CHEYENNE, WYOMING AREA
AIR POLLUTANT EMISSION INVENTORY

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service

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INTRODUCTION

This report is a summary of the Cheyenne, Wyoming Area air pollutant emission inventory conducted in June 1970. Since these inventories are based on a calendar year, the data and emission estimates presented here are representative of the year 1969 and should be considered to indicate conditions that existed during that year.

The Study Area, which was chosen on the basis of population and air pollution sources, consists of four counties in the southeastern corner of the state of Wyoming. These four counties cover an area of over 11,000 square miles and had a 1969 population of approximately 98,000.

A grid coordinate system was used to show geographic distribution of emissions within the Study Area. The grid coordinate system divides the Study Area into 43 grid zones ranging in size from 25 square kilometers in urban areas to 1,600 square kilometers in outlying 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 sources was further 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, on-site burning, residential fuel users, and small industries, were considered collectively as area sources. For this inventory, 19 individual sources were classified as point sources based on available information.

Emissions were estimated by using various indicators such as fuel consumption, refuse burning rates, production data, control efficiencies and vehicle-miles and emission factors relating these indicators to emission rates.[2,3] 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 here 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 in defining the extent and distribution of air pollutant emissions in the Study Area.

SUMMARY OF RESULTS

The annual air pollutant emissions as estimated in the Cheyenne, Wyoming Area Air Pollutant Emission Inventory are as follows (tons/year):

Sulfur Oxides	2,570
Particulates	35,110
Carbon Monoxide	85,600
Hydrocarbons	19,310
Nitrogen Oxides	9,510

The following is a brief summary of pollutant emissions and sources as presented in Tables 1 and 1A.

Sulfur Oxides: The largest source of sulfur oxides in the Study Area is stationary fuel combustion. This source results in 54.3 percent of this pollutant emission. The remaining 45.7 percent consists primarily of transportation and process losses.

Particulates: The largest single source of particulates (80.2%) is industrial process losses. Cement manufacturing is the major contributor to this source category. Stationary fuel combustion contributes 11.7 percent.

Carbon Monoxide: Transportation sources contribute approximately 60,000 tons of carbon monoxide (over 70 percent of the total) in the Study Area. Process losses (primarily oil refining) contribute 25.3 percent of the carbon monoxide.

Hydrocarbons: Of the annual emission of 19,310 tons of this pollutant, 49.2 percent is the result of evaporative losses, 32.3 percent is emitted from transportation sources and 12.2 percent is from processes losses.

Oxides of Nitrogen: The largest source of this pollutant is transportation (53.4 percent). 26.2 percent of this pollutant is produced by natural gas combustion due to its widespread and large consumption.

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

(Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Road Vehicles	440	850	52,560	4,840	4,720
Other	0	40	7,440	1,390	360
Subtotal	440	890	60,000	6,230	5,080
Stationary Fuel Combustion					
Industrial	1,200	4,030	110	40	1,840
Commercial-Institutional	120	70	10	0	410
Residential	80	50	0	0	250
Subtotal	1,400	4,150	120	40	2,500
Refuse Disposal					
Incineration	30	140	640	10	40
Open Burning	40	610	3,260	1,150	420
Subtotal	70	750	3,900	1,160	460
Industrial Processes	660	29,320	21,580	2,360	1,470
Evaporative Losses	--	--	--	9,520	--
GRAND TOTAL	2,570	35,110	85,600	19,310	9,510

TABLE 1A SUMMARY OF AIR POLLUTANT EMISSIONS IN THE STUDY AREA, 1969
(10^3 Kg./Year)

Source Category	Sulfur Oxides	Partic- ulates	Carbon Monoxide	Hydro- carbons	Nitrogen Oxides
Transportation					
Road Vehicles	400	770	47,680	4,390	4,280
Other	0	40	6,750	1,260	330
Subtotal	400	810	54,430	5,650	4,610
Stationary Fuel Combustion					
Industiral	1,090	3,660	100	40	1,670
Commercial-Institutional	110	60	10	0	370
Residential	70	50	0	0	230
Subtotal	1,270	3,770	110	40	2,270
Refuse Disposal					
Incineration	30	130	580	10	40
Open Burning	40	550	2,960	1,040	380
Subtotal	70	680	3,540	1,050	420
Industrial Processes	600	26,600	19,580	2,140	1,330
Evaporative Losses	--	--	--	8,640	--
GRAND TOTAL	2,340	31,860	77,660	17,520	8,630

DESCRIPTION OF THE STUDY AREA

The Study Area for the emission survey of the Cheyenne, Wyoming Area consists of four counties in Wyoming--Laramie, Albany, Goshen, and Platte. These four counties are located in the southeastern corner of the State. Figure 1 shows the Study Area and its location relative to neighboring cities and states.

Figure 2 represents a more detailed map of the Study Area showing the major urban areas. The Study Area occupies a land area of 11,270 square miles and had an estimated 1969 population of 98,350. This figure represents a 2 percent decrease from 1960 (Table 3). The population density map, Figure 3, shows the heaviest population concentrations in and near the city of Cheyenne.

TOPOGRAPHY[5]

The Study Area, located in the southeastern corner of Wyoming, is bordered on the south by Colorado and the east by Nebraska. It is divided in two by the Laramie Mountains, one of the ranges of the Rockies, with peaks of over 9,000 feet in elevation. The Laramie Mountains extend in a north-south direction. Much of the remainder of the Study Area is rolling prairie which lends itself to the grazing of livestock.

Cheyenne, the largest urban area in the Study Area and the State Capitol, is located in the extreme southern part of the state at an elevation of approximately 6,100 feet. The Laramie Mountains rise to over 9,000 feet 30 miles west of Cheyenne between Cheyenne and the City of Laramie.

CLIMATOLOGY[5]

The Study Area experiences large annual temperature variations. The average annual temperature ranges from 70.0 degrees in the summer months to 25.4 degrees in the winter. Sunshine averages 64 percent on a yearly basis, with little month-to-month variation. There are frequent windy days in the winter and the spring with the prevailing winds from the west-northwest at an average speed of 12.8 mph.

The majority of the precipitation occurs during the growing season (70 percent). Most of the snow that does fall occurs in early spring and late winter.

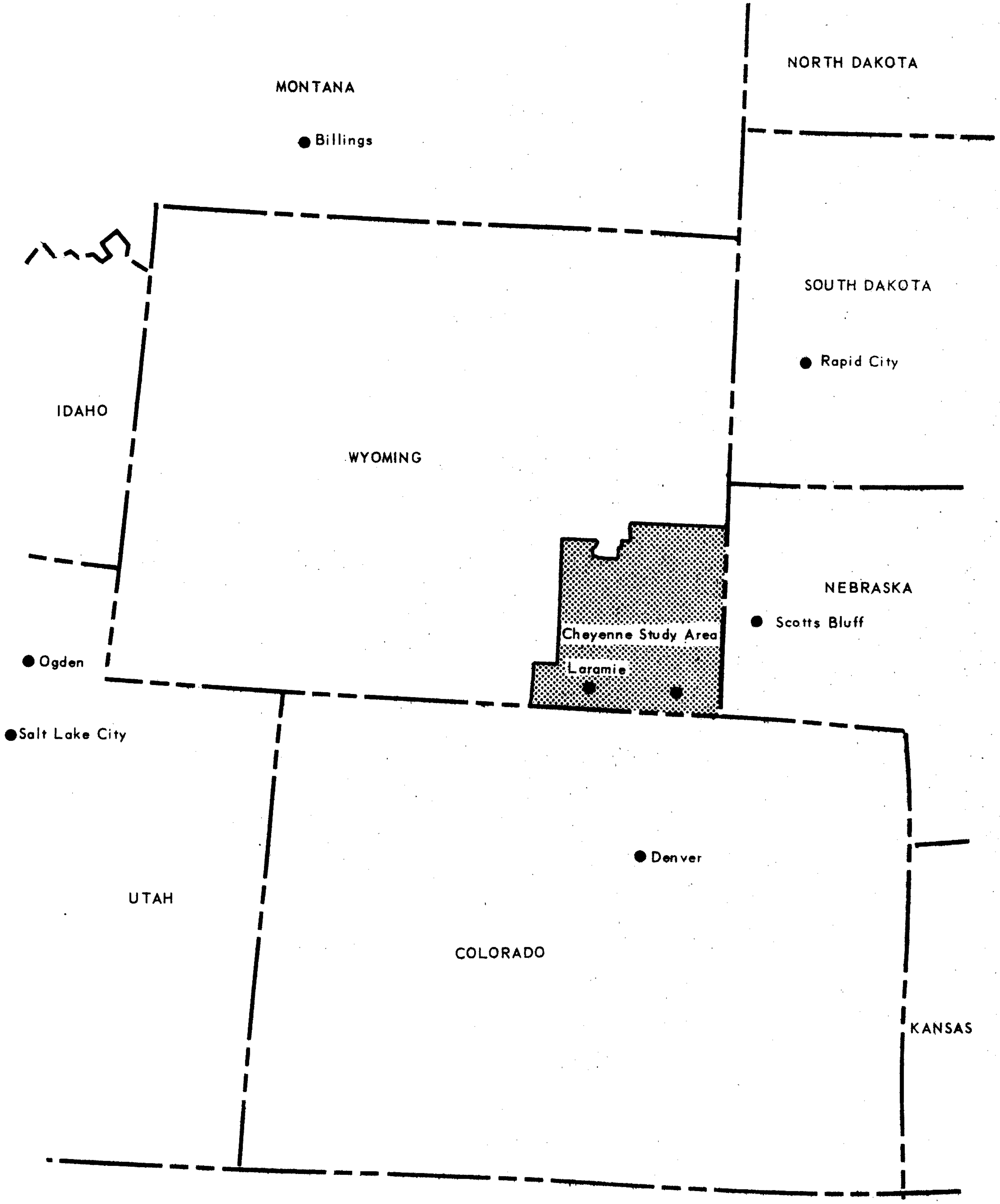

Figure 1. Map of the study area and vicinity.

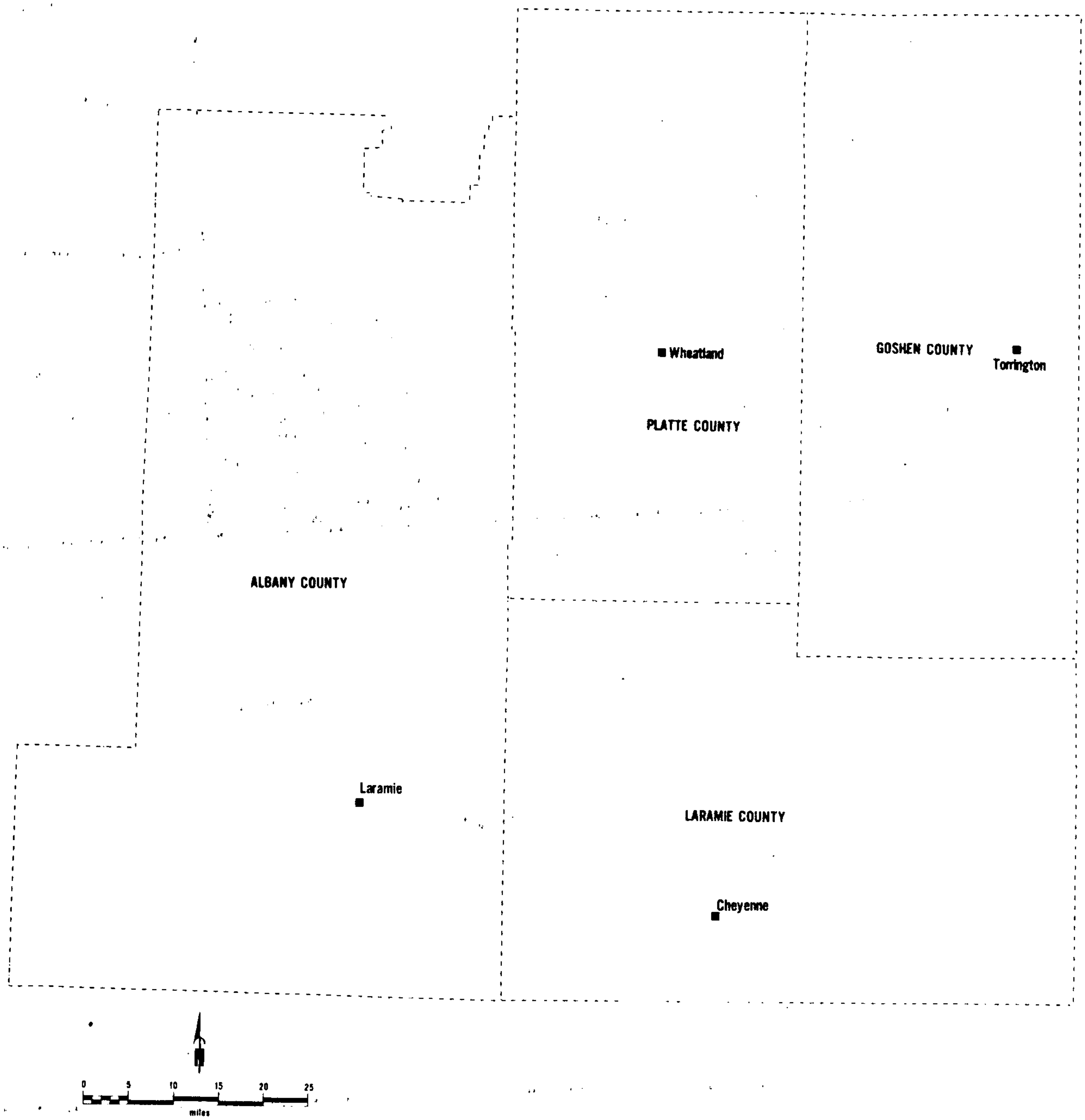

Figure 2. Map of the Cheyenne, Wyoming study area.

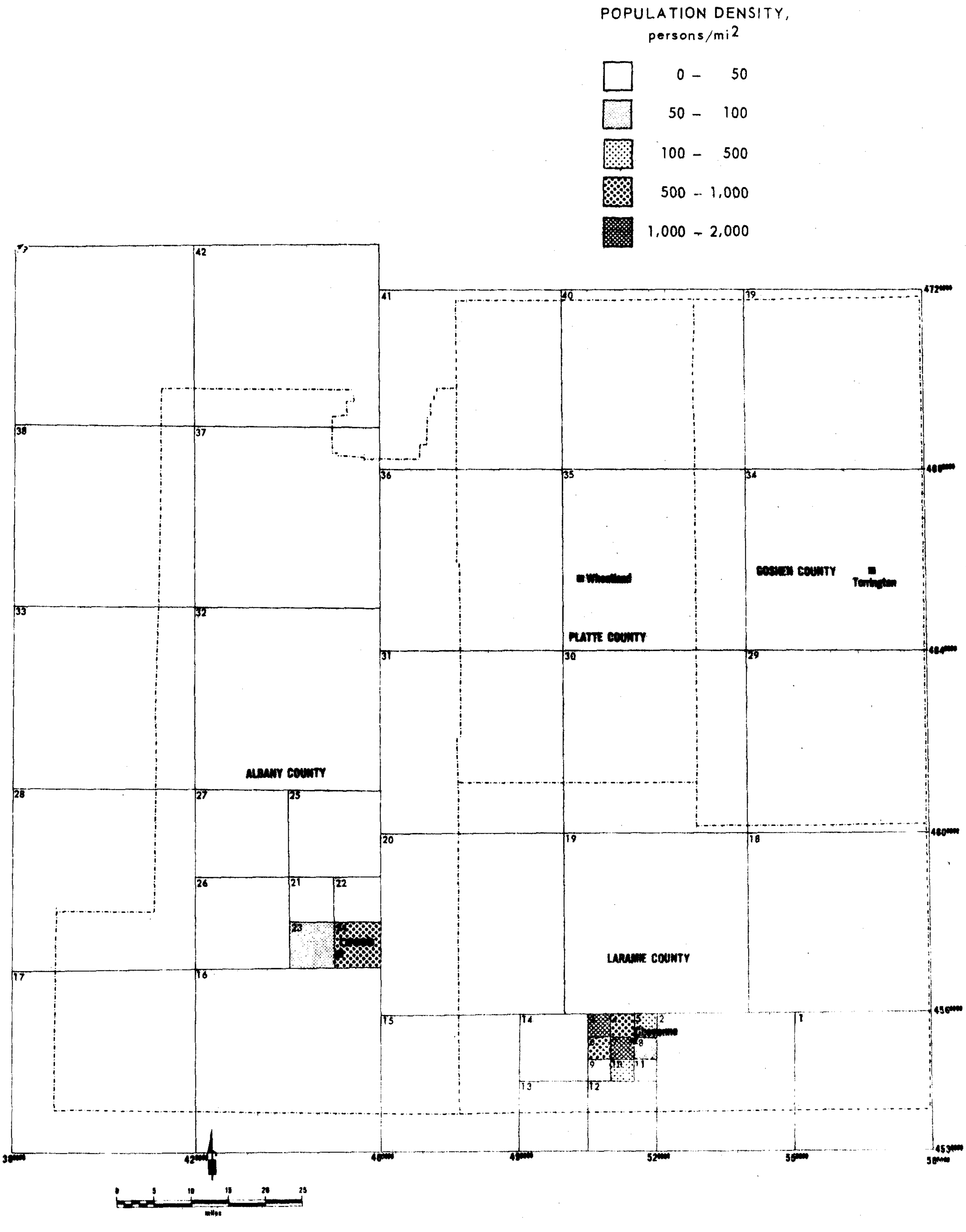

Figure 3. Population density for the Cheyenne study area, 1969.

GRID COORDINATE SYSTEM

A grid coordinate system, based on the Universal Transverse Mercator Projection (UTM), was used in the Cheyenne Study Area to indicate the geographical distribution of emissions. A map showing the grid coordinate system is presented in Figure 4.

An evaluation of all the available coordinate systems was completed before the UTM system was chosen to present emissions. The most convenient systems evaluated were the State Plane, Longitude-Latitude, and UTM. Although each of the systems had valuable qualities, the use of the UTM coordinate system was felt to be necessary to meet the requirements of these emission inventories.

The two primary requisites of the grid coordinate system were used to evaluate each system. The first requirement was that the grid coordinate system had to have square grid zones, since the data were to be used in meteorological dispersion models. The grid zones, which the UTM system and most of the State Plane systems project, are always square, but the longitude-latitude system projects grid zones that become skewed as the zones become further from the equator. The other quality the grid coordinate had to possess was consistency. Each emission inventory should be conducted on a grid coordinate system which uses the same reference point throughout the Study Area. Since some air pollutant inventories would include areas in two or more states, the State Plane systems could not be used. However, since the UTM system, as well as the longitude-latitude system, is not referenced to points in individual states, it is not influenced by jurisdiction boundaries. The UTM system was chosen since it was the only prevalent coordinate system which can project square grid zones over any Study Area using a common reference point.

The Universe Transverse Mercator Projection is based upon the metric system. Each north-south and east-west grid lines, as illustrated in Figure 4, is identified by a coordinate number expressed in meters.

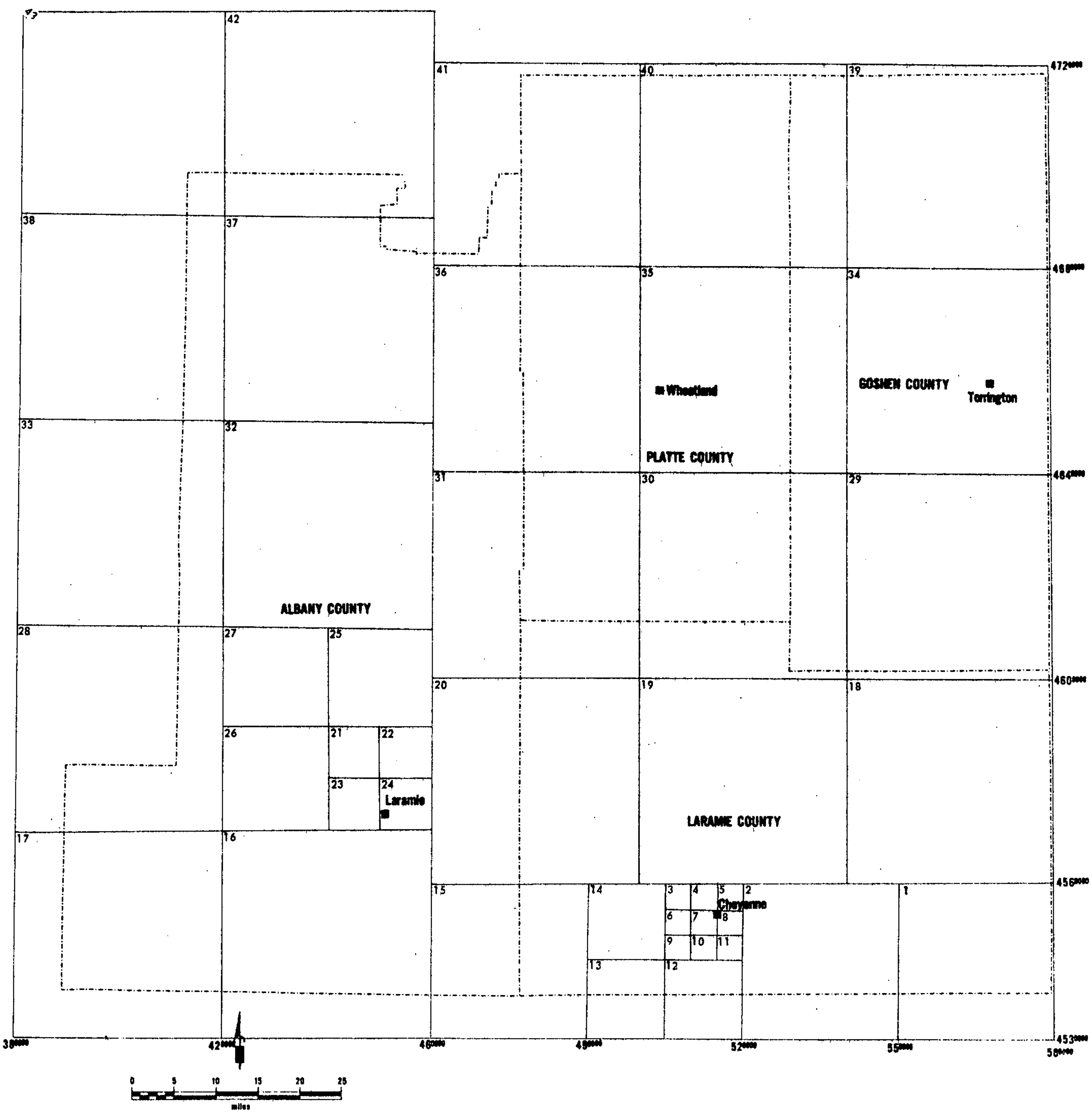

Figure 4. Grid coordinate system for the Cheyenne study area.

EMISSIONS BY CATEGORY

TRANSPORTATION

Transportation, a mobile source of air pollution, includes: road vehicles (gasoline and diesel powered), aircraft, and railroads. With the exception of aircraft, all transportation sources are dealt with as area pollution sources. Aircraft are considered to be point sources because the majority of emissions are attributable to the immediate vicinity of airports.

Road Vehicles

METHODOLOGY: Total vehicle-miles of travel were obtained by applying an average fuel consumption figure to gasoline sales (gallons) obtained from the Wyoming Department of Revenue (see Table 4).

Vehicle-miles of travel were apportioned onto the grid system by population and traffic flow maps. A state-wide flow map was obtained from the Wyoming Highway Department as were maps of the cities of Cheyenne and Laramie.

Approximately 1.5 to 2.0 percent of gasoline is lost through evaporation from gasoline tanks and from carburetor losses. (This is exclusive of exhaust hydrocarbon emissions.) It was assumed that no diesel fuel was lost through evaporation. Since 1963 the majority of new automobiles have been equipped with positive crankcase ventilation (PCV) valves that reduce crankcase hydrocarbon emissions by about 90 percent. It was assumed that only 20 percent of the automobiles were not equipped with PCV valves due to lag time in automobile replacement.

RESULTS: Road vehicles, gasoline-powered ones in particular, are the major contributors of three of the five pollutants in the Study Area. They result in the annual emission of 53,000 tons of carbon monoxide, 8,500 tons of hydrocarbons, and 4,700 tons of nitrogen oxides. Table 5 is a summary breakdown of pollutant emissions from transportation sources.

Each point source and grid, using its geographical center, is identified by a horizontal and vertical coordinate to the nearest 100 meters.

Grid zones of different sizes are used in the grid coordinate system to allow a satisfactory definition of the geographical gradation of emissions and to limit the number of grid zones. The majority of the emissions is usually concentrated in the populated and industrialized portions of a Study Area. Smaller grids are placed over these areas to allow the grid coordinate system to reflect the changes of emissions over short distances. Grid zones smaller than the 25 square kilometer grid zones used in this report are not usually warranted because of the inherent inaccuracites in the data. Larger grid zones are used in the rural portions, because a smaller percentage of the total emissions usually occurs in sparsely populated areas.

TABLE 2 PERCENTAGE CONTRIBUTION OF EACH SOURCE CATEGORY TO TOTAL EMISSIONS, 1969

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Road Vehicles	17.1	2.4	61.4	25.1	49.6
Other	0	0.1	8.7	7.2	3.8
Subtotal	17.1	2.5	70.1	32.3	53.4
Stationary Fuel Combustion					
Industrial	46.6	11.4	0.1	0.2	19.3
Commercial-Institutional	4.6	0.2	0.0	0	4.3
Residential	3.1	0.1	0	0	2.6
Subtotal	54.3	11.7	0.1	0.2	26.2
Refuse Disposal					
Incineration	1.1	3.9	0.7	0.1	0.4
Open Burning	1.5	1.7	3.8	6.0	4.4
Subtotal	2.6	5.6	4.5	6.1	4.8
Industrial Processes	26.0	80.2	25.3	12.2	15.6
Evaporative Losses	--	--	--	49.2	--
GRAND TOTAL	100.0	100.0	100.0	100.0	100.0

TABLE 3 AREA AND POPULATION CHARACTERISTICS FOR THE CHEYENNE STUDY AREA[4]

Jurisdiction	(Sq. Mi.) Land Area	Population 1960	1969	Population Density
Laramie	2,700	60,150	55,350	20.5
Albany	4,250	21,290	26,080	6.1
Goshen	2,230	11,940	10,600	4.8
Platte	2,090	7,200	6,320	3.0
TOTAL	11,270	100,580	98,350	8.7

TABLE 4 VEHICLE MILES OF TRAVEL AND MOTOR FUEL CONSUMPTION FOR THE STUDY AREA, 1969

Jurisdiction	10^3/Day Total Vehicle-Miles	10^3 Gal/Year Gasoline	10^3 Gal/Year Diesel Fuel
Laramie	1,160	32,160	5,170
Albany	600	16,780	2,440
Goshen	260	7,310	990
Platte	220	6,040	590
TOTAL	2,240	62,290	9,190

TABLE 5 SUMMARY OF AIR POLLUTANT EMISSIONS FROM TRANSPORTATION SOURCES, 1969 (Tons/Year)

Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Road Vehicles					
Gasoline	260	350	52,290	4,220	3,720
Diesel	180	500	270	610	1,000
Evaporative Losses	--	--	--	3,680*	--
Subtotal	440	850	52,560	8,510	4,720
Aircraft					
Jet	N	0	0	10	0
Piston	N	30	7,440	1,380	350
Turboprop	N	0	0	0	0
Subtotal	N	30	7,440	1,390	350
Railroads	0	0	0	0	0
GRAND TOTAL	440	880	60,000	9,900	5,070

* - Included in the evaporative losses category also.

N - Negligible

Aircraft

METHODOLOGY: The total number of flights (one flight equals a take-off and a landing) were obtained from the Federal Aviation Administration for the one major Study Area airport, Cheyenne Airport. Estimates of the flights by airplane type and number of engines were obtained from the control tower at Cheyenne Airport. Table 6 contains a breakdown of air traffic for the Study Area.

RESULTS: The emissions from aircraft are given in Table 5. Aircraft contributes 7,440 tons per year of carbon monoxide to the 60,000 tons per year from all transportation sources.

Railroads

METHODOLOGY: The total fuel use by the railroads in the State of Wyoming was obtained from the Bureau of Mines' Mineral Industry Surveys.[6] The quantity used in each county was arrived at by multiplying the ratio of the county population to the state population by the state fuel consumption. The fuel was then apportioned to the grid system based on the railroad route length in each grid.

RESULTS: Table 5 lists pollutant emissions as zero due to rounding. In contrast to the other transportation sources, railroad emissions of all pollutants are negligible.

STATIONARY FUEL COMBUSTION

Only two of the major fuels (natural gas and fuel oil) are widely consumed in the Cheyenne Study Area. The only significant coal user is one large industrial firm. Natural gas is by far the most important of the two major fuels and is consumed by the majority of the three user categories: industrial, commercial-institutional, and residential. In 1969 natural gas produced 18.9×10^{12} BTU's of energy (87% of the total), fuel oil produced 1.1×10^{12} BTU's (5% of the total) and coal produced 1.8×10^{12} BTU's (8% of the total) in the Study Area.

TABLE 6 AIR TRAFFIC ACTIVITY AT THE CHEYENNE AIRPORT, 1969
(Flights/Year)[a]

Type Engine	Number of Flights 1 engine	2 engines	4 engines
Conventional	0	0	0
Fan Jet	0	700	0
Turboprop	0	2,900	0
Piston	28,800	6,700	16,700

a - Flight is defined as a combination of a landing and a take-off.

Natural gas, as stated above, is the major fuel and is used widely by industry and other consumers. Fuel oil is used primarily by commercial-institutional and residential consumers. Since no industrial users were identifiable, it was assumed that fuel oil used by industry was negligible. There are no steam-electric power plants in the Study Area other than a small stand-by facility in Cheyenne. Power is generated outside of the area. Tables 7 and 8 show fuel consumption by user category.

METHODOLOGY: Natural gas consumption was obtained from the Utilities Director of the State of Wyoming Public Services Commission. Totals are considered to be accurate, but user category breakdowns of commercial-institutional and industrial users are estimates.

Fuel oil consumption (distillate) was obtained from Bureau of Mines' Mineral Industry Surveys state totals. County fuel oil use was arrived at by multiplying state consumption times the county-to-state population ratio. Usage was broken down into two categories: commercial-institutional and residential by basing residential consumption on housing units using fuel oil and apportioning the remaining oil to commercial-institutional users.

Coal usage for the one industrial user was obtained from them directly.

RESULTS: In 1969, 70,276 tons of coal; 18,890 million cubic feet of natural gas; and 7,430,000 gallons of distillate fuel oil were consumed in the Study Area. The emissions from the combustion of these fuels are summarized in Table 9.

Coal, although only number two in energy production, was the major contributor of four of the five pollutants (all except nitrogen oxides) in the Study Area.

Stationary fuel combustion is the source of a large portion of the sulfur oxides (54.3 percent) and nitrogen oxides (26.2 percent) emitted in the Study Area.

TABLE 7 NATURAL GAS CONSUMPTION BY USER CATEGORY, 1969
(10^6 Ft^3/Year)

County	Residential	Commercial	Industrial
Laramie	2,170	2,820	7,220
Albany	1,330	970	1,940
Goshen	300	120	1,110
Platte	200	350	360
TOTAL	4,000	4,260	10,630

TABLE 8 DISTILLATE FUEL OIL CONSUMPTION FOR THE STUDY AREA BY USER CATEGORY, 1969 (10^3 Gallons/Year)

County	Residential	Commercial	Industrial
Laramie	1,940	2,210	N
Albany	350	1,660	N
Goshen	290	500	N
Platte	250	230	N
TOTAL	2,830	4,600	N

TABLE 9 AIR POLLUTANT EMISSIONS FROM THE COMBUSTION OF FUELS IN STATIONARY SOURCES, 1969 (Tons/Year)

User Category	Sulfur Oxides	Partic- ulates	Carbon Monoxide	Hydro- carbons	Nitrogen Oxides
Coal					
Industrial	1,200	3,940	100	40	700
Commercial- Institutional	0	0	0	0	0
Residential	0	0	0	0	0
Subtotal	1,200	3,940	100	40	700
Distillate Oil					
Industrial	0	0	0	0	0
Commercial- Institutional	120	30	0	0	160
Residential	80	10	0	0	20
Subtotal	200	40	0	0	180
Natural Gas					
Industrial	0	100	0	0	1,140
Commercial- Institutional	0	40	0	0	250
Residential	0	40	0	0	230
Subtotal	0	180	0	0	1,620
GRAND TOTAL	1,400	4,160	100	40	2,500

TABLE 10 SUMMARY OF DOMESTIC HEATING FUELS BY NUMBER OF DWELLING UNITS, 1969 (Estimated)

Jurisdiction	Coal	Distillate Fuel Oil	Natural Gas
Laramie	0	2,040	14,800
Albany	0	380	8,920
Goshen	0	330	2,220
Platte	0	250	1,320
TOTAL IN STUDY AREA	0	3,000	27,260
OVERALL PERCENTAGE	0	10	90

SOLID WASTE DISPOSAL

METHODOLOGY: The total solid waste generation for the Study Area was found by applying the national average per capita rate of 10 pounds of refuse per day.[7] Due to the lack of large industrial refuse sources in the area, 3 pounds per day per capita was subtracted from this and the remaining 7 pounds per day figure applied to the Study Area population. This waste generation rate includes 5.5 pounds per day collected waste and 1.5 pounds per day uncollected waste.

Disposal methods were obtained from the Wyoming Division of Health and Medical Services in all cases except for the city of Laramie where information was obtained from the Laramie Public Works Department.

The Cheyenne metropolitan area has some sections where on-site incineration and ash collection is the method of solid waste disposal. This is reflected in the solid waste balance (Table 11).

Although at present open burning dumps are the predominant means of solid waste disposal in the Study Area, a trend toward sanitary landfills is evidenced by the fact that the city of Laramie is converting to this method in the near future. Cheyenne presently makes use of the sanitary landfill method in addition to on-site incineration.

There are no large commercial or municipal incinerators in the Study Area. Uncollected waste was divided into on-site open burning (1.0 pounds/day-capita) and on-site incineration (0.5 pounds/day-capita).

RESULTS: Table 12 gives the summary of emissions from this source category.

INDUSTRIAL PROCESSES

There are several significant process sources in the Study Area, although they are widely dispersed geographically. Major industries located in the area include: cement manufacturing, sugar refining, oil refining, fertilizer manufacturing and lumber and wood. Ther are

TABLE 11 SOLID WASTE BALANCE FOR THE STUDY AREA, 1969
(Tons/Year)

Jurisdiction	Total Refuse Generated	Sanitary Landfills	Open Burning Dumps	Open Burning On-Site	On-Site Incineration
Laramie	71,000	20,100	15,600	10,200	25,100
Albany	33,300	N	26,200	4,700	2,400
Goshen	13,500	N	10,700	1,900	900
Platte	8,100	N	6,400	1,200	500
GRAND TOTALS	125,900	20,100	58,900	18,000	28,900

TABLE 12 AIR POLLUTANT EMISSIONS FROM SOLID WASTE DISPOSAL, 1969

(Tons/Year)

Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Incineration					
On-Site	30	140	640	10	40
Open Burning					
On-Site	20	400	2,120	750	280
Dump	10	210	1,140	400	150
Total	30	610	3,260	1,150	430
GRAND TOTAL	60	750	3,900	1,160	470

also several wigwam burners in the area and several concrete batching plants.

The process emission totals include emissions from the wigwam burners in the Study Area. Appendix C lists the emission factors for wigwam burning of wood waste. (Wigwam burners in the Study Area are used exclusively for wood waste.)

Table 13 summarizes emissions from each type of industrial process. Cement manufacturing and petroleum refining are the largest overall sources of process loss emissions in the Study Area.

EVAPORATIVE LOSSES

Four sources of solvent evaporation were considered in this survey: motor vehicles, dry cleaning, gasoline storage and handling, and refinery petroleum products storage.

METHODOLOGY: Dry cleaning evaporation was calculated using the per capita factor of 4.0 pounds per year.[8] This was apportioned on the grid system by population. Gasoline handling losses were figured using the factor of 9.4 pounds per 1,000 gallons of throughput for filling service station tanks and 11.6 pounds per 1,000 gallons of throughput for filling automobile tanks. This also was apportioned by population to the grid system. Automotive evaporative losses at the gasoline tank and carburetor were calculated taking into account vehicle-miles, age of vehicle, and extent of control equipment. These emissions were apportioned the same as motor vehicle exhaust emissions (see TRANSPORTATION-Road Vehicles). Storage capacities by product type for the petroelum refinery tank farm were obtained by product type and the appropriate emission factors were applied.[9]

RESULTS: Table 14 lists emissions by type for this source category.

TABLE 13 SUMMARY OF AIR POLLUTANT EMISSIONS FROM INDUSTRIAL PROCESSES, 1969 (Tons/Year)

Industry Type	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Cement Manufacture	--	28,920	--	--	--
Lumber Products (Disposal of Waste)	--	40	1,580	130	10
Oil Refining	660	20	20,000	2,230	150
Sugar Refining	--	350	--	--	--
Fertilizer Manufacture	--	--	--	--	1,310
Concrete Batching	--	N	--	--	--
TOTAL	660	29,330	21,580	2,360	1,470

TABLE 14 SUMMARY OF HYDROCARBON EMISSIONS DUE TO EVAPORATIVE LOSSES IN THE STUDY AREA, 1969 (Tons/Year)

Source Type	Hydrocarbons
Gasoline Handling	650
Petroleum Refinery Storage and Handling	5,000
Automobiles	3,680
Solvent Consumption	
Dry Cleaning	190
Industrial	0
GRAND TOTAL	9,520

EMISSIONS BY JURISDICTION

Up until this point, this report has dealt primarily with emissions by source category. Tables 15 through 18 present emissions by jurisdiction.

TABLE 15 SUMMARY OF AIR POLLUTANT EMISSIONS IN LARAMIE COUNTY, 1969

(Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Road Vehicles	250	480	30,970	2,820	2,700
Other	N	40	7,440	1,390	360
Subtotal	250	520	38,410	4,210	3,060
Stationary Fuel Combustion					
Industrial	N	60	N	N	770
Commercial-Institutional	60	40	N	N	240
Residential	50	30	N	N	140
Subtotal	110	130	N	N	1,150
Refuse Disposal					
Incineration	30	120	550	10	40
Open Burning	10	210	1,090	390	140
Subtotal	40	330	1,640	400	180
Process Losses	660	20	20,000	2,230	1,460
Evaporative Losses	--	--	--	7,550	--
GRAND TOTAL	1,060	1,000	60,050	14,390	5,850

N = Negligible

TABLE 16 SUMMARY OF AIR POLLUTANT EMISSIONS IN ALBANY COUNTY, 1969

(Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Road Vehicles	100	200	12,890	1,170	1,130
Other	N	N	N	N	N
Subtotal	100	200	12,890	1,170	1,130
Stationary Fuel Combustion					
Industrial	1,200	3,950	100	40	910
Commercial-Institutional	40	20	N	N	120
Residential	10	10	N	N	80
Subtotal	2,150	3,980	100	40	1,110
Refuse Disposal					
Incineration	N	10	50	N	N
Open Burning	20	250	1,310	460	170
Subtotal	20	260	1,360	460	170
Process Losses	N	28,920	1,580	140	10
Evaporative Losses	--	--	--	1,100	--
GRAND TOTAL	1,370	33,360	15,930	2,910	2,420

N = Negligible

TABLE 17 SUMMARY OF AIR POLLUTANT EMISSIONS IN GOSHEN COUNTY, 1969

(Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Road Vehicles	50	90	4,770	460	490
Other	N	N	N	N	N
Subtotal	50	90	4,770	460	490
Stationary Fuel Combustion					
Industrial	N	10	N	N	120
Commercial-Institutional	10	N	N	N	20
Residential	10	N	N	N	20
Subtotal	20	10	N	N	160
Refuse Disposal					
Incineration	N	N	20	N	N
Open Burning	10	100	540	190	70
Subtotal	10	100	560	190	70
Process Losses	N	350	N	N	N
Evaporative Losses	--	--	--	480	--
GRAND TOTAL	80	550	5,330	1,130	720

N = Negligible

TABLE 18 SUMMARY OF AIR POLLUTANT EMISSIONS IN PLATTE COUNTY, 1969

(Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Road Vehicles	40	70	3,930	380	400
Other	N	N	N	N	N
Subtotal	40	70	3,930	380	400
Stationary Fuel Combustion					
Industrial	N	N	N	N	40
Commercial-Institutional	10	10	N	N	30
Residential	10	N	N	N	10
Subtotal	20	10	N	N	80
Refuse Disposal					
Incineration	N	N	10	N	N
Open Burning	N	60	320	110	40
Subtotal	N	60	330	110	40
Process Losses	N	N	N	N	N
Evaporative Losses	--	--	--	390	--
GRAND TOTAL	60	140	4,260	880	520

EMISSIONS BY GRID

In the following tables emissions by grid are given for the purpose of describing geographic distribution of air pollutant emissions. Emissions were divided into two source groups--point and area sources. The 19 point sources are identified individually with respect to locations and emissions.

Figure 5 shows the location of the 19 point sources in the area. Collectively these point sources account for 71 percent of the sulfur oxides, 96 percent of the particulates, 26 percent of the carbon monoxide, 42 percent of the hydrocarbons, and 22 percent of the nitrogen oxides emitted in the Study Area. The large industrial particulate emissions are caused by cement manufacturing and coal combustion. Sulfur oxides are produced primarily by coal combustion. A summary of point source emissions is given in Table 19.

Area sources are sources of pollutant emissions that are relatively insignificant by themselves, but emit a large quantity of pollutants collectively. Examples of area sources are: motor vehicles, residential housing, backyard burning, and small commercial and industrial establishments. Table 20 is a summary of total emissions by grid for the Study Area.

The emissions are presented for an annual average day, an average winter day (December, January, February) and an average summer day (June, July, August). The annual average daily emission rates were obtained by dividing yearly totals by 365. Seasonal variations were calculated by the use of space heating variations in fuel consumption and variations in motor vehicle traffic activity. This method is described in detail in the appendix. Other sources were assumed to be constant throughout the year.

TABLE 19 SUMMARY OF AIR POLLUTANT EMISSIONS FROM POINT SOURCES
TONS/DAY

				SOX			PART			CO			HC			NOX		
ID	GR	HC	VC	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
5	1	5770	45570	0.0	0.0	0.0	0.02	0.02	0.02	0.10	0.10	0.10	0.03	0.03	0.03	0.01	0.01	0.01
3	3	5070	45570	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
7	4	5150	45560	0.0	0.0	0.0	0.09	0.09	0.09	20.39	20.39	20.39	3.81	3.81	3.81	0.97	0.97	0.97
3	6	5140	45530	0.0	0.0	0.0	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.07
2	7	5180	45540	1.8	1.8	1.8	0.04	0.04	0.04	54.79	54.79	54.79	19.79	19.79	19.79	0.41	0.41	0.41
2	7	5120	45520	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	9	5090	45480	0.0	0.0	0.0	0.07	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	4.43	4.43	4.43
2	16	4490	45650	3.2	3.2	3.2	90.00	90.00	90.00	0.28	0.28	0.28	0.09	0.09	0.09	1.92	1.92	1.92
2	21	4490	45750	0.0	0.0	0.0	0.00	0.20	0.10	0.00	7.79	3.89	0.00	0.66	0.33	0.00	0.04	0.02
2	21	4440	45840	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	22	4510	45770	0.0	0.0	0.0	0.40	0.40	0.40	2.12	2.12	2.12	0.75	0.75	0.75	0.27	0.27	0.27
2	23	4490	45720	0.0	0.0	0.0	0.01	0.01	0.01	0.43	0.43	0.43	0.04	0.04	0.04	0.03	0.03	0.03
2	23	4440	45740	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	30	5060	46250	0.0	0.0	0.0	0.00	0.00	0.00	0.03	0.03	0.03	0.01	0.01	0.01	0.00	0.00	0.00
2	34	5650	46560	0.0	0.0	0.0	0.02	0.02	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.29	0.29
5	34	5730	466 0	0.0	0.0	0.0	0.09	0.09	0.09	0.48	0.48	0.48	0.17	0.17	0.17	0.06	0.06	0.06
2	35	5210	46790	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	35	5200	468 0	0.0	0.0	0.0	0.01	0.01	0.01	0.08	0.08	0.08	0.03	0.03	0.03	0.01	0.01	0.01
5	35	5025	46570	0.0	0.0	0.0	0.05	0.05	0.05	0.27	0.27	0.27	0.09	0.09	0.09	0.03	0.03	0.03

TABLE 20 SUMMARY OF AIR POLLUTANT EMISSIONS FROM ALL SOURCES

TONS/ DAY

		SOX			PART			CO			HC			NOX		
GRID	AREA	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
1	347.4	0.0	0.1	0.1	0.1	0.1	0.1	4.7	3.4	3.9	0.9	0.7	0.8	0.5	0.5	0.5
2	347.4	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.2	1.4	0.3	0.2	0.3	0.2	0.2	0.2
3	9.6	0.1	0.2	0.2	0.4	0.5	0.5	17.0	12.4	14.1	3.0	2.3	2.5	1.5	1.9	1.7
4	9.6	0.1	0.2	0.1	0.4	0.5	0.4	33.5	29.9	31.2	6.1	5.5	5.7	2.1	2.4	2.2
5	9.6	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.0	1.2	0.3	0.2	0.2	0.2	0.2	0.2
6	9.6	0.1	0.1	0.1	0.3	0.3	0.3	13.1	9.4	10.8	2.2	1.6	1.8	1.1	1.3	1.2
7	9.6	2.0	2.1	2.0	0.6	0.7	0.7	79.3	72.7	75.1	23.7	22.7	23.1	2.2	2.9	2.5
8	9.6	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.0	1.1	0.3	0.2	0.2	0.1	0.1	0.1
9	9.6	0.0	0.0	0.0	0.1	0.1	0.1	0.6	0.5	0.5	0.1	0.1	0.1	4.5	4.5	4.5
10	9.6	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.9	1.1	0.3	0.2	0.2	0.1	0.2	0.2
11	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.3	0.1	0.0	0.1	0.0	0.0	0.0
12	86.8	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.7	0.8	0.2	0.1	0.2	0.1	0.1	0.1
13	86.8	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.5	0.5	0.1	0.1	0.1	0.1	0.1	0.1
14	86.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1
15	347.4	0.0	0.0	0.0	0.1	0.1	0.1	4.3	2.8	3.3	0.8	0.5	0.6	0.5	0.3	0.4
16	617.7	3.3	3.3	3.3	90.0	90.0	90.0	3.1	1.9	2.3	0.6	0.4	0.5	2.2	2.1	2.2
17	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.4	0.6	0.1	0.1	0.1	0.1	0.1	0.1
18	617.7	0.2	0.1	0.2	0.4	0.3	0.3	19.5	13.9	16.0	3.5	2.5	2.8	2.0	1.5	1.7
19	617.7	0.0	0.0	0.0	0.1	0.1	0.1	4.4	3.2	3.6	0.8	0.6	0.7	0.5	0.4	0.4
20	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.5	0.1	0.1	0.1	0.1	0.1	0.1
21	38.6	0.0	0.0	0.0	0.0	0.2	0.1	1.7	8.8	5.2	0.3	0.8	0.6	0.2	0.2	0.2
22	38.6	0.0	0.0	0.0	0.4	0.4	0.4	3.8	3.1	3.4	1.1	0.9	1.0	0.5	0.4	0.4
23	38.6	0.0	0.0	0.0	0.1	0.1	0.1	2.7	1.8	2.1	0.5	0.3	0.4	0.3	0.4	0.3
24	38.6	0.1	0.3	0.2	0.5	0.6	0.5	20.0	11.9	14.9	3.6	2.3	2.7	1.5	2.3	1.9
25	154.4	0.0	0.0	0.0	0.1	0.0	0.0	3.2	1.8	2.3	0.6	0.3	0.4	0.3	0.2	0.2
26	154.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.3	0.1	0.0	0.1	0.0	0.0	0.0
27	154.4	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.5	0.6	0.2	0.1	0.1	0.1	0.1	0.1
28	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

29	617.7	0.0	0.0	0.0	0.1	0.0	0.0	1.7	1.2	1.4	0.4	0.2	0.3	0.2	0.2	0.2
30	617.7	0.0	0.0	0.0	0.1	0.1	0.1	5.0	3.1	3.8	1.0	0.6	0.8	0.5	0.4	0.4
31	617.7	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.7	0.9	0.2	0.1	0.2	0.1	0.1	0.1
32	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0
33	617.7	0.1	0.0	0.0	0.1	0.1	0.1	7.0	4.0	5.1	1.2	0.7	0.9	0.7	0.4	0.5
34	617.7	0.1	0.2	0.1	0.5	0.4	1.4	12.5	8.8	10.4	2.6	1.9	2.2	1.6	1.4	1.5
35	617.7	0.1	0.1	0.1	0.3	0.2	0.2	8.3	4.9	6.2	1.7	1.1	1.3	0.9	0.7	0.8
36	617.7	0.0	0.0	0.0	0.0	0.0	0.0	2.1	1.2	1.5	0.4	0.2	0.3	0.2	0.2	0.2
37	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
38	617.7	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.7	0.2	0.1	0.1	0.1	0.1	0.1
39	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.6	0.7	0.2	0.1	0.1	0.1	0.1	0.1
40	617.7	0.0	0.0	0.0	0.1	0.1	0.1	3.2	1.9	2.4	0.6	0.4	0.5	0.3	0.3	0.3
41	617.7	0.0	0.0	0.0	0.1	0.1	0.1	4.3	2.4	3.1	0.8	0.4	0.6	0.4	0.3	0.3
42	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.3	0.1	0.0	0.1	0.0	0.0	0.0
43	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.4	0.5	0.1	0.1	0.1	0.1	0.0	0.1

EMISSION DENSITIES

In order to provide a visual representation of the emissions of pollutants by grid, emission density maps have been provided. Figures 6 through 10 show variation in emission densities for the respective grids throughout the Study Area. As expected the emissions generally follow the pattern and degree of urbanization. Emission densities are higher in grids with high populations and correspondingly high vehicular and industrial activity.

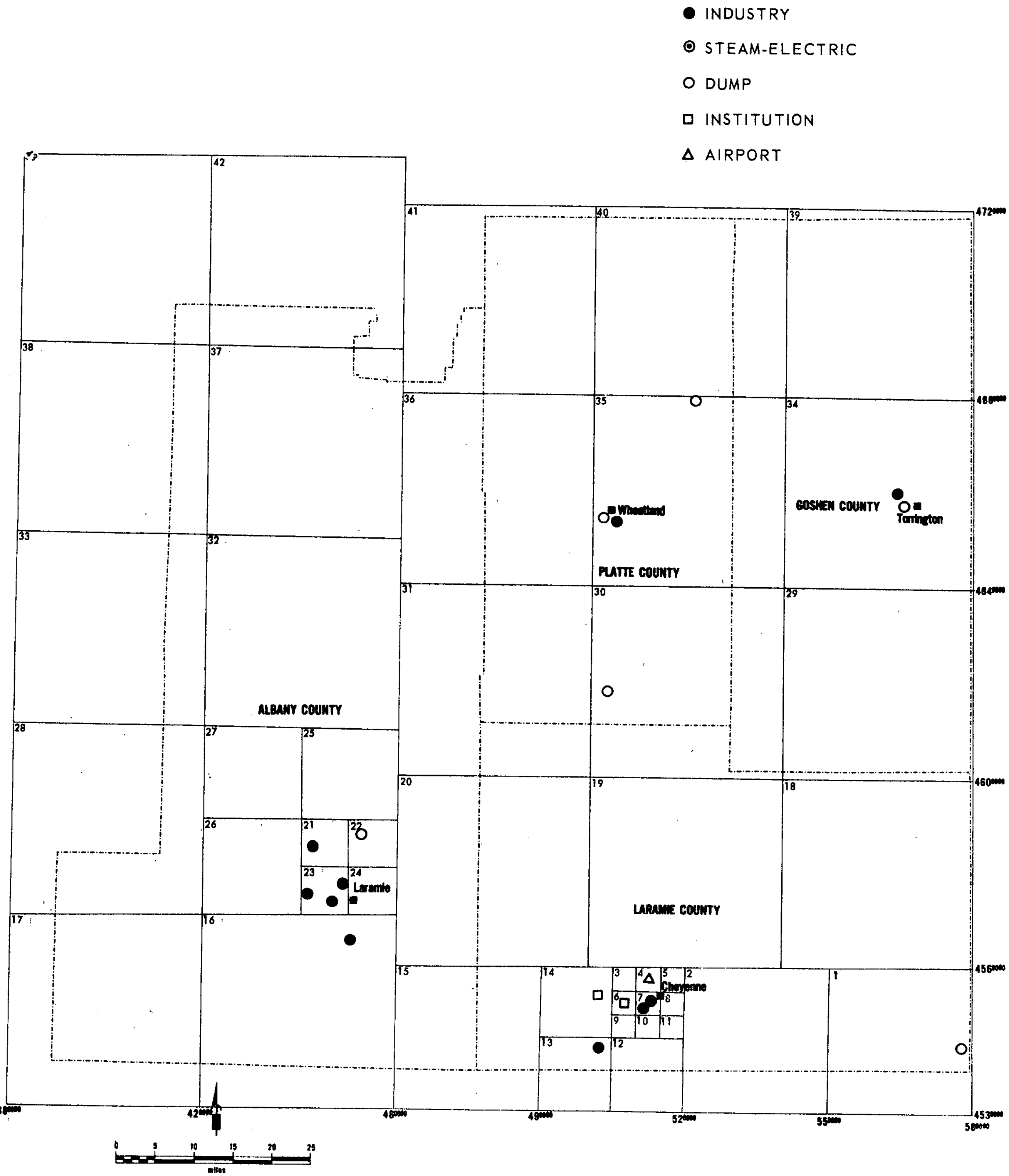

Figure 5. Point source locations in the study area.

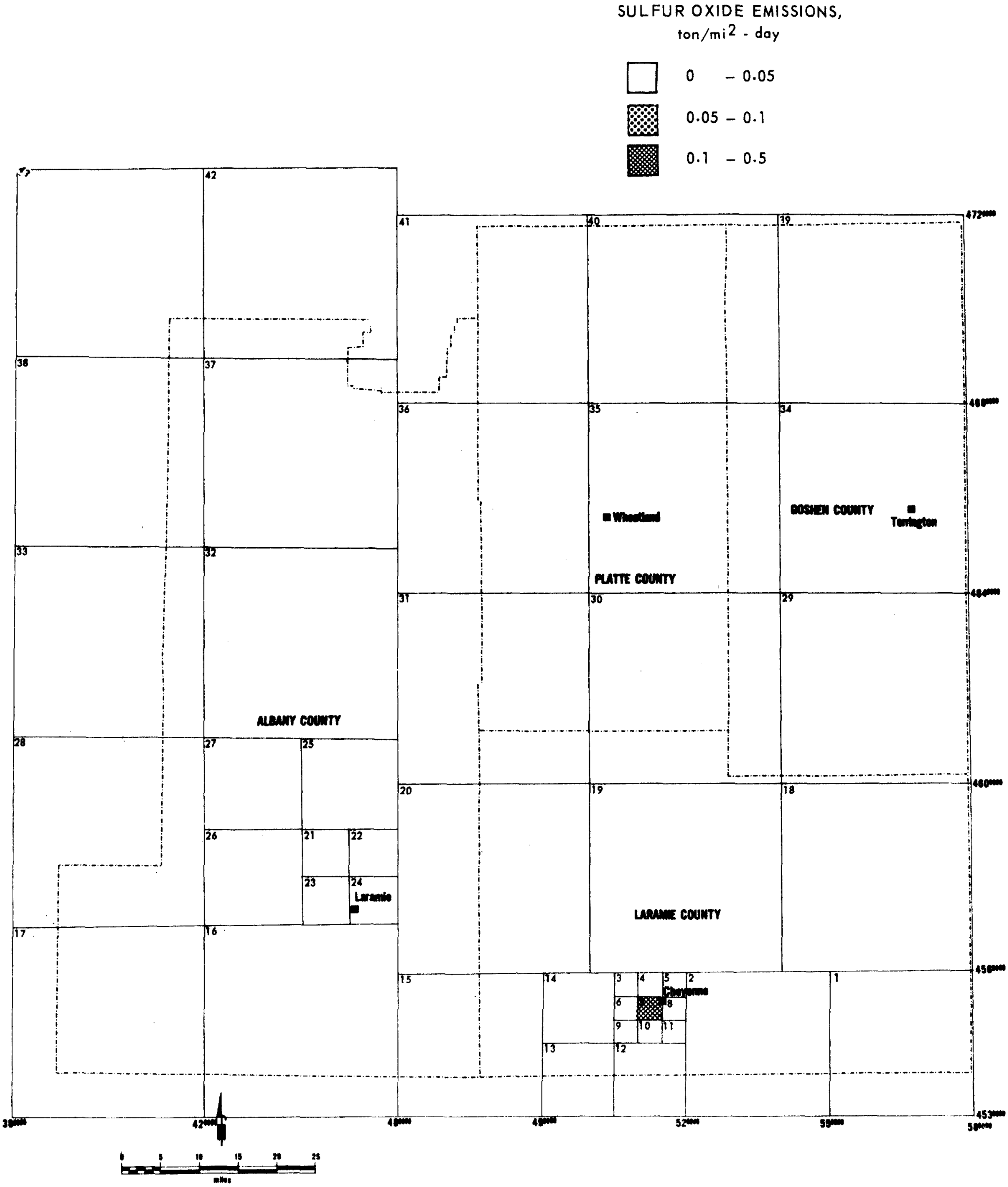

Figure 6. Sulfur oxide emission densities for the study area, 1969.

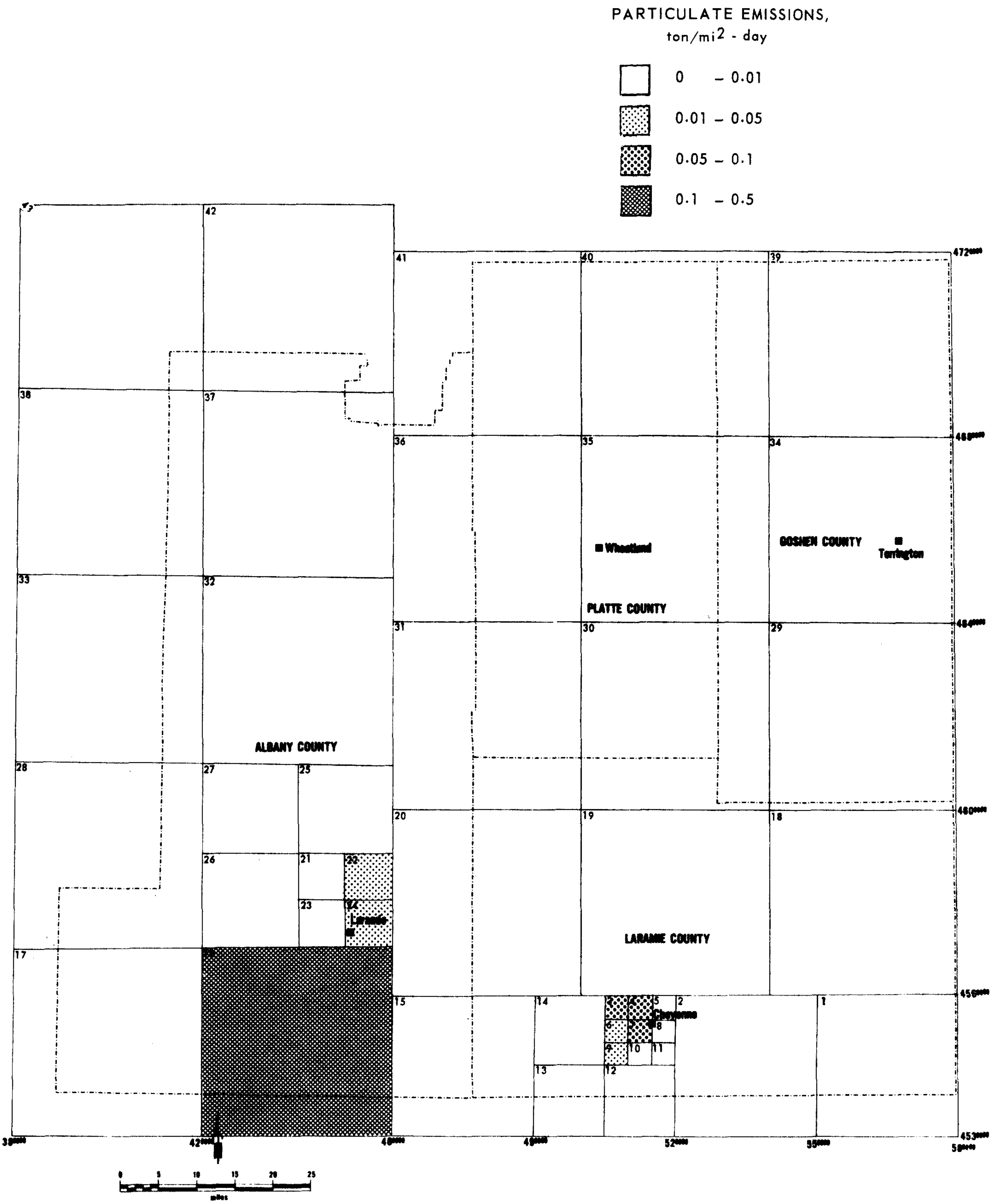

Figure 7. Particulate emission densities for the study area, 1969.

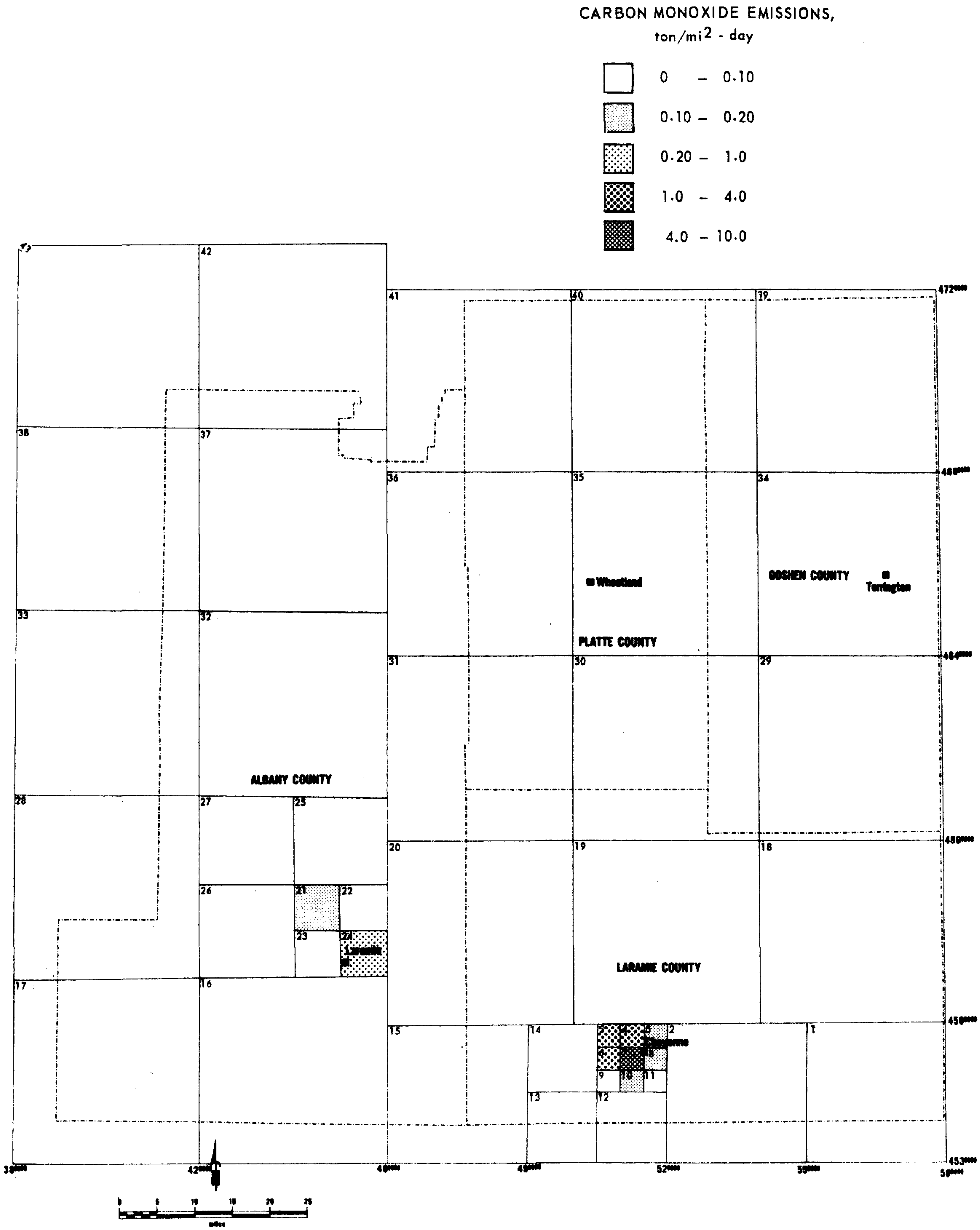

Figure 8. Carbon monoxide emission densities for the study area, 1969.

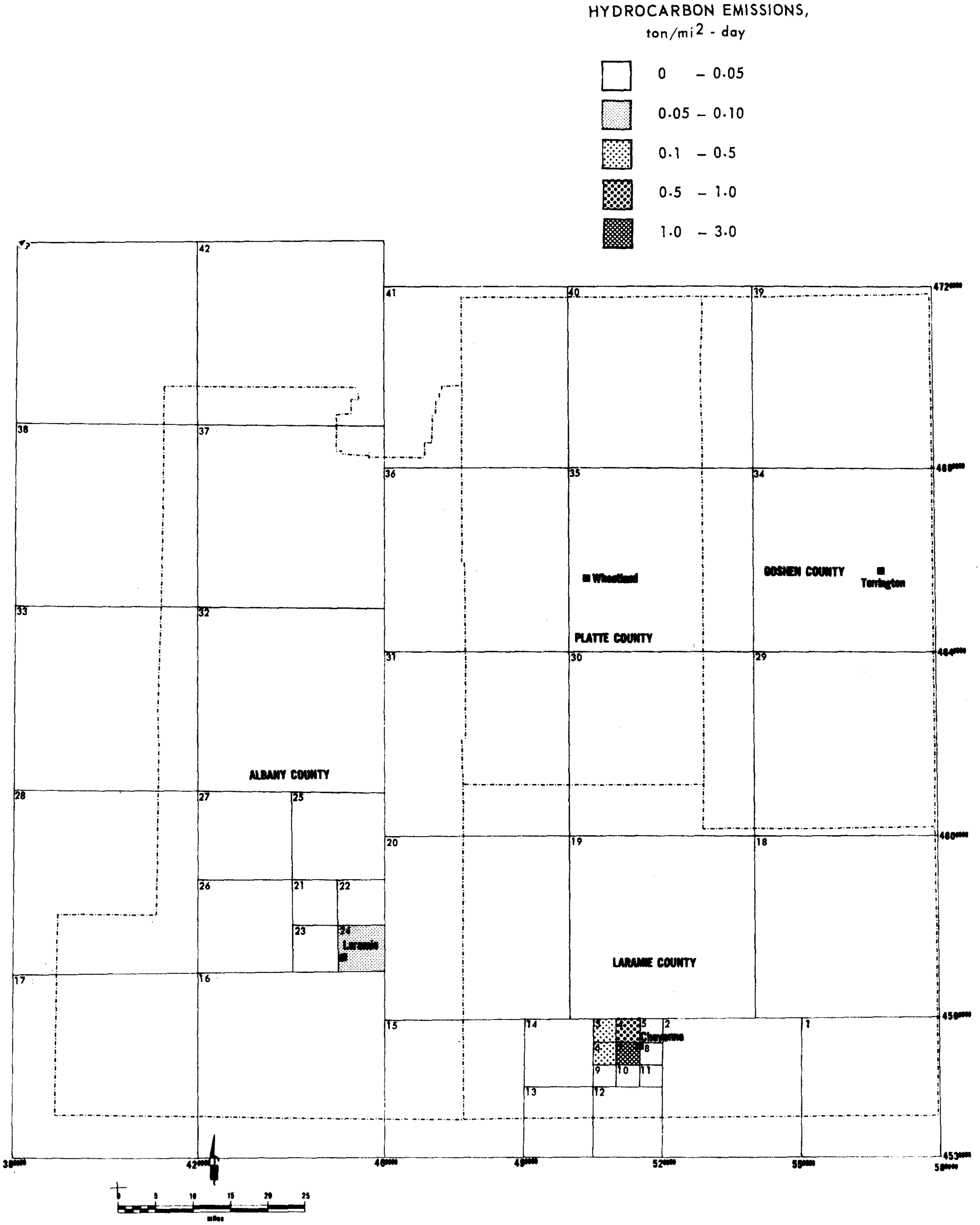

Figure 9. Hydrocarbon emission densities for the study area, 1969.

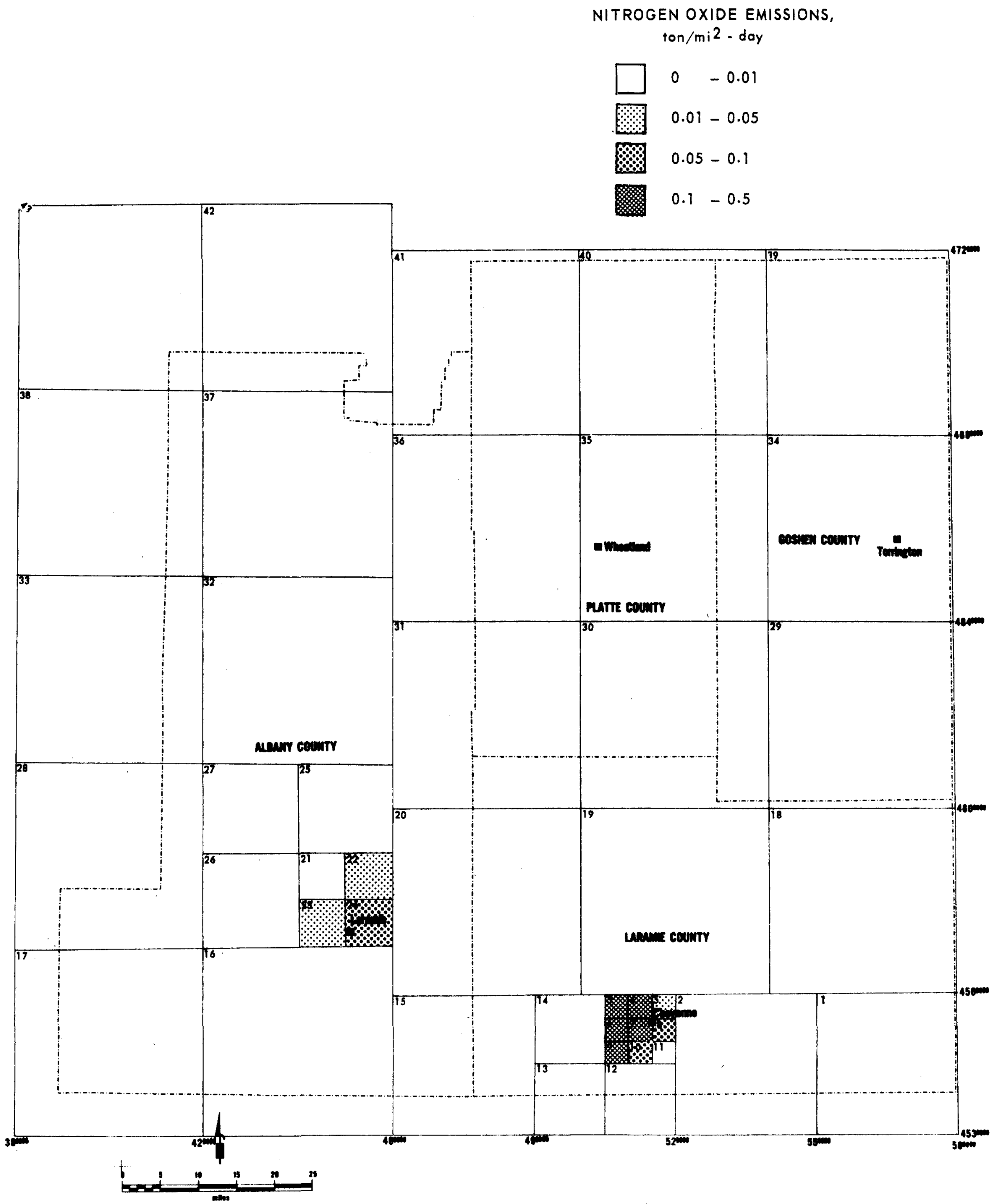

Figure 10. Nitrogen oxide emission densities for the study area, 1969.

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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

APPENDIX C

EMISSION FACTORS - WOOD WASTE

	Wigman lb/unit (dry)
Sulfur Oxides	0.2
Particulate	7
Carbon Monoxide	260
Hydrocarbons	22
Nitrogen Oxides	1.3

One unit (dry) is approximately one ton.