Study Area are not conducive

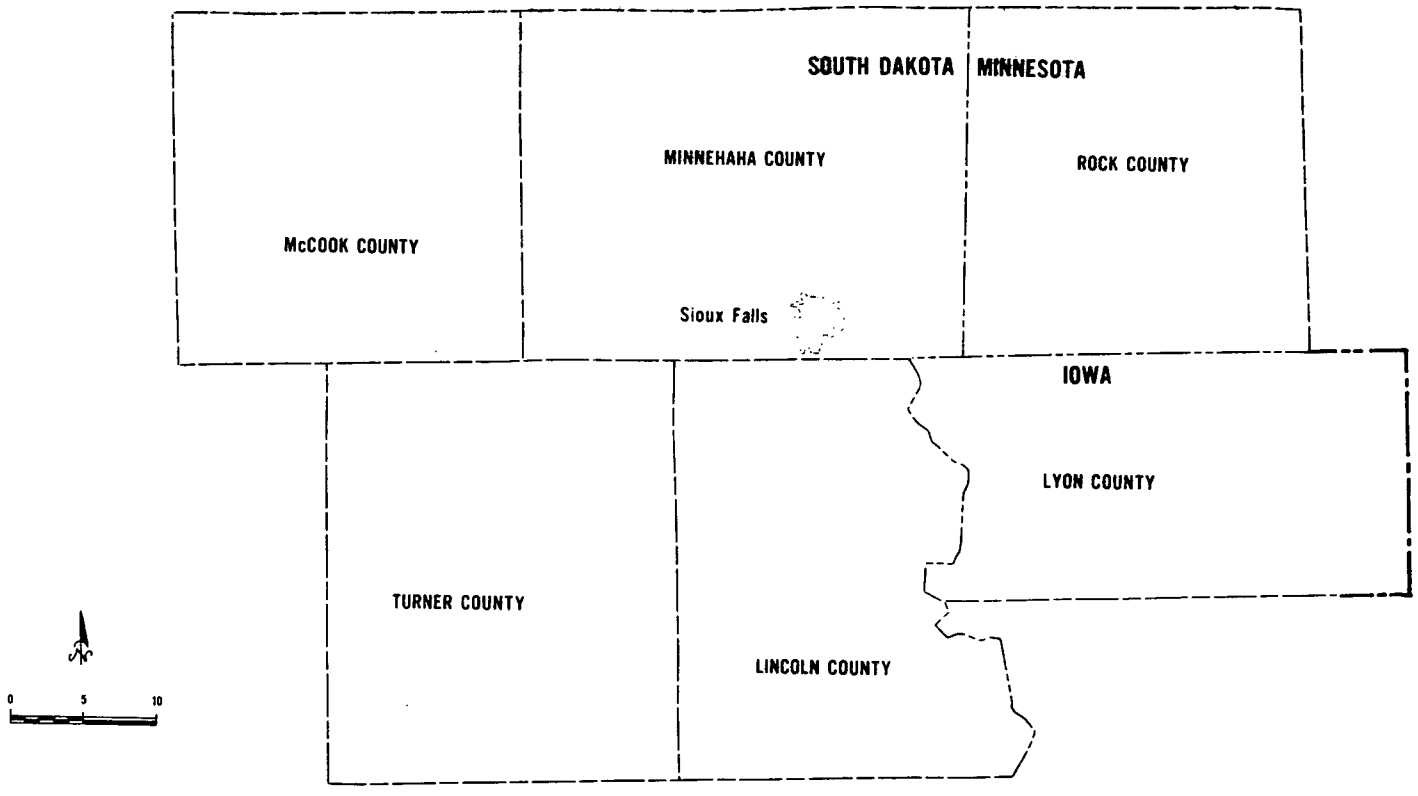

Figure 1. Map of the Sioux Falls Study Area

TABLE 3 AREA AND POPULATION CHARACTERISTICS FOR SIOUX FALLS STUDY AREA

Political Jurisdiction	Land Area (Sq. Mi.)	Population 1960	Population 1970	Population Density (1970)
Minnehaha County, South Dakota	813	86,575	95,271	117
Lincoln County, South Dakota	576	12,371	11,445	20
McCook County, South Dakota	575	8,268	7,130	12
Turner County, South Dakota	612	11,157	9,696	16
South Dakota Subtotal	2,576	118,733	123,542	48
Rock County, Minnesota	485	11,864	11,101	23
Lyon County, Iowa	588	14,468	14,000	24
GRAND TOTAL	3,649	144,705	148,643	41

Source: 1960 Census, 1970 Preliminary Census

for the accumulation of large concentrations of pollutants. The strongest inversions usually occur on cold nights under clear skies, and pollutants tend to accumulate under these conditions.[4]

MAJOR INDUSTRIAL FACTORS

There are no major manufacturing establishments in the Study Area. Most of the industry is located in Sioux Falls and outlying Minnehaha County. Of the tabulated point source emitters (Table 4) there are only five that are of importance. These are one meat packing plant, the two utility power plants, the Sioux Falls Foss Airport, and the Sioux Falls open burning city dump. The latter is a major source of carbon monoxide and hydrocarbons, and is an odor source. There is also one untabulated rendering plant that is a source of noxious odors that are offensive to the community. Minor point sources of emissions scattered over the Study Area include several local open burning refuse dumps, and various grain handling and mixing operations.[5]

TABLE 4 SELECTED MANUFACTURING ESTABLISHMENTS IN THE SIOUX FALLS STUDY AREA, 1969

Jurisdiction	Grain Feed Mixing	Grain Elevators	Meat Packing	Rendering	Metal Mfg.	Fiber Glass	Misc.	Total
Minnehaha Co., S. D.	11	4	2	2	2	1	3	25
Lincoln Co., S. D.	0	6	0	0	0	0	0	6
McCook Co., S. D.	5	4	0	0	0	0	0	9
Turner Co., S. D.	2	4	0	0	0	0	0	6
Rock Co., S. D.	1	16	0	0	3	0	4	21
Lyon Co., Iowa	0	10	0	0	0	0	2	12

Source: Personal communications with local agencies

GRID COORDINATE SYSTEM

A grid coordinate system, based on the Universal Transverse Mercator Projection (UTM) was used in the Sioux Falls Study Area to show the geographical distribution of emissions. A map of this grid system is presented in Figure 2.

The UTM system was chosen due to its advantages over other standard grid systems such as the Latitude-Longitude and State Plane Coordinate Systems. The major advantages of this system are that (1) it is continuous across the country and is not hindered by political subdivisions, (2) the grids are of uniform size throughout the country, (3) it has world-wide use, and (4) the grids are square in shape--a necessary feature for use in meteorological dispersion models.

The Universal Transverse Mercator Projection is based upon the metric system. Each north-south and east-west grid line, as illustrated in Figure 2, is identified by a coordinate number expressed in meters. Each point source and grid is identified by the horizontal (HC) and vertical coordinates (VC) of their geographical center to the nearest 100 meters.

As shown in Figure 2, the Study Area was divided into 18 grids of four different sizes--25, 100, 400, and 1,600 square kilometers. Grid zones of different sizes are used to limit the number of grid zones and yet allow a satisfactory definition of the geographical gradation of emissions. The majority of the emissions is usually concentrated in the populated and industrialized portion of a Study Area. Smaller grids are placed over these areas in order to reflect abrupt changes in emissions within short distances. The use of grid zones smaller than 25 kilometers is not warranted because of the inherent inaccuracies in the data. Since only a small percentage of the total emissions occur in rural areas, larger grid zones are normally used to show the distribution of emissions in these lightly populated portions of a Study Area.

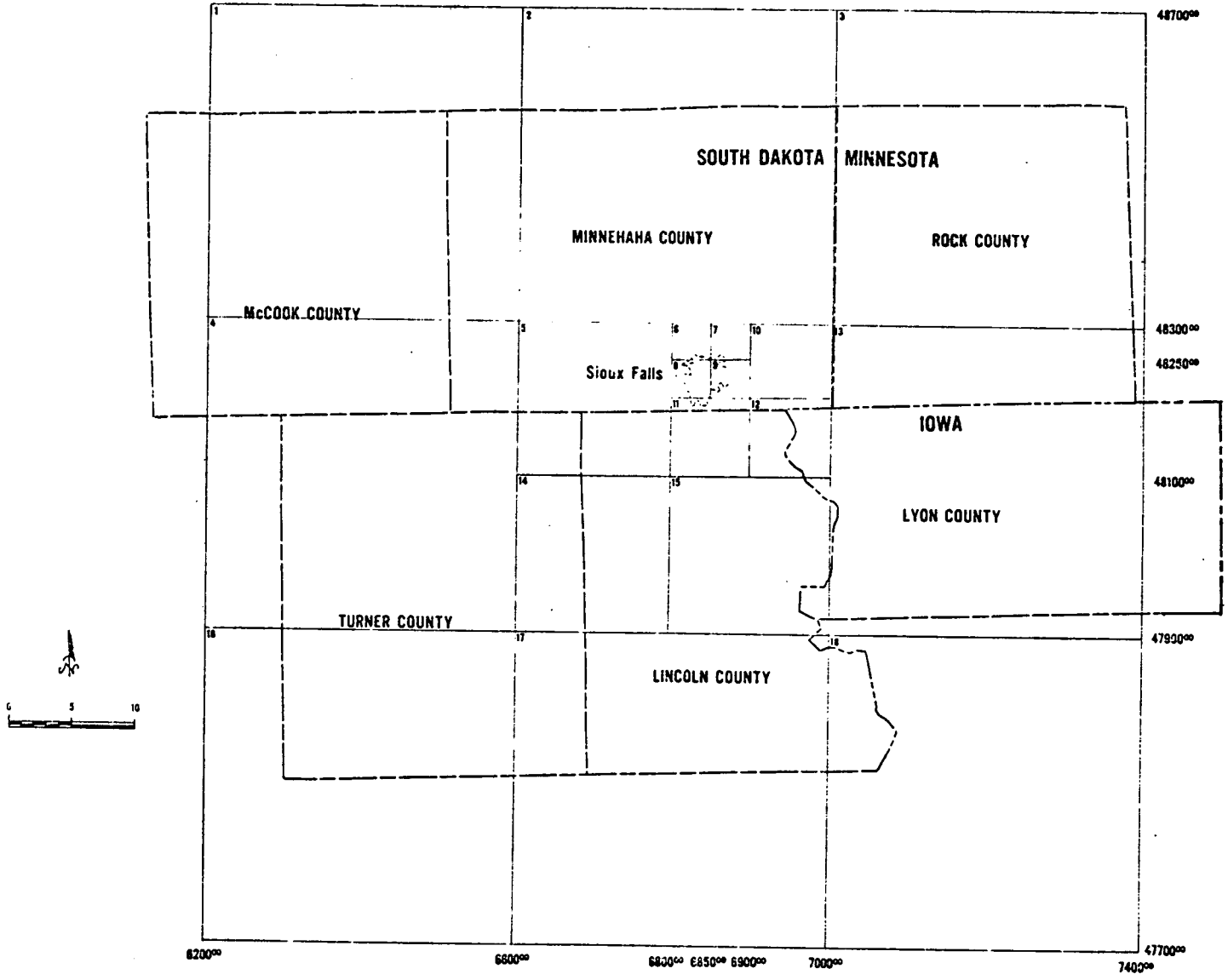

FIGURE 2. GRID COORDINATE SYSTEM FOR THE SIOUX FALLS STUDY AREA

EMISSIONS BY CATEGORY

For the purpose of compiling the basic data and emission estimates, the air pollutant sources were classified into the following five categories:

1. Stationary fuel combustion
2. Transportation
3. Solid waste disposal
4. Industrial processes
5. Evaporative losses

Each of these categories is considered individually in this section where data sources are given and methods of calculation discussed.

STATIONARY FUEL COMBUSTION

The stationary fuel combustion category is concerned with any fixed source which burns fuels for either space heating or process heating. The four primary sources in this category are industrial facilities, steam-electric plants, residential housing, and commercial and institutional establishments. In the Sioux Falls area, coal, distillate oil, residual oil and natural gas were all being used. Table 5 presents a summary of the fuels consumed in the Study Area, and Table 6 presents an average chemical analysis of these fuels. Table 7 is an estimate of the emissions resulting from the combustion of these fuels.

Steam-Electric Utility

METHODOLOGY: Data on the two power plants in the area were acquired from the Northern States Power Company.[6] The data included the annual fuel consumption for 1969, type and efficiency of control equipment, sulfur and ash content of the fuel and the type of furnace. The two plants burn natural gas during warm weather periods; this is a relatively clean fuel with practically no sulfur to produce sulfur oxides and burns with negligible particulate.

TABLE 5 ANNUAL FUEL CONSUMPTION **IN THE STUDY AREA FOR 1969**

FUEL	JURISDICTION	STEAM-ELECTRIC	INDUSTRY	COMMERCIAL AND INSTITUTIONAL	RESIDENTIAL	TOTAL
COAL (TONS/YEAR)	MINNEHAHA	26474.	1436.	0.	0.	27910.
	LINCOLN	0.	0.	0.	0.	0.
	MCCOOK	0.	0.	0.	0.	0.
	TURNER	0.	0.	0.	0.	0.
	ROCK	0.	0.	0.	0.	0.
	LYON	0.	0.	0.	0.	0.
	TOTALS	26474.	1436.	0.	0.	27910.
DISTILLATE OIL (1000 BBL/YEAR)	MINNEHAHA	0.	77.	195.	9482.	9754.
	LINCOLN	0.	0.	380.	1754.	2134.
	MCCOOK	0.	0.	285.	1120.	1405.
	TURNER	0.	0.	330.	1624.	1954.
	ROCK	0.	0.	376.	1540.	1916.
	LYON	0.	0.	450.	2520.	2970.
	TOTALS	0.	77.	2016.	18042.	20135.
RESIDUAL OIL (1000 BBL/YEAR)	MINNEHAHA	2300.	2123.	0.	0.	4423.
	LINCOLN	0.	0.	0.	0.	0.
	MCCOOK	0.	0.	0.	0.	0.
	TURNER	0.	0.	0.	0.	0.
	ROCK	0.	0.	0.	0.	0.
	LYON	0.	0.	0.	0.	0.
	TOTALS	2300.	2123.	0.	0.	4423.
NATURAL GAS (MIL. CU. FT./YEAR)	MINNEHAHA	2033.	1294.	1529.	4342.	9198.
	LINCOLN	0.	0.	139.	523.	661.
	MCCOOK	0.	0.	70.	336.	406.
	TURNER	0.	0.	112.	518.	630.
	ROCK	0.	0.	121.	517.	638.
	LYON	0.	0.	135.	569.	704.
	TOTALS	2033.	1294.	2105.	6907.	12239.

TABLE 6 AVERAGE CHEMICAL ANALYSIS OF FUELS CONSUMED IN THE SIOUX FALLS STUDY AREA, 1969

Type Fuel	Type Source	% by Weight Ash Content	% by Weight Sulfur Content
Coal	Steam-Electric	12.4	3.78
	Industrial	12.4	3.78
	Domestic-Commercial	NU	NU
Residual Fuel Oil	Steam-Electric	N	2.0
	Industrial	N	2.0
	Domestic-Commercial	NU	NU
Distillate Fuel Oil	Steam-Electric	NU	NU
	Industrial	N	0.2
	Domestic-Commercial	N	0.2

N = Negligible

NU = Fuel not used by this type source

Source: Sioux Falls Health Department Records

TABLE 7 AIR POLLUTANT EMISSIONS FROM THE COMBUSTION OF FUELS IN STATIONARY SOURCES IN THE SIOUX FALLS STUDY AREA, 1969 (Tons/Year)

User Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Coal					
Industrial	100	140	2	0	14
Steam-Electric	1,910	2,500	6	2	264
Residential	0	0	0	0	0
Commercial and Institutional	0	0	0	0	0
Subtotal	2,010	2,640	10	n	280
Fuel Oil					
Industrial	340	25	2	2	79
Steam-Electric	370	11	0	3	120
Residential	290	72	18	27	110
Commercial and Institutional	29	15	2	2	72
Subtotal	1,030	120	20	30	380
Gas					
Industrial	0	11	0	0	140
Steam-Electric	0	15	0	0	400
Residential	1	64	1	0	390
Commercial and Institutional	0	19	0	0	120
Subtotal	n	100	n	n	1,050
GRAND TOTAL	3,040	2,860	30	30	1,700

Totals have been rounded

n = negligible

In the cold weather periods the Lawrence Plant converts to coal with 12.4 percent average ash content, and a 3.78 percent sulfur content. The Pathfinder Plant converts to No. 6 residual fuel oil of about 2 percent sulfur content. This pattern results in practically zero pollutant emission during much of each year and only modest amounts of sulfur dioxide and some particulate emission in the winter months. The fuel usage of the two plants in 1969 was:

Lawrence:	Gas	1,008.9	MMCF
	Coal	26,474	tons
Pathfinder:	Gas	1,024.4	MMCF
	No. 6 Oil	54,765	bbls

Air pollutant emissions from fuel combustion at these plants and all other stationary fuel combustion sources are summarized in Table 7. The steam-electric plants were the largest sources of sulfur oxides, particulates and nitrogen oxides in the Study Area. Over 75 percent of the total sulfur oxides from stationary fuel combustion, 88 percent of the particulates, and 46 percent of the nitrogen oxides were attributed to these two plants.

Residential

METHODOLOGY: Natural gas and distillate fuel oil were the primary fuels used for residential home heating. There were homes heated by other fuels, but they represent a small percentage of the total. Data on the amount of natural gas used for domestic heating was supplied by the Northern Natural Gas Company and compared with the rapid survey technique of estimating the fuel used for home heating. Distillate oil consumption data were estimated based on data supplied by local agencies and on the rapid survey technique. Delivery data were not available from dealers.

RESULTS: Table 8 gives an estimate of the number of homes that use each type fuel in the Study Area. The percentage of the number of homes that use natural gas is 69 percent of the dwelling units, and fuel oil is 31 percent. The number burning coal is negligible.

TABLE 8 ESTIMATE OF DOMESTIC HEATING BY JURISDICTION IN THE SIOUX FALLS STUDY AREA, 1969

County	Number of Housing Units			
	Coal	Oil	Gas	Total
Minnehaha	0	7,600	20,100	27,700
Lincoln	0	1,300	2,100	3,400
McCook	0	800	1,300	2,100
Turner	0	1,100	1,900	3,000
Rock	0	1,100	2,000	3,100
Lyon	0	1,800	2,200	4,000
Total for Study Area	0	13,700	29,600	43,300
Percent of Total	n	31	69	100

n = negligible

Emissions resulting from residential fuel combustion are relatively low for all pollutants. The contribution to total particulate emissions from stationary fuel combustion by domestic heating was quite small although the contribution to carbon monoxide was 55%, and to hydrocarbons was 71%.

Commercial-Institutional

METHODOLOGY: Commercial and institutional establishments in the Study Area used only two of the previously mentioned fuels--distillate oil and natural gas. Data on the total amounts of these fuels used in the area as well as the consumption at individual establishments were supplied by fuel associations, the gas company, and the local agencies.
RESULTS: The estimated emissions for commercial and institutional establishments are given in Table 7.

TRANSPORTATION

Three types of transportation sources of air pollution were considered in this survey--motor vehicles, aircraft, and railroads. Motor vehicles, which are by far the most significant source in this category, are further subdivided according to type of fuel--gasoline or diesel.

Motor Vehicles

More than 3 million miles were traveled by motor vehicles in 1969 in the Sioux Falls Study Area. In the process, 91.2 million gallons of gasoline and 5.2 million gallons of diesel fuel were consumed for highway purposes. Table 9 shows the miles of travel for gasoline and diesel vehicles for each county in the Study Area.

Vehicle-mile data for essentially all of the roads, by road, in the South Dakota Counties were supplied by the Research and Planning Division of the South Dakota Department of Highways. In the non-South Dakota Counties, vehicle-mile information was not available, and thus gasoline consumption alone was used to find vehicular emissions.

The contribution to the total motor vehicle pollution by diesel powered vehicles was determined by assuming that approximately six percent of the total vehicle miles traveled were by diesel powered vehicles. This was checked by estimating diesel fuel consumption in each county. These emissions were apportioned on a grid basis by assuming they were proportional to gasoline emissions.

Emissions from motor vehicles are a function of the speed at which the vehicle travels. Average speeds of 10-20 mph were assumed for downtown area, 20-30 mph for the residential areas, and 30-45 mph for the rural areas to calculate vehicle emissions.

From all transportation sources, motor vehicles accounted for 82 percent of the sulfur oxides, 70 percent of the particulates, 99 percent of the carbon monoxide, 94 percent of the hydrocarbons (excluding evaporation), and 85 percent of the nitrogen oxides. Gasoline powered motor vehicles contributed a greater percent of all pollutants than diesel powered motor vehicles. Emissions from transportation sources are summarized in Table 10.

TABLE 9 VEHICLE MILES OF TRAVEL FOR MOTOR VEHICLES IN THE SIOUX FALLS STUDY AREA, 1969 (Vehicle Miles/Day)

Jurisdiction	Gasoline Vehicle Miles	Diesel Vehicle Miles	Total
Minnehaha Co., S. D.	1,899,110	54,405	1,953,405[a]
Lincoln Co., S. D.	399,270	11,503	410,773[a]
McCook Co., S. D.	211,630	6,097	217,727[a]
Turner Co., S. D.	141,800	4,085	145,885[a]
Rock Co., Minn.	240,000	6,914	246,914[b]
Lyon Co., Iowa	280,000	8,067	288,067[c]
GRAND TOTAL	3,171,810	91,071	3,262,771

Sources: a - Reserach and Planning Division, South Dakota Department of Highways

b - Pollution Control Agency, State of Minnesota

c - Estimated

TABLE 10 SUMMARY OF AIR POLLUTANT EMISSIONS IN THE SIOUX FALLS STUDY AREA FROM TRANSPORTATION SOURCES, 1969 (Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Motor Vehicles					
Gasoline	350	460	87,400	6,720	4,920
Diesel	130	360	200	450	730
Evaporation*				4,860	
Subtotal	480	820	87,600	12,030	5,650
Aircraft					
Jet	0	74	51	14	45
Piston	0	1	208	41	9
Turboprop	0	4	10	4	7
Subtotal	0	80	271	60	60
Railroads	100	280	150	350	570
Vessels	0	0	0	0	0
GRAND TOTAL	580	1,200	88,000	17,600	6,280

*Evaporation not included in Grand Total.

Aircraft

Table 11 shows the air traffic activity at the one major airport in the Study Area. An estimate of the number of flights by engine type was supplied by the traffic controller at the airport and summarized.

The air pollutant emissions from aircraft include all phases of operation (taxi, take-off, climb out, approach and landing) that take place below the arbitrarily chosen altitude of 3,500 feet. Emissions at cruise altitude (above 3,500 feet) are not of concern in an emission inventory. Considering all transportation sources, aircraft accounted for only a small percentage of the pollutants emitted.

Railroads

Railroad operations (mainly locomotive) consume about 13 million gallons of diesel fuel per year within the Study Area. This quantity is about 20 percent of the amount of diesel fuel consumed by motor vehicles. The majority of this fuel is consumed during switching operations. Diesel fuel consumption data were supplied by the major railroads in the Sioux Falls Area.[5]

Railroad operations contribute about 17.5 percent of the sulfur oxides and account for substantially less of the emissions of other pollutants. The estimates are also summarized in Table 10.

TABLE 11 AIR TRAFFIC ACTIVITY AT THE JOE FOSS AIRPORT AT SIOUX FALLS, S. D., 1969 (Flights/Year)[a]

Type Engine	Number of Engines 1	2	3	4
Jet Conventional	7,300	5,100	0	0
Fan Jet	0	0	0	0
Turbo-prop	0	7,300	0	0
Piston	5,500	0	0	0
Totals	12,800	12,400	0	0

a = Flight is defined as a combination of a landing and a takeoff.

Source: FAA Air Traffic Control Office at Joe Foss Airport.

SOLID WASTE DISPOSAL

Approximately 196,000 tons of refuse was generated by all sources in the Sioux Falls Study Area during 1969. Table 12 presents a solid waste balance for the area for that year, showing the methods of disposal and the quantities disposed by each method. These methods are open dumps, generally burning, or landfills, and on site (generally residential backyard) burning. Only in Minnehaha County is there a comparatively large amount of waste disposed of in a burning municipal dump. In the rest of the study area only about a third of the refuse was disposed of in small landfills or public burning dumps. Sioux Falls was instituting a program in 1970 to increase refuse collections for transportation to the city dump to reduce on-site burning.

Refuse data for all of the South Dakota counties were supplied by the South Dakota State Department of Health, Division of Sanitary Engineering, Solid Wastes Section, from their recent field inspection and survey. The remaining two counties, one in Iowa, and one in Minnesota, were estimated on the basis of their rural and semi-rural populations. By reference to Table 2 it may be noted that the solid waste disposal practices prevalent in the study area account for 16 percent of the particulate, 9 percent of the carbon monoxide, 38 percent of the hydrocarbons, and 20 percent of the nitrogen oxide pollutants.

Emissions from solid waste disposal are summarized in Table 13 for the Sioux Falls Study Area.

TABLE 12 SOLID WASTE DISPOSAL FOR SIOUX FALLS STUDY AREA, 1969

(Public Agency Disposal-all open burning dumps)

Jurisdiction	Total Tons Generated	Collected Tons of Refuse	Tons burned on site
Minnehaha Co., S. D.	152,000	78,557	73,443[a]
Lincoln Co., S. D.	9,400	2,740	6,660[a]
McCook Co., S. D.	5,800	1,295	4,505[a]
Turner Co., S. D.	8,000	1,770	6,230[a]
Rock Co., Minn.	9,200	2,700	6,500[b]
Lyon Co., Iowa	11,500	3,100	8,400[b]
Total	195,900	90,162	105,738

Sources: a - Personal Communication with Mr. Perry Van Beek, Chief, Solid Wastes Section, Division of Sanitary Engineering, South Dakota State Department of Health.

b - Estimated.

TABLE 13 AIR POLLUTANT EMISSIONS FROM SOLID-WASTE DISPOSAL IN THE SIOUX FALLS STUDY AREA

Tons/Year

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Incineration					
Municipal	0	0	0	0	0
On-Site	n	n	n	n	n
Subtotal	n	n	n	n	n
Open Burning					
On-Site	0	52	5,300	6,608	1,600
Dump	50	720	3,800	1,400	500
Subtotal	50	770	9,100	8,000	2,100
GRAND TOTAL	50	770	9,100	8,000	2,100

n = negligible

INDUSTRIAL PROCESSES

There are no major manufacturing establishments in the Study Area. Most of the industry is located in Sioux Falls and outlying Minnehaha County. Of the tabulated point source emitters there are only five that are of importance. These are one meat packing plant, the two utility power plants, the Sioux Falls Foss Airport, and the Sioux Falls open burning city dump. The latter is a major source of carbon monoxide and hydrocarbons, and is an odor source. There is also one untabulated rendering plant that is a source of noxious odors that are offensive to the community. Minor point sources of emissions scattered over the Study Area include several local open burning dumps, and various grain handling and mixing operations. The emissions from industrial processes are sufficiently small such that they are not presented in a table for this report.

EVAPORATIVE LOSSES

Three source categories were considered for evaporative losses--automobiles, gasoline storage and handling, and the consumption of solvents. The hydrocarbon emissions from all sources by evaporative losses are shown in Table 14.

Automobiles

Automobile evaporation losses include gas tank and carburetor evaporation and engine crankcase blowby. Since 1963, most new automobiles were equipped with positive crankcase ventilation (PCV) valves that reduce hydrocarbon emissions from the crankcase by about 90 percent. Due to a lag time in the automobile replacement rate, it was assumed that 20 percent of the automobiles were not equipped with PCV valves.

The hydrocarbon emissions from automobiles were calculated from vehicle-mile data and were apportioned onto grids using the same methods as for motor vehicles discussed earlier. Evaporative losses from automobiles accounted for 56 percent of the total hydrocarbon emissions from evaporative losses in the Study Area.

Gasoline Storage and Handling

There are four major points (excluding evaporation from the motor vehicle) of hydrocarbon emissions in the storage and handling of gasoline. These are:

1. Breathing and filling losses from storage tanks.
2. Filling losses from loading tank conveyances.
3. Filling losses from loading underground storage tanks at service stations.
4. Spillage and filling losses in filling automobile gas tanks at service stations.

In this study all gasoline storage and handling evaporation is included in the "auto" category in Table 14.

TABLE 14 HYDROCARBON EMISSIONS FROM EVAPORATIVE LOSSES IN THE SIOUX FALLS STUDY AREA, 1969

Type of Source	HC Emissions-Tons/Year
Automobiles	4862
Dry Cleaning and Miscellaneous	296
TOTAL	5158

Consumption of Solvents

This category included the consumption of solvents at dry cleaning plants, industrial solvent usage and the miscellaneous use of solvents by small commercial establishments and domestic units. Organic solvents emitted from these operations were determined by assuming an emission rate of 4 lb/capita/year for dry cleaning plants.[2]

EMISSIONS BY JURISDICTION

The previous section presented the air pollutant emissions by source category. In order to show the contribution of each county to the pollution in the entire Study Area, their emissions are summarized in Tables 15 through 20.

As can be expected, since power plants play such a big part in the overall air pollution by sulfur oxides and particulates Minnehaha County with its power plants seems to be the most significant from this standpoint.

Because of the higher degree of urbanization than the other counties and corresponding higher vehicular activity, Minnehaha County also contributes the majority of the carbon monoxide, hydrocarbons, and nitrogen oxides.

TABLE 15 SUMMARY OF AIR POLLUTANT EMISSIONS IN MINNEHAHA COUNTY
TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	285.	492.	57983.	4626.	3378.
OTHER	66.	263.	371.	286.	431.
SUB-TOTAL	352.	755.	58354.	4912.	3810.
COMBUSTION OF FUELS					
INDUSTRY	442.	177.	4.	2.	232.
STEAM-ELEC	2277.	2521.	6.	6.	780.
RESIDENTIAL	151.	79.	10.	14.	308.
COMM AND INST.	3.	15.	0.	0.	95.
SUB-TOTAL	2875.	2793.	22.	23.	1417.
REFUSE DISPOSAL					
INCINERATION	0.	0.	0.	0.	0.
OPEN BURNING	39.	665.	7010.	5768.	1533.
SUB-TOTAL	39.	665.	7010.	5768.	1533.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				3099.	
GRAND TOTAL	3267.	4214.	65387.	13804.	6762.

TABLE 16 SUMMARY OF AIR POLLUTANT EMISSIONS IN LINCOLN COUNTY
TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	60.	103.	9305.	797.	711.
OTHER	8.	21.	12.	27.	44.
SUB-TOTAL	68.	125.	9317.	824.	755.
COMBUSTION OF FUELS					
INDUSTRY	0.	0.	0.	0.	0.
STEAM-ELEC	0.	0.	0.	0.	0.
RESIDENTIAL	27.	11.	1.	2.	40.
COMM AND INST.	5.	4.	0.	0.	21.
SUB-TOTAL	33.	16.	2.	3.	62.
REFUSE DISPOSAL					
INCINERATION	0.	0.	0.	0.	0.
OPEN BURNING	1.	25.	449.	457.	114.
SUB-TOTAL	1.	25.	449.	457.	114.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				635.	
GRAND TOTAL	102.	167.	9769.	1920.	933.

TABLE 17 SUMMARY OF AIR POLLUTANT EMISSIONS IN MCCOOK COUNTY
TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	31.	54.	4935.	422.	377.
OTHER	3.	10.	5.	13.	22.
SUB-TOTAL	35.	65.	4941.	436.	399.
COMBUSTION OF FUELS					
INDUSTRY	0.	0.	0.	0.	0.
STEAM-ELEC	0.	0.	0.	0.	0.
RESIDENTIAL	17.	7.	1.	1.	26.
COMM AND INST.	4.	2.	0.	0.	14.
SUB-TOTAL	21.	10.	1.	1.	40.
REFUSE DISPOSAL					
INCINERATION	0.	0.	0.	0.	0.
OPEN BURNING	0.	12.	280.	300.	74.
SUB-TOTAL	0.	12.	280.	300.	74.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				338.	
GRAND TOTAL	56.	89.	5223.	1078.	514.

TABLE 18 SUMMARY OF AIR POLLUTANT EMISSIONS IN TURNER COUNTY
TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	21.	36.	3305.	283.	252.
OTHER	6.	16.	9.	20.	33.
SUB-TOTAL	27.	53.	3314.	303.	285.
COMBUSTION OF FUELS					
INDUSTRY	0.	0.	0.	0.	0.
STEAM-ELEC	0.	0.	0.	0.	0.
RESIDENTIAL	25.	11.	1.	2.	39.
COMM AND INST.	4.	3.	0.	0.	18.
SUB-TOTAL	30.	14.	2.	2.	58.
REFUSE DISPOSAL					
INCINERATION	0.	0.	0.	0.	0.
OPEN BURNING	0.	17.	396.	415.	103.
SUB-TOTAL	0.	17.	396.	415.	103.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				236.	
GRAND TOTAL	58.	85.	3703.	958.	447.

TABLE 19 SUMMARY OF AIR POLLUTANT EMISSIONS IN ROCK COUNTY
TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	36.	62.	5592.	479.	427.
OTHER	7.	21.	11.	27.	44.
SUB-TOTAL	44.	84.	5604.	506.	471.
COMBUSTION OF FUELS					
INDUSTRY	0.	0.	0.	0.	0.
STEAM-ELEC	0.	0.	0.	0.	0.
RESIDENTIAL	24.	11.	1.	2.	39.
COMM AND INST.	5.	3.	0.	0.	20.
SUB-TOTAL	30.	15.	2.	2.	59.
REFUSE DISPOSAL					
INCINERATION	0.	0.	0.	0.	0.
OPEN BURNING	1.	24.	439.	446.	112.
SUB-TOTAL	1.	24.	439.	446.	112.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				389.	
GRAND TOTAL	75.	124.	6046.	1345.	643.

TABLE 20 SUMMARY OF AIR POLLUTANT EMISSIONS IN LYON COUNTY
TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	42.	72.	6520.	558.	498.
OTHER	10.	27.	15.	34.	55.
SUB-TOTAL	52.	100.	6535.	592.	553.
COMBUSTION OF FUELS					
INDUSTRY	0.	0.	0.	0.	0.
STEAM-ELEC	0.	0.	0.	0.	0.
RESIDENTIAL	40.	15.	2.	3.	48.
COMM AND INST.	6.	4.	0.	0.	24.
SUB-TOTAL	46.	20.	3.	4.	72.
REFUSE DISPOSAL					
INCINERATION	0.	0.	0.	0.	0.
OPE BURNING	1.	28.	551.	571.	143.
SUB-TOTAL	1.	28.	551.	571.	143.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				457.	
GRAND TOTAL	100.	149.	7090.	1626.	768.

EMISSIONS BY GRID

For the purpose of defining the geographical variation of air pollutant emissions in the Study Area, the resulting emissions were apportioned on the grid coordinate system. The emissions were divided into two source groups--point and area sources. Point sources are identified individually with respect to location and emissions. Each of these point sources emitted more than 0.5 tons per average annual day of any pollutant. Point sources emitting less than this amount are not listed.

CONTRIBUTIONS OF POINT AND AREA SOURCES

Figure 3 shows the location of all point sources in the area. Collectively the point sources account for 69 percent of the sulfur oxides, 66 percent of the particulates, 14 percent of the nitrogen oxides, and only 4 percent of the carbon monoxide and 6 percent of the hydrocarbons. The percentage contribution to carbon monoxide emissions is low because motor vehicles, which are area sources, contribute 96 percent of the total carbon monoxide emissions. Similarly, the contribution to total hydrocarbon emissions is low since two groups of area sources, motor vehicles and evaporative losses are the major sources. Table 21 presents the emissions of point sources. Each source is identified by source category, grid number and horizontal and vertical coordinates. The emissions of sulfur oxides are shown for an average annual day, average winter day (December, January, February), and average summer day (June, July, August). The appendix presents the method of calculating these three averages.

Area sources are sources of emissions that are insignificant by themselves, but as a group may emit a large portion of the Study Area's total pollution. Examples of area sources are motor vehicles, residences, light commercial and industrial establishments and backyard burning. The emissions from area sources (Table 22) have been added to that for point sources to obtain total emissions from all sources by grid, as

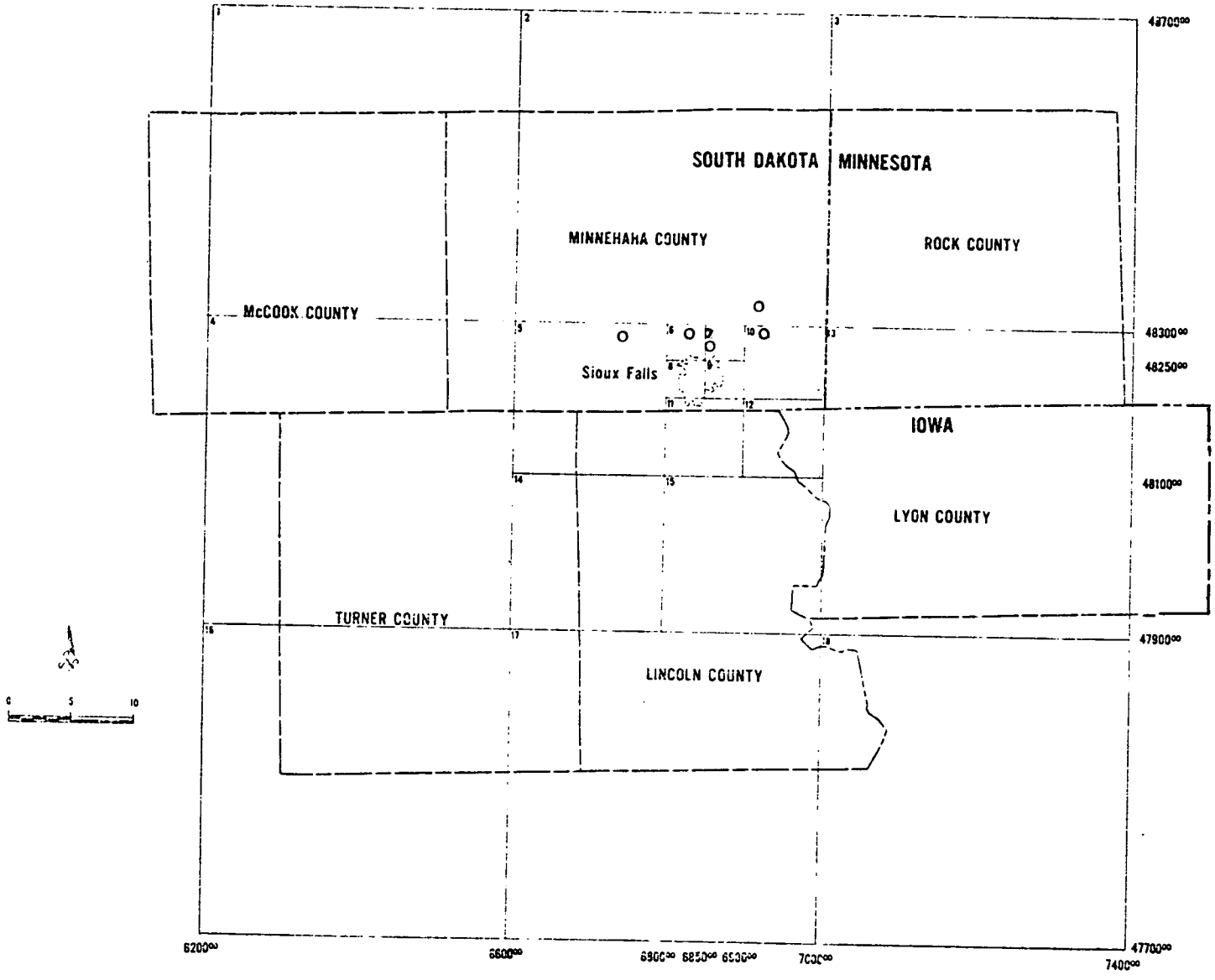

FIGURE 3 POINT SOURCE LOCATIONS FOR THE SIOUX FALLS STUDY AREA

TABLE 21 SUMMARY OF AIR POLLUTANT EMISSIONS FROM POINT SOURCES FOR THE SIOUX FALLS STUDY AREA, 1969

Tons/Day

	GP	HC	VC	SOX			PART			CO			HC			NOX		
				S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
Power Plant	2	6924	48313	1.0	1.0	1.0	0.05	0.05	0.05	0.00	0.00	0.00	0.01	0.01	0.01	0.88	0.88	0.87
City Dump	5	6750	48270	0.1	0.1	0.1	1.66	1.66	1.66	8.82	8.82	8.82	3.11	3.11	3.11	1.14	1.14	1.14
Airport	6	6835	48275	0.0	0.0	0.0	0.21	0.21	0.21	0.74	0.74	0.74	0.16	0.16	0.16	0.17	0.17	0.17
Packing Plant	7	6857	48265	0.9	1.5	1.2	0.36	0.62	0.48	0.00	0.01	0.01	0.00	0.01	0.00	0.45	0.77	0.60
Power Plant	10	6903	48298	5.3	5.3	5.2	6.95	6.95	6.85	0.01	0.01	0.01	0.00	0.00	0.00	1.28	1.28	1.26

S - Summer Day
W - Winter Day
A - Average Day

TABLE 22 AREA SOURCE EMISSIONS FOR THE SIOUX FALLS STUDY AREA
TONS/DAY

GRID	AREA	HC	VC	SOX S	PART W	PART A	PART S	CO W	CO A	CO S	HC W	HC A	HC S	NOX W	NOX A
1	617.7	6400	485	[illegible]	0.13	0.10	0.17	0.17	0.17	10.37	7.25	8.72	2.08	1.62	1.84	0.96	0.86	0.90
2	617.7	6800	485	0.10	0.15	0.12	0.20	0.20	0.19	14.45	12.92	15.54	3.48	2.77	3.10	1.39	1.24	1.30
3	617.7	7200	485	0.15	0.27	0.20	0.35	0.36	0.35	19.52	13.74	16.47	4.12	3.27	3.67	1.86	1.72	1.77
4	617.7	6400	481	0.10	0.19	0.14	0.23	0.24	0.23	13.51	9.49	11.39	2.84	2.25	2.53	1.29	1.19	1.22
5	154.4	6700	482	0.07	0.13	0.09	0.16	0.16	0.16	10.89	7.64	9.18	2.15	1.71	1.91	0.93	0.86	0.88
6	9.6	6825	48275	0.09	0.14	0.11	0.18	0.19	0.19	15.32	10.73	12.91	2.98	2.39	2.67	1.21	1.14	1.16
7	9.6	6875	48275	0.12	0.18	0.15	0.24	0.24	0.23	22.98	16.09	19.35	4.45	3.56	3.98	1.71	1.53	1.60
8	9.6	6825	48225	0.38	0.60	0.47	0.73	0.73	0.71	76.56	53.59	64.47	14.31	11.35	12.75	5.54	5.04	5.22
9	9.6	6875	48225	0.20	0.31	0.24	0.38	0.39	0.39	38.29	26.81	32.24	7.39	5.91	6.61	2.84	2.60	2.69
10	38.6	6950	48250	0.04	0.07	0.05	0.10	0.10	0.10	7.39	5.18	6.23	1.46	1.17	1.31	0.60	0.54	0.56
11	38.6	6850	48150	0.05	0.08	0.06	0.12	0.11	0.11	7.71	5.45	6.56	1.50	1.18	1.33	0.66	0.59	0.62
12	38.6	6950	48150	0.04	[illegible]	0.05	0.10	[illegible]	0.08	5.25	3.68	4.42	1.07	0.85	0.95	0.51	0.46	0.48
13	617.7	7200	481	0.27	[illegible]	.30	0.47	[illegible]	0.48	25.67	18.10	21.68	5.55	4.44	4.97	2.50	2.33	2.39
14	154.4	6700	48[illegible]	0.10	[illegible]	0.14	0.22	[illegible]	0.22	14.36	10.05	12.09	2.88	2.23	2.54	1.30	1.16	1.22
15	154.4	6900	48[illegible]	[illegible]	[illegible]	0.09	0.16	0.15	0.16	11.21	7.81	9.42	2.12	1.61	1.85	0.98	0.83	0.90
16	617.7	6400	477	[illegible]	[illegible]	0.01	0.02	0.02	0.02	1.25	0.89	1.06	0.30	0.25	0.27	0.12	0.13	0.12
17	617.7	6800	477	0.04	[illegible]	.06	0.09	0.10	[illegible]	5.38	3.80	4.55	1.18	0.95	1.06	0.51	0.49	0.50
18	617.7	7200	477	[illegible]	[illegible]	.0	[illegible]	[illegible]	[illegible]	0.44	0.31	0.37	0.08	0.06	0.07	0.03	0.03	0.03
TOTAL				1.92	3.24	2.50	4.00	4.07	3.98	304.72	213.60	256.76	60.01	47.65	53.50	25.03	22.85	23.64

S - Summer Day
W - Winter Day
A - Average Day

shown in Table 23. The emissions from all sources are also shown for an annual average, winter and summer day.

EMISSION DENSITIES

Emission densities have been calculated for the major pollutants for all grid areas (Table 24). These computed densities were found to be similar and the typical pattern was plotted as Figure 4.

TABLE 23 SUMMARY OF AIR POLLUTANT EMISSIONS, TOTAL TONS FOR THE SIOUX FALLS STUDY AREA, 1969

		SOX			PART			CO			HC			NOX		
GRID	AREA	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
1	617.7	0.1	0.1	0.1	0.2	0.2	0.2	10.4	7.3	8.7	2.1	1.6	1.8	1.0	0.9	0.9
2	617.7	1.1	1.2	1.1	0.3	0.3	0.3	18.5	12.9	15.5	3.5	2.8	3.1	2.3	2.1	2.2
3	617.7	0.2	0.3	0.2	0.4	0.4	0.4	19.5	13.7	16.5	4.1	3.3	3.7	1.9	1.7	1.8
4	617.7	0.1	0.2	0.1	0.2	0.2	0.2	13.5	9.5	11.4	2.8	2.3	2.5	1.3	1.2	1.2
5	154.4	0.2	0.2	0.2	1.8	1.8	1.8	19.7	16.5	18.0	5.3	4.8	5.0	2.1	2.0	2.0
6	9.6	0.1	0.1	0.1	0.4	0.4	0.4	16.1	11.5	13.7	3.2	2.6	2.8	1.4	1.3	1.3
7	9.6	1.0	1.7	1.4	0.6	0.9	0.7	23.0	16.1	19.4	4.5	3.6	4.0	2.2	2.3	2.2
8	9.6	0.4	0.6	0.5	0.7	0.7	0.7	76.6	53.6	64.5	14.3	11.4	12.8	5.5	5.0	5.2
9	9.6	0.2	0.3	0.2	0.4	0.4	0.4	38.3	26.8	32.2	7.4	5.9	6.6	2.8	2.6	2.7
10	38.6	5.4	5.4	5.3	7.1	7.1	7.0	7.4	5.2	6.2	1.5	1.2	1.3	1.9	1.8	1.8
11	38.6	0.1	0.1	0.1	0.1	0.1	0.1	7.8	5.5	6.6	1.5	1.2	1.3	0.7	0.6	0.6
12	38.6	0.0	0.1	0.1	0.1	0.1	0.1	5.3	3.7	4.4	1.1	0.9	1.0	0.5	0.5	0.5
13	617.7	0.2	0.4	.3	0.5	0.5	0.5	25.7	18.1	21.7	5.6	4.4	5.0	2.5	2.3	2.4
14	154.4	0.1	0.2	0.1	0.2	0.2	0.2	14.4	10.1	12.1	2.9	2.2	2.5	1.3	1.2	1.2
15	154.4	0.1	0.1	0.1	0.2	0.2	0.2	11.2	7.8	9.4	2.1	1.6	1.9	1.0	0.8	0.9
16	617.7	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.9	1.1	0.3	0.3	0.3	0.1	0.1	0.1
17	617.7	0.0	0.1	0.1	0.1	0.1	0.1	5.4	3.8	4.6	1.2	1.0	1.1	0.5	0.5	0.5
18	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.4	0.1	0.1	0.1	0.0	0.0	0.0
TOTAL		10.1	12.1	10.9	14.1	14.4	14.1	315.2	224.1	267.2	64.2	51.8	57.7	29.8	28.0	28.5

S - Summer Day
W - Winter Day
A - Average Day

TABLE 24 EMISSION DENSITIES
FOR THE SIOUX FALLS STUDY AREA
TONS/SQ. MILE

		SOX			PART			CO			HC			NOX		
GRID	AREA	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
1	617.7	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	617.7	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.01	0.00	0.01	0.00	0.00	0.00
3	617.7	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.01	0.01	0.01	0.00	0.00	0.00
4	617.7	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
5	154.4	0.00	0.00	0.00	0.01	0.01	0.01	0.13	0.11	0.12	0.03	0.03	0.03	0.01	0.01	0.01
6	9.6	0.01	0.01	0.01	0.04	0.04	0.04	1.67	1.19	1.41	0.33	0.27	0.29	0.14	0.14	0.14
7	9.6	0.11	0.18	0.14	0.06	0.09	0.07	2.38	1.67	2.01	0.46	0.37	0.41	0.22	0.24	0.23
8	9.6	0.04	0.06	0.05	0.08	0.08	0.07	7.93	5.55	6.68	1.48	1.18	1.32	0.57	0.52	0.54
9	9.6	0.02	0.03	0.03	0.04	0.04	0.04	3.97	2.78	3.34	0.77	0.61	0.69	0.29	0.27	0.28
10	38.6	0.14	0.14	0.14	0.18	0.18	0.18	0.19	0.13	0.16	0.04	0.03	0.03	0.05	0.05	0.05
11	38.6	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.14	0.17	0.04	0.03	0.03	0.02	0.02	0.02
12	38.6	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.10	0.11	0.03	0.02	0.02	0.01	0.01	0.01
13	617.7	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.04	0.01	0.01	0.01	0.00	0.00	0.00
14	154.4	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.07	0.08	0.02	0.01	0.02	0.01	0.01	0.01
15	154.4	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.05	0.06	0.01	0.01	0.01	0.01	0.01	0.01
16	617.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	617.7	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
18	617.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

S - Summer Day
W - Winter Day
A - Average Day

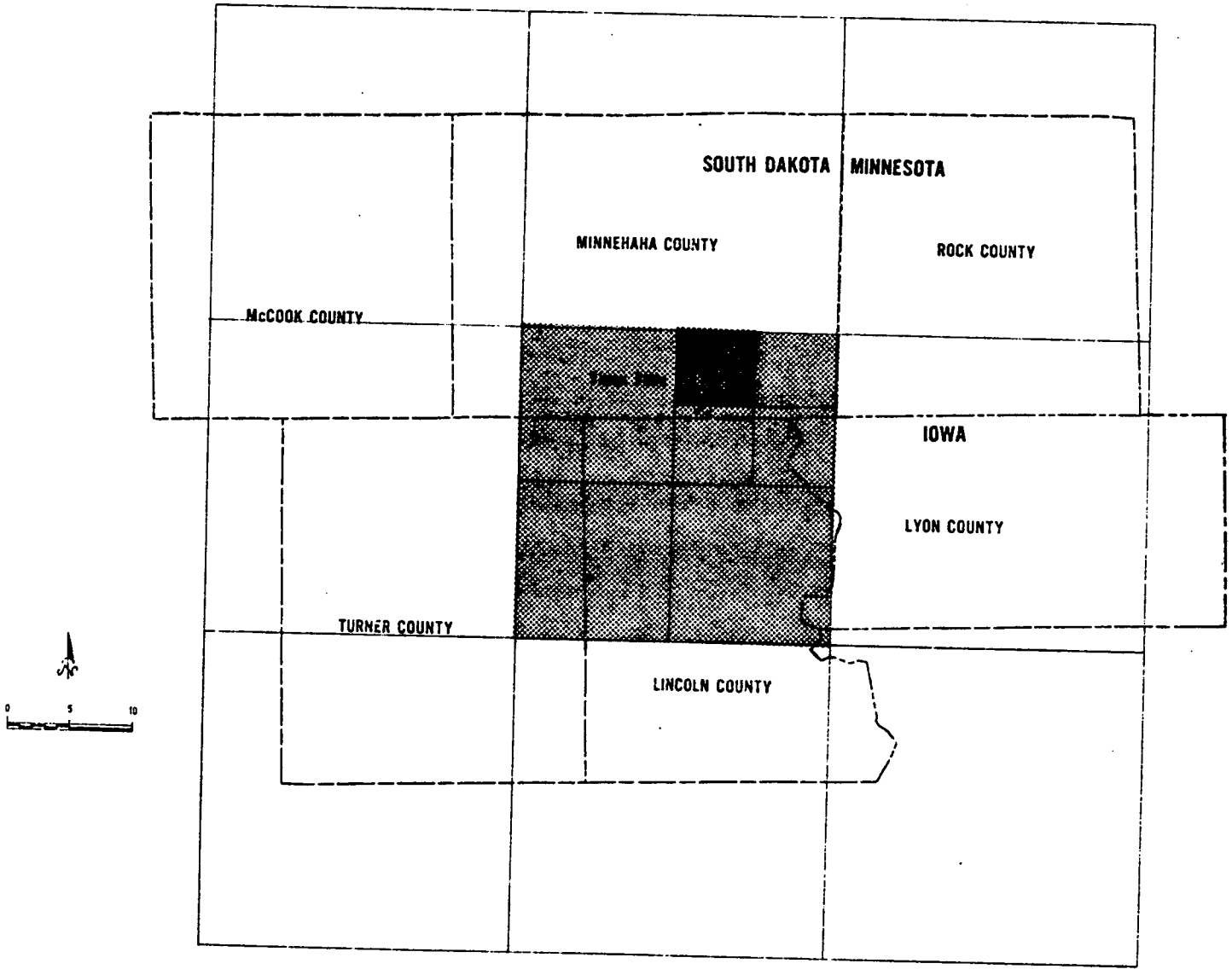

Figure 4. Typical Emission Density
From All Sources in the Sioux Falls Study Area

TABLE 25 GRID AREA DATA AND HOUSING UNITS (HV)
FOR THE SIOUX FALLS STUDY AREA

GRID	HC	VC	AREA SQ. MILE	POPULATION	PERSONS SQ. MILE	HU COAL	HU OIL	HU GAS	TOTAL HU
1	6400	485 0	617.76	4424.	7.	0.	469.	834.	1304.
2	6800	485 0	617.76	8741.	14.	0.	697.	1843.	2540.
3	7200	485 0	617.76	10864.	17.	0.	1059.	1984.	3044.
4	6400	481 0	617.76	6976.	11.	0.	759.	1334.	2093.
5	6700	482 0	154.44	5320.	34.	0.	486.	1085.	1571.
6	6825	48275	9.65	7257.	751.	0.	578.	1530.	2109.
7	6875	48275	9.65	10885.	1127.	0.	868.	2295.	3164.
8	6825	48225	9.65	36286.	3759.	0.	2893.	7653.	10547.
9	6875	48225	9.65	18143.	1879.	0.	1446.	3826.	5273.
10	6950	48250	38.61	3496.	90.	0.	278.	737.	1016.
11	6850	48150	38.61	3425.	88.	0.	300.	700.	1001.
12	6950	48150	38.61	2376.	61.	0.	251.	442.	693.
13	7200	481 0	617.76	15284.	24.	0.	1889.	2474.	4364.
14	6700	480 0	154.44	6566.	42.	0.	747.	1239.	1986.
15	6900	480 0	154.44	4014.	25.	0.	457.	739.	1197.
16	6400	477 0	617.76	1021.	1.	0.	115.	200.	315.
17	6800	477 0	617.76	3355.	5.	0.	381.	647.	1028.
18	7200	477 0	617.76	160.	0.	0.	18.	29.	47.
TOTAL			5559.83	148599.		0.	13699.	29599.	43299.

REFERENCES

1. Ozolins, Guntis and Raymond Smith, Rapid Survey Techniques for Estimating Community Air Pollution Emissions. DHEW, PHS, October 1966.

2. Duprey, R. L., Compilation of Air Pollutant Emission Factors, United States, DHEW, PHS, 1968.

3. 1960 Census and Preliminary 1970 Census.

4. Appraisal of Air Pollution in South Dakota, South Dakota State Department of Health and the Public Health Service, 1962.

5. Personal Communication with State and/or Local Agencies.

6. Personal Communication with Northern States Power Company.

7. Personal Communication with Mr. Perry Van Beek, Chief, Solid Wastes Section, Division of Sanitary Engineering, South Dakota State Department of Health.

APPENDIX A

METHOD FOR CALCULATING SUMMER, WINTER AND ANNUAL AVERAGE EMISSIONS FOR FUEL CONSUMPTION IN STATIONARY SOURCES

YEARLY AVERAGE (A)

$$A = \frac{\text{Fuel Consumed} \times \text{Emission Factor (E. F.)}}{\text{Days of Operation}}$$

e.g. A plant consumed 100,000 tons of coal in 1967 while operating 365 days. The total degree days for the area was 4,800 and 2,800 for the three winter months. The plant was estimated to use 15 percent of the fuel for space heating and 85 percent for process heating. From this information, the annual average emission for carbon monoxide would be the following:

$$A = \frac{100{,}000 \text{ Tons/year} \times 3 \text{ lbs. CO/Ton coal}}{365 \text{ Days/year} \times 2{,}000 \text{ lb./Ton}}$$

$$A = 0.41 \text{ Ton/Day}$$

WINTER AVERAGE (W)

$$W = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Winter Operation}} \times \frac{\text{Winter Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$W = \left[\frac{100{,}000 \times 2{,}800}{90 \times 4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$W = 0.49 \text{ Ton/Day}$$

SUMMER AVERAGE (S)

$$S = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Summer Operation}} \times \frac{\text{Summer Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$S = \left[\frac{100{,}000}{90} \times \frac{0}{4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$S = 0.35 \text{ Ton/Day}$$

APPENDIX B
METRIC CONVERSION FACTORS

Multiply	By.	To Obtain
Feet	0.3048	Meters
Miles	1609	Meters
Square Feet	0.0929	Square meters
Square Miles	2.59	Square kilometers
Pounds	453.6	Grams
Pounds	$453.6/10^4$	Tons (metric)
Tons (metric)	1.103	Tons (short)
Tons (short)	907.2	Kilograms
Tons (short)	.9072	Tons (metric)

To Obtain	By	Divide