OCS Study
MMS 95-0040

Gulf of Mexico Air Quality Study, Final Report

Volume III: Inventory Preparation, Appendices N-P

BEST AVAILABLE COPY

Prepared by

Systems Applications International
101 Lucas Valley Road
San Rafael, California 94903

Sonoma Technology, Inc.
5510 Skylane Boulevard, Suite 101
Santa Rosa, California 95403

Earth Tech
196 Baker Avenue
Concord, Massachusetts 01742

Alpine Geophysics
P. O. Box 17344
Covington, Kentucky 41017

A.T. Kearney
225 Reinekers Lane
Alexandria, Virginia 22313

Prepared under MMS Contract
14-35-0001-30604
by
Systems Applications International
101 Lucas Valley Road
San Rafael, California 94903

Published by

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

New Orleans
August 1995

DISCLAIMER

This report was prepared under contract between the Minerals Management Service (MMS) and SAI. This report has been technically reviewed by the MMS and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Service, nor does mention of trade names or commercial products constitute endorsement of recommendations for use. It is, however, exempt from review and compliance with MMS editorial standards.

REPORT AVAILABILITY

Extra copies of the report may be obtained from the Public Information Unit (Mail Stop 5034) at the following address:

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region
Public Information Unit (MS 5034)
1201 Elmwood Park Boulevard
New Orleans, Louisiana 70123-2394

Telephone Number: (504) 736-2519 or 1-800-200-GULF

SUGGESTED CITATION

Systems Applications International, Sonoma Technology Inc., Earth Tech, Alpine Geophysics, and A. T. Kearney. 1995. Gulf of Mexico air quality study, final report. Volume III: Inventory preparation, appendices N-P. OCS Study MMS 95-0040. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La. 189 pp.

TABLE OF CONTENTS

APPENDIX N

OFFSHORE EMISSIONS INVENTORY PREPARATION

Contents

Appendix N

OFFSHORE EMISSIONS INVENTORY PREPARATION

1 INTRODUCTION

Development of a comprehensive emissions database for the Gulf of Mexico region considered the following offshore emission sources:

- oil and gas production facilities
- oil and gas support vessels
- oil and gas support helicopters
- recreational vessels
- deep draft commercial shipping
- commercial fishing
- intercoastal barges
- exploration facilities and vessels
- Louisiana Offshore Oil Port (LOOP)
- pipeline vessels
- military vessels

The offshore emission inventory that was developed includes the sources listed above for both the Outer Continental Shelf (OCS) and state waters in central and western portions of the Gulf of Mexico. The methodology for estimating emissions for these sources is described in this appendix. Platforms located in state waters are considered to be under the jurisdiction of the individual states and, as such, are included in the inventories processed for each state.

The focus of the OCS inventory was the production platform emissions related to oil and gas production processes. The major activities associated with offshore oil and gas production are extraction and processing. First, the product must be extracted from geologic formations and then processed for transport to onshore refineries. In the Gulf of Mexico, total daily OCS production rates are about 750,000 bbl/day for crude oil and 12.5 billion ft^3/day for natural gas (Steorts, August 1992).

Oil and Gas Extraction

Extraction is the recovery of oil and gas from geologic formations through the production well to the platform. Wells producing liquid hydrocarbons usually start out with sufficient natural gas pressure that they do not require artificial lift. After years of production, a well may require artificial lift to maintain previous production rates. One common method of artificial lift is formation pressure regulation, in which well pressure is maintained by reinjecting gas into the formation. Secondary extraction is sometimes practiced to obtain additional oil and gas from the reserves. Both gas injection and water injection are used in secondary extraction. Water injection involves pumping water under pressure into the reservoir by means of input wells.

Oil and Gas Processing

Oil and gas leave the wellhead as a mixture of oil, gas, water, and sand. The water and oil are usually in the form of an emulsion (stable water droplets in the oil). The gas is initially dissolved in the crude oil, but effervesces when brought to the surface at reduced pressures.

As the first processing step, gas is separated from the oil/water mixture. One separation method, which uses gravity, employs a two-phase unit. A diverter in the unit causes liquid droplets to fall out of the oil/water stream, while gas bubbles escape. Additional small liquid droplets are removed from the gas by wire mesh or closely packed plates within the two-phase vessel. The oil/water then enters a free water knockout vessel, where large water drops coalesce and settle due to gravity. The oil/water emulsion, now an emulsion with fine water droplets in oil, is treated further by using either an electrostatic separator or by injecting a demulsifying chemical. Often heat is used to reduce crude viscosity and thus reduce coalescence time. Heat input requirements for the above process can range from 11,000 to 17,000 Btu/bbl (McGregor, 1985), depending on the water content of the emulsion and the temperature increase. This heat is typically obtained from gas-fired burners, electric heaters, or turbine waste heat exchangers.

The gas stream leaving the two-phase separator is further dehydrated using a glycol dehydrate. Glycol, which absorbs the moisture in the gas stream, is mixed with the wet gas. The wet glycol stream is than regenerated using a glycol reboiler. The reboiler often uses an electric heater or waste heat.

Some platforms remove H_2S from the gas stream using a gas sweetening process. Typically, an amine (diethanolamine) solution is used to remove H_2S and CO_2 from the sour gas in an absorption tower. The acid gas stream may be flared, incinerated, or processed further to recover the sulfur.

2 SOURCES OF DATA FOR OCS

Information had to be collected regarding specific activities associated with each platform to estimate emissions from Gulf OCS oil and gas production and support activities. Approximately 3,400 platforms exist in the Gulf, falling into several types: production, satellite, living quarter, support (i.e., platforms which support a pipeline), and abandoned platforms. No stratification is available as to how many of the 3,400 platforms belong to each of these categories (Steorts, May 1993). In conjunction with MMS, three survey forms were designed to solicit the information needed to estimate emissions from production platforms, crew/supply boats, and crew/supply helicopters. MMS distributed the platform surveys to all platform operators located in OCS waters and distributed crew/supply boat and helicopter surveys to all companies servicing platforms. The information that was solicited is summarized in Tables N-1a and N-1b.

Table N-1a. Information solicited for each OCS oil and gas production platform.

	Platform Data	
Block ID	Number of oil storage tanks	1991 average daily natural gas production
Platform ID	Number of fuel storage tanks	Summer percent of annual oil production
Latitude and longitude	API gravity of crude oil	Summer percent of annual natural gas production
Number of wells	API gravity of condensate	
Total crude oil/condensate storage	1991 average daily oil production	
Total liquid fuel storage		
	Natural Gas Flare/Venting Data	
Average daily gas flared	Flare height	Venting stack height
Average daily gas vented	Flare temperature	Venting stack diameter
	Oil/Condensate Storage Tank Data	
Tank ID	Exterior color (white/ non-white)	Tank dimensions
Capacity	Exposure to sunlight (yes/no)	Type of vapor recovery controls
Average daily throughput		
	Sulfur Removal (Amine) Process Data	
Amine circulation rate	Operating pressure	Sulfur recovery unit:
Sulfur input and output concentrations	Annual hours in operation	Sulfur production rate
		Throughput
	Non-Electric Equipment Data	
Manufacturer/model number	Usage:	Power rating
Equipment type:	Air compressor	Annual fuel usage
Turbine	Generator	Annual hours in operation
Reciprocating engine	Gas compressor	
Heater	Crane	Primary hours of operation
Status:	Reboiler	Stack height
Operational	Line/process heater	Stack diameter
Emergency	Treater	Stack temperature
Standby	Fire pump	Stack exhaust flowrate
Fuel type:	Oil pump	Stack angle from horizontal
Diesel	Well pump	For glycol reboilers:
Condensate	Glycol reboiler	Average daily throughput
Natural gas		Glycol circulation rate

The data collected by the survey for the platforms were entered into three database files: a general platform database file, a platform equipment database file, and a platform crude tank database file. In the platform database, the average daily throughput information is for 1991, while all the other information that was requested is for May 1992. For the boats and helicopter databases, the survey period is from June 1991 to May 1992.

The survey responses for oil and gas production platforms were entered by MMS into Paradox database files (V3.5) for input to the OCS Platform Inventory System (OPIS), which was designed for this study to estimate emissions. OPIS is described in Section 5 of this appendix. The platform database file contains information on 1,855 platforms, corresponding to a survey response rate of approximately 85 percent. Since all of the major gas and oil production companies in the Gulf responded to the survey, these 1,855 platforms represent the majority of operational production platforms in the Gulf.

The survey responses for crew/supply boats and helicopters were entered by MMS into Paradox database files and later translated to spreadsheets for emissions-related calculations. The helicopter data were obtained from MMS in two different sets of database files, each with a unique format. Both data sets contain approximately the same information, except that one did not contain landing-takeoff (LTO) information. The response rates from the helicopter and boat surveys were 94 percent and 64 percent, respectively.

Table N-1b. Information solicited for crew and supply boats and helicopters.

Crew and Supply Boats	
Manufacturer	Monthly fuel usage (6/91 - 5/92)
Length and gross weight	Fuel type:
Type of usage:	Gasoline
Crew/supply	Diesel
Tugs	Geographical area served
Drilling	For each engine on boat:
Barge	Manufacturer and model number
Monthly hours of operation (6/91 - 5/92)	Rated capacity
Primary hours of operation	Fuel usage at rated capacity
Average time at idle at platforms during hours of operation	Annual hours in operation
Helicopters	
Manufacturer and model number	Average cruising speed
Home airport location (latitude and longitude)	Average cruising altitude
Monthly hours of operation (6/91 - 5/92)	Geographical area served
Average number of landings and takeoffs per month	For each engine on helicopter:
Fuel type:	Manufacturer and model number
Jet fuel	Rated capacity
Aviation gasoline	Fuel usage at rated capacity
	Annual hours in operation

3 EMISSIONS ESTIMATION METHODOLOGY FOR OIL AND GAS PRODUCTION PLATFORMS

This section describes the methodology used to estimate emissions for the OCS production platforms in the Gulf of Mexico. The following platform-related emission sources have been considered:

- Crude and diesel storage tanks
- Miscellaneous combustion equipment, including boilers, compressors, and pumps
- Flares
- Gas vents
- Gas sweetening
- Fugitive emissions

The methodologies used to calculate these platform-related emissions are described respectively in subsections 3.1 through 3.6.

3.1 Crude and Diesel Storage Tank Emissions

For this study, emissions from crude oil and diesel storage tanks were estimated using the equations provided in Chapter 12 of EPA's compilation document for emission factors, *AP-42* (EPA-I, 1985).

Based on standard operating practices in the Gulf of Mexico OCS, all nonpressurized storage tanks located on production platforms were assumed to be fixed roof tanks. Fixed roof tanks typically consist of a cylindrical steel shell with a permanently affixed roof which may be cone, dome, or flat shaped. These tanks are commonly equipped with a roof manhole, sampling port, gage hatch, and pressure/vacuum valve. The pressure valve is used to maintain the internal tank pressure which reduces evaporation losses and minimizes the possibility of exceeding the maximum design pressure.

Evaporation is the primary driving force for emissions from storage tanks. For fixed roof tanks, evaporation losses are quantified as breathing (or standing storage) and working losses. Breathing losses occur because of temperature changes in the atmosphere surrounding the storage tank. Each cycle of temperature change, either diurnal or seasonal, generates breathing of the gas volume above the liquid surface. As the temperature decreases, the gas volume contracts and air is drawn into the tank. When the temperature rises, the volume expands, forcing the vapor-saturated air out of the tank. During this cycle, air and vapor reach equilibrium and as the tank exhales, the lighter components of the stored liquid evaporate. These changes result in the expulsion of vapor from the tank due to expansion and contraction of the vapor phase above the liquid. The evaporation loss occurs without changes in the liquid level in the tank. Breathing losses in pounds per year are estimated using the following equation:

$$L_b = 365 \cdot V_v \cdot W_v \cdot K_e \cdot K_s$$

where V_v is the tank vapor space (ft^3), W_v is the vapor density (lb/ft^3), K_e is the vapor expansion factor (dimensionless), and K_s is the vented vapor saturation factor (dimensionless).

Working losses occur when a tank is filled or emptied. When a tank is filled, the air inside the tank is expelled. When a tank is emptied, air is drawn into the tank to replace the displaced liquid. This air becomes saturated with the organic vapor and expands. If the saturated vapor exceeds the vapor space of the tank, it is released. The total working loss in pounds per year depends on the number of turnovers, N, in a given length of time and is estimated using the following equation:

$$L_w = 0.0010 \cdot M_v \cdot P_{va} \cdot Q \cdot K_n \cdot K_p$$

where M_v is vapor molecular weight (lb/lb-mole), P_{va} is the vapor pressure at the daily average liquid surface temperature (psia), Q is the annual throughput (bbl/day), K_n is the turnover factor (dimensionless), and K_p is the working loss product factor (dimensionless).

The total emissions for the tank are a combination of the working and breathing losses:

$$\text{Total Loss } (L) = \text{Breathing Loss } (L_b) + \text{Working Loss } (L_w)$$

In order to estimate the tank emissions from the OCS inventory, several assumptions were made, as listed below.

Assumptions for Crude and Diesel Tanks:

- All OCS tanks are vertical, fixed roof tanks with flat lids that are bolted or riveted shut.
- The average tank liquid level equals half the given tank height, and the maximum liquid level in the tank is 95 percent of the tank height.
- The maximum and minimum daily average annual temperatures in the modeling region are assumed to be 78.9°F and 58.8°F. These values are based on an average of the daily average annual temperatures listed in *AP-42* (Chapter 12) for Lake Charles, Baton Rouge, New Orleans, Corpus Christi, and Houston.
- No emissions are released from pressure safety release valves.
- For tanks not painted white, an average paint factor has been assumed based on the average of all nonwhite paint factors in good condition.

Additional Assumptions for Diesel Tanks Only:

- The tank capacity is equal to the platform diesel tank total capacity divided by the number of diesel tanks on the platform.
- All diesel tanks are painted nonwhite and the paint is in good condition.
- No emission controls exist on diesel tanks.
- The tank height and radius are calculated from the diesel tank capacity by assuming the radius is one-third the tank height. The diesel tank average throughput is 3.3 bbl/day. These assumptions are based on a small sample of diesel tank data supplied by some platform operators in the Gulf.

Table N-2 lists the variables used to estimate working and breathing losses for tanks located on OCS platforms. Crude oil, fuel oil, and condensate can be stored on platforms. We have assumed that any fuel oil utilized on platforms is diesel fuel, which is modeled as Distillate Fuel Oil #2. Since only minor amounts of condensate are actually stored on the platforms, condensate tank emissions were not estimated in this study. The variables W_v, K_e, K_s, and P_{va} were estimated by assuming a daily annual average temperature range. The variables M_v and K_p are constants and are given in *AP-42*.

Table N-2. Breathing and working loss variables used to estimate emissions for tanks on OCS production platforms.[1] The variables *H*, *D*, and *N* represent the tank shell height (ft), tank diameter (ft), and tank turnover rate[2] (dimensionless), respectively.

Variable (Units)	Color	Crude Oil	Distillate #2
V_v (ft^3)	White or Nonwhite	$\pi/8\ (D^2H)$	$\pi/8\ (D^2H)$
W_v (lb/ft^3)	White	0.230	0.0019
	Nonwhite	0.229	0.0022
K_e (dimensionless)	White	0.37	0.31
	Nonwhite	0.58	0.45
K_s (dimensionless)	White	$1/(1+0.1H)$	1
	Nonwhite	$1/(1+0.09H)$	1
M_v (lb/lb mole)	White or Nonwhite	50	130
P_{va} (psia)	White	3.5	0.011
	Nonwhite	3.8	0.014
K_n (dimensionless)	White or Nonwhite	$(180+N)/6N$	$(180+N)/6N$
K_p (dimensionless)	White or Nonwhite	0.75	1.0

[1] Assuming daily annual average maximum temperature is 78.9°F and daily annual average minimum temperature is 58.8°F.

[2] Turnover rate equals 5.614 times the annual throughput (bbl/yr) divided by the maximum volume of liquid in the tank (ft^3).

To estimate emissions for crude oil storage tanks, we identified three tank operation modes as shown in Table N-3: case 1, normal crude oil storage operation; case 2, nonstorage crude oil operation; and case 3, crude oil standby storage operation.

Table N-3. Crude oil tank operation cases.

Case	Case Description	Turnover[1] (N) Restriction	Emissions Calculated
1	Normal Storage Tanks	$N < 180$	Breathing & Working
2	Nonstorage Tanks	$N \leq 180$	Breathing & 0.1 Working
3	Standby Storage Tanks	$N = 0$	None

[1] Turnover rate is 5.614 times the annual throughput (bbl/yr) divided by the maximum volume of liquid in the tank (ft^3).

The turnover restrictions given in Table N-3 are based on three distinct yearly average turnover ranges seen in the OPIS database. These ranges are on the order of 100, 1000, and 0 for cases 1, 2, and 3, respectively. In case 2, crude oil is continually flowing through the tank at a rate consistent with a static level, which results in a large turnover rate. As shown in Table N-3, both working and breathing losses were estimated for case 1. For case 2, breathing and working losses were also estimated, but the working loss was assumed to be equal to 10 percent of the normal working loss, since the tank is at a constant liquid level, resulting in minimal working losses. Emissions were not estimated for standby tanks (case 3), even though there may be some liquid in these tanks subject to evaporation.

For crude tanks, emissions were calculated only for tanks larger than 99 barrels because these were the only tanks for which information was solicited in the OCS survey. Furthermore, for crude tanks, pollution control devices were accounted for as follows:

- Vapor Recovery System: 90 percent reduction in both breathing and working losses.
- Low Pressure Inert Gas Blanket: 96 percent reduction in both breathing and working losses.
- Static Level Tank Controls: 90 percent reduction in working losses.

Table N-4 lists the Source Classification Codes (SCCs) assigned for storage tank emissions.

3.2 Platform Equipment Emissions

The general equation used to estimate process equipment emission rates for OCS platforms can be expressed as:

$$\text{Emission Rate (lb/day)} = EF \cdot FC$$

Table N-4. Storage tank standard classification codes (SCC).

Fluid Stored	Emission Type	SCC	Comments
Crude	Breathing Loss	40301010	Capacity ≤ 67,000 bbl
Crude	Breathing Loss	40301011	Capacity > 67,000 bbl
Crude	Working Loss	40301012	
Distillate #2	Breathing Loss	40301019	Capacity ≤ 67,000 bbl
Distillate #2	Breathing Loss	40301020	Capacity > 67,000 bbl
Distillate #2	Working Loss	40301021	

where EF is the emission factor (lb/unit throughput) and FC is the fuel consumption rate (unit throughput/day). Table N-5 lists the types of equipment that were surveyed. Each equipment type is further classified according to engine type (Reciprocating, Turbine, or Heater) and fuel type (Diesel, Condensate, or natural Gas). Table N-6 lists the combinations of equipment, engine, and fuel types found on the platforms as reported by the survey respondents. Only one gas compressor and line heater were reported as condensate fueled.

Compressors are used in various gas processes, including dehydration units, H_2S removal units, and process tanks that have low pressure valves. Gas turbines are primarily used to drive electric generators and sometimes gas compressors. Process heaters or treaters are used to raise the temperature in various product streams using gas-fired burners, electric motors, or waste heat from other equipment.

Table N-7 presents the emission factors used to calculate emissions by equipment, engine, and fuel classification. In this table, an "X" in the equipment type column indicates that the SCC code shown will be assigned for all equipment usages that are not explicitly listed elsewhere in the table.

Table N-5. MMS survey equipment, engine and fuel classifications.

Variable	Description	Variable	Description
Equipment Usage		**Equipment Type**	
A	Air Compressor	L	Line/process Heater
G	Generator	T	Treater
C	Gas Compressor	F	Fire Pump
R	Crane	O	Oil Pump
B	Reboiler	W	Well Pump
Y	Glycol Reboiler		
Engine Type		**Fuel Type**	
H	Heater	D	Diesel
R	Reciprocating Engine	C	Condensate
T	Turbine	G	Natural Gas

Table N-6. Combinations of equipment, engine, and fuels types observed in the database.

Equipment Usage	Engine Type	Fuel Type
Air Compressor (A)	Reciprocating	Natural Gas and Diesel
Crane (R)	Reciprocating	Natural Gas and Diesel
	Turbine	Natural Gas
	Heater	Natural Gas
Fire Pump (F)	Reciprocating	Natural Gas and Diesel
	Heater	Diesel
Gas Compressor (G)	Reciprocating	Natural Gas, Diesel, and Condensate
	Turbine	Natural Gas
	Heater	Natural Gas
Generator (G)	Reciprocating	Natural Gas and Diesel
	Turbine	Natural Gas and Diesel
	Heater	Natural Gas
Glycol Reboiler (Y)	Reciprocating	Natural Gas
	Heater	Natural Gas and Diesel
Line/Process Heater (L)	Reciprocating	Natural Gas, Diesel, and Condensate
	Turbine	Natural Gas
	Heater	Natural Gas
Oil Pump (O)	Reciprocating	Natural Gas and Diesel
	Turbine	Natural Gas
Reboiler (B)	Heater	Natural Gas
Treater (T)	Reciprocating	Natural Gas
	Heater	Natural Gas
Well Pump (W)	Reciprocating	Natural Gas and Diesel
	Turbine	Natural Gas

The following assumptions were used to estimate process equipment emissions:

- The condensate and diesel fuels used on the platforms have similar properties to Distillate Fuel Oil #2.
- The equipment on the platforms does not utilize air pollution control devices.
- If the annual fuel use (or fuel consumption) given for a piece of equipment is zero, then the equipment is driven by either waste heat, electricity, or by some means other than combustion.

Table N-7. Equipment emission factors based on SCC, engine type, equipment usage, and fuel type (EPA-I, 1985; CARB, August 1991; STAPPA, 1991).

Fuel Type	Engine Type	Equipment Usage	Emission Factors (lb/unit throughput)						SCC	AP-42 Table	Comments
			CO	NO_x	SO_x	THC	TSP	Unit			
C	H	X	5	20	28.5[a]	0.2052	2	M Gal	10200501	1.3-1	Industrial Boiler - Dist. Oil
C	R	X	130	604	40	50	43	M Gal	20200102	3.3-1	Industrial Engine ≤600 hp
D	H	L or T	5	20	28.5[a]	0.2052	2	M Gal	31000401	1.3-1	Process Heater - Dist. Oil
D	H	X	5	20	28.5[a]	0.2052	2	M Gal	10200501	1.3-1	Industrial Boiler - Dist. Oil
D	T	X	15.4	67.8	140.0	4.77	5.0	M Gal	20200101	—	Internal Combust. - Dist. Oil
D	R	X	130	604	40	49	43	M Gal	20200102	3.3-1	Industrial Engine ≤600 hp
D	R	X	111	425	28[a]	12.3	10.45	M Gal	20200401	3.4[c]	Large Bore Engine >600 hp
G	H	X	40.0	550.0	0.6	1.7	5	MMCF	10200601	1.4[d]	Utility Boiler
G	H	X	35.0	140.0	0.6	5.8	13.7	MMCF	10200602	1.4[d]	Industrial Boiler
G	H	X	21.0	100.0	0.6	11.0	12.0	MMCF	10200603	1.4[d]	Commer. & Domestic Boiler
G	H	L or T	35.0	140.0	0.6	5.8	13.7	MMCF	31000404	1.4[d]	Industrial Boiler
G	H	G	35.0	140.0	0.6	5.8	13.7	MMCF	31000414	1.4[d]	Industrial Boiler
G	R	X	620	2850	0.3[b]	1300	35	MMCF	20200202	3.2[e]	Weighted Reciprocal Engine
G	T	X	180	360	0.3[b]	56	35	MMCF	20200201	3.2[e]	Gas Turbine Prime Mover

[a] 0.2 wt % sulfur in condensate/diesel fuel.
[b] Average sulfur = 2000 grain/10^6 SCF in natural gas.
[c] Tables 3.4-1, 3.4-5, and A.3.
[d] Tables 1.4-1, 1.4-2, and 1.4-3.
[e] Tables 3.2-1 and A.3. For Pm, Tables 3.2-4 and 3.2-5.

- The heating values assumed for natural gas and condensate/diesel were 1050 Btu/ft^3 and 137 Btu/gal, respectively.

- The average sulfur content in diesel and condensate fuel is assumed to be 0.2 weight percent. The average sulfur content in natural gas is assumed to be 2,000 grains/ million ft^3.

- For prime movers (gas-powered reciprocating and turbine engines), an average particulate emission factor was calculated from Tables 3.2-4 and 3.2-5 of *AP-42* by assuming a weighted population of 66.7 percent for 2-stroke engines and 33.4 percent for 4-stroke engines. For prime movers with reciprocating gas-powered engines, a population mix of 66.7 percent 2-stroke, 16.7 percent 4-stroke-lean, and 16.7 percent 4-stroke-rich engines was assumed.

- Whenever an equipment size (or rating) was needed to apply the emission factors and the size or rating was unknown, the highest emission factors for that class of equipment were used.

External Combustion Equipment

For heaters (engine type "H"), the *AP-42* emission factors for boilers (i.e., external combustion) were used. Boilers can be further classified by their heat inputs:

Domestic and Commercial	< 10 million Btu/hr
Industrial	10 - 100 million Btu/hr
Utility	> 100 million Btu/hr

For condensate and diesel-fueled equipment (fuel types "C" and "D"), emission factors for the industrial boiler size (10–100) were used since this was the only size reported by the survey respondents. For natural-gas-fueled equipment (fuel type "G"), the reported equipment ratings were used to determine the boiler size and thus emission factors.

About 99 percent of the boilers (engine type "H") in the Gulf were reported by the survey respondents to be gas-powered. For any gas-fueled boilers in the database with unknown ratings, the utility (SCC 10200601) boiler emission factors were used to calculate emissions, since the NO_x emission factor for utility boilers is higher than any other boiler group.

Internal Combustion Equipment

For engine types "R" and "T", internal combustion emission factors were used. Both reciprocating engines and gas turbines are used in the Gulf region. Gas turbines emit less pollutants than reciprocating engines, but reciprocating engines are more fuel efficient. For reciprocating engines, platform operators reported that 53.4 percent were diesel-powered and 46.3 percent were gas-powered. One reciprocating engine was reported as condensate-powered. Operators reported that about 99 percent of turbine engines were gas-powered.

For diesel-powered reciprocating engines (Fuel "D", Engine type "R"), emission factors were assigned based on the rating of the engine. Two rating classes were used: ≤ 600 and >600 hp. For any diesel-powered reciprocating engines with unknown ratings, the emission factors corresponding to SCC 20200102 (engines with less than or equal to 600 hp ratings) were used. The one condensate-powered reciprocating engine reported was ≤ 600 horsepower.

Table N-7 shows the resulting emission factor assignments for internal combustion equipment.

3.3 Platform Flares

A flare is a burning stack which is used for disposal of hydrocarbon vapors. Flares usually operate continuously; however, some flares are only used for process upsets, when flaring becomes necessary for safety reasons.

THC, NO_x, and CO emissions from flaring of natural gas were calculated using the following equation:

$$\text{Emissions Rate (lb/day)} = EF \cdot HV \cdot FC$$

where EF is the emission factor (lb/million Btu), HV is the heating value (Btu/ft^3), and FC is the fuel consumption rate (gal/day or million ft^3/day). The following emission factors from *AP-42* (Section 11.5) were used:

EF_{THC} = 0.14 lb/million Btu
EF_{NOx} = 0.068 lb/million Btu
EF_{CO} = 0.37 lb/million Btu

The heating value of natural gas was assumed to be 1050 Btu/ft^3.

Any sulfur compounds in the flare gas are converted to SO_2 when burned. The amount of SO_x emitted depends directly on the quantity of sulfur in the flared gases. For this inventory, the H_2S concentration was assumed to equal 2,000 grains/million ft^3, which corresponds to a SO_x emission factor of 0.3 lb/million ft^3. This concentration is comparable to that of commercially available natural gas. Particulate emissions for natural gas flaring are negligible.

Operators in the Gulf of Mexico define process gas piped through a flare as flared, regardless if the flare is ignited. Obviously, the emissions from a flare differ depending on whether or not the flare is ignited. In order to estimate the emissions, flares were classified into two different operational modes: ignited and nonignited. For this inventory, a flare (ignited) was distinguished from a vent (nonignited) by the flare temperature. If the reported flare temperature was below 250°F, the flare was assumed to be nonignited and thus acting as a vent. The temperature of 250°F was selected based on review of the values included in the flare temperature field in the platform database. From these data, nonignited flares or vents have gas temperatures on the order of 100°F or less, while ignited flares have temperatures closer to 1,000°F; there appeared to be no flare temperature data close to the 250°F range. The emissions factors used for gas venting (or nonignited flares) are described in the following section. The SCC code assigned for ignited flares is 31000205.

3.4 Gas Venting

A vent is basically a pipe that extends above the top of a platform and carries moderate amounts of unburned waste hydrocarbons. For safety reasons, only platforms that handle sweet gas use this type of system for gas disposal. As reported by Gulf of Mexico platform operators, up to 2 percent of the natural gas throughput is vented. A few platforms in the Gulf of Mexico reported that up to 10 percent of the gas throughput is vented. The amount of pollutants emitted by a vent depends on the characteristics of the gas and oil being produced. Since platform-specific characteristics of gas and oil were not available, the average natural gas composition shown in Table N-8 was assumed.

Table N-8. Examples of natural gas compositions (wt pct) in the Gulf of Mexico OCS.[a]

Species	Example A[b]	Example B[b]	Normalized Average Composition
Methane	97.5	83.402	90.45
Ethane	0.2	6.732	3.47
Propane	0.7	4.564	2.63
iso-butane	0.1	1.079	0.59
n-Butane	0.1	1.733	0.92
n-Pentane	—	0.690	0.35
iso-Pentane	0.3	0.650	0.48
n-Hexane	—	0.126	0.06
iso-Hexane	—	0.201	0.10
Heptanes	0.1	0.186	0.143
Benzene	—	0.005	0.003
Toluene	—	0.005	0.003
Octanes	—	0.085	0.043
Nitrogen	0.3	0.441	0.371
Carbon dioxide	0.7	0.099	0.40
Hydrogen sulfide	0.0	0.0	0.0
Ethylene benzene	—	0.001	0.001

[a] Examples A and B from personal communication, W. Steorts, Nov. 2, 1992.
[b] "—" indicates no data given; for average composition calculation, "—" = 0.

The emission rate of hydrocarbons (lb/unit time) for vented gas is equal to the product of gas flow rate (ft^3/unit time) and the gas density (lb/ft^3). The average natural gas composition shown in Table N-8 was used to calculate the natural gas density, and the Ideal Gas Law was used to estimate the individual gas densities at 20°C and atmospheric pressure of the natural gas components. For each of the components, the calculated individual densities were then multiplied by the mass fraction of each component in the mixture to yield a calculated average natural gas density of 0.047 lb/ft^3.

Based on the vent stack height, some vents release gas below the water surface (i.e., vent stack height equals a negative number in the database). When a process stream is vented underwater, some of the hydrocarbons will be absorbed in the water column. For these vents, a worst case scenario was assumed and no adjustments were made to the emission rate.

For vents, the SCC assigned is 99000030. This is an internal code specific to the OPIS system, and does not correspond to the EPA SCC definitions. The internal SCC was used to distinguish between emissions from ignited and nonignited flares.

3.5 Gas Sweetening (Amine Process)

Some platforms produce natural gas containing unacceptable amounts of hydrogen sulfide (H_2S), which must be removed before the gas can be sold to consumers. Some platform operators chose to remove the sulfur on the platforms, while others pipe the sour gas onshore for onshore sulfur removal. The most widely used method for H_2S removal ("gas sweetening") is the amine process, in which various amine solutions are used to absorb H_2S. After the H_2S gas has been separated from the natural gas using the amine process, it may be vented, flared, incinerated, or used for feedstock in elemental sulfur production.

Emissions result from gas sweetening only if the acid waste gas from the amine process is flared or incinerated. When flaring, the major pollutant of concern is sulfur dioxide. Most facilities use elevated smokeless flares or tail gas incinerators to ensure complete combustion of all waste gas constituents. Little particulate, smoke, or hydrocarbon emissions result from these devices. Since the gas temperatures usually do not exceed 1,200°F, significant qualities of NO_x are not formed (EPA-I, 1985). For platforms with amine processes, it was assumed that all of the gas throughput on the platform is processed through the sweetening plant before leaving the platform, and that the H_2S is destroyed by flaring.

The concentration of H_2S in natural gas in the Gulf had to be determined in order to estimate SO_x emissions from the sweetening plants. West of Timbailer Bay (Louisiana), the concentration of H_2S in natural gas is usually assumed negligible. East of Timbailer Bay, H_2S is sometime present in the natural gas produced, therefore an average regional H_2S concentration was assumed. The value of 2000 grains/million ft^3 which was used to estimate emissions for flares and vents is not valid for the gas sweetening process, since this concentration is not above the acceptable standard. To estimate the H_2S content in the Gulf region, the weighted average H_2S concentrations in the Alabama (Mobile), Florida (Pensacola, Panama City), Mississippi (Southern Mississippi), and Texas (Corpus Christi-

Victoria) were averaged from Table 9.2-2 of Section 9.2 of *AP-42*. The resulting regional weighted average H_2S concentration was 1.3 mole percent.

Assuming a flaring system, the emissions rate from the amine process is given by:

$$\text{Emissions Rate (lb/day)} = \text{EF} \cdot \text{TGP}$$

where EF is the emission factor (lb/million ft^3) and TGP is the total gas sweetened through the amine process (million ft^3/day). The emission factor for SO_x equals $1685 \cdot S$ lb/million ft^3 (EPA-I, 1985). The parameter S is defined as the molar percentage sour gas H_2S content, which corresponds to a SO_x emission factor equal to 3200 lb/million ft^3 based on the regional average 1.3 mole percent H_2S. The amine process flaring systems were assumed to operate so as to minimize the emissions of the other species; accordingly, emissions of other pollutants are assumed negligible. The SCC assigned to this emission source was 31000201.

3.6 Fugitive Emissions

Several methods are used by industry to estimate fugitive emissions. These are briefly described below (Davenport and McGregor, 1987).

SOCMI Factors. The SOCMI (Synthetic Organic Chemical Manufacturing Industry) method is the simplest approach to calculating fugitive emissions. In this method, the number of emission sources per stream type are added together and multiplied by an emission factor. Emission rates for all of the sources per service are then summed to yield the total process emission rate. There are no corrections for process conditions or equipment size. The major advantage of this method is that no field measurements are needed to estimate fugitive emissions. The major disadvantage of this method is that the emission estimate is usually overly conservative.

Leak/No Leak Factors. This method was used by the EPA to determine the average SOCMI factors described above. For this method, the number of leaking and nonleaking sources are counted using EPA Method 21. A leaking component is defined as having a concentration of 10,000 ppm or greater. The measured percentage of leaking and nonleaking sources is applied to the EPA-determined leak/no leak emission factors to develop the overall fugitive emission factors. The overall emission factor is the product of the percentage of nonleaking sources and the nonleaking emission factor plus the product of the percentage of leaking sources and the leaking emission factor. The fugitive emission rate is then determined by multiplying the number of sources by the overall emission factor.

Leak Concentration Factors. This method estimates an emission rate for each source based on the maximum measured concentration at the leak. These emission rates are summed to estimate the total emission rate for the facility.

Unit-Specific Factors. This method is the most labor intensive, but is also the most accurate. Actual measured emission rates are determined by bagging sources; the measured rates are then added together to estimate total fugitive emissions.

Mass Balance. Inside buildings, the fugitive losses from a process can be measured by the exhaust air flow and inlet and outlet concentrations of the fugitive compound. The mass balance method is never used when the chemical is either a raw material or a product component because of large measuring errors. This method is accurate only when the fugitive emission rate is large relative to errors in the measurements.

Ideally, one of these methods could be used to estimate fugitive emission rates for the Gulf of Mexico OCS platforms. However, because of the large number of platforms and therefore components (e.g., the number of components per platform can be as high as 25,000) located in the OCS, these methods were not feasible given the scope of this study. Thus, in order to estimate the fugitive emission rates, a simple model was needed that utilizes available data. One such model, which uses platform production rates, is called the Platform-Oriented Model (POM) (MMS, 1992).

The POM model was developed from a database of seven Pacific OCS oil and gas production platforms. The Pacific platforms range in size from 1.4 to 62 million ft^3/day for gas production and 30 to 23,880 bbl/day for oil production. POM is simply a regression of these seven platform fugitive emission rates versus the platform production rates. The regression model is given by the following relationship:

$$\text{Fugitive Emission Rate (lb/day)} = 24.3 + (0.677 \cdot GP) + (0.0025 \cdot OP)$$

where GP is the gas production rate in million ft^3/day, and OP is the oil production rate in bbl/day. The model developers recommend that platforms being modeled using POM should correspond realistically to the sample population of platforms from which the model was developed (i.e., the seven Pacific OCS platforms).

The exact differences between the Pacific and Gulf OCS facilities have not been quantified, but they include differences in operating practices, product ratio (e.g., Gulf platforms produce primarily natural gas, while Pacific platforms produce primarily crude), and platform configurations. Furthermore, the Pacific production rates used to develop POM are smaller than those in the Gulf by approximately one order of magnitude. Despite these differences, POM was still chosen to estimate fugitive emission rates for the Gulf OCS platforms because it is the most applicable model based on the information available.

About a decade ago, it was shown that facilities in the Gulf of Mexico have fugitive emission rates per component which are approximately double the Pacific OCS fugitive emissions rates. This difference may be greater today, since the average fugitive emission rates for Pacific OCS facilities have been reported to decrease by about 75 percent over the last 10 years (Eaton et al., 1980; MMS, 1992). This information suggests that the POM model underestimates fugitive emissions in the Gulf Region. In a recent study on the fugitive emissions rate of a Gulf OCS production facility (Jelinek et al., 1993), the authors estimated a fugitive emission rate of 16.2 ton/yr using a site-specific correlation equation based on the Organic Vapor Analyzer reading. As a comparison, based on the daily average 1991 production rates of 7,513 bbl/day and 35.1 million ft^3/day, POM predicts a fugitive emission rate of 12.1 ton/yr for this platform. In the Jelinek study, fugitive emissions were measured for only one platform. Accordingly, this comparison is by no means is a validation or invalidation of the Platform-Oriented Model for Gulf OCS platforms.

A FORTRAN routine was written to apply the POM model to the OCS inventory and generate an EPS 2.0 compatible AFS workfile. The SCC assigned for platform fugitive emissions is 31088801.

4 EMISSIONS ESTIMATION METHODOLOGY FOR OTHER OCS SOURCES

In addition to the emission sources located on the OCS platforms, there are a number of other sources for which emissions must be estimated to develop a comprehensive inventory of emissions in the Gulf of Mexico OCS. Some are directly associated with oil and gas production:

- crew and supply support vessels
- crew and supply support helicopters
- exploration facilities and vessels
- pipeline vessels

Others are not related to oil and gas production but must also be addressed in the OCS inventory:

- the Louisiana Offshore Oil Port (LOOP)
- recreational vessels
- deep draft commercial shipping
- commercial fishing
- intercoastal barges
- military vessels

The information needed to estimate emissions from marine sources was compiled by A. T. Kearney, Inc., and submitted to SAI for inclusion in the OCS inventory in a report entitled *Baseline Offshore Emissions from Marine Sources in the Gulf of Mexico*, prepared in March 1993. The sections of this report relevant to the emission source categories listed above have been reproduced and included in this document as attachments, starting on page N-45:

Attachment A: Support vessels
Attachment B: Survey and exploration vessels
Attachment C: Louisiana offshore oil port (LOOP)
Attachment D: Recreational vessels
Attachment E: Deep draft commercial shipping

Attachment F: Commercial fishing
Attachment G: Intercoastal barge

4.1 Crew and Supply Support Vessels

Platform crews require periodic supply deliveries as well as equipment to maintain drilling operations. Crew and supply boats shuttle workers and supplies to and from a number of staging areas along the coast. Crew boats are typically small, speedy vessels (e.g., 100 feet in length) while supply boats are generally larger (120 to 250 feet long) and operate similarly to crew boats except that they carry supplies rather than personnel.

The emission factors used to estimate crew and supply vessel emissions are summarized in Table N-9. Crew and supply vessels are typically powered by diesel engines. The vessels identified in the survey were classified into the following categories: crew boats, supply boats, tugboats, and barges. The diesel engine ratings shown in Table N-9 are derived from the Crew and Supply Boat Database described in Section 2 of this appendix.

Annual emissions from support vessels in the Gulf of Mexico were estimated using the following formula:

$$\text{Emission Rate} = EF \cdot FC$$

where EF is the emission factor in kilograms per thousands of liters of fuel and FC is the fuel consumption rate in thousands of liters per year. For support vessels, the fuel consumption rates derived from the Crew and Supply Boat Survey are included in Table N-9. Attachment A provides a detailed description of the methodology used to estimate emissions for oil and gas support vessels.

4.2 Crew and Supply Support Helicopters

Support helicopters function similarly to crew and supply boats. Both serve as shuttles for workers and supplies to and from staging areas along the coast to OCS platforms.

Helicopter emissions for the MMS Gulf region were calculated based on two sets of Paradox files provided to SAI by MMS. These files contain data collected by MMS for individual helicopters operated by various companies. For each helicopter, the location of its home base and the area in the Gulf it services is provided, as well as daily hours of operation, and fuel usage and hours of operation by month. Data contained in the files include average flights per month for each helicopter, as well as supplementary information on the makes and models of the engines used in the various helicopter types.

The first step in the emissions estimation process was to conduct a literature search to determine the availability of emission factors for helicopters. Although *AP-42* includes landing-takeoff (LTO) time-in-mode data, it does not list emission factors for helicopters. Instead, helicopter emission factors developed by the South Coast Air Quality Management

Table N-9. Emission factors for oil and gas support vessels. (Source: EPA, 1991; MMS, 1992)

	Pollutant (kg/1,000 L of fuel)					Fuel Consumption	Pollutant (kg/hr)				
Vessel Type	NO_x	HC	CO	SO_x	TSP	(1,000 L/hr)	NO_x	HC	CO	SO_x	TSP
Crew Boats (Diesel Engine—Average 480 hp)											
Hotelling/Idle	40.39	6.78	7.06	0.15	2.03	0.01	0.32	0.05	0.06	0.00	0.02
Cruise	46.58	6.11	5.66	0.15	2.03	0.04	2.05	0.27	0.25	0.01	0.09
Full Power	32.92	2.51	7.00	0.15	2.03	0.08	2.63	0.20	0.56	0.01	0.16
Supply Boats (Diesel Engine—Average 868 hp)											
Hotelling/Idle	20.01	2.01	7.44	0.15	2.03	0.01	0.28	0.03	0.10	0.00	0.03
Cruise	35.90	2.05	9.68	0.15	2.03	0.08	2.76	0.16	0.75	0.01	0.16
Full Power	35.90	2.87	7.30	0.15	2.03	0.14	5.03	0.40	1.02	0.02	0.28
Tugboats (Diesel Engine—Average 2,234 hp)											
Hotelling/Idle	44.63	2.87	14.65	0.15	2.03	0.04	1.73	0.11	0.57	0.01	0.08
Cruise	74.56	2.87	5.34	0.15	2.03	0.21	15.99	0.62	1.14	0.03	0.44
Full Power	56.48	2.01	28.44	0.15	2.03	0.39	22.03	0.78	11.09	0.06	0.79
Barges (Diesel Engine—Average 308 hp)											
Hotelling/Idle	40.39	6.78	7.06	0.15	2.03	0.01	0.28	0.05	0.05	0.00	0.01
Cruise	46.58	6.11	5.66	0.15	2.03	0.04	1.79	0.24	0.22	0.01	0.01
Full Power	32.92	2.51	7.00	0.15	2.03	0.07	2.30	0.18	0.49	0.01	0.14

District of California were used (SCAQMD, 1991). The SCAQMD document lists emission factors by LTO cycle for a number of helicopter types, but does not provide emission factors for the cruise mode. Cruise mode emission factors were obtained by assuming that the "climb" mode factors approximate the cruise mode (Ewars, 1992). For helicopter types in the Gulf, for which no emission factor data were available, the Helicopter Specification Book (HeliValue$, 1990) was used to assign surrogate helicopter types for which emission factors were available.

To calculate the annual emissions for the LTO mode, the annual number of LTOs was multiplied by the appropriate emission factor (lb/LTO) for that helicopter type. To calculate cruise mode emissions, the annual time spent by each helicopter in cruise mode had to be determined, since the emission factors for cruise mode are specified in pounds per hour. First, the total monthly hours of operation for each helicopter in the database were summed to calculate total hours per year. The total time spent in LTO mode was then subtracted to estimate annual hours in cruise mode. *AP-42* (Section II-1) indicates that one helicopter LTO cycle takes a total of 20 minutes, so the annual time in LTO mode in hours was calculated by multiplying the annual number of LTO cycles by 0.333. The annual cruise mode time estimate was then multiplied by the appropriate emission factor (lb/hr) to estimate annual emissions from cruise mode. Some helicopters proved to have a very high number of LTOs per hour of use ratio, so their estimated time in cruise mode was zero.

The second set of data obtained from MMS contained no LTO data, so an average number of LTOs per hour of operation was estimated based on the information from the first data set. This average, which was 1.8 LTOs per hour, was multiplied by the annual hours of operation for each helicopter to estimate annual LTOs. Emissions for LTO mode and cruise mode were then calculated exactly as they were for the first data set. Table N-10 contains the emission factors used to estimate the OCS crew/supply helicopter emissions.

4.3 Geophysical Surveying and Exploration Vessels

Exploration includes all activities undertaken to determine whether commercial quantities of oil and gas are present in a geographic area. The two major activities associated with exploration are geophysical surveying and exploratory drilling. The types of vessels associated with exploratory drilling are drillships, jack-up rigs, and semisubmersible rigs.

In addition to emissions from the diesel engines which drive them, exploratory drilling vessels have emissions related to drilling. Diesel engines on these vessels also power prime movers (i.e, primary generator sets), mud pumps, and the drawworks. The prime movers are powered by diesel engines which range from 1,000 to over 3,500 horsepower.

Geophysical surveying is used to identify areas with potential oil and gas reserves. Seismic or geophysical survey vessels are typically powered by diesel engines. Table N-11 lists emission factors for seismic and survey vessels with engines rated at an average of 766 hp.

A detailed description of the methodology used to estimate survey vessels emissions is given in Attachment B.

Table N-10. Helicopter LTO and cruise emission factors by helicopter type and engine (SCAQMD, 1991; Ewars, 1991).

Helicopter Type	Engine Type	LTO (lb/LTO)			Cruise (lb/hr)		
		CO	THC	NO_x	CO	THC	NO_x
Bell 206 L3	Allison 250 C30P	1.40	0.21	0.19	2.21	0.09	1.46
MBB B0105CBS	Allison C20B	2.80	0.41	0.38	4.42	0.18	2.92
Aerospatiale SA365N	Lycoming LTS101	1.92	0.84	0.86	1.66	0.06	5.78
Bell 206 B3	Allison 250 C20J	1.40	0.21	0.19	2.21	0.09	1.46
Bell 412	PW PT6-3B	4.00	5.04	1.97	2.92	2.94	9.82
Bell 212	PW PT6-3B	4.00	5.04	1.97	2.92	2.94	9.82
Aerospatiale AS355	Allison C20B	2.80	0.41	0.38	4.42	0.18	2.92
Bell 206	Allison 250 C28	1.40	0.21	0.19	2.21	0.09	1.46
Sikorsky S76	Allison 250 C30S	2.80	0.41	0.38	4.42	0.18	2.92
Bell 214ST	GE CT7-2A	0.92	1.09	1.11	2.00	0.20	5.00
Sikorsky 576	Allison C30	2.80	0.41	0.38	4.42	0.18	2.92
Sikorsky 76AT	Arriel 1S	1.92	0.84	0.86	1.66	0.06	5.78

4.4 Pipeline Vessels

Each pipeline installation or repair activity, involving vessel support, may last from a few weeks to a few months. Several types of vessels are needed when installing a new pipeline, such as pipeline lay barges, anchor handling tugs, pipe hauling tugs, burying tugs, tie-in tugs, and crew/supply boats. Combustion equipment that emits criteria pollutants is operated on these vessels. For example, the pipeline lay barge may employ generators, anchor winches, air compressors, welding machines, and deck and sea cranes in addition to the main engines.

Since there is no documented information regarding typical pipeline operations, the following gross assumptions were made to estimate emissions (Steorts, May 1993):

- Pipeline operations need six vessels to install 300 ft of pipeline per day.
- Each pipeline vessel consumes 50 bbl (2,100 gal) of diesel fuel per day.
- The average diesel-powered vessel engine is 1200 hp.

Table N-12 shows the emission factors used for pipeline vessels; the total pipeline miles installed in the Gulf from 1984 to 1991 are given in Table N-13.

Table N-11. Emission factors for geophysical surveying and exploration vessels. (Source: EPA, 1991; Ocean Industry, 1992; MMS, 1992)

Vessel Type	Pollutant (kg/1,000 L of fuel)					Fuel Consumption (1,000 L/hr)	Pollutant (kg/hr)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Seismic/Survey											
Primary Engine Avg. 766 hp Maneuver/Cruise	35.90	2.05	9.68	0.15	2.03	0.04	1.49	0.08	0.40	0.01	0.08
Drillship											
Primary Engine Avg. 2,500 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25
Pumps Avg. 1,600 hp (75% load)	74.56	2.87	5.34	0.15	2.03	0.12	9.22	0.36	0.66	0.02	0.25
Drawworks Avg. 3,000 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25
Jack-up											
Primary Engine Avg. 1,600 hp (75% load)	74.56	2.87	5.34	0.15	2.03	0.12	9.22	0.36	0.66	0.02	0.25
Pumps Avg. 1,600 hp (75% load)	74.56	2.87	5.34	0.15	2.03	0.12	9.22	0.36	0.66	0.02	0.25
Drawworks Avg. 2,000 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25
Semisubmersible											
Primary Engine Avg. 2,034 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25
Pumps Avg. 1,600 hp (75% load)	74.56	2.87	5.34	0.15	2.03	0.12	9.22	0.36	0.66	0.02	0.25
Drawworks Avg. 3,000 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25

Table N-12. Emission factors for Louisiana offshore oil port. (Source: EPA, 1985 and 1991; CARB, 1991a,b; Kludjian, 1993; LOOP, Inc., 1993)

Vessel Type	Pollutant (kg/1,000 L of fuel)					Fuel Consumption (1,000 L/hr)	Pollutant (kg/hr)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Steam Propulsion											
Hotelling	4.37	0.380	n/a	0.382	1.20	0.70	3.06	0.27	0.000	0.27	0.84
Maneuver/Cruise	6.70	0.082	0.414	0.382	2.40	3.85	25.80	0.316	1.594	1.471	9.24
Full Power	7.63	0.206	0.872	0.382	6.78	7.00	53.41	1.442	6.10	2.674	47.46
Diesel Motor Propulsion											
Hotelling, Auxilliary Diesel Engines 500 kW (50% load)	35.10	9.80	5.76	3.20	2.03	0.08	2.81	0.78	0.46	0.26	0.16
Maneuver/Cruise	65.81	2.87	7.30	0.38	3.95	1.96	128.99	5.63	14.31	0.74	7.74
Full Power	65.81	2.87	7.30	0.38	3.95	3.56	234.30	10.22	25.99	1.34	14.06
Primary Diesel Propulsion (7,300 hp)											
All Operating Modes	65.81	2.87	7.30	0.38	3.95	1.19	78.57	4.43	8.71	0.45	4.71
Diesel Generator 1,000 kW (50% load)	70.12	19.60	11.51	6.46	4.07	0.23	15.95	4.46	2.62	1.47	0.93

Table N-13. Emission factors used for pipeline vessels assuming vessel emission factors for inland tugboats/tows at 1,200 hp (EPA, 1991).

Operating Mode	Emission Factor (kg/1000 L of fuel)				
	NO_x	THC	CO	SO_x	TSP
Full Power	35.90	2.87	7.30	0.15	2.03

4.5 The Louisiana Offshore Oil Port (LOOP)

The Louisiana Offshore Oil Port (LOOP) is the only deepwater port in the Gulf of Mexico. It is located approximately 19 miles off the Louisiana shoreline in 115 feet of water in Grand Isle Block 59. The port provides offshore terminal facilities for offloading crude oil from tankers which are too large for conventional ports. The LOOP currently consists of three single-point moorings, pipelines, a pumping platform, and a control platform.

There are three major types of emissions sources associated with the LOOP: tanker engines, tanker ballasting operations, and platform pump engines and generator.

The tanker engine emissions are estimated using the relationship

$$\text{Emission Rate} = EF \cdot VH$$

where EF is the emission factor in kg/hr and VH is the annual vessel hours. Table N-14 presents the emission factors used to estimate emissions for the LOOP. Annual vessel hours were estimated based on

- number of vessels (Rollins, 1993)
- shipping lane length in each lease block (MMS, 1989)
- average rate of speed of a vessel (Rollins, 1993)
- operating mode (Rollins, 1993)
- propulsion type (LMIS, 1992)

For ballasting operations, emissions are generated after the oil cargo is offloaded from the tanker and the tanker tanks are refilled partially with water to offset oil weight loss. The average VOC emissions vented at the LOOP from ballasting operations were estimated at 2.13 tons per tanker (USDT, 1976).

The emissions from the LOOP platform pump engines and generator were estimated by assuming a combined total of 13,500 hours of diesel engine operation (Rollins, 1993). The emission factors for the 7,300 horsepower diesel engines are also shown in Table N-14. Attachment C provides a detailed description of the methodology used to estimate LOOP emissions.

Table N-14. Total pipeline installed between 1984 and 1991 (Steorts, April 1993).

Year	Total Pipelines Installed	Pipeline Installed (miles)
1984	285	–
1985	276	–
1986	212	–
1987	237	715
1988	225	654
1989	242	757
1990	313	803
1991	278	843
Average	259	736

4.6 Recreational Vessels

Recreational boating in the Gulf of Mexico can be stratified into two basic type of activities, boating and fishing. Both primarily involve privately owned vessels. They include:

Recreational Boating
- cruising
- swimming
- racing
- waterskiing
- diving

Recreational Fishing
- deep sea fishing (trawling)
- coastal-oriented fishing (drift fishing and trawling)

Recreational vessels are typically powered by three type of engines: 2-stroke gasoline outboards, 4-stroke gasoline inboard/sterndrives, and diesel inboards. Table N-15 contains the emission factors used for both gasoline and diesel recreation vessel engines. In order to estimate total emission factors by fuel type, emission factor data for each gasoline engine type were aggregated to represent a composite data set for all gasoline engines. To derive these data, the emission factor data for each gasoline engine type were weighted based on the percentage of recreational boats classified as gasoline outboard, inboard, and inboard/sterndrive based on information from the U.S. Coast Guard survey (USCG, 1991). From this study, it was also estimated that the recreational vessel fleet is composed of 75.7 percent gasoline-powered engines and 24.3 percent diesel-powered engines.

The total emissions were estimated from

$$\text{Emission Rate} = EF \cdot FC$$

Table N-15. Emission factors for recreational boating. (Source: EPA, 1991)

Engine Type	Pollutant (kg/L)					Fuel Consumption (1,000 L/hr at 75% power)	Pollutant (kg/hr)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Gasoline											
2-Stroke Outboard (avg. 25 hp)	0.003	0.262	0.381	0.001	0.013	11.60	0.04	3.03	4.42	0.01	0.15
4-Stroke Inboard (avg. 162 hp)	0.012	0.029	0.431								
Diesel											
Inbound (avg. 172 hp)	0.046	0.06	0.010	0.003	0.003	32.25	1.47	0.21	0.32	0.10	0.09

where EF is the emission factor (kg/1000 L) and FC is the fuel consumption rate (1000 L/yr). The fuel consumption rate in each OCS lease block area was estimated as follows:

- The total fuel used in each state was obtained from the National Recreational Boating Survey (USFWS, 1992).

- Marine fuel consumption was adjusted by the number of registered boaters in coastal counties (Thorndale, 1993; LDWFP, 1993; Jordan, 1993; Allen, 1993).

- 58 percent of recreational vessels were assumed to be used for fishing, and 42 percent were assumed to be used for recreational boating (Nichols and Goldbloom, 1989).

Attachment D provides a detailed description of the methodology used to estimate recreational boating emissions.

4.7 Deep Draft Commercial Shipping

Deep draft commercial shipping refers to cargo carrying, oceangoing steam and motor vessels of 1,000 gross tons or more; these include freighters, bull carriers, and tankers.

Commercial vessels are powered by two types of engines: steam and diesel propulsion systems. Steam propulsion systems are typically found in older vessels, whose engines range from about 5,000 to 26,000 hp (CARB, 1991b). Based on this range, an average steamship in commercial service would be rated at approximately 15,500 hp. Deep draft commercial vessels with diesel engines are typically powered by large, low-speed diesel engines which commonly burn residual or bunker fuel oil. The low-speed two-stroke engines range in size from about 1,350 to 67,000 hp (CARB, 1991b).

The total emissions were estimated from

$$\text{Emission Rate} = EF \cdot VH$$

where EF is the emission factor in kilograms per hour and VH is the annual vessel hours. The annual vessel hours in the OCS region were estimated from

- number of vessels (USDACE, 1991; USDC, 1990)
- shipping lane length in each Fips area (MMS, 1991)
- average rate of speed of a vessel (USDT, 1991)
- operating mode
- propulsion type

Table N-16 shows the fuel consumption and emission factors used for commercial deep draft shipping. A detailed description of the methodology used to estimate commercial shipping emissions is given in Attachment E.

Table N-16. Emission factors for deep draft commercial shipping. (Source: EPA, 1985, 1991; CARB, 1991a,b; Kludjian, 1993).

Operating Mode	Pollutant (kg/1,000 L of fuel)					Fuel Consumption (1,000 L/hr)	Pollutant (kg/hr)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Steam Propulsion											
Hotelling	4.37	0.380	0.000	0.382	1.20	0.340	1.486	0.129	0.000	0.130	0.408
Maneuver/Cruise	6.70	0.082	0.414	0.382	2.40	1.890	12.660	0.155	0.782	0.722	4.540
Full Power	7.63	0.206	0.872	0.382	6.78	3.440	26.250	0.709	3.000	1.314	23.320
Diesel Motor Propulsion											
Hotelling, Auxilliary Diesel Engines 500 kW (50% load)	35.10	9.80	5.76	3.20	2.03	0.08	2.81	0.78	0.46	0.26	0.16
Maneuver/Cruise	65.81	2.87	7.30	0.38	3.95	1.19	78.45	3.42	8.70	0.45	4.71
Full Power	65.81	2.87	7.30	0.38	3.95	2.17	142.68	6.23	15.82	0.81	8.56

4.8 Commercial Fishing

Commercial fishing in the Gulf of Mexico takes place in open waters as well as in the bays and estuaries along the coastline. The shrimp fishing industry is predominant in the Gulf region. Major fishing activities include

- offshore and inshore shrimp fishing
- offshore reef fishing
- offshore pelagic line fishing
- inshore oyster fishing
- inshore crab fishing
- inshore fishing for miscellaneous finfish

Fishing vessels have a wide variety of sizes, types, and operating characteristics. Commercial fishing vessels are powered by three types of engines: 2-stroke gasoline outboards, 4-stroke gasoline inboards, and diesel propulsion systems. Based on the available data, it was concluded that the most appropriate way to estimate emissions was to estimate the amount of fuel consumed by each industry and apply emission factors based on fuel usage.

Annual emissions from fishing operations were estimated from

$$\text{Emission Rate} = EF \cdot FC$$

where EF is the emission factor (kg/1000 L) and FC is the annual fuel consumption (1000 L/yr). The annual fuel consumption for the offshore shrimp, offshore reef, and offshore pelagic line fisheries were estimated based on the number of operating days per year and the average daily fuel usage. For the inshore shrimp, oyster, crab and miscellaneous finfish fishery, estimates of fuel usage per pound of catch were made. Table N-17 presents the emission factors used. Attachment F provides a detailed description of the methodology used to estimate commercial fishing emissions.

4.9 Intercoastal Barges

Cargo is moved on the navigable internal waterways of the Gulf Coast, including the Gulf Intracoastal Waterway. Barges are generally moved by towing vessels, typically a towboat. There are several types of barges. Open hopper barges carry dry bulk commodities not susceptible to weather damage, such as coal, rock, or sand. Covered hopper barges transport commodities needing protection from the elements, such as grain. Deck barges transport vehicles and equipment. Tank barges transport petroleum and chemicals.

Tugboats that supply power for barges are typically powered by diesel engines. For this analysis, emission factors were derived for inland and oceangoing barges. The average

Table N-17. Emission factors for commercial fishing vessels.

Engine Type	Pollutant (kg/L of fuel)					Source
	NO_x	HC	CO	SO_x	TSP	
2-Stroke Outboard Gasoline (average 36–150+hp)	0.002	0.226	0.434	0.001	0.013	EPA, 1991b; Tables 2-07e, I-11a
4-Stroke Inboard Sterndrive Gasoline (average 120–200 hp)	0.012	0.029	0.416	0.001	0.0002	EPA, 1991b; Table 2-07c.
Diesel, Cruise Mode						
<500 hp	0.047	0.006	0.006	0.0002*	0.0002*	EPA, 1991a; Exhibit 3.
500–1,000 hp	0.036	0.002	0.010	0.0002*	0.0002*	EPA, 1991a; Exhibit 3.
1,000–1,500 hp	0.036	0.003	0.007	0.0002*	0.0002*	EPA, 1991a; Exhibit 3.

horsepower ratings used to derive the emission factors were 1,200 and 1,600 for inland and oceangoing vessels, respectively. Table N-18 presents the emission factors which were used.

Annual emissions from intracoastal barge traffic were estimated from

$$\text{Emission Rate} = EF \cdot VH$$

where EF is the emission factor (kg/hr) and the VH is the annual vessel hours. The annual fuel vessel hours were estimated based on

- the number of vessels (USDACE, 1991)
- the shipping lane length in each lease block (MMS, 1989)
- the average rate of speed of a vessel (CBL, 1993; Annessa, 1993)
- the operating mode
- the propulsion type

Attachment G provides a detailed description of the methodology used to estimate barge traffic emissions.

4.10 Military Vessels

In order to estimate emissions from military vessels, the U.S. Navy was contacted regarding Gulf of Mexico operations. The Navy provided a list of its ships operating in the Gulf and their operational areas (Hayden, 1993). Naval vessels operating in the Gulf are powered by two types of engines: steam and diesel propulsion systems. Steam propulsion systems are typically found in vessels with engines ranging from about 5,000 to 32,500 hp. Naval vessels using diesel engines are typically powered by large, low-speed diesel engines. The low-speed two-stroke engines range in size from about 575 to 13,500 hp. Since naval activity in the Gulf modeling domain is minimal, and commercial ships have similar engine types and sizes as the military, we used the commercial shipping emission factors. The emission factors and other parameters used to estimate emissions from military vessels are summarized in Table N-19.

The total emissions were estimated from

$$\text{Emission Rate} = EF \cdot FC$$

where EF is the emission factor (lbs/1000 L) and the FC is the fuel consumption (1000 L/yr). The total vessel fuel consumption in each OCS lease block area was based on data supplied by the navy (Hayden, 1993).

Table N-18. Emission factors for intracoastal barge traffic. (Source: EPA, 1991).

	Pollutant (kg/1,000 L of fuel)					Fuel Consumption	Pollutant (kg/hr)				
Vessel Type by Operating Mode	NO_x	HC	CO	SO_x	TSP	(1,000 L/hr)	NO_x	HC	CO	SO_x	TSP
Inland Tugboats/Tows (1,000 hp)											
Hotelling	35.90	2.87	7.30	0.15	2.03	0.01	0.36	0.03	0.07	0.00	0.02
Maneuver/Cruise	35.90	2.87	7.30	0.15	2.03	0.07	2.51	0.20	0.51	0.01	0.14
Full Power	35.90	2.87	7.30	0.15	2.03	0.12	4.31	0.34	0.88	0.02	0.24
Oceangoing Tugs/Tows (6,000 hp)											
Hotelling	50.21	2.70	7.16	0.15	2.03	0.02	1.00	0.05	0.14	0.00	0.04
Maneuver/Cruise	46.87	2.01	9.37	0.15	2.03	0.09	4.22	0.18	0.84	0.01	0.18
Full Power	47.82	2.55	11.48	0.15	2.03	0.16	7.65	0.41	1.84	0.02	0.33

Table N-19. Naval ship emission factors and fuel consumption rates by ship. Ships acronyms were given to SAI by the Navy.

Naval Ship Emission Factors (kg/1000 L)[1]		
Species	Boiler & Turbine Engines Steam Propulsion	Diesel Engines
NO_x	7.63	65.81
THC	0.21	2.87
CO	0.87	7.30
SO_x	0.38	0.38
TSP	6.78	3.95

Ship Type and Fuel Consumption[2] by Naval Ship					
Ship	Number of Engines	Engine Type	Engine HP	Fuel Usage (bbl)	Fuel Usage (1000 L)
LPH	4	BOILER	5,750	590	93.79
FF	2	BOILER	8,750	2475	393.45
TAK(I)	2	BOILER	15,000	0	0.00
AVT	8	BOILER	32,500	53,037.5	8431.37
CG	4	TURBINE	20,000	2,100	333.84
DD	4	TURBINE	20,000	812	129.08
FFG	2	TURBINE	20,500	826	131.31
MSO	4	DIESEL	575	77	12.24
MCM	4	DIESEL	600	0	0.00
PHM	2	DIESEL	800	895.5	142.36
TAG	2	DIESEL	1,400	629.2	100.02
TAGS(50)	1	DIESEL	2,500	230	36.56
LSD	4	DIESEL	10,250	496.5	78.93
TAGS(40)	2	DIESEL	12,000	132.5	21.06
TAK(II)	2	DIESEL	13,500	0	0.00

[1] EPA-II, 1985; EPA 1991; CARB, 1991b, c; Kludjian, 1993.
[2] Hayden, 1993.

5 OFFSHORE PLATFORM INVENTORY SYSTEM (OPIS)

The platform data were obtained from a survey of platform operators conducted by MMS, who also entered the data into Paradox (v3.5) database tables. SAI developed the Offshore Platform Inventory System (OPIS) to calculate platform emissions; Figure N-1 provides an overview of OPIS. OPIS accesses the MMS database, assigns quality assurance tracking codes, makes data corrections, calculates emissions, and prepares the emissions data files in the format required by the EPA's UAM Emissions Preprocessor System 2.0 (EPS 2.0).

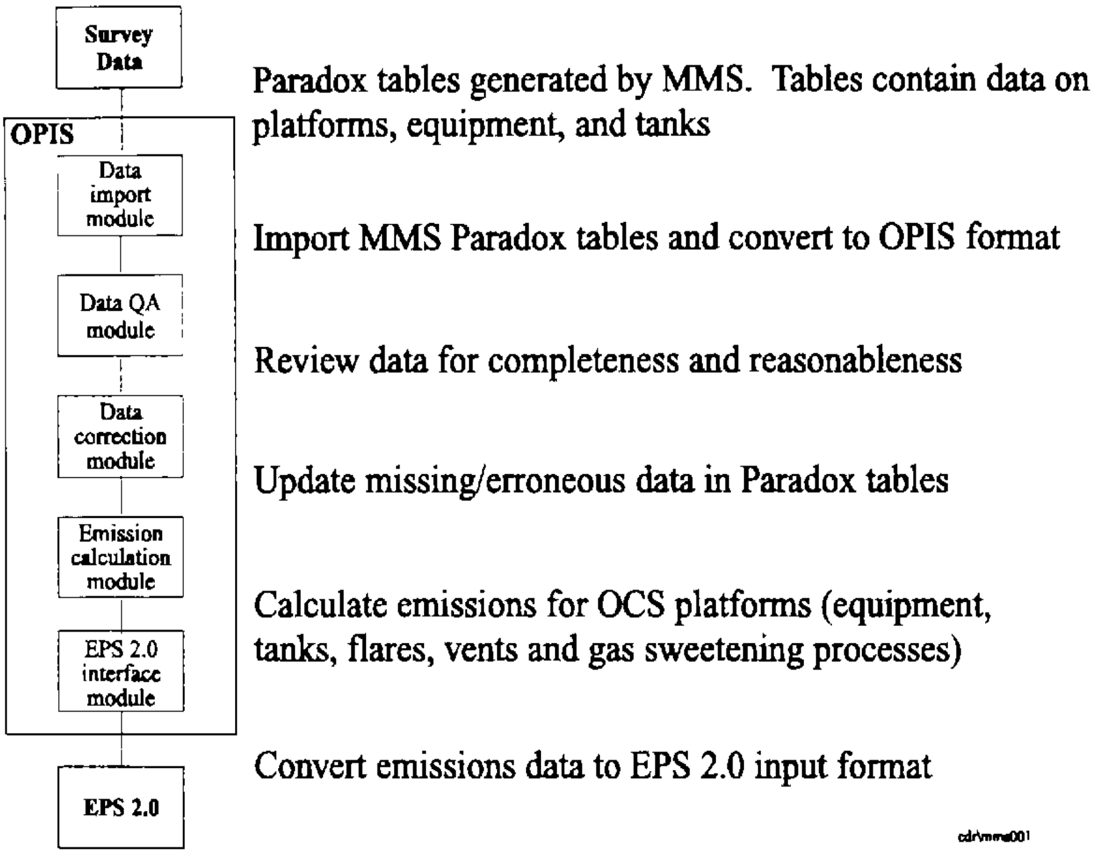


FIGURE N-1. Structure of OPIS.

The first module in OPIS imports the survey database files and assigns each record a quality assurance tracking code. The second module checks the data for completeness and validity; erroneous or questionable data are summarized in a system report. The third module allows the user to modify the data in the OPIS system files. This module automatically updates the quality assurance tracking information for each modified record. The fourth module calculates OCS offshore platforms emissions based on the preceding methodology descriptions and activity data provided by the survey. The final module produces a Paradox-formatted file that contains all of the information necessary for EPS 2.0. The Paradox file can then be exported using Paradox's export function to an ASCII file that is formatted for input into EPS 2.0.

6 DATA QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance (QA) and Quality Control (QC) of the Gulf of Mexico OCS production platform survey data was a major task during emissions development. As previously mentioned, the data were entered by MMS into Paradox database files (v3.5) for input to the OCS Platform Inventory System (OPIS). The second module in OPIS performs Quality Control checks on the database and produces a system report for data review and correction. All QA/QC procedures described below are implemented in OPIS.

The QC process used for this study is as follows:

1. Each diskette received from MMS was assigned a diskette tracking code.
2. Each record in the database was assigned a diskette tracking code.
3. Every change made to a record in the database was assigned a version code.

The above process permitted tracking of data for MMS origination as well as any implemented data modifications or corrections.

Several errors were found in the database files prepared by MMS, including typographical errors, omitted data, and erroneous data. To identify these errors, selected fields in each record of the database were reviewed. The following sections discuss this process.

The QA review process for the database was as follows:

1. Data were flagged as either missing or erroneous.
2. Flagged data were sent to MMS for review.
3. MMS contacted survey respondents to determine the validity of the data.
4. MMS corrected any data and returned corrections to SAI.
5. SAI corrected records in the database.

A description of the fields checked and the types of limits placed on the fields is given below for each table in the database. The database consists of three types of tables: platform data, equipment data, and tank data.

6.1 Platform Data Quality Assurance

The following fields in the platform tables were reviewed:

- platform latitude and longitude
- daily crude/condensate throughput or production rate
- daily gas throughput or production rate
- percentage of crude/condensate production in summer
- percentage of gas production in summer
- flare and vent stack heights
- vent stack velocities
- vent diameter

The latitude and longitude were checked for every platform in the database. Platforms with missing or erroneous location data were flagged.

Since each platform can produce gas, gas and oil, or oil, both crude and gas production rates are not required for each platform. If a crude/condensate production rate was greater than 5,000 bbl/day, the record was flagged. If gas production rates exceeded 60 million ft^3/day, the record was flagged. In addition, if the gas or crude/condensate production rate exceeded zero, the percentage of production in summer was checked (i.e., pct summer production

> 0). Lastly, stack parameters were reviewed for stack heights exceeding 195 ft, stack diameters exceeding 5.5 ft, and stack velocities exceeding 1,600 ft/s. For vents, the stack velocity is a calculated value based on the stack volumetric flow rate and diameter. Since the flare diameter is not included in the database, a velocity of 200 ft/s (Bland, 1967) is assumed for flares. From the assumed velocity and the flare volumetric flow rate, the flare stack diameter was calculated and reviewed.

In addition to checking the fields listed above, the percentages of gas flared and vented were calculated by taking the average daily flaring and venting rates and dividing them by the total average daily production/throughput rate for gas. If the percent flared or vented exceeded 10 percent, the quantity flared or vented was reviewed as well as the daily gas throughput rate.

Before diesel storage tank emissions could be calculated, several fields in the platform database had to be reviewed. These fields included (1) total liquid fuel oil storage capacity and (2) number of fuel storage tanks. If the liquid fuel oil storage capacity was greater than zero, the tank emissions were calculated. If the liquid fuel oil storage capacity was zero or blank, no emissions were calculated. No limits were put on the capacity or quantity of tanks. Only missing values were checked for (e.g., if a nonzero liquid storage capacity was given, then the record was checked to verify a nonzero number of tanks, and vice versa).

6.2 Equipment Data Quality Assurance

The following fields in each record were reviewed for data entry and missing data errors:

- engine type
- equipment type
- fuel type
- annual use
- annual fuel use
- equipment stack velocity
- equipment stack height
- equipment stack diameter

For annual fuel use and hours in usage, limits were placed on the minimum and maximum values. For obvious reasons, annual hours in usage must be between zero and 8760. For annual fuel use, the limits were based on the fuel type. For natural-gas-powered equipment, any annual fuel use greater than 100 million ft^3/yr was flagged and reviewed by MMS staff. For diesel fuel, annual average fuel use values greater than 50 gal/hr were flagged.

All equipment ratings were reviewed. All gas-powered equipment ratings were converted to units of millions of Btu/hr, and all diesel- and condensate-powered equipment ratings were converted to units of horsepower. Any equipment ratings with a magnitude greater than 5,000 were flagged. Many of the pieces of equipment in the database have equipment ratings that were reported by the platform operators as unknown. There are several reasons for this: the equipment may be modified and the manufacturer's rating is no longer valid, or the equipment is old and the manufacturer's name plate is no longer legible.

To evaluate errors in annual usage hours, annual fuel use, rating, and equipment/engine type, an Annual Average Load (AAL) was calculated and compared to the equipment rating:

$$AAL = \text{(Annual Fuel Use)} / \text{(Annual Usage Rate)} \cdot FC$$

where FC is the fuel consumption rate. Table N-20 gives the fuel consumption rates used to calculate equipment AALs. Once the AAL was calculated, it was compared to the reported equipment ratings. Only equipment with STATUS equal to operational were reviewed using this method. An equipment record in the database was flagged if the AAL was greater than 200 percent or less than 15 percent of the equipment rating. Because the AAL is a theoretical load, the AAL is not an absolute indicator of data correctness but rather a general indication of data aberration. For this reason, we set the AAL maximum limit at 200 percent rather than 100 or 120 percent.

Table N-20. Fuel consumption rates used for calculating equipment Annual Average Loads (AAL) by engine and fuel type.

Engine Type	Fuel Type	Fuel Consumption Rate
R	D or C	18 hp-hr/gal
R	G	318 Btu/ft^3
T	D or C	13.5 hp-hr/gal
T	G	254.5 Btu/ft^3
H	D or C	53.0 hp-hr/gal
H	G	1000 Btu/ft^3

Many of the AALs did not match the reported equipment ratings. This inconsistency can be attributed to several reasons, including inaccurate fuel consumption rates. Much of the equipment in the Gulf is powered by natural gas, and since this fuel is produced on the platform it is often not metered. This leads to an estimated fuel consumption rate that may be inaccurate. In addition to inaccurate fuel consumption rates, the equipment rating may be incorrect for the reasons described above. Furthermore, we noticed that much of the equipment with AALs 200 percent or greater than the equipment ratings had small annual usage (e.g., less than 500 hr/yr). Because these pieces of equipment are not operating very often during the year, a small error in the fuel consumption rate or annual hours can lead to an over- or underestimation of the AAL.

Table N-21 summarizes the parameter limits set on the equipment variables as part of the QA/QC process.

Table N-21. Equipment database parameters and their limits used during the QA/QC procedures.[1]

Parameter	Maximum	Minimum	Units	Comments
Annual Fuel Usage	100	0	$MMft^3/yr$	Gas-powered equipment only
	50	0	gal/hr	Diesel-powered equipment only
Annual Usage	8,760	0	hr	
Equipment Rating	5,000	0	hp or MMBTU/hr	
Annual Average Load/ Equipment Rating	200	10	percent	Calculated AAL. See text Section 3.4.
Equipment Stack Height	195	0	ft	
Equipment Stack Velocity	1,600	0	ft/s	
Equipment Stack Diameter	5.5	0	ft	

1 The invalid Usage-Engine-Fuel combinations checked are:

Engine	**Usage Fuel**
T or H	R or FAll
R	R or FG
H	C or GAll
H or T	O or WAll
R or T	B or L or TAll

6.3 Crude Tank Data Quality Assurance

The following fields in the crude tank tables were reviewed:

- capacity
- average daily throughput
- dimensions
- tank color

If any of the above fields were missing (blank), the record was flagged and sent to MMS.

In addition to the simple checks above, the tank capacity was checked against a calculated tank capacity. The calculated tank capacity was estimated using the tank dimensions. Any given capacities greater than 120 or less than 25 percent of the calculated capacity were flagged and reviewed. Some errors were found because of unit problems (e.g., tank dimensions were given in inches instead of feet).

The parameter limits used to QA/QC the tank database are given in Table N-22.

Table N-22. Tank database parameters and their limits used during the QA/QC procedures.

Parameter	Maximum	Minimum	Units	Comments
Given Capacity ÷ Calculated Capacity	120	25	percent	Calculated capacity based on tank dimensions
Tank Capacity	—	—	bbl	Check for missing value only
Tank Throughput	—	—	bbl	Check for missing value only
Tank Color	—	—	—	Check for missing value only

REFERENCES

Allen, P. 1993. Texas Parks and Wildlife Department, Austin, Texas, personal communication, January 1993.

Annessa, C. 1993. Tidewater Marine, personal communication, January 1993.

Bland, W.F., Davidson, R.L. 1967. *Petroleum Processing Handbook.* McGraw-Hill, New York, page 8-74.

CARB. 1991a. *Instructions for the Emission Data System Review and Update Report, Appendix III, Source Classification Codes and EPA Emission Factors*, California Air Resources Board, Technical Division, August 1991.

CARB. 1991b. *Notice of Public Meeting to Consider a Plan for the Control of Emissions from Marine Vessels (Mailout #90-58).* California Air Resources Board, Staff Report, September 1991.

CARB. 1991c. *Regulatory Strategies for Reducing Emission from Marine Vessels in California Waters.* Prepared by Sierra Research, Inc., for California Air Resources Board, October 1991.

CBL. 1993. Canal Barge Line, personal communication with engineering representative, January 1993.

Davenport, J.W., McGregor, L.J. 1987. *Fugitive Emissions Calculations Guidelines*, 80th Annual Meeting of APCA, New York, June 21-26, 1987.

Eaton, W.S., et al. 1980. *Fugitive Hydrocarbon Emissions from Petroleum Production Operations.* API 4322, American Petroleum Institute, Washington, DC.

EPA-I. 1985. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*, Fourth Edition and Supplements. AP-42, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA-II. 1985. *Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources*, Fourth Edition and Supplements. AP-42, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA. 1991. *Commercial Marine Vessel Contribution to Emission Inventories*. Prepared by Booz, Allen, and Hamilton, Inc., Los Angeles, California.

Ewars, N. 1992. Private Consultant, Irvine, CA, personal communication with S. Reid on December 14, 1992.

Hayden, W.B. 1993. Memorandum from Department of the Navy to SAI, Commander in Chief, U.S. Atlantic Fleet, May 24 1993.

HeliValue$. 1990. *The Official Helicopter Specification Book*, 2nd ed. ISBN 0-943791-95-2, HeliValue$, Inc., P.O. Box 876, Lincolnshire, IL.

Jelinek, K.A., T. Rooney, and M. Webb. 1993. *Fugitive Emissions From an Offshore Gas and Oil Production Platform*. SPE/EPA Exploration & Production Environmental Conference, San Antonio, TX, March 7-10, 1993.

Jordan, S. 1993. Mississippi Department of Wildlife, Fisheries, and Parks, Jackson, Mississippi, personal communication, January 1993.

Kludjian, A. 1993. Caterpillar Diesel Engines, Authorized Dealer, Peterson Power Systems, Inc., San Leandro, California, personal communication, January 1993.

LDWFP. 1993. Louisiana Department of Wildlife, Fisheries, and Parks, Baton Rouge, personal communication, January 1993.

LMIS. 1992. *Lloyd's Register Statistical Tables*. Lloyd's Maritime Information Services.

Louisiana Offshore Oil Port (LOOP), Inc. 1993. Personal communication with D. Rollins, New Orleans, Louisiana. January.

McGregor, C. D. 1985. *Air Emission Source and Control Technologies for Offshore Oil and Gas Facilities*. Presented at California Offshore Petroleum conference: Resources, Technology, The Environment and Regulation, Long Beach, California, March 26-29, 1985.

MMS. 1989. *Historic Leasing and Infrastructure*. Visual 1, U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, March 1989.

MMS. 1991. *Outer Continental Shelf Natural Gas and Oil Resource Management Comprehensive Program (1992-1997)*. Visual I, U.S. Department of the Interior, Minerals Management Service, June 1991.

MMS. 1992. *Final Report Fugitive Hydrocarbon Emissions From Pacific OCS Facilities*, Volumes 1 and 2. U.S. Department of the Interior, Minerals Management Service, OCS Report MMS 92-0043, Contract No. 14-35-0001-30428, November 30, 1992.

Nichols, K.N, and A.P. Goldbloom. 1989. *Texans Outdoors: An Analysis of 1985 Participation in Outdoor Recreation Activities*. Texas Parks and Wildlife Department, Comprehensive Planning Branch, Parks Division, Austin, Texas.

Ocean Industry. 1992. "Ocean Industry's 1992 Guide to Marine Drilling Rigs." *Ocean Industry* 27:7(19-118).

Rollins, D. 1993. Louisiana Offshore Oil Port, Inc., New Orleans, Louisiana, personal communication, January 1993.

SCAQMD. 1991. *Final Air Quality Management Plan*, 1991 Revision, Final Technical Report III-G, *1987 Aircraft Emission Inventory in the South Coast Air Basin*. South Coast Air Quality Management District, July 1991.

STAPPA. 1991. *Air Quality Permits: A Handbook for Regulators and Industry*, Volume I. State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO), Washington DC.

Steorts, W.L. 1992. Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, personal communication, August 1992.

Steorts, W.L. 1993. Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, personal communication, April 1993.

Steorts, W.L. 1993. Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, personal communication, May 1993.

Thorndale, R. 1993. Alabama Department of Conservation and Natural Resources, Marine Police Division, Montgomery, Alabama, personal communication, January, 1993.

USCG. 1991. *American Red Cross National Boating Survey: A Study of Recreational Boats, Boaters, and Accidents in the United States*. Prepared by the American Red Cross, USCG, U.S. Department of Transportation, Coast Guard.

USDACE. 1991. *Waterborne Commerce of the United States*, Calendar Year 1989, Part 2, Gulf Coast, Mississippi River System, and Antilles. U.S. Department of the Army Corps of Engineers.

USDC. 1990. *United States Foreign Trade Vessel Entrances and Clearances*. 1988 Annual Report, FT975-88, U.S. Department of Commerce, Bureau of the Census.

USDT. 1976. *Draft Environmental Impact/4(f) Statement*. LOOP Deepwater Port License Application, U.S. Department of Transportation, Coast Guard, Office of Marine Environmental and Systems, Deepwater Ports Project, Washington, D.C.

USDT. 1991. *Domestic Waterborne Trade of the United States, 1987-1989*. U.S. Department of Transportation, Maritime Administration.

USFWS. 1992. *National Recreational Boating Survey: Draft Final Report*, Volume 1 of 2. U.S. Fish and Wildlife Service and the U.S. Coast Guard, Contract #14-16-00009-90-006, prepared by Price Waterhouse.

ATTACHMENT A: OIL AND GAS SUPPORT VESSELS

Description of the Sector

Oil and gas platforms operating in the Gulf of Mexico require periodic resupply of food and other living requirements for workers as well as drilling equipment. Exploratory vessels and construction activities also require frequent deliveries of food, fuel, personnel, and construction materials. Supply operations originate from a number of bases along the Gulf of Mexico coast, and are conducted throughout the Outer Continental Shelf and within state waters. Supply operations are conducted with four basic types of vessels, called crew boats, supply boats, tugs, and barges.

Crew boats shuttle workers to and from staging areas along the coast. These are typically small, speedy vessels (under 100 feet in length). For more distant sites or trips involving senior personnel, air transport is also used. Aircraft emissions associated with crew and supply operations are addressed in a distinct section because of their distinct emissions and different operating bases. Supply boats are generally larger (120 to 250 feet long) and operate similarly to crew boats except that they carry supplies rather than workers. Tugs and barges are typically used together to carry larger, heavier supplies, such as pipes, to drilling platforms or construction project sites. While barges are not self-propelled, they often are equipped with small (relative to other support vessels) diesel engines which power cranes or machinery or serve as generators.

Typically, all platforms with human operators on them will require periodic delivery of supplies. Unmanned operations will still require frequent visits by maintenance personnel. Therefore, all lease areas with drilling activity are expected to require crew and supply vessel trips which result in some pollutant emissions.

Emission Factors

Support vessels for oil and gas operations are typically powered by diesel engines. Emission factors were derived for the following types of vessels: crew boats, supply boats, tugboats, and barges. Diesel engines used in these marine applications, on average, range from less than 500 horsepower to over 2,000 horsepower (MMS, 1992). Support vessels are generally powered by medium- to high-speed diesel engines. These engines tend to be used in smaller vessels and are commonly lighter and more compact than their low-speed counterparts at equivalent horsepower ratings (CARB, 1991).

Estimates of engine sizes were derived from a survey of offshore operators conducted for the Minerals Management Service by the Offshore Operators Committee, a operators' trade association. This survey served as a census of support vessels and their engines in the Gulf of Mexico region. Additional data obtained in the survey included boat type, monthly fuel usage, and hours of operation for boats, and manufacturer, model number, horsepower rating, and fuel usage at maximum power for engines.

For crew boats, emission factors were estimated based on the survey-reported average of 480 horsepower. At full power, a crew boat with this horsepower rating would, on average, consume fuel at the rate of approximately 82.7 liters per hour (21.8 gallons per hour) (MMS, 1992).

To estimate emission factors for supply vessels, the average horsepower rating used was 868. At full power, a supply vessel with a horsepower rating of this magnitude would, on average, burn fuel at the rate of approximately 142.3 liters per hour (37.6 gallons per hour) (MMS, 1992).

Tugboats are typically operated by diesel engines with a higher horsepower rating than those engines used for crew or supply vessels. According to the Offshore Operators Committee boat and engine inventory, the average rated diesel engine used to operate a tugboat is 2,234 horsepower (MMS, 1992). At full power, tugboats with a horsepower rating of this magnitude would, on average, consume fuel at the rate of approximately 385.6 liters per hour (101.7 gallons per hour) (MMS, 1992).

Like crew boats, barges are commonly equipped with auxiliary diesel generators rated at less than 500 horsepower. The boat inventory showed that, on average, barges operate with a diesel engine rated at 308 horsepower (MMS, 1992). At full power, barges with a horsepower rating of this magnitude would, on average, consume fuel at the rate of approximately 70.9 liters per hour (18.7 gallons per hour) (MMS, 1992).

Support vessels normally operate at just below full power while cruising at sea and at much lower loads while idling at sea or hotelling at berth. To determine fuel consumption for the cruise and hotelling operating modes, a ratio of the total fuel consumption when operating at full power was taken to represent each of these operating modes. The ratios were based on reported data for commercial steamships which estimates the percentage of full power used for other operating modes (EPA, 1985). Specifically, it is estimated that operation in the hotelling mode uses about 10 percent of available power. Similarly, operating in the cruise mode may require from 35 to 75 percent of available power; here, an average of 55 percent was used (EPA, 1985).

For the calculation of air emissions from support vessels, the following estimates were derived for the relative percentage each vessel type operates at each power mode:

	(Percent of Total Operations)		
Vessel Type	Hotelling	Cruise	Full
Crew boats	10%	10%	80%
Supply boats	45%	10%	45%
Tugs	33%	33%	33%
Barges	50%	0%	50%

The primary pollutants emitted by diesel engines while in any mode of operation include the following: nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), sulfur oxides (SO_x), and particulates (PM) (EPA, 1985). Total particulate matter equates to total suspended particulate (TSP) and is referred to as TSP in the model and the remainder of this analysis. Also the HC emissions measured here represent total emissions (i.e., not just the VOC component). The primary emission factors are derived in terms of kilograms per 1,000 liters of fuel used. Historical emission factors for each pollutant by mode of operation were multiplied by the associated annual fuel consumption rate to estimate the level of emissions generated from support vessels per year. Emission factors are presented in terms of kilograms of pollutants per 1,000 liters of fuel used as well as per hour of use in Table A-1.

Methodology

Annual emissions from support vessels in the Gulf of Mexico were estimated using the following formula:

Annual Fuel Consumption (L/yr) × Emission Factors by Pollutant (kg/1,000 L fuel) × 0.0011 ton/kg = Total Emissions by Pollutant (ton/yr)

Emissions were then allocated to each lease area by deriving a vector (i.e., supply route) between the predominant supply base or bases and the center of drilling platforms in each area. Because data on number of trips to individual lease areas were not available, offshore employment figures by MMS lease area were used as a surrogate to indicate supply needs in each area. The proportion of total pollutants resulting from each route is given by the following formula:

$$p_i = \frac{e_i \cdot d_i}{\sum_{i=1}^{96} (e_i \cdot d_i)}$$

where

p_i = the proportion of supply trips to area i,
e_i = offshore employment in area i, and
d_i = distance from the predominant supply base to platform centroid in area i.

The components of the above calculations were derived based on the following:

- Offshore employment figures were taken from a study of economic impacts of oil and gas development in the Gulf of Mexico (MMS, 1986). This report includes an exhaustive survey of offshore personnel, and details the home location, staging area (for transport to platforms), and lease area for offshore workers. This report is the only known source of information on number of individuals working in the various offshore areas.

TABLE A-1. Emission factors for oil and gas support vessels.

Vessel Type	Pollutant (kg/1,000 liters of fuel)					Fuel Consumption (1,000 liters /hour)	Pollutant (kg/hour)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Crew Boats (Diesel Engine - Avg 480 hp)											
Hotelling/Idle	40.39	6.78	7.06	0.15	2.03	0.01	0.32	0.05	0.06	0.00	0.02
Cruise	46.58	6.11	5.66	0.15	2.03	0.04	2.05	0.27	0.25	0.01	0.09
Full Power	32.92	2.51	7.00	0.15	2.03	0.08	2.63	0.20	0.56	0.01	0.16
Supply Boats (Diesel Engine - Avg 868 hp)											
Hotelling/Idle	20.01	2.01	7.44	0.15	2.03	0.01	0.28	0.03	0.10	0.00	0.03
Cruise	35.90	2.05	9.68	0.15	2.03	0.08	2.76	0.16	0.75	0.01	0.16
Full Power	35.90	2.87	7.30	0.15	2.03	0.14	5.03	0.40	1.02	0.02	0.28
Tugboats (Diesel Engine - Avg 2,234 hp)											
Hotelling/Idle	44.63	2.87	14.65	0.15	2.03	0.04	1.73	0.11	0.57	0.01	0.08
Cruise	74.56	2.87	5.34	0.15	2.03	0.21	15.99	0.62	1.14	0.03	0.44
Full Power	56.48	2.01	28.44	0.15	2.03	0.39	22.03	0.78	11.09	0.06	0.79
Barges (Diesel Engine - Avg 308 hp)											
Hotelling/Idle	40.39	6.78	7.06	0.15	2.03	0.01	0.28	0.05	0.05	0.00	0.01
Cruise	46.58	6.11	5.66	0.15	2.03	0.04	1.79	0.24	0.22	0.01	0.08
Full Power	32.92	2.51	7.00	0.15	2.03	0.07	2.30	0.18	0.49	0.01	0.14

Source: EPA, 1991; MMS, 1992.

- For those lease areas with drilling activity that did not have estimated employment data in the MMS economic impact study, an estimate of 50 persons was assigned per platform in deep waters (e.g., Garden Banks), and 20 persons per platform in nearshore OCS and state waters. This estimate was derived from the above MMS study for comparable platforms.

- The midpoint of the cluster of drilling platforms, the "platform centroids" within each lease area, was visually determined for all lease areas on the OCS which indicated any drilling activity. The midpoints of platforms in State waters were also determined in a similar fashion.

- Each offshore lease area was matched with a corresponding supply base(s) using information from the 1986 MMS economic impact study. This study provided information on the "commuting" patterns between most planning areas and the major supply bases. For operations which did not exist in 1986, contacts were made directly with the offshore operator to determine which bases were supporting specific offshore operations. For example, Mobil Oil provided detailed information on their crew and supply efforts in support of their operations in Mobile Bay and off the State of Alabama (Mobil, 1993).

- Distances from the primary crew and supply staging areas to the platform centroids were determined using Visual No. 1 of Active Leases and Infrastructure (MMS, 1991). The MMS economic impact report provided survey data on the primary supply locations used by in each lease area, while the Minerals Management Service visual indicated which lease areas contain drilling activity, as well as the locations of the major and minor supply bases throughout the Gulf.

- The latitude and longitude coordinates (to the nearest tenth of a degree) were also derived from Visual No. 1 of Active Leases and Infrastructure (MMS, 1991).

- The air pollutant emission factors used to determine total annual pollutant emissions associated with support vessels were derived from the U.S. Environmental Protection Agency document titled *Commercial Marine Vessel Contributions to Emission Inventories* (EPA, 1991). This document reports data on air pollutant emission factors for various types of marine vessels. This source identifies data on emission factors for harbor vessel applications and incorporates previously published data on emission factors for other mobile source applications.

- Total air emissions from support vessels were obtained using emission factors multiplied by fuel used annually. Annual fuel use was obtained using the Offshore Operators Committee survey data (MMS, 1992).

- The Offshore Operators Committee survey provided detailed information of support vessels and their engines in the Gulf of Mexico. The boat inventory data base recorded boat type, hours of operation, and fuel usage data for 517 support vessels in the Gulf of Mexico. Upon closer scrutiny, 16 of these vessels were found to be either exploration (e.g., seismic) vessels, jackup exploration rigs, or in one case, unknown. These records were taken out of the data base and used in the exploration section of this emissions inventory. The 501 relevant boats had a total of 1,417 diesel engines. Engine data reported included manufacturer, model number, horsepower, fuel usage at maximum power, and annual usage for each engine. Of the total number of vessels, there were 88 crew boats with 433 engines, 326 supply boats with 773 engines, 60 tug boats with 124 engines, and 27 barges with 87 engines. Data were for a 12 month period starting in June of 1991. The data were used as representative of all years during the study period.

Baseline

Table A-2 presents the annual baseline emissions. It shows that emissions are highest for supply trips to the Eugene Island OCS and State areas, as well as the Ship Shoal OCS and State areas. Pollutant emissions result from trips to virtually all lease areas. Only those which lack drilling operations do not result in air emissions.

The Offshore Operators Committee survey data indicate that supply vessel trips are fairly constant throughout the year, as well as fairly continuous throughout the day. The Offshore Operator Committee survey fuel use data were examined for variations in fuel usage throughout the year. The trend line of fuel usage was found to be very flat (i.e., showed no seasonal variation) for all vessel types except tugs. Some variation in fuel usage was shown for tugs which indicated that slightly more fuel was used in the summer months. Barges, which must be used in conjunction with tugs, showed relatively constant levels of fuel usage. Since there was no basis for determining seasonal differences, no adjustments were made to account for seasonal differences in support boat vessel traffic. The survey data also indicated no real difference in the time of day of operation. Support vessels are typically "on call" all day, and the survey data supported this, showing that these boats operated 21 hours per day on average. Finally, no adjustments to reflect future growth or decline of supply vessel traffic was made, since platforms require maintenance, and servicing and manning regardless of specific production levels. Only massive abandonment of existing structures during the study period would be expected to substantially reduce crew or supply boat trips. Given the relatively small emissions from crew and supply boats, emissions from this sector were set at a fixed level throughout the 1987 to 2000 study period. This is believed to be a conservative prediction (i.e., may slightly overstate emissions).

TABLE A-2. Baseline (1992) crew and supply vessels emissions.

FIPS	County/Area Name	Total Emissions by Pollutant (tons/yr)				
		NO_x	HC	CO	SO_x	TSP
01003	Baldwin County, AL	NA	NA	NA	NA	NA
01097	Mobile County, AL	7	1	2	0	0
22019	Calcasieu, LA	18	1	4	0	1
22023	Cameron Parish, LA	140	11	34	1	8
22045	Iberia Parish, LA	3	0	1	0	0
22051	Jefferson Parish, LA	164	13	40	1	10
22057	Lafourche Parish, LA	145	12	35	1	9
22071	Orleans Parish, LA	NA	NA	NA	NA	NA
22075	Plaquemines Parish, LA	820	65	200	4	48
22087	St. Bernard Parish, LA	NA	NA	NA	NA	NA
22101	St. Mary Parish, LA	1031	82	251	4	60
22109	Terrebonne Parish, LA	1186	94	289	5	69
22113	Vermilion Parish, LA	303	24	74	1	18
28045	Hancock County, MS	NA	NA	NA	NA	NA
28047	Harrison County, MS	NA	NA	NA	NA	NA
28059	Jackson County, MS	102	8	25	0	6
48007	Aransas County, TX	NA	NA	NA	NA	NA
48039	Brazoria County, TX	229	18	56	1	13
48057	Calhoun County, TX	9	1	2	0	1
48061	Cameron County, TX	3	0	1	0	0
48071	Chambers County, TX	1	0	0	0	0
48167	Galveston County, TX	66	5	16	0	4

Continued

TABLE A-2. Continued.

FIPS	County/Area Name	Total Emissions by Pollutant (tons/yr)				
		NO_x	HC	CO	SO_x	TSP
48201	Harris County, TX	NA	NA	NA	NA	NA
48239	Jackson County, TX	0	0	0	0	0
48245	Jefferson County, TX	22	2	5	0	1
48261	Kenedy County, TX	NA	NA	NA	NA	NA
48273	Kleberg County, TX	NA	NA	NA	NA	NA
48321	Matagorda County, TX	116	9	28	1	7
48355	Nueces County, TX	NA	NA	NA	NA	NA
48489	Willacy County, TX	NA	NA	NA	NA	NA
99001	Alaminos Canyon	NA	NA	NA	NA	NA
99005	Atwater Valley	NA	NA	NA	NA	NA
99007	Brazos	106	8	26	0	6
99009	Brazos South Addition	4	0	1	0	0
99011	Breton Sound	13	1	3	0	1
99013	Chandeleur	3	0	1	0	0
99015	Chandeleur East Addition	1	0	0	0	0
99017	Corpus Christi	NA	NA	NA	NA	NA
99023	East Breaks	1	0	0	0	0
99025	East Cameron	356	28	87	2	21
99027	East Cameron South Addition	14	1	4	0	1
99029	Eugene Island	975	77	237	4	57
99031	Eugene Island South Addition	113	9	27	0	7
99033	Ewing Bank	1	0	0	0	0

Continued

TABLE A-2. Continued.

FIPS	County/Area Name	Total Emissions by Pollutant (tons/yr)				
		NO_x	HC	CO	SO_x	TSP
99037	Galveston	276	22	67	1	16
99039	Galveston South Addition	11	1	3	0	1
99041	Garden Banks	8	1	2	0	0
99043	Grand Isle - LOOP	NA	NA	NA	NA	NA
99043	Grand Isle	73	6	18	0	4
99045	Grand Isle South Addition	6	0	1	0	0
99047	Green Canyon	16	1	4	0	1
99049	High Island	66	5	16	0	4
99051	High Island East Addtion	23	2	6	0	1
99053	High Isl. East Add. South Ext.	96	8	23	0	6
99055	High Island South Addition	148	12	36	1	9
99059	Keathley Canyon	NA	NA	NA	NA	NA
99063	Main Pass	177	14	43	1	10
99065	Main Pass South and East Add.	7	1	2	0	0
99067	Matagorda Island	53	4	13	0	3
99069	Mississippi Canyon	11	1	3	0	1
99071	Mobile	49	4	12	0	3
99073	Mustang Island	11	1	3	0	1
99075	Mustang Island East Addition	20	2	5	0	1
99077	NG 15-8	NA	NA	NA	NA	NA
99079	NG 15-9	NA	NA	NA	NA	NA
99081	NG 16-4	NA	NA	NA	NA	NA

Continued

TABLE A-2. Continued.

FIPS	County/Area Name	Total Emissions by Pollutant (tons/yr) NO_x	HC	CO	SO_x	TSP
99085	NG 16-7	NA	NA	NA	NA	NA
99087	North Padre Island	3	0	1	0	0
99089	North Padre Island East Add.	15	1	4	0	1
99093	Port Isabel	NA	NA	NA	NA	NA
99097	Sabine Pass	2	0	0	0	0
99099	Ship Shoal	1176	93	286	5	69
99101	Ship Shoal South Addition	232	18	56	1	14
99103	South Marsh Island	48	4	12	0	3
99105	South Marsh Island North Add.	167	13	41	1	10
99107	South Marsh Island South Add.	8	1	2	0	0
99109	South Padre Island	1	0	0	0	0
99111	South Padre Island East Add.	NA	NA	NA	NA	NA
99113	South Pass	69	5	17	0	4
99115	South Pass East Addition	30	2	7	0	2
99117	South Pass South Addition	30	2	7	0	2
99119	South Pelto	9	1	2	0	1
99121	South Timbalier	190	15	46	1	11
99123	South Timbalier South Addition	28	2	7	0	2
99127	Vermilion	326	26	79	1	19
99129	Vermilion South Addition	53	4	13	0	3
99133	Viosca Knoll	NA	NA	NA	NA	NA
99135	Walker Ridge	NA	NA	NA	NA	NA

Continued

TABLE A-2. Concluded.

FIPS	County/Area Name	Total Emissions by Pollutant (tons/yr)				
		NO_x	HC	CO	SO_x	TSP
99137	West Cameron	570	45	139	2	33
99139	West Cameron South Addition	174	14	42	1	10
99141	West Cameron West Addition	181	14	44	1	11
99143	West Delta	337	27	82	1	20
99145	West Delta South Addition	29	2	7	0	2
99147	WX-1	NA	NA	NA	NA	NA
99149	Apalachicola	NA	NA	NA	NA	NA
99151	DeSoto Canyon	NA	NA	NA	NA	NA
99153	Destin Dome	NA	NA	NA	NA	NA
99155	Florida Middle Ground	0	0	0	0	0
99157	Howell Hook	NA	NA	NA	NA	NA
99159	Lloyd Ridge	0	0	0	0	0
99161	NG 16-5	NA	NA	NA	NA	NA
99163	Pensacola	NA	NA	NA	NA	NA
99165	Rankin	NA	NA	NA	NA	NA
99167	The Elbow	NA	NA	NA	NA	NA
99169	Vernon Basin	NA	NA	NA	NA	NA

The following table indicates the forecast adjustment factor used for the future projections of emissions from crew and supply boats.

Year	Activity Level (Fuel Use in Liters)	Adjustment Factor
1987	279,586,396	1.0
1988	279,586,396	1.0
1990	279,586,396	-
1991*	279,586,396	1.0
1993	279,586,396	1.0
1995	279,586,396	1.0
2000	279,586,396	1.0

* Activity was derived from the Offshore Operators Committee for the period June 1, 1991 through May 31, 1992.

Section References

CARB. 1991. California Air Resources Board. Notice of Public Meeting to Consider a Plan for the Control of Emission from Marine Vessels (Mailout #90-58), September.

EPA. 1985. U.S. Environmental Protection Agency. Compilation of Air Emission Factors, Volume II, EPA Report No. AP-42, Fourth Edition, Research Triangle Park, North Carolina, Office of Air Quality Planning and Standards.

EPA. 1991. U.S. Environmental Protection Agency. Commercial Marine Vessel Contributions to Emission Inventories, Final Report prepared by Booz, Allen, and Hamilton, Inc., Los Angeles, California. October.

MMS. 1986. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico Region. Indicators of the Direct Economic Impacts Due to Oil and Gas Development in the Gulf of Mexico, Volume II/Exhibits and Data, Results of Year I. Prepared by Centaur Associates, Inc. January.

MMS. 1991. U.S. Department of the Interior, Minerals Management Service. Visual No. 1, Active Leases and Infrastructure. Gulf of Mexico Regional Office. October.

MMS. 1992. U.S. Department of the Interior, Minerals Management Service. Survey of Offshore Operators Undertaken by the Offshore Operators Committee. Database of Boat Inventory Survey. October.

Mobil. 1993. Personal communication with M. Otitta, Alabama Operations, New Orleans, Louisiana. March.

ATTACHMENT B: GEOPHYSICAL SURVEYING AND EXPLORATION VESSELS

Description of the Sector

Exploration includes all the activities undertaken to determine whether commercial quantities of oil and gas are present in a geographic area. The two major activities associated with exploration are geophysical surveying and exploratory drilling.

Geophysical Surveying

Geophysical surveying is used to identify areas with potential oil and gas reserves. It is usually conducted prior to a lease sale to determine seismic properties of underlying geologic formations, or after a lease sale to collect more data for identifying and locating favorable reservoir rocks and structures where oil and gas may be located. It is the first of several activities related to offshore oil and gas exploration which may, if exploration is successful, lead to offshore oil and gas development and production.

The most common geophysical surveying technique is seismic analysis which uses blasts from underwater air guns and detection of refractions off geologic strata from these sound blasts. Digital processing of the complex acoustical responses provides information on the hydrocarbon-bearing characteristics of underlying geologic formations. The air gun consists of a chamber filled with compressed air which is suddenly released. Air is pumped back into the guns and released again, resulting in another blast. Blasts occur at about 10-second intervals. Four to 12 air guns are usually towed behind the survey vessel, at a depth of about 30 feet, with hoses extending from them to air compressors on deck. Lines of air guns are up to 2 to 3 miles long (MMS, 1991).

Geophysical or seismic vessels range in size from about 50 to over 250 feet. A seismic crew can survey approximately 1,200 to 1,800 line miles per month (Whale, 1984). A single block survey (3 miles square) may take 3 to 5 days. However, a seismic vessel more typically conducts larger surveys, sometimes for more than one client. For pre-lease sale deep-seismic work, the surveys are usually regional in nature and can last for several months. Post-lease sale surveys for an exploration program generally last from 1 week to 1 month and are geographically focused (MMS, 1991).

Exploratory Drilling

Exploratory drilling is used to search for commercial quantities of oil and gas resources. It involves the use of a mobile drilling rig which is moved onto the lease for the purpose of drilling a set number of exploration and delineation wells. The rig drills a hole in the ocean floor by turning a drill bit attached to a string of pipe made of tubular steel, called a drill stem. Exploratory wells are drilled in search of oil and gas. Delineation wells are drilled so that the probable outline of an oil and gas field can be identified. After drilling, the wells are tested and abandoned, and the rig is then moved offsite.

The types of rigs used in offshore exploration include: jack-ups, semisubmersibles, and drillships. The selection of the type of rig to be used depends primarily on availability of equipment and characteristics of the drilling locations such as weather conditions, water depth, and type of sea bottom. Jack-up rigs are generally restricted to working in water depths up to 375 feet. Semisubmersibles usually operate in water depths from 300 to 2,000 feet. Drillships are the only drilling rig which currently can operate in water of 2,000 feet in depth (MMS, 1991).

Exploratory drilling typically lasts between 45 and 120 days per well. Factors which influence an exploration schedule include the date of arrival of the drilling vessel, seasonal weather conditions, number of wells to be drilled, well depth, and water depth. On average, exploration programs drill between two and six wells per lease (MMS, 1991).

In exploratory drilling, the rig drills a hole in the ocean floor by turning a drill bit attached to a string of pipe made of tubular steel, called a drill stem.

Emission Factors

For exploration activity in the Gulf of Mexico, emission factors were derived for geophysical surveying vessels and drilling units.

Seismic or geophysical survey vessels are typically powered by diesel engines. Based on a sample of survey vessels which operate in the Gulf of Mexico, diesel engines used for this marine application range from a horsepower rating of 80 to over 3,500 horsepower (MMS, 1992a). For survey vessels, emission factors were estimated based on an average horsepower rating of 766. At full power, a survey vessel with this horsepower rating would consume fuel at the rate of approximately 75.3 liters per hour (19.9 gallons per hour) (EPA, 1991).

There are several types of drilling units which operate in any given location, based on the depth of drilling. For this analysis, drilling units consist of all rig types. For each drilling unit application, operations are typically powered by medium- to high-speed diesel engines.

Diesel engines which are used on drillships power the prime movers (i.e., primary generator sets), mud pumps, and the drawworks. The prime movers are powered by diesel engines which range from about 1,100 horsepower to over 3,500 horsepower (Ocean Industry, 1984; 1992). Emission factors associated with the operation of prime movers were estimated based on an average horsepower rating of 2,500. Diesel engines used to power the mud pumps and drawworks on a drillship are typically rated at 1,600 horsepower and 3,000 horsepower, respectively. Data on common engine specifications were based on a review of drillships which have been or currently are contracted for use in the Gulf of Mexico. Diesel engines over 1,500 horsepower, when run at full load, would typically consume fuel at the rate of approximately 164.9 liters per hour (43.5 gallons per hour) (EPA, 1991).

Similar to drillships, the prime movers, mud pumps, and drawworks located on jack-up rigs are powered by diesel engines. Based on a sample of jack-up rigs in the Gulf of Mexico, diesel engines used to operate prime movers range from approximately 1,000 horsepower to 2,250 horsepower (Ocean Industry, 1992). For jack-up rigs, emission factors were estimated for the prime movers based on an average horsepower rating of 1,660. Diesel engines used to power the mud pumps and drawworks on jack-up rigs are typically rated at 1,600 horsepower and 2,000 horsepower, respectively (Ocean Industry, 1992). Fuel consumption rates for diesel engines on jack-up rigs are similar to those specified above for drillships.

Semisubmersible rigs located in the Gulf of Mexico have engine specifications similar to the power sources identified for drillships and jack-up rigs. Based on a review of semisubmersible rigs currently located in the Gulf of Mexico, diesel engines which operate prime movers on these rigs typically have a horsepower rating which ranges from 1,325 horsepower to just over 3,000 horsepower (Ocean Industry, 1992). For semisubmersible rigs, emission factors were estimated based on an average horsepower rating of 2,034. Diesel engines used to power the mud pumps and drawworks on semi-submersible rigs are typically rated at 1,600 horsepower and 3,000 horsepower, respectively (Ocean Industry, 1992). Fuel consumption rates for diesel engines on semi-submersible rigs are similar to those specified above for drillships.

The primary pollutants emitted by diesel engines while in any mode of operation include the following: nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), sulfur oxides (SO_x), and particulates (PM). Total particulate matter equates to total suspended particulate (TSP) and is referred to as TSP in the model and the remainder of this analysis. The primary emission factors are derived in terms of kilograms per 1,000 liters of fuel used. Historical emission factors for each pollutant were multiplied by the associated fuel consumption rate (in terms of 1,000 liters per hour of use) to estimate the level of emissions generated from exploration and drilling activities per hour of use. Emission factors are therefore derived in terms of kilograms per hour of use, as shown in Table B-1.

For drilling units, emission factor data are provided in Table B-1 for each equipment type. In order to estimate total emission factors for each drilling unit, emission factor data were aggregated to represent a composite data set for total engine activity on drilling units. To derive these data, the emission factor data for each equipment type (as shown in the last five columns of Table B-1) were weighted based on the percentage of time each type of equipment is in use (i.e., prime movers, mud pumps, and drawworks).

In a typical drilling operation, some, if not all, of the power sources are continuously engaged. The prime movers are typically in operation on a continuous cycle. These generators are generally not operated at full capacity and, on average, are run at 50 to 75 percent of full load (Diamond M-Odeco Drilling, Inc., 1993; Sonat Offshore Drilling Co., 1993). The engines which operate mud pumps can run continuously throughout the duration of the activity, but, on average, are run at about 50 percent of the time (Diamond M-Odeco Drilling, Inc., 1993). Like prime movers, mud pumps are generally not operated at full capacity and, on average, are run at 50 to 75 percent of full load (Diamond M-Odeco Drilling, Inc., 1993; Sonat Drilling Co., 1993). For this analysis, the emission factors were estimated based on the higher load rate (i.e., 75 percent). Diesel engines which operate the drawworks are typically engaged 80 percent of the time, and are also run at 50 to 75 percent of full load (Diamond M-Odeco Drilling, Inc., 1993; Sonat Offshore Drilling Co., 1993).

The emission factors identified in Table B-1 for each drilling unit were weighted to reflect the percentage of time each engine is used in a given operation. The adjusted emission factors for exploration and drilling activity by type of offshore unit are shown in Table B-2.

Methodology

Emissions from geophysical surveying and exploratory drilling were estimated separately and combined to derive an estimate of emissions from exploration activity. The steps used to estimate each are described below.

Emissions from geophysical surveying were estimated based on total fuel burned in surveying as reported in a survey of offshore oil and gas-related vessels operating in the Gulf of Mexico and the emissions from typical surveying vessels as reported in the vessel survey (MMS, 1992a). The survey of offshore oil and gas-related vessels was

TABLE B-1. Emission factors for geophysical surveying and exploration vessels.

Vessel Type	Pollutant (kg/1,000 liters of fuel)					Fuel Consumption (1,000 liters/ hour)	Pollutant (kg/hour)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Seismic /Survey											
Primary Engine – Avg. 766 hp Maneuver/Cruise	35.90	2.05	9.68	0.15	2.03	0.04	1.49	0.08	0.40	0.01	0.08
Drillship											
Primary Engine – Avg. 2,500 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25
Pumps – Avg. 1,600 hp (75% load)	74.56	2.87	5.34	0.15	2.03	0.12	9.22	0.36	0.66	0.02	0.25
Drawworks – Avg. 3,000 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25
Jack-up											
Primary Engine – Avg. 1,600 hp (75% load)	74.56	2.87	5.34	0.15	2.03	0.12	9.22	0.36	0.66	0.02	0.25
Pumps – Avg. 1,600 hp (75% load)	74.56	2.87	5.34	0.15	2.03	0.12	9.22	0.36	0.66	0.02	0.25
Drawworks – Avg. 2,000 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25
Semisubmersible											
Primary Engine – Avg. 2,034 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25
Pumps – Avg. 1,600 hp (75% load)	74.56	2.87	5.34	0.15	2.03	0.12	9.22	0.36	0.66	0.02	0.25
Drawworks – Avg. 3,000 hp (75% load)	46.87	2.01	9.37	0.15	2.03	0.12	5.80	0.25	1.16	0.02	0.25

Source: EPA, 1991; Ocean Industry, 1992; MMS, 1992a.

TABLE B-2. Adjusted emission factors for geophysical surveying and exploration vessels.*

Vessel Type	Pollutant (kg/hour)				
	NO_x	HC	CO	SO_x	TSP
Seismic /Survey	1.49	0.08	0.40	0.01	0.08
Drillship	15.04	0.62	2.42	0.04	0.58
Jack-up	18.47	0.73	1.92	0.04	0.58
Semisubmersible	15.04	0.62	2.42	0.04	0.58

**Adjusted for drilling vessels based on estimated percentage of time equipment is in use.*
Source: Exhibit 2-1; Diamond M-Odeco Drilling Inc., 1993; Sonat Drilling Co., 1993.

prepared for the Minerals Management Service by the Offshore Operators Committee, the operators' trade association. The survey included 12 seismic and geophysical surveying vessels. There were no reports of geophysical surveying permits in Mississippi or Florida State waters, so no emissions were allocated to these areas.

Emissions from exploratory drilling were based on the number of historical and predicted exploratory wells and the type of drilling rig used. For the OCS, data on historical wells by lease area were used (MMS, 1993b). Predicted exploratory wells were available for subplanning areas (MMS, 1992b) and allocated to lease areas based on historical and predicted levels of activity. Exploratory wells for the Eastern OCS Planning Area shown in the MMS source document used to allocate predicted exploration activity in lease areas were assumed to be drilled after 2000 because of the proposed timing of the next Lease Sale in that planning area and the current moratorium on drilling in that area. Therefore, no emissions are predicted to occur in the Eastern OCS Planning Area. Estimates of exploratory wells in Alabama State waters were based on the number of permits issued (Alabama Geological Survey, 1993). For Louisiana and Texas State waters, the number of exploratory wells was estimated using the number of production wells and the number of exploratory wells per discovery (EPA, 1993). The total number of wells estimated were divided by 45 years (the number of years of offshore production reported by Louisiana) to determine the annual number of exploratory wells. Predicted wells in State waters were estimated using projected exploration activity on the OCS (MMS, 1992b). There were no reports of exploratory drilling permits in Mississippi or Florida State waters.

The type of drilling rig and days of drilling used varied by location and, in the case of OCS waters, by the length of the lease terms. The type of drilling rig and days of drilling assumed are as follows:

- Jack-up rig - used in State waters with 45 days of drilling per well, and in the 5-year lease zone on the OCS with 60 days of drilling per well.
- Semisubmersibles - used in the 8-year lease zone on the OCS with 90 days of drilling per well.
- Drillships - used in the 10-year lease zone on the OCS with 120 days of drilling per well.

The air pollutant emission factors used to determine total annual pollutant emissions associated with exploration and drilling activity were derived from the U.S. Environmental Protection Agency document titled *Commercial Marine Vessel Contributions to Emission Inventories* (EPA, 1991). This document reports data on air pollutant emission factors for various types of marine vessels. This source identifies data on emission factors for marine vessel applications and incorporates previously published data on emission factors for other mobile source applications.

Emission factors for SO_x are typically represented by a variable which can be converted into a numerical estimate based on the percentage of sulfur present in the type of fuel used. For medium- to high-speed engines, as used on exploration vessels and drilling units, a common fuel used is marine diesel fuel. This type of fuel contains, on average, a 0.8 percent sulfur content (EPA, 1991). SO_x emission factors were calculated using this percentage. All emission factors were derived in terms of kilograms per 1,000 liters of fuel.

Baseline

The baseline emissions are shown in Table B-3. The historical emissions are shown in Table B-4. Projections of emissions are shown in Table B-5. These tables show that overtime emissions from exploration vessels shift from areas close to shore to lease areas in deeper water, farther from shore.

Section References

Alabama Geological Survey, Oil and Gas Board. 1993. Personal communication with D. Burroughs, Montgomery, Alabama. February.

Diamond M-Odeco Drilling Inc. 1993. Personal communication with R. James, Operations Manager, Houston, Texas. February.

TABLE B-3. Baseline emissions, geophysical surveying and exploration vessels.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1990 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	3	66.2	2.6	6.9	0.1	2.1
Mobile County, AL	01097	6	132.4	5.2	13.9	0.3	4.2
Jackson County, MS	28059	0	NA	NA	NA	NA	NA
Harrison County, MS	28047	0	NA	NA	NA	NA	NA
Hancock County, MS	28045	0	NA	NA	NA	NA	NA
Orleans Parish, LA	22071	0	NA	NA	NA	NA	NA
St. Bernard Parish, LA	22087	25	547.1	21.7	57.4	1.2	17.2
Plaquemines Parish, LA	22075	120	2636.4	104.4	276.4	5.8	83.1
Jefferson Parish, LA	22051	1	33.0	1.3	3.5	0.1	1.0
Lafourche Parish, LA	22057	16	363.5	14.4	38.1	0.8	11.5
Terrebonne Parish, LA	22109	2	36.7	1.5	3.8	0.1	1.2
St. Mary Parish, LA	22101	8	187.3	7.4	19.6	0.4	5.9
Iberia Parish, LA	22045	7	157.9	6.3	16.6	0.3	5.0
Vermilion Parish, LA	22113	4	80.8	3.2	8.5	0.2	2.5
Cameron Parish, LA	22023	5	117.5	4.7	12.3	0.3	3.7
Calcasieu Parish, LA	22019	0	NA	NA	NA	NA	NA
Orange County, TX	48361	0	NA	NA	NA	NA	NA
Jefferson County, TX	48245	7	164.4	6.5	17.2	0.4	5.2
Chambers County, TX	48071	20	433.2	17.2	45.4	0.9	13.7
Harris County, TX	48201	1	12.6	0.5	1.3	0.0	0.4
Galveston County, TX	48167	5	120.2	4.8	12.6	0.3	3.8
Brazoria County, TX	48039	5	104.3	4.1	10.9	0.2	3.3
Matagorda County, TX	48321	21	464.8	18.4	48.7	1.0	14.7
Calhoun County, TX	48057	17	382.6	15.2	40.1	0.8	12.1
Jackson County, TX	48239	1	25.3	1.0	2.7	0.1	0.8
Refugio County, TX	48391	0	NA	NA	NA	NA	NA
Aransas County, TX	48007	13	278.3	11.0	29.2	0.6	8.8
San Patricio County, TX	48409	0	NA	NA	NA	NA	NA
Nueces County, TX	48355	22	490.1	19.4	51.4	1.1	15.4
Kleberg County, TX	48273	7	151.8	6.0	15.9	0.3	4.8
Kenedy County, TX	48261	8	170.7	6.8	17.9	0.4	5.4
Willacy County, TX	48489	3	66.4	2.6	7.0	0.1	2.1
Cameron County, TX	48061	1	28.5	1.1	3.0	0.1	0.9
Alaminos Canyon	99001	0	NA	NA	NA	NA	NA
Atwater Valley	99005	1	47.8	2.0	7.7	0.1	1.8
Brazos	99007	20	597.3	23.6	62.5	1.3	18.8
Brazos South Addition	99009	0	NA	NA	NA	NA	NA

TABLE B-3. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1990 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Breton Sound	99011	0	NA	NA	NA	NA	NA
Chandeleur	99013	2	58.7	2.3	6.1	0.1	1.9
Chandeleur East Addition	99015	0	NA	NA	NA	NA	NA
Corpus Christi	99017	0	NA	NA	NA	NA	NA
East Breaks	99023	5	223.3	9.2	36.0	0.6	8.6
East Cameron	99025	21	607.1	24.0	63.5	1.3	19.1
East Cameron South Addition	99027	0	NA	NA	NA	NA	NA
Eugene Island	99029	17	489.6	19.4	51.2	1.1	15.4
Eugene Island South Addition	99031	11	313.3	12.4	32.8	0.7	9.9
Ewing Bank	99033	9	254.6	10.1	26.6	0.6	8.0
Galveston	99037	17	509.2	20.2	53.3	1.1	16.0
Galveston South Addition	99039	0	NA	NA	NA	NA	NA
Garden Banks	99041	15	526.4	21.7	85.0	1.4	20.3
Grand Isle	99043	5	156.7	6.2	16.4	0.3	4.9
Grand Isle South Addition	99045	2	68.5	2.7	7.2	0.1	2.2
Green Canyon	99047	14	669.8	27.6	108.1	1.8	25.9
High Island	99049	14	401.5	15.9	42.0	0.9	12.6
High Island East Addtion	99051	4	107.7	4.3	11.3	0.2	3.4
High Island East Add. South Ext.	99053	6	176.2	7.0	18.4	0.4	5.6
High Island South Addition	99055	5	146.9	5.8	15.4	0.3	4.6
Keathley Canyon	99059	1	31.9	1.3	5.1	0.1	1.2
Main Pass	99063	6	166.5	6.6	17.4	0.4	5.2
Main Pass South and East Addition	99065	26	763.7	30.2	79.9	1.7	24.1
Matagorda Island	99067	11	332.9	13.2	34.8	0.7	10.5
Mississippi Canyon	99069	17	797.4	32.9	128.7	2.1	30.8
Mobile	99071	4	107.7	4.3	11.3	0.2	3.4
Mustang Island	99073	6	176.2	7.0	18.4	0.4	5.6
Mustang Island East Addition	99075	0	NA	NA	NA	NA	NA
NG 15-8	99077	0	NA	NA	NA	NA	NA
NG 15-9	99079	0	NA	NA	NA	NA	NA
NG 16-4	99081	0	NA	NA	NA	NA	NA
NG 16-7	99085	0	NA	NA	NA	NA	NA
North Padre Island	99087	0	NA	NA	NA	NA	NA
North Padre Island East Addition	99089	2	49.0	1.9	5.1	0.1	1.5
Port Isabel	99093	0	NA	NA	NA	NA	NA
Sabine Pass	99097	0	NA	NA	NA	NA	NA
Ship Shoal	99099	12	342.7	13.6	35.9	0.7	10.8

TABLE B-3. Concluded.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1990 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Ship Shoal South Addition	99101	13	391.7	15.5	41.0	0.9	12.3
South Marsh Island	99103	3	88.1	3.5	9.2	0.2	2.8
South Marsh Island North Addition	99105	12	362.3	14.3	37.9	0.8	11.4
South Marsh Island South Addition	99107	5	156.7	6.2	16.4	0.3	4.9
South Padre Island	99109	0	NA	NA	NA	NA	NA
South Padre Island East Addition	99111	0	NA	NA	NA	NA	NA
South Pass	99113	0	NA	NA	NA	NA	NA
South Pass East Addition	99115	1	19.6	0.8	2.0	0.0	0.6
South Pass South Addition	99117	6	186.0	7.4	19.5	0.4	5.9
South Pelto	99119	2	49.0	1.9	5.1	0.1	1.5
South Timbalier	99121	4	117.5	4.7	12.3	0.3	3.7
South Timbalier South Addition	99123	14	421.0	16.7	44.0	0.9	13.3
Vermilion	99127	26	773.5	30.6	80.9	1.7	24.4
Vermilion South Addition	99129	0	NA	NA	NA	NA	NA
Viosca Knoll	99133	9	323.0	13.3	52.1	0.9	12.5
Walker Ridge	99135	0	NA	NA	NA	NA	NA
West Cameron	99137	9	254.6	10.1	26.6	0.6	8.0
West Cameron South Addition	99139	7	215.4	8.5	22.5	0.5	6.8
West Cameron West Addition	99141	10	284.0	11.2	29.7	0.6	8.9
West Delta	99143	5	156.7	6.2	16.4	0.3	4.9
West Delta South Addition	99145	4	127.3	5.0	13.3	0.3	4.0
WX-1	99147	0	NA	NA	NA	NA	NA
Apalachicola	99149	0	NA	NA	NA	NA	NA
DeSoto Canyon	99151	0	NA	NA	NA	NA	NA
Destin Dome	99153	0	NA	NA	NA	NA	NA
Florida Middle Ground	99155	0	NA	NA	NA	NA	NA
Howell Hook	99157	0	NA	NA	NA	NA	NA
Lloyd Ridge	99159	0	NA	NA	NA	NA	NA
NG 16-5	99161	0	NA	NA	NA	NA	NA
Pensacola	99163	0	NA	NA	NA	NA	NA
Rankin	99165	0	NA	NA	NA	NA	NA
The Elbow	99167	0	NA	NA	NA	NA	NA
Vernon Basin	99169	0	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: MMS, 1992a, 1992b, 1992c; EPA, 1993; International Association of Geophysical Contractors, 1993; Alabama Geological Survey, 1993; Mississippi Bureau of Marine Resources, 1993.

TABLE B-4. Historical emissions, geophysical surveying and exploration vessels.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1987 Total Emissions by Pollutant (tons/yr) NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	1	22.1	0.9	2.3	0.0	0.7
Mobile County, AL	01097	2	44.1	1.7	4.6	0.1	1.4
Jackson County, MS	28059	0	NA	NA	NA	NA	NA
Harrison County, MS	28047	0	NA	NA	NA	NA	NA
Hancock County, MS	28045	0	NA	NA	NA	NA	NA
Orleans Parish, LA	22071	0	NA	NA	NA	NA	NA
St. Bernard Parish, LA	22087	25	547.1	21.7	57.4	1.2	17.2
Plaquemines Parish, LA	22075	120	2636.4	104.4	276.4	5.8	83.1
Jefferson Parish, LA	22051	1	33.0	1.3	3.5	0.1	1.0
Lafourche Parish, LA	22057	16	363.5	14.4	38.1	0.8	11.5
Terrebonne Parish, LA	22109	2	36.7	1.5	3.8	0.1	1.2
St. Mary Parish, LA	22101	8	187.3	7.4	19.6	0.4	5.9
Iberia Parish, LA	22045	7	157.9	6.3	16.6	0.3	5.0
Vermilion Parish, LA	22113	4	80.8	3.2	8.5	0.2	2.5
Cameron Parish, LA	22023	5	117.5	4.7	12.3	0.3	3.7
Calcasieu Parish, LA	22019	0	NA	NA	NA	NA	NA
Orange County, TX	48361	0	NA	NA	NA	NA	NA
Jefferson County, TX	48245	7	164.4	6.5	17.2	0.4	5.2
Chambers County, TX	48071	20	433.2	17.2	45.4	0.9	13.7
Harris County, TX	48201	1	12.6	0.5	1.3	0.0	0.4
Galveston County, TX	48167	5	120.2	4.8	12.6	0.3	3.8
Brazoria County, TX	48039	5	104.3	4.1	10.9	0.2	3.3
Matagorda County, TX	48321	21	464.8	18.4	48.7	1.0	14.7
Calhoun County, TX	48057	17	382.6	15.2	40.1	0.8	12.1
Jackson County, TX	48239	1	25.3	1.0	2.7	0.1	0.8
Refugio County, TX	48391	0	NA	NA	NA	NA	NA
Aransas County, TX	48007	13	278.3	11.0	29.2	0.6	8.8
San Patricio County, TX	48409	0	NA	NA	NA	NA	NA
Nueces County, TX	48355	22	490.1	19.4	51.4	1.1	15.4
Kleberg County, TX	48273	7	151.8	6.0	15.9	0.3	4.8
Kenedy County, TX	48261	8	170.7	6.8	17.9	0.4	5.4
Willacy County, TX	48489	3	66.4	2.6	7.0	0.1	2.1
Cameron County, TX	48061	1	28.5	1.1	3.0	0.1	0.9
Alaminos Canyon	99001	0	NA	NA	NA	NA	NA
Atwater Valley	99005	0	NA	NA	NA	NA	NA
Brazos	99007	1	29.4	1.2	3.1	0.1	0.9
Brazos South Addition	99009	5	146.9	5.8	15.4	0.3	4.6

TABLE B-4. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1987 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Breton Sound	99011	0	NA	NA	NA	NA	NA
Chandeleur	99013	3	88.1	3.5	9.2	0.2	2.8
Chandeleur East Addition	99015	2	58.7	2.3	6.1	0.1	1.9
Corpus Christi	99017	0	NA	NA	NA	NA	NA
East Breaks	99023	5	239.2	9.9	38.6	0.6	9.2
East Cameron	99025	27	793.1	31.4	83.0	1.7	25.0
East Cameron South Addition	99027	0	NA	NA	NA	NA	NA
Eugene Island	99029	16	470.0	18.6	49.2	1.0	14.8
Eugene Island South Addition	99031	17	499.4	19.8	52.2	1.1	15.7
Ewing Bank	99033	8	235.0	9.3	24.6	0.5	7.4
Galveston	99037	9	264.4	10.5	27.7	0.6	8.3
Galveston South Addition	99039	2	58.7	2.3	6.1	0.1	1.9
Garden Banks	99041	10	358.9	14.8	57.9	1.0	13.9
Grand Isle	99043	0	NA	NA	NA	NA	NA
Grand Isle South Addition	99045	1	29.4	1.2	3.1	0.1	0.9
Green Canyon	99047	12	574.1	23.7	92.6	1.5	22.2
High Island	99049	13	381.9	15.1	39.9	0.8	12.0
High Island East Addtion	99051	9	264.4	10.5	27.7	0.6	8.3
High Island East Add. South Ext.	99053	6	176.2	7.0	18.4	0.4	5.6
High Island South Addition	99055	6	176.2	7.0	18.4	0.4	5.6
Keathley Canyon	99059	0	NA	NA	NA	NA	NA
Main Pass	99063	6	176.2	7.0	18.4	0.4	5.6
Main Pass South and East Addition	99065	24	705.0	27.9	73.8	1.5	22.2
Matagorda Island	99067	16	470.0	18.6	49.2	1.0	14.8
Mississippi Canyon	99069	14	669.8	27.6	108.1	1.8	25.9
Mobile	99071	18	528.7	20.9	55.3	1.2	16.7
Mustang Island	99073	8	235.0	9.3	24.6	0.5	7.4
Mustang Island East Addition	99075	1	29.4	1.2	3.1	0.1	0.9
NG 15−8	99077	0	NA	NA	NA	NA	NA
NG 15−9	99079	0	NA	NA	NA	NA	NA
NG 16−4	99081	0	NA	NA	NA	NA	NA
NG 16−7	99085	0	NA	NA	NA	NA	NA
North Padre Island	99087	1	29.4	1.2	3.1	0.1	0.9
North Padre Island East Addition	99089	3	88.1	3.5	9.2	0.2	2.8
Port Isabel	99093	0	NA	NA	NA	NA	NA
Sabine Pass	99097	0	NA	NA	NA	NA	NA
Ship Shoal	99099	11	323.1	12.8	33.8	0.7	10.2

TABLE B-4. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1987 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Ship Shoal South Addition	99101	9	264.4	10.5	27.7	0.6	8.3
South Marsh Island	99103	0	NA	NA	NA	NA	NA
South Marsh Island North Addition	99105	3	88.1	3.5	9.2	0.2	2.8
South Marsh Island South Addition	99107	8	235.0	9.3	24.6	0.5	7.4
South Padre Island	99109	1	29.4	1.2	3.1	0.1	0.9
South Padre Island East Addition	99111	0	NA	NA	NA	NA	NA
South Pass	99113	1	29.4	1.2	3.1	0.1	0.9
South Pass East Addition	99115	1	29.4	1.2	3.1	0.1	0.9
South Pass South Addition	99117	2	58.7	2.3	6.1	0.1	1.9
South Pelto	99119	1	29.4	1.2	3.1	0.1	0.9
South Timbalier	99121	5	146.9	5.8	15.4	0.3	4.6
South Timbalier South Addition	99123	14	411.2	16.3	43.0	0.9	13.0
Vermilion	99127	23	675.6	26.7	70.7	1.5	21.3
Vermilion South Addition	99129	0	NA	NA	NA	NA	NA
Viosca Knoll	99133	14	502.5	20.7	81.1	1.3	19.4
Walker Ridge	99135	0	NA	NA	NA	NA	NA
West Cameron	99137	2	58.7	2.3	6.1	0.1	1.9
West Cameron South Addition	99139	17	499.4	19.8	52.2	1.1	15.7
West Cameron West Addition	99141	14	411.2	16.3	43.0	0.9	13.0
West Delta	99143	8	235.0	9.3	24.6	0.5	7.4
West Delta South Addition	99145	6	176.2	7.0	18.4	0.4	5.6
WX−1	99147	0	NA	NA	NA	NA	NA
Apalachicola	99149	0	NA	NA	NA	NA	NA
DeSoto Canyon	99151	0	NA	NA	NA	NA	NA
Destin Dome	99153	2	71.8	3.0	11.6	0.2	2.8
Florida Middle Ground	99155	0	NA	NA	NA	NA	NA
Howell Hook	99157	0	NA	NA	NA	NA	NA
Lloyd Ridge	99159	0	NA	NA	NA	NA	NA
NG 16−5	99161	0	NA	NA	NA	NA	NA
Pensacola	99163	2	58.7	2.3	6.1	0.1	1.9
Rankin	99165	0	NA	NA	NA	NA	NA
The Elbow	99167	0	NA	NA	NA	NA	NA
Vernon Basin	99169	0	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: MMS, 1992a, 1992b, 1992c; EPA, 1993; International Association of Geophysical Contractors, 1993; Alabama Geological Survey, 1993; Mississippi Bureau of Marine Resources, 1993.

TABLE B-4. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1988 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	1	22.1	0.9	2.3	0.0	0.7
Mobile County, AL	01097	3	66.2	2.6	6.9	0.1	2.1
Jackson County, MS	28059	0	NA	NA	NA	NA	NA
Harrison County, MS	28047	0	NA	NA	NA	NA	NA
Hancock County, MS	28045	0	NA	NA	NA	NA	NA
Orleans Parish, LA	22071	0	NA	NA	NA	NA	NA
St. Bernard Parish, LA	22087	25	547.1	21.7	57.4	1.2	17.2
Plaquemines Parish, LA	22075	120	2636.4	104.4	276.4	5.8	83.1
Jefferson Parish, LA	22051	1	33.0	1.3	3.5	0.1	1.0
Lafourche Parish, LA	22057	16	363.5	14.4	38.1	0.8	11.5
Terrebonne Parish, LA	22109	2	36.7	1.5	3.8	0.1	1.2
St. Mary Parish, LA	22101	8	187.3	7.4	19.6	0.4	5.9
Iberia Parish, LA	22045	7	157.9	6.3	16.6	0.3	5.0
Vermilion Parish, LA	22113	4	80.8	3.2	8.5	0.2	2.5
Cameron Parish, LA	22023	5	117.5	4.7	12.3	0.3	3.7
Calcasieu Parish, LA	22019	0	NA	NA	NA	NA	NA
Orange County, TX	48361	0	NA	NA	NA	NA	NA
Jefferson County, TX	48245	7	164.4	6.5	17.2	0.4	5.2
Chambers County, TX	48071	20	433.2	17.2	45.4	0.9	13.7
Harris County, TX	48201	1	12.6	0.5	1.3	0.0	0.4
Galveston County, TX	48167	5	120.2	4.8	12.6	0.3	3.8
Brazoria County, TX	48039	5	104.3	4.1	10.9	0.2	3.3
Matagorda County, TX	48321	21	464.8	18.4	48.7	1.0	14.7
Calhoun County, TX	48057	17	382.6	15.2	40.1	0.8	12.1
Jackson County, TX	48239	1	25.3	1.0	2.7	0.1	0.8
Refugio County, TX	48391	0	NA	NA	NA	NA	NA
Aransas County, TX	48007	13	278.3	11.0	29.2	0.6	8.8
San Patricio County, TX	48409	0	NA	NA	NA	NA	NA
Nueces County, TX	48355	22	490.1	19.4	51.4	1.1	15.4
Kleberg County, TX	48273	7	151.8	6.0	15.9	0.3	4.8
Kenedy County, TX	48261	8	170.7	6.8	17.9	0.4	5.4
Willacy County, TX	48489	3	66.4	2.6	7.0	0.1	2.1
Cameron County, TX	48061	1	28.5	1.1	3.0	0.1	0.9
Alaminos Canyon	99001	0	NA	NA	NA	NA	NA
Atwater Valley	99005	1	47.8	2.0	7.7	0.1	1.8
Brazos	99007	11	323.1	12.8	33.8	0.7	10.2
Brazos South Addition	99009	1	29.4	1.2	3.1	0.1	0.9

TABLE B-4. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1988 Total Emissions by Pollutant (tons/yr) NOx	HC	CO	SOx	TSP
Breton Sound	99011	0	NA	NA	NA	NA	NA
Chandeleur	99013	4	117.5	4.7	12.3	0.3	3.7
Chandeleur East Addition	99015	4	117.5	4.7	12.3	0.3	3.7
Corpus Christi	99017	0	NA	NA	NA	NA	NA
East Breaks	99023	6	287.1	11.8	46.3	0.8	11.1
East Cameron	99025	38	1116.2	44.2	116.8	2.4	35.2
East Cameron South Addition	99027	0	NA	NA	NA	NA	NA
Eugene Island	99029	14	411.2	16.3	43.0	0.9	13.0
Eugene Island South Addition	99031	22	646.2	25.6	67.6	1.4	20.4
Ewing Bank	99033	10	293.7	11.6	30.7	0.6	9.3
Galveston	99037	16	470.0	18.6	49.2	1.0	14.8
Galveston South Addition	99039	2	58.7	2.3	6.1	0.1	1.9
Garden Banks	99041	12	430.7	17.8	69.5	1.2	16.6
Grand Isle	99043	8	235.0	9.3	24.6	0.5	7.4
Grand Isle South Addition	99045	3	88.1	3.5	9.2	0.2	2.8
Green Canyon	99047	24	1148.2	47.4	185.3	3.1	44.4
High Island	99049	25	734.4	29.1	76.8	1.6	23.1
High Island East Addtion	99051	9	264.4	10.5	27.7	0.6	8.3
High Island East Add. South Ext.	99053	8	235.0	9.3	24.6	0.5	7.4
High Island South Addition	99055	9	264.4	10.5	27.7	0.6	8.3
Keathley Canyon	99059	0	NA	NA	NA	NA	NA
Main Pass	99063	11	323.1	12.8	33.8	0.7	10.2
Main Pass South and East Addition	99065	16	470.0	18.6	49.2	1.0	14.8
Matagorda Island	99067	22	646.2	25.6	67.6	1.4	20.4
Mississippi Canyon	99069	26	1243.9	51.3	200.7	3.3	48.0
Mobile	99071	5	146.9	5.8	15.4	0.3	4.6
Mustang Island	99073	8	235.0	9.3	24.6	0.5	7.4
Mustang Island East Addition	99075	5	146.9	5.8	15.4	0.3	4.6
NG 15−8	99077	0	NA	NA	NA	NA	NA
NG 15−9	99079	0	NA	NA	NA	NA	NA
NG 16−4	99081	0	NA	NA	NA	NA	NA
NG 16−7	99085	0	NA	NA	NA	NA	NA
North Padre Island	99087	2	58.7	2.3	6.1	0.1	1.9
North Padre Island East Addition	99089	1	29.4	1.2	3.1	0.1	0.9
Port Isabel	99093	0	NA	NA	NA	NA	NA
Sabine Pass	99097	0	NA	NA	NA	NA	NA
Ship Shoal	99099	17	499.4	19.8	52.2	1.1	15.7

TABLE B-4. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1988 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Ship Shoal South Addition	99101	10	293.7	11.6	30.7	0.6	9.3
South Marsh Island	99103	5	146.9	5.8	15.4	0.3	4.6
South Marsh Island North Addition	99105	15	440.6	17.4	46.1	1.0	13.9
South Marsh Island South Addition	99107	6	176.2	7.0	18.4	0.4	5.6
South Padre Island	99109	1	29.4	1.2	3.1	0.1	0.9
South Padre Island East Addition	99111	0	NA	NA	NA	NA	NA
South Pass	99113	3	88.1	3.5	9.2	0.2	2.8
South Pass East Addition	99115	0	NA	NA	NA	NA	NA
South Pass South Addition	99117	13	381.9	15.1	39.9	0.8	12.0
South Pelto	99119	3	88.1	3.5	9.2	0.2	2.8
South Timbalier	99121	2	58.7	2.3	6.1	0.1	1.9
South Timbalier South Addition	99123	11	323.1	12.8	33.8	0.7	10.2
Vermilion	99127	31	910.6	36.0	95.3	2.0	28.7
Vermilion South Addition	99129	0	NA	NA	NA	NA	NA
Viosca Knoll	99133	17	610.2	25.2	98.5	1.6	23.6
Walker Ridge	99135	0	NA	NA	NA	NA	NA
West Cameron	99137	6	176.2	7.0	18.4	0.4	5.6
West Cameron South Addition	99139	16	470.0	18.6	49.2	1.0	14.8
West Cameron West Addition	99141	15	440.6	17.4	46.1	1.0	13.9
West Delta	99143	12	352.5	14.0	36.9	0.8	11.1
West Delta South Addition	99145	5	146.9	5.8	15.4	0.3	4.6
WX-1	99147	0	NA	NA	NA	NA	NA
Apalachicola	99149	0	NA	NA	NA	NA	NA
DeSoto Canyon	99151	0	NA	NA	NA	NA	NA
Destin Dome	99153	0	NA	NA	NA	NA	NA
Florida Middle Ground	99155	0	NA	NA	NA	NA	NA
Howell Hook	99157	0	NA	NA	NA	NA	NA
Lloyd Ridge	99159	0	NA	NA	NA	NA	NA
NG 16-5	99161	0	NA	NA	NA	NA	NA
Pensacola	99163	1	29.4	1.2	3.1	0.1	0.9
Rankin	99165	0	NA	NA	NA	NA	NA
The Elbow	99167	0	NA	NA	NA	NA	NA
Vernon Basin	99169	0	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: MMS, 1992a, 1992b, 1992c; EPA, 1993; International Association of Geophysical Contractors, 1993; Alabama Geological Survey, 1993; Mississippi Bureau of Marine Resources, 1993.

TABLE B-4. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1991 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	4	88.2	3.5	9.3	0.2	2.8
Mobile County, AL	01097	9	198.5	7.9	20.8	0.4	6.3
Jackson County, MS	28059	0	NA	NA	NA	NA	NA
Harrison County, MS	28047	0	NA	NA	NA	NA	NA
Hancock County, MS	28045	0	NA	NA	NA	NA	NA
Orleans Parish, LA	22071	0	NA	NA	NA	NA	NA
St. Bernard Parish, LA	22087	25	547.1	21.7	57.4	1.2	17.2
Plaquemines Parish, LA	22075	120	2636.4	104.4	276.4	5.8	83.1
Jefferson Parish, LA	22051	1	33.0	1.3	3.5	0.1	1.0
Lafourche Parish, LA	22057	16	363.5	14.4	38.1	0.8	11.5
Terrebonne Parish, LA	22109	2	36.7	1.5	3.8	0.1	1.2
St. Mary Parish, LA	22101	8	187.3	7.4	19.6	0.4	5.9
Iberia Parish, LA	22045	7	157.9	6.3	16.6	0.3	5.0
Vermilion Parish, LA	22113	4	80.8	3.2	8.5	0.2	2.5
Cameron Parish, LA	22023	5	117.5	4.7	12.3	0.3	3.7
Calcasieu Parish, LA	22019	0	NA	NA	NA	NA	NA
Orange County, TX	48361	0	NA	NA	NA	NA	NA
Jefferson County, TX	48245	7	164.4	6.5	17.2	0.4	5.2
Chambers County, TX	48071	20	433.2	17.2	45.4	0.9	13.7
Harris County, TX	48201	1	12.6	0.5	1.3	0.0	0.4
Galveston County, TX	48167	5	120.2	4.8	12.6	0.3	3.8
Brazoria County, TX	48039	5	104.3	4.1	10.9	0.2	3.3
Matagorda County, TX	48321	21	464.8	18.4	48.7	1.0	14.7
Calhoun County, TX	48057	17	382.6	15.2	40.1	0.8	12.1
Jackson County, TX	48239	1	25.3	1.0	2.7	0.1	0.8
Refugio County, TX	48391	0	NA	NA	NA	NA	NA
Aransas County, TX	48007	13	278.3	11.0	29.2	0.6	8.8
San Patricio County, TX	48409	0	NA	NA	NA	NA	NA
Nueces County, TX	48355	22	490.1	19.4	51.4	1.1	15.4
Kleberg County, TX	48273	7	151.8	6.0	15.9	0.3	4.8
Kenedy County, TX	48261	8	170.7	6.8	17.9	0.4	5.4
Willacy County, TX	48489	3	66.4	2.6	7.0	0.1	2.1
Cameron County, TX	48061	1	28.5	1.1	3.0	0.1	0.9
Alaminos Canyon	99001	0	NA	NA	NA	NA	NA
Atwater Valley	99005	1	47.8	2.0	7.7	0.1	1.8
Brazos	99007	25	734.4	29.1	76.8	1.6	23.1
Brazos South Addition	99009	0	NA	NA	NA	NA	NA

TABLE B-4. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1991 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Breton Sound	99011	0	NA	NA	NA	NA	NA
Chandeleur	99013	1	29.4	1.2	3.1	0.1	0.9
Chandeleur East Addition	99015	0	NA	NA	NA	NA	NA
Corpus Christi	99017	0	NA	NA	NA	NA	NA
East Breaks	99023	4	191.4	7.9	30.9	0.5	7.4
East Cameron	99025	12	352.5	14.0	36.9	0.8	11.1
East Cameron South Addition	99027	0	NA	NA	NA	NA	NA
Eugene Island	99029	18	528.7	20.9	55.3	1.2	16.7
Eugene Island South Addition	99031	5	146.9	5.8	15.4	0.3	4.6
Ewing Bank	99033	8	235.0	9.3	24.6	0.5	7.4
Galveston	99037	18	528.7	20.9	55.3	1.2	16.7
Galveston South Addition	99039	0	NA	NA	NA	NA	NA
Garden Banks	99041	16	574.3	23.7	92.7	1.5	22.2
Grand Isle	99043	4	117.5	4.7	12.3	0.3	3.7
Grand Isle South Addition	99045	2	58.7	2.3	6.1	0.1	1.9
Green Canyon	99047	9	430.6	17.8	69.5	1.2	16.6
High Island	99049	8	235.0	9.3	24.6	0.5	7.4
High Island East Addtion	99051	1	29.4	1.2	3.1	0.1	0.9
High Island East Add. South Ext.	99053	5	146.9	5.8	15.4	0.3	4.6
High Island South Addition	99055	3	88.1	3.5	9.2	0.2	2.8
Keathley Canyon	99059	1	47.8	2.0	7.7	0.1	1.8
Main Pass	99063	3	88.1	3.5	9.2	0.2	2.8
Main Pass South and East Addition	99065	31	910.6	36.0	95.3	2.0	28.7
Matagorda Island	99067	6	176.2	7.0	18.4	0.4	5.6
Mississippi Canyon	99069	12	574.1	23.7	92.6	1.5	22.2
Mobile	99071	3	88.1	3.5	9.2	0.2	2.8
Mustang Island	99073	5	146.9	5.8	15.4	0.3	4.6
Mustang Island East Addition	99075	0	NA	NA	NA	NA	NA
NG 15-8	99077	0	NA	NA	NA	NA	NA
NG 15-9	99079	0	NA	NA	NA	NA	NA
NG 16-4	99081	0	NA	NA	NA	NA	NA
NG 16-7	99085	0	NA	NA	NA	NA	NA
North Padre Island	99087	0	NA	NA	NA	NA	NA
North Padre Island East Addition	99089	2	58.7	2.3	6.1	0.1	1.9
Port Isabel	99093	0	NA	NA	NA	NA	NA
Sabine Pass	99097	0	NA	NA	NA	NA	NA
Ship Shoal	99099	9	264.4	10.5	27.7	0.6	8.3

TABLE B-4. Concluded.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1991 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Ship Shoal South Addition	99101	15	440.6	17.4	46.1	1.0	13.9
South Marsh Island	99103	2	58.7	2.3	6.1	0.1	1.9
South Marsh Island North Addition	99105	11	323.1	12.8	33.8	0.7	10.2
South Marsh Island South Addition	99107	5	146.9	5.8	15.4	0.3	4.6
South Padre Island	99109	0	NA	NA	NA	NA	NA
South Padre Island East Addition	99111	0	NA	NA	NA	NA	NA
South Pass	99113	0	NA	NA	NA	NA	NA
South Pass East Addition	99115	1	29.4	1.2	3.1	0.1	0.9
South Pass South Addition	99117	3	88.1	3.5	9.2	0.2	2.8
South Pelto	99119	1	29.4	1.2	3.1	0.1	0.9
South Timbalier	99121	5	146.9	5.8	15.4	0.3	4.6
South Timbalier South Addition	99123	16	470.0	18.6	49.2	1.0	14.8
Vermilion	99127	24	705.0	27.9	73.8	1.5	22.2
Vermilion South Addition	99129	0	NA	NA	NA	NA	NA
Viosca Knoll	99133	5	179.5	7.4	29.0	0.5	6.9
Walker Ridge	99135	0	NA	NA	NA	NA	NA
West Cameron	99137	10	293.7	11.6	30.7	0.6	9.3
West Cameron South Addition	99139	3	88.1	3.5	9.2	0.2	2.8
West Cameron West Addition	99141	7	205.6	8.1	21.5	0.4	6.5
West Delta	99143	2	58.7	2.3	6.1	0.1	1.9
West Delta South Addition	99145	4	117.5	4.7	12.3	0.3	3.7
WX-1	99147	0	NA	NA	NA	NA	NA
Apalachicola	99149	0	NA	NA	NA	NA	NA
DeSoto Canyon	99151	0	NA	NA	NA	NA	NA
Destin Dome	99153	0	NA	NA	NA	NA	NA
Florida Middle Ground	99155	0	NA	NA	NA	NA	NA
Howell Hook	99157	0	NA	NA	NA	NA	NA
Lloyd Ridge	99159	0	NA	NA	NA	NA	NA
NG 16-5	99161	0	NA	NA	NA	NA	NA
Pensacola	99163	0	NA	NA	NA	NA	NA
Rankin	99165	0	NA	NA	NA	NA	NA
The Elbow	99167	0	NA	NA	NA	NA	NA
Vernon Basin	99169	0	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: MMS, 1992a, 1992b, 1992c; EPA, 1993; International Association of Geophysical Contractors, 1993; Alabama Geological Survey, 1993; Mississippi Bureau of Marine Resources, 1993.

TABLE B-5. Projected emissions, geophysical surveying and exploration vessels.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1993 Total Emissions by Pollutant (tons/yr) NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	2	44.1	1.7	4.6	0.1	1.4
Mobile County, AL	01097	5	110.3	4.4	11.6	0.2	3.5
Jackson County, MS	28059	0	NA	NA	NA	NA	NA
Harrison County, MS	28047	0	NA	NA	NA	NA	NA
Hancock County, MS	28045	0	NA	NA	NA	NA	NA
Orleans Parish, LA	22071	0	NA	NA	NA	NA	NA
St. Bernard Parish, LA	22087	25	547.1	21.7	57.4	1.2	17.2
Plaquemines Parish, LA	22075	120	2636.4	104.4	276.4	5.8	83.1
Jefferson Parish, LA	22051	1	33.0	1.3	3.5	0.1	1.0
Lafourche Parish, LA	22057	16	363.5	14.4	38.1	0.8	11.5
Terrebonne Parish, LA	22109	2	36.7	1.5	3.8	0.1	1.2
St. Mary Parish, LA	22101	8	187.3	7.4	19.6	0.4	5.9
Iberia Parish, LA	22045	7	157.9	6.3	16.6	0.3	5.0
Vermilion Parish, LA	22113	4	80.8	3.2	8.5	0.2	2.5
Cameron Parish, LA	22023	5	117.5	4.7	12.3	0.3	3.7
Calcasieu Parish, LA	22019	0	NA	NA	NA	NA	NA
Orange County, TX	48361	0	NA	NA	NA	NA	NA
Jefferson County, TX	48245	7	164.4	6.5	17.2	0.4	5.2
Chambers County, TX	48071	20	433.2	17.2	45.4	0.9	13.7
Harris County, TX	48201	1	12.6	0.5	1.3	0.0	0.4
Galveston County, TX	48167	5	120.2	4.8	12.6	0.3	3.8
Brazoria County, TX	48039	5	104.3	4.1	10.9	0.2	3.3
Matagorda County, TX	48321	21	464.8	18.4	48.7	1.0	14.7
Calhoun County, TX	48057	17	382.6	15.2	40.1	0.8	12.1
Jackson County, TX	48239	1	25.3	1.0	2.7	0.1	0.8
Refugio County, TX	48391	0	NA	NA	NA	NA	NA
Aransas County, TX	48007	13	278.3	11.0	29.2	0.6	8.8
San Patricio County, TX	48409	0	NA	NA	NA	NA	NA
Nueces County, TX	48355	22	490.1	19.4	51.4	1.1	15.4
Kleberg County, TX	48273	7	151.8	6.0	15.9	0.3	4.8
Kenedy County, TX	48261	8	170.7	6.8	17.9	0.4	5.4
Willacy County, TX	48489	3	66.4	2.6	7.0	0.1	2.1
Cameron County, TX	48061	1	28.5	1.1	3.0	0.1	0.9
Alaminos Canyon	99001	0	NA	NA	NA	NA	NA
Atwater Valley	99005	1	34.3	1.4	5.5	0.1	1.3
Brazos	99007	3	84.9	3.4	8.9	0.2	2.7
Brazos South Addition	99009	0	NA	NA	NA	NA	NA

TABLE B-5. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1993 Total Emissions by Pollutant (tons/yr) NOx	HC	CO	SOx	TSP
Breton Sound	99011	0	NA	NA	NA	NA	NA
Chandeleur	99013	1	42.2	1.7	4.4	0.1	1.3
Chandeleur East Addition	99015	0	NA	NA	NA	NA	NA
Corpus Christi	99017	0	NA	NA	NA	NA	NA
East Breaks	99023	6	299.4	12.4	48.3	0.8	11.6
East Cameron	99025	4	111.8	4.4	11.7	0.2	3.5
East Cameron South Addition	99027	0	NA	NA	NA	NA	NA
Eugene Island	99029	3	90.2	3.6	9.4	0.2	2.8
Eugene Island South Addition	99031	7	205.7	8.1	21.5	0.4	6.5
Ewing Bank	99033	6	167.2	6.6	17.5	0.4	5.3
Galveston	99037	2	72.4	2.9	7.6	0.2	2.3
Galveston South Addition	99039	0	NA	NA	NA	NA	NA
Garden Banks	99041	20	706.0	29.1	113.9	1.9	27.3
Grand Isle	99043	1	28.9	1.1	3.0	0.1	0.9
Grand Isle South Addition	99045	2	45.0	1.8	4.7	0.1	1.4
Green Canyon	99047	9	439.8	18.2	71.0	1.2	17.0
High Island	99049	2	57.1	2.3	6.0	0.1	1.8
High Island East Addtion	99051	5	144.5	5.7	15.1	0.3	4.5
High Island East Add. South Ext.	99053	8	236.4	9.4	24.7	0.5	7.4
High Island South Addition	99055	7	197.0	7.8	20.6	0.4	6.2
Keathley Canyon	99059	100	4770.0	196.9	769.6	12.8	184.2
Main Pass	99063	4	119.5	4.7	12.5	0.3	3.8
Main Pass South and East Addition	99065	19	548.2	21.7	57.3	1.2	17.3
Matagorda Island	99067	2	47.3	1.9	5.0	0.1	1.5
Mississippi Canyon	99069	12	572.3	23.6	92.3	1.5	22.1
Mobile	99071	3	77.3	3.1	8.1	0.2	2.4
Mustang Island	99073	1	25.1	1.0	2.6	0.1	0.8
Mustang Island East Addition	99075	0	NA	NA	NA	NA	NA
NG 15-8	99077	0	NA	NA	NA	NA	NA
NG 15-9	99079	11	519.1	21.4	83.8	1.4	20.1
NG 16-4	99081	11	519.1	21.4	83.8	1.4	20.1
NG 16-7	99085	11	519.1	21.4	83.8	1.4	20.1
North Padre Island	99087	0	NA	NA	NA	NA	NA
North Padre Island East Addition	99089	0	7.0	0.3	0.7	0.0	0.2
Port Isabel	99093	0	NA	NA	NA	NA	NA
Sabine Pass	99097	0	NA	NA	NA	NA	NA
Ship Shoal	99099	2	63.1	2.5	6.6	0.1	2.0

TABLE B-5. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1993 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Ship Shoal South Addition	99101	9	257.2	10.2	26.9	0.6	8.1
South Marsh Island	99103	1	16.2	0.6	1.7	0.0	0.5
South Marsh Island North Addition	99105	2	66.7	2.6	7.0	0.1	2.1
South Marsh Island South Addition	99107	4	102.9	4.1	10.8	0.2	3.2
South Padre Island	99109	0	NA	NA	NA	NA	NA
South Padre Island East Addition	99111	0	NA	NA	NA	NA	NA
South Pass	99113	0	NA	NA	NA	NA	NA
South Pass East Addition	99115	0	14.1	0.6	1.5	0.0	0.4
South Pass South Addition	99117	5	133.5	5.3	14.0	0.3	4.2
South Pelto	99119	0	9.0	0.4	0.9	0.0	0.3
South Timbalier	99121	1	21.6	0.9	2.3	0.0	0.7
South Timbalier South Addition	99123	9	276.4	10.9	28.9	0.6	8.7
Vermilion	99127	5	142.5	5.6	14.9	0.3	4.5
Vermilion South Addition	99129	0	NA	NA	NA	NA	NA
Viosca Knoll	99133	6	231.9	9.6	37.4	0.6	9.0
Walker Ridge	99135	11	519.1	21.4	83.8	1.4	20.1
West Cameron	99137	2	46.9	1.9	4.9	0.1	1.5
West Cameron South Addition	99139	5	141.4	5.6	14.8	0.3	4.5
West Cameron West Addition	99141	2	52.3	2.1	5.5	0.1	1.6
West Delta	99143	4	112.4	4.5	11.8	0.2	3.5
West Delta South Addition	99145	3	91.4	3.6	9.6	0.2	2.9
WX-1	99147	0	NA	NA	NA	NA	NA
Apalachicola	99149	5	139.6	5.5	14.6	0.3	4.4
DeSoto Canyon	99151	0	NA	NA	NA	NA	NA
Destin Dome	99153	5	170.6	7.0	27.5	0.5	6.6
Florida Middle Ground	99155	0	NA	NA	NA	NA	NA
Howell Hook	99157	0	NA	NA	NA	NA	NA
Lloyd Ridge	99159	0	NA	NA	NA	NA	NA
NG 16-5	99161	0	NA	NA	NA	NA	NA
Pensacola	99163	5	139.6	5.5	14.6	0.3	4.4
Rankin	99165	0	NA	NA	NA	NA	NA
The Elbow	99167	0	NA	NA	NA	NA	NA
Vernon Basin	99169	0	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: MMS, 1992a, 1992b, 1992c; EPA, 1993; International Association of Geophysical Contractors, 1993; Alabama Geological Survey, 1993; Mississippi Bureau of Marine Resources, 1993.

TABLE B-5. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1995 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	1	22.1	0.9	2.3	0.0	0.7
Mobile County, AL	01097	2	44.1	1.7	4.6	0.1	1.4
Jackson County, MS	28059	0	NA	NA	NA	NA	NA
Harrison County, MS	28047	0	NA	NA	NA	NA	NA
Hancock County, MS	28045	0	NA	NA	NA	NA	NA
Orleans Parish, LA	22071	0	NA	NA	NA	NA	NA
St. Bernard Parish, LA	22087	25	547.1	21.7	57.4	1.2	17.2
Plaquemines Parish, LA	22075	120	2636.4	104.4	276.4	5.8	83.1
Jefferson Parish, LA	22051	1	33.0	1.3	3.5	0.1	1.0
Lafourche Parish, LA	22057	16	363.5	14.4	38.1	0.8	11.5
Terrebonne Parish, LA	22109	2	36.7	1.5	3.8	0.1	1.2
St. Mary Parish, LA	22101	8	187.3	7.4	19.6	0.4	5.9
Iberia Parish, LA	22045	7	157.9	6.3	16.6	0.3	5.0
Vermilion Parish, LA	22113	4	80.8	3.2	8.5	0.2	2.5
Cameron Parish, LA	22023	5	117.5	4.7	12.3	0.3	3.7
Calcasieu Parish, LA	22019	0	NA	NA	NA	NA	NA
Orange County, TX	48361	0	NA	NA	NA	NA	NA
Jefferson County, TX	48245	7	164.4	6.5	17.2	0.4	5.2
Chambers County, TX	48071	20	433.2	17.2	45.4	0.9	13.7
Harris County, TX	48201	1	12.6	0.5	1.3	0.0	0.4
Galveston County, TX	48167	5	120.2	4.8	12.6	0.3	3.8
Brazoria County, TX	48039	5	104.3	4.1	10.9	0.2	3.3
Matagorda County, TX	48321	21	464.8	18.4	48.7	1.0	14.7
Calhoun County, TX	48057	17	382.6	15.2	40.1	0.8	12.1
Jackson County, TX	48239	1	25.3	1.0	2.7	0.1	0.8
Refugio County, TX	48391	0	NA	NA	NA	NA	NA
Aransas County, TX	48007	13	278.3	11.0	29.2	0.6	8.8
San Patricio County, TX	48409	0	NA	NA	NA	NA	NA
Nueces County, TX	48355	22	490.1	19.4	51.4	1.1	15.4
Kleberg County, TX	48273	7	151.8	6.0	15.9	0.3	4.8
Kenedy County, TX	48261	8	170.7	6.8	17.9	0.4	5.4
Willacy County, TX	48489	3	66.4	2.6	7.0	0.1	2.1
Cameron County, TX	48061	1	28.5	1.1	3.0	0.1	0.9
Alaminos Canyon	99001	0	NA	NA	NA	NA	NA
Atwater Valley	99005	1	34.3	1.4	5.5	0.1	1.3
Brazos	99007	3	84.9	3.4	8.9	0.2	2.7
Brazos South Addition	99009	0	NA	NA	NA	NA	NA

TABLE B-5. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1995 Total Emissions by Pollutant (tons/yr) NOx	HC	CO	SOx	TSP
Breton Sound	99011	0	NA	NA	NA	NA	NA
Chandeleur	99013	1	42.2	1.7	4.4	0.1	1.3
Chandeleur East Addition	99015	0	NA	NA	NA	NA	NA
Corpus Christi	99017	0	NA	NA	NA	NA	NA
East Breaks	99023	6	299.4	12.4	48.3	0.8	11.6
East Cameron	99025	4	111.8	4.4	11.7	0.2	3.5
East Cameron South Addition	99027	0	NA	NA	NA	NA	NA
Eugene Island	99029	3	90.2	3.6	9.4	0.2	2.8
Eugene Island South Addition	99031	7	205.7	8.1	21.5	0.4	6.5
Ewing Bank	99033	6	167.2	6.6	17.5	0.4	5.3
Galveston	99037	2	72.4	2.9	7.6	0.2	2.3
Galveston South Addition	99039	0	NA	NA	NA	NA	NA
Garden Banks	99041	20	706.0	29.1	113.9	1.9	27.3
Grand Isle	99043	1	28.9	1.1	3.0	0.1	0.9
Grand Isle South Addition	99045	2	45.0	1.8	4.7	0.1	1.4
Green Canyon	99047	9	439.8	18.2	71.0	1.2	17.0
High Island	99049	2	57.1	2.3	6.0	0.1	1.8
High Island East Addtion	99051	5	144.5	5.7	15.1	0.3	4.5
High Island East Add. South Ext.	99053	8	236.4	9.4	24.7	0.5	7.4
High Island South Addition	99055	7	197.0	7.8	20.6	0.4	6.2
Keathley Canyon	99059	100	4770.0	196.9	769.6	12.8	184.2
Main Pass	99063	4	119.5	4.7	12.5	0.3	3.8
Main Pass South and East Addition	99065	19	548.2	21.7	57.3	1.2	17.3
Matagorda Island	99067	2	47.3	1.9	5.0	0.1	1.5
Mississippi Canyon	99069	12	572.3	23.6	92.3	1.5	22.1
Mobile	99071	3	77.3	3.1	8.1	0.2	2.4
Mustang Island	99073	1	25.1	1.0	2.6	0.1	0.8
Mustang Island East Addition	99075	0	NA	NA	NA	NA	NA
NG 15−8	99077	0	NA	NA	NA	NA	NA
NG 15−9	99079	11	519.1	21.4	83.8	1.4	20.1
NG 16−4	99081	11	519.1	21.4	83.8	1.4	20.1
NG 16−7	99085	11	519.1	21.4	83.8	1.4	20.1
North Padre Island	99087	0	NA	NA	NA	NA	NA
North Padre Island East Addition	99089	0	7.0	0.3	0.7	0.0	0.2
Port Isabel	99093	0	NA	NA	NA	NA	NA
Sabine Pass	99097	0	NA	NA	NA	NA	NA
Ship Shoal	99099	2	63.1	2.5	6.6	0.1	2.0

TABLE B-5. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	1995 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Ship Shoal South Addition	99101	9	257.2	10.2	26.9	0.6	8.1
South Marsh Island	99103	1	16.2	0.6	1.7	0.0	0.5
South Marsh Island North Addition	99105	2	66.7	2.6	7.0	0.1	2.1
South Marsh Island South Addition	99107	4	102.9	4.1	10.8	0.2	3.2
South Padre Island	99109	0	NA	NA	NA	NA	NA
South Padre Island East Addition	99111	0	NA	NA	NA	NA	NA
South Pass	99113	0	NA	NA	NA	NA	NA
South Pass East Addition	99115	0	14.1	0.6	1.5	0.0	0.4
South Pass South Addition	99117	5	133.5	5.3	14.0	0.3	4.2
South Pelto	99119	0	9.0	0.4	0.9	0.0	0.3
South Timbalier	99121	1	21.6	0.9	2.3	0.0	0.7
South Timbalier South Addition	99123	9	276.4	10.9	28.9	0.6	8.7
Vermilion	99127	5	142.5	5.6	14.9	0.3	4.5
Vermilion South Addition	99129	0	NA	NA	NA	NA	NA
Viosca Knoll	99133	6	231.9	9.6	37.4	0.6	9.0
Walker Ridge	99135	11	519.1	21.4	83.8	1.4	20.1
West Cameron	99137	2	46.9	1.9	4.9	0.1	1.5
West Cameron South Addition	99139	5	141.4	5.6	14.8	0.3	4.5
West Cameron West Addition	99141	2	52.3	2.1	5.5	0.1	1.6
West Delta	99143	4	112.4	4.5	11.8	0.2	3.5
West Delta South Addition	99145	3	91.4	3.6	9.6	0.2	2.9
WX-1	99147	0	NA	NA	NA	NA	NA
Apalachicola	99149	5	139.6	5.5	14.6	0.3	4.4
DeSoto Canyon	99151	0	NA	NA	NA	NA	NA
Destin Dome	99153	5	170.6	7.0	27.5	0.5	6.6
Florida Middle Ground	99155	0	NA	NA	NA	NA	NA
Howell Hook	99157	0	NA	NA	NA	NA	NA
Lloyd Ridge	99159	0	NA	NA	NA	NA	NA
NG 16-5	99161	0	NA	NA	NA	NA	NA
Pensacola	99163	5	139.6	5.5	14.6	0.3	4.4
Rankin	99165	0	NA	NA	NA	NA	NA
The Elbow	99167	0	NA	NA	NA	NA	NA
Vernon Basin	99169	0	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: MMS, 1992a, 1992b, 1992c; EPA, 1993; International Association of Geophysical Contractors, 1993; Alabama Geological Survey, 1993; Mississippi Bureau of Marine Resources, 1993.

TABLE B-5. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	2000 Total Emissions by Pollutant (tons/yr) NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	1	22.1	0.9	2.3	0.0	0.7
Mobile County, AL	01097	2	44.1	1.7	4.6	0.1	1.4
Jackson County, MS	28059	0	NA	NA	NA	NA	NA
Harrison County, MS	28047	0	NA	NA	NA	NA	NA
Hancock County, MS	28045	0	NA	NA	NA	NA	NA
Orleans Parish, LA	22071	0	NA	NA	NA	NA	NA
St. Bernard Parish, LA	22087	25	547.1	21.7	57.4	1.2	17.2
Plaquemines Parish, LA	22075	120	2636.4	104.4	276.4	5.8	83.1
Jefferson Parish, LA	22051	1	33.0	1.3	3.5	0.1	1.0
Lafourche Parish, LA	22057	16	363.5	14.4	38.1	0.8	11.5
Terrebonne Parish, LA	22109	2	36.7	1.5	3.8	0.1	1.2
St. Mary Parish, LA	22101	8	187.3	7.4	19.6	0.4	5.9
Iberia Parish, LA	22045	7	157.9	6.3	16.6	0.3	5.0
Vermilion Parish, LA	22113	4	80.8	3.2	8.5	0.2	2.5
Cameron Parish, LA	22023	5	117.5	4.7	12.3	0.3	3.7
Calcasieu Parish, LA	22019	0	NA	NA	NA	NA	NA
Orange County, TX	48361	0	NA	NA	NA	NA	NA
Jefferson County, TX	48245	7	164.4	6.5	17.2	0.4	5.2
Chambers County, TX	48071	20	433.2	17.2	45.4	0.9	13.7
Harris County, TX	48201	1	12.6	0.5	1.3	0.0	0.4
Galveston County, TX	48167	5	120.2	4.8	12.6	0.3	3.8
Brazoria County, TX	48039	5	104.3	4.1	10.9	0.2	3.3
Matagorda County, TX	48321	21	464.8	18.4	48.7	1.0	14.7
Calhoun County, TX	48057	17	382.6	15.2	40.1	0.8	12.1
Jackson County, TX	48239	1	25.3	1.0	2.7	0.1	0.8
Refugio County, TX	48391	0	NA	NA	NA	NA	NA
Aransas County, TX	48007	13	278.3	11.0	29.2	0.6	8.8
San Patricio County, TX	48409	0	NA	NA	NA	NA	NA
Nueces County, TX	48355	22	490.1	19.4	51.4	1.1	15.4
Kleberg County, TX	48273	7	151.8	6.0	15.9	0.3	4.8
Kenedy County, TX	48261	8	170.7	6.8	17.9	0.4	5.4
Willacy County, TX	48489	3	66.4	2.6	7.0	0.1	2.1
Cameron County, TX	48061	1	28.5	1.1	3.0	0.1	0.9
Alaminos Canyon	99001	0	NA	NA	NA	NA	NA
Atwater Valley	99005	1	34.3	1.4	5.5	0.1	1.3
Brazos	99007	3	84.9	3.4	8.9	0.2	2.7
Brazos South Addition	99009	0	NA	NA	NA	NA	NA

TABLE B-5. Continued.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	2000 Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Breton Sound	99011	0	NA	NA	NA	NA	NA
Chandeleur	99013	1	42.2	1.7	4.4	0.1	1.3
Chandeleur East Addition	99015	0	NA	NA	NA	NA	NA
Corpus Christi	99017	0	NA	NA	NA	NA	NA
East Breaks	99023	6	299.4	12.4	48.3	0.8	11.6
East Cameron	99025	4	111.8	4.4	11.7	0.2	3.5
East Cameron South Addition	99027	0	NA	NA	NA	NA	NA
Eugene Island	99029	3	90.2	3.6	9.4	0.2	2.8
Eugene Island South Addition	99031	7	205.7	8.1	21.5	0.4	6.5
Ewing Bank	99033	6	167.2	6.6	17.5	0.4	5.3
Galveston	99037	2	72.4	2.9	7.6	0.2	2.3
Galveston South Addition	99039	0	NA	NA	NA	NA	NA
Garden Banks	99041	20	706.0	29.1	113.9	1.9	27.3
Grand Isle	99043	1	28.9	1.1	3.0	0.1	0.9
Grand Isle South Addition	99045	2	45.0	1.8	4.7	0.1	1.4
Green Canyon	99047	9	439.8	18.2	71.0	1.2	17.0
High Island	99049	2	57.1	2.3	6.0	0.1	1.8
High Island East Addtion	99051	5	144.5	5.7	15.1	0.3	4.5
High Island East Add. South Ext.	99053	8	236.4	9.4	24.7	0.5	7.4
High Island South Addition	99055	7	197.0	7.8	20.6	0.4	6.2
Keathley Canyon	99059	100	4770.0	196.9	769.6	12.8	184.2
Main Pass	99063	4	119.5	4.7	12.5	0.3	3.8
Main Pass South and East Addition	99065	19	548.2	21.7	57.3	1.2	17.3
Matagorda Island	99067	2	47.3	1.9	5.0	0.1	1.5
Mississippi Canyon	99069	12	572.3	23.6	92.3	1.5	22.1
Mobile	99071	3	77.3	3.1	8.1	0.2	2.4
Mustang Island	99073	1	25.1	1.0	2.6	0.1	0.8
Mustang Island East Addition	99075	0	NA	NA	NA	NA	NA
NG 15-8	99077	0	NA	NA	NA	NA	NA
NG 15-9	99079	11	519.1	21.4	83.8	1.4	20.1
NG 16-4	99081	11	519.1	21.4	83.8	1.4	20.1
NG 16-7	99085	11	519.1	21.4	83.8	1.4	20.1
North Padre Island	99087	0	NA	NA	NA	NA	NA
North Padre Island East Addition	99089	0	7.0	0.3	0.7	0.0	0.2
Port Isabel	99093	0	NA	NA	NA	NA	NA
Sabine Pass	99097	0	NA	NA	NA	NA	NA
Ship Shoal	99099	2	63.1	2.5	6.6	0.1	2.0

TABLE B-5. Concluded.

County/Area Name	County Code (FIPS)	No. of Explor. Wells	2000 Total Emissions by Pollutant (tons/yr) NOx	HC	CO	SOx	TSP
Ship Shoal South Addition	99101	9	257.2	10.2	26.9	0.6	8.1
South Marsh Island	99103	1	16.2	0.6	1.7	0.0	0.5
South Marsh Island North Addition	99105	2	66.7	2.6	7.0	0.1	2.1
South Marsh Island South Addition	99107	4	102.9	4.1	10.8	0.2	3.2
South Padre Island	99109	0	NA	NA	NA	NA	NA
South Padre Island East Addition	99111	0	NA	NA	NA	NA	NA
South Pass	99113	0	NA	NA	NA	NA	NA
South Pass East Addition	99115	0	14.1	0.6	1.5	0.0	0.4
South Pass South Addition	99117	5	133.5	5.3	14.0	0.3	4.2
South Pelto	99119	0	9.0	0.4	0.9	0.0	0.3
South Timbalier	99121	1	21.6	0.9	2.3	0.0	0.7
South Timbalier South Addition	99123	9	276.4	10.9	28.9	0.6	8.7
Vermilion	99127	5	142.5	5.6	14.9	0.3	4.5
Vermilion South Addition	99129	0	NA	NA	NA	NA	NA
Viosca Knoll	99133	6	231.9	9.6	37.4	0.6	9.0
Walker Ridge	99135	11	519.1	21.4	83.8	1.4	20.1
West Cameron	99137	2	46.9	1.9	4.9	0.1	1.5
West Cameron South Addition	99139	5	141.4	5.6	14.8	0.3	4.5
West Cameron West Addition	99141	2	52.3	2.1	5.5	0.1	1.6
West Delta	99143	4	112.4	4.5	11.8	0.2	3.5
West Delta South Addition	99145	3	91.4	3.6	9.6	0.2	2.9
WX-1	99147	0	NA	NA	NA	NA	NA
Apalachicola	99149	5	139.6	5.5	14.6	0.3	4.4
DeSoto Canyon	99151	0	NA	NA	NA	NA	NA
Destin Dome	99153	5	170.6	7.0	27.5	0.5	6.6
Florida Middle Ground	99155	0	NA	NA	NA	NA	NA
Howell Hook	99157	0	NA	NA	NA	NA	NA
Lloyd Ridge	99159	0	NA	NA	NA	NA	NA
NG 16-5	99161	0	NA	NA	NA	NA	NA
Pensacola	99163	5	139.6	5.5	14.6	0.3	4.4
Rankin	99165	0	NA	NA	NA	NA	NA
The Elbow	99167	0	NA	NA	NA	NA	NA
Vernon Basin	99169	0	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: MMS, 1992a, 1992b, 1992c; EPA, 1993; International Association of Geophysical Contractors, 1993; Alabama Geological Survey, 1993; Mississippi Bureau of Marine Resources, 1993.

EPA. 1991. U.S. Environmental Protection Agency. Commercial Marine Vessel Contributions to Emission Inventories, Final Report. Prepared by Booz, Allen, and Hamilton, Inc., Los Angeles, California, October.

EPA. 1993. U.S. Environmental Protection Agency, Office of Water. Economic Impact Analysis of Final Effluent Limitations Guidelines and Standards of Performance for the Offshore Oil and Gas Industry. Prepared by Eastern Research Group.

International Association of Drilling Contractors. 1993. Personal communication with A. Spackman, Houston, Texas. February.

International Association of Geophysical Contractors. 1993. Personal communication with J. McCarthy, Houston, Texas. January.

Mississippi Bureau of Marine Resources, 1993. Personal communication. January.

MMS. 1991. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region. Impacts of Oil and Gas Exploration, Development, and Production on the Atlantic Outer Continental Shelf. Prepared by A.T. Kearney, Inc. January.

MMS. 1992a. U.S. Department of the Interior, Minerals Management Service. Survey of Offshore Operators Undertaken by the Offshore Operators Committee. Data Base of Boat Inventory Survey. October.

MMS. 1992b. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. Gulf of Mexico Sales 142 and 143: Central and Western Planning Areas. Final Environmental Impact Statement. Volume I. New Orleans, Louisiana. November.

MMS. 1992c. U.S. Department of the Interior, Minerals Management Service, Office of Statistics and Information. Federal Offshore Statistics: 1991. November.

MMS. 1993a. U.S. Department of the Interior, Minerals Management Service. Personal communication with R. Winnor, Herndon, Virginia, February.

MMS. 1993b. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. Borehole Data Base.

Ocean Industry. 1984. "1984-85 Directory of Marine Drilling Rigs." Reprinted from *Ocean Industry*. September.

Ocean Industry. 1992. "Ocean Industry's 1992 Guide to Marine Drilling Rigs." *Ocean Industry* 27:7(19-118).

Radian Corporation. 1982. Assessment of No_x Control Measures for Diesel Engines on Offshore Exploratory Drilling Vessels and Rigs. Prepared for Industry/Government Task Force. July.

Sonat Offshore Drilling Co. 1993. Personal communication with J. Adams, Offshore Contracts, Houston, Texas. February.

Whale, R.H. 1984. Seismic Surveying: A Basic Overview. Oil Patch. July/August: 18-21.

ATTACHMENT C: LOUISIANA OFFSHORE OIL PORT

Description of the Sector

The Louisiana Offshore Oil Port (LOOP) is the only deep water port in the Gulf of Mexico. It is located approximately 19 miles from the Louisiana shore in 115 feet of water in Grand Isle Block 59. The port provides offshore terminal facilities for offloading crude oil from tankers which are too large for conventional ports, thus eliminating the need for lightering oil tankers. Tankers using LOOP typically have drafts greater than 40 feet and weigh up to 700,000 deadweight tons (dwt) (USCG, 1976). The LOOP, however, is not restricted to Very Large Crude Carriers (VLCCs) and Ultra Large Crude Carriers (ULCCs), it also serves tankers as small as 67,000 dwt. Between 1987 and 1991, an average of 265 vessels per year used the LOOP facilities (LOOP, Inc., 1993).

The LOOP currently consists of three single-point moorings and associated submarine pipelines, a pumping platform, a control platform, and a single pipeline to the shore. Although the structure was originally designed to have a total of six moorings and two pipelines, no plans currently exist to expand the present structure to meet the original design capacity (LOOP, Inc., 1993; USCG, 1976). The LOOP site was selected because

Louisiana has the second largest refining complex in the nation and has access to existing pipeline distribution systems which are capable of serving refineries in Louisiana and the Midwest. This provides LOOP with access to more than 30 percent of the nation's refining capacity (LOOP, Inc., 1993).

After the vessels offload their cargo, the oil is transported through a single 48-inch pipeline to LOOP's Clovelly Dome Storage Terminal located 28 miles inland. LOOP was designed to offload tankers at a rate up to 100,000 barrels per hour, or 1.4 million barrels per day. The practical capacity of LOOP is approximately 1.2 million barrels per day (LOOP, Inc., 1993). Vessels are unloaded at one of the three single-point moorings at the platform. Oil is transferred through hoses connected at the base of the mooring to a submarine pipeline to the pumping platform (USCG, 1976). Between 1987 and 1992, the LOOP has supported an average throughput of 828,000 barrels per day (LOOP, Inc., 1993).

Designated safety zones and fairways provide vessels with safe access to the LOOP. No mobile drilling operations or installation of permanent structures may take place in these areas. The safety fairways associated with the LOOP are designated in 33 CFR 166. An anchorage area is also designated in the vicinity of the LOOP (MMS, 1992).

LOOP is operated as a common carrier and is subject to the regulatory jurisdiction of the Department of Transportation and the Louisiana Offshore Terminal Authority (LOOP, Inc., 1993).

Emission Factors

There are three types of emission sources associated with LOOP that give off significant levels of emissions. These sources consist of: 1) tanker engines; 2) ballast operations; and 3) platform pump engines and generator.

Tanker Engine Emissions

Large oceangoing tankers can be powered by two types of engines: steam or diesel propulsion systems. The propulsion systems of steam-powered vessels consist of boilers with steam or gas turbines. Steam propulsion systems are typically found in older vessels such as cargo vessels and tankers built prior to 1982. Large tankers (i.e., those greater than 100,000 dwt) which run on steam power have an average horsepower rating of 34,980. At full power, a steamship of this horsepower rating would consume fuel at the rate of approximately 6,996 liters per hour (1,846 gallons per hour) (EPA, 1991).

In recent years, steam-powered vessels are increasingly being outnumbered by diesel motorships, as new vessels tend to be powered by the more efficient diesel engines (CARB, 1991a, 1991b). Deep draft commercial vessels (e.g., tankers) using diesel engines are typically powered by large, low-speed diesel engines which commonly burn residual or bunker fuel oil. Low-speed two-stroke engines range in size from about 1,350 to 67,000 horsepower (CARB, 1991a). Large tankers (i.e., those greater than 100,000 dead weight tons) which run on diesel engines have an average horsepower rating of 23,200. At full power, a motorship of this horsepower would consume fuel at the rate of approximately 3,563 liters per hour (940 gallons per hour) (EPA, 1991).

All vessels normally operate at below full power while cruising at sea and at much lower loads while hotelling at the LOOP (CARB, 1991b). Fuel consumption for the cruise and hotelling operating modes was estimated using a ratio of the total fuel consumption when operating at full power. The ratios were based on reported data for commercial steamships which estimate the percentage of full power used for other operating modes. The hotelling mode is estimated to use about 10 percent of available power.[1] The cruise mode may require 35 to 75 percent of available power (EPA, 1985). In this analysis, the cruise mode is estimated to use 55 percent of available power.

The primary pollutants emitted by both steam and diesel engines while in any mode of operation include the following: nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), sulfur oxides (SO_x), and particulates (PM) (EPA, 1985). Total particulate matter equates to total suspended particulate (TSP) and is referred to as TSP in the model and the remainder of this analysis. In a diesel engine most of suspended particulates would be PM-10. However, estimates provided here are for PM or TSP. The primary emission factors are derived in terms of kilograms per 1,000 liters of fuel used. Historical emission factors for each pollutant by engine type and mode of operation were multiplied by the associated fuel consumption rate (in terms of 1,000 liters per hour of use) to estimate the level of emissions generated from commercial shipping vessels per hour of use. Adjusted emission factors are, therefore, derived in terms of kilograms per hour of use. These adjusted emission factors for large tankers are shown in Table C-1.

Ballast Operation Emissions

After oil cargo is offloaded from a tanker, the tanks must be partially filled with water to replace the weight of the oil before the tanker returns to sea. During this process of ballasting, the residual hydrocarbon gas solely consisting of volatile organic compounds (VOC), from the empty tanks, is released into the atmosphere through a venting system. These VOC emissions specifically exclude significant quantities of methane, which may also be produced by the ballasting process. No direct estimates of methane or total HC emissions are available and remain to be estimated through alternative sources. The average VOC emissions vented at the LOOP from ballasting operations was estimated at 2.13 tons per tanker in the LOOP's environmental assessment process (USCG, 1976).

---

[1] The exception is the hotelling mode for diesel vessels. It is common for a diesel powered vessel to be powered while at berth by auxiliary diesel-powered electrical generators. The fuel consumption rate for this engine type was derived from industry data (Caterpillar, 1993).

TABLE C-1. Emission factors for Louisiana Offshore Oil Port.

Operating Mode	Pollutant (kg/1,000 liters of fuel)					Fuel Consumption (1,000 liters/hour)	Pollutant (kg/hour)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Steam Propulsion											
Hotelling	4.37	0.380	N/A	0.382	1.20	0.70	3.06	0.27	0.000	0.27	0.84
Maneuver/Cruise	6.70	0.082	0.414	0.382	2.40	3.85	25.80	0.316	1.594	1.471	9.24
Full Power	7.63	0.206	0.872	0.382	6.78	7.00	53.41	1.442	6.10	2.674	47.46
Diesel Motor Propulsion											
Hotelling Auxillary Diesel Engines 500kw (50% load)	35.10	9.80	5.76	3.20	2.03	0.08	2.81	0.78	0.46	0.26	0.16
Maneuver/Cruise	65.81	2.87	7.30	0.38	3.95	1.96	128.99	5.63	14.31	0.74	7.74
Full Power	65.81	2.87	7.30	0.38	3.95	3.56	234.30	10.22	25.99	1.34	14.06
Primary Diesel Propulsion (7,300 hp)											
All Operating Modes	65.81	2.87	7.30	0.38	3.95	1.19	78.57	3.43	8.71	0.45	4.71
Diesel Generator 1,000 kw (50% load)	70.12	19.60	11.51	6.46	4.07	0.23	15.95	4.46	2.62	1.47	0.93

Source: EPA, 1985 and 1991; CARB, 1991a,b; Caterpillar, 1993; LOOP, Inc., 1993.

Platform Pump Engines and Generator Emissions

The LOOP currently has four 7,500 horsepower diesel engines which provide power for the pumps transporting oil from the platform to the onshore facility.[2] These engines typically consume fuel at a rate of 1,190 liters per hour (315 gallons per hour). During the course of a year, the engines are used a combined total of 13,500 hours (LOOP, Inc., 1993). Contrary to the vessel engines, these engines run at a constant rate. The related emission factors for this type of engine are shown in Table C-1 (EPA, 1991). The hydrocarbon (HC) category represents the total hydrocarbon (THC) category, although a majority of the THC emissions come from fugitive emissions, evaporation from refueling, and exhaust emissions, which are virtually all VOCs (EPA, 1993a).

A one-megawatt diesel generator is also in use at the LOOP platform. This generator provides electric power to other, non-pumping, activities on the platform. The fuel consumption rate of this generator is 230 liters per hour (60 gallons per hour). The generator runs on a continual basis year-round at approximately 50 percent of full power (LOOP, Inc., 1993). The associated emission factors for this type of generator are also provided in Table C-1 (EPA, 1991).

Methodology

Annual emissions from deep draft tankers utilizing the LOOP were estimated using the following formula:

Annual Vessel Hours (hr/yr) × Emission Factors by Pollutant (kg/hr) × 0.0011 tons/kg
= Total Emissions by Pollutant (ton/yr)

Annual vessel hours in each county or area were estimated based on the following:

- Shipping lane length in the FIPS area: The length (in nautical miles) of shipping lanes in each FIPS area was estimated using safety fairways shown in the MMS Gulf of Mexico Areas of Multiple Use map (MMS, 1982). Tankers utilizing the LOOP facilities were predicted to approach the port from the south or southeast directions in equal proportions using the established safety fairways. Shipping lanes which discontinue in deep, open waters were predicted to continue in the same direction once beyond the formal safety fairway designation.

- Number of vessels: The number of tankers utilizing the LOOP facilities on an annual basis was determined from records maintained by LOOP, Inc. (1993).

---

[2] Historically, the LOOP has operated the platform pumps by turbine engines. Within the last 2 years, these engines have been replaced with more efficient diesel engines. Because the characteristics of the replaced engines are not available, the current situation was used throughout this analysis.

Actual vessel counts were obtained for the years 1987 through 1991. The number of vessels using the LOOP during 1990, 255 vessels, was used to determine the baseline emissions. A detailed discussion of this assumption is provided later in this section.

- Rate of speed: The average speed for the tankers using LOOP, 12 knots (nautical miles per hour), was provided by LOOP, Inc. (1993) and was estimated to be the speed at full power. Upon entering the safety fairway leading to LOOP, tankers proceed at full power until they enter the approximate vicinity of the Grand Isle lease area, where they slow to an average cruising/maneuvering speed of 5.5 knots (LOOP, Inc., 1993).

- Operating mode: Vessels assigned to safety fairways leading to LOOP, as shown in the MMS Gulf of Mexico Areas of Multiple Use map, were predicted to be operating at a full speed of 12 knots. Those vessels assigned to safety fairways within the Grand Isle lease area were estimated to be operating at a reduced speed of 5.5 knots for maneuvering and turning purposes upon entrance or departure of the LOOP facilities. LOOP maintains more than a two-mile safety zone/maneuvering area around the mooring areas. Once vessels enter this zone, they are predicted to be operating at hotelling mode for a 40 hour-period while the cargo is offloaded through the pipeline (LOOP, Inc., 1993).

- Propulsion type. Oil tankers are powered by either steam or diesel engines. According to *Lloyd's Register Statistical Tables* (Lloyd's Maritime Information Services, 1992), approximately 98 percent of the world's merchant fleet is powered by diesel engines. The proportion of steam-powered vessels in the world fleet, currently almost 2 percent, will become even smaller since diesel engines have been the preferred deep draft vessel power source for the last decade. Because the two engine types emit varying levels of emissions, these proportions were used in the analysis to determine the annual vessel hours for each type of engine to correspond with the related emission factors.

The emission factors used to determine total annual pollutant emissions associated with large tanker activity, ballast operations, and platform pump engines and generator were derived from available data for different engines used in marine vessel applications. The derivation of emission factors for this analysis for each of these engine types is described below.

- Emission factors for steam-powered commercial vessels. Data on air pollutant factors for steam-powered commercial vessels were derived from *Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources, 1985* (EPA, 1985) (hereafter referred to as Report AP-42). Personal communication with regulatory agency personnel and a review of recent publications were used to confirm that this document provides the best available source of emission data for steamships (EPA, 1993b; CARB, 1993; EPA, 1991; CARB, 1991b).

Emission factors for all pollutants, except SO_x, were taken from Report AP-42 (EPA, 1985; Table II-3-2). Emissions factors for SO_x are typically represented by a variable which can be converted to a numerical estimate based on the percentage of sulfur present in the type of fuel used. For steamship vessel operations, a common fuel used is residual fuel oil. This type of fuel contains, on average, a 2 percent sulfur content (EPA, 1991; CARB, 1991a). SO_x emission factors were calculated using this percentage. All emission factors were derived in terms of kilograms per 1,000 liters of fuel.

- Emission factors for diesel motorships. Data on air pollutant factors for diesel motorships were derived primarily from *Commercial Marine Vessel Emission Contributions to Emission Inventories* (EPA, 1991; Exhibit 2). Additional sources used include: Report AP-42 (EPA, 1985); Notice of Public Meeting to Consider a Plan for the Control of Emissions from Marine Vessels (CARB, 1991a). SO_x emission factors were calculated in the same way as they were for steam-powered commercial vessels.

- Emissions factors for ballasting operations. The average emission rates per tanker resulting from venting VOC during ballasting activities were derived from the Environmental Impact Statement (EIS) for LOOP, completed for the U.S. Coast Guard (USCG, 1976).

- Emission factors for platform pump engines and generator. The emission factors for the diesel pump engines and platform generator were derived from the same source used for diesel motorships, *Commercial Marine Vessel Emission Contributions to Emission Inventories* (EPA, 1991). Fuel consumption rates for these engines were obtained from LOOP, Inc. (1993).

Baseline

Table C-2 presents the baseline emissions by county and area for pollution resulting from tanker engine activity associated with the LOOP. As shown in the table, the only affected lease areas are Atwater Valley, Grand Isle, Mississippi Canyon, NG 16-4, NG 16-7, South Pass South Addition, and West Delta South Addition. Grand Isle consistently has the greatest number of vessel hours because each vessel spends on average a 40-hour period at the LOOP in the hotelling operating mode, in addition to travel time within the safety fairways located within this lease area. The related emissions, however, are lower in comparison to some other areas with fewer vessel hours. The Grand Isle vessel hours reflect the hours tankers spent in cruising/maneuvering and hotelling operating modes. Tankers operating at these slower modes of operation generate emissions at a lower rate, therefore, the oil tankers travelling through the other lease areas at full operating capacity, emit more emissions.

TABLE C-2. Baseline emissions, Louisiana Offshore Oil Port.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr	Total Emissions by Pollutant (in tons/year)				
			NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	NA	NA	NA	NA	NA	NA
Mobile County, AL	01097	NA	NA	NA	NA	NA	NA
Jackson County, MS	28059	NA	NA	NA	NA	NA	NA
Harrison County, MS	28047	NA	NA	NA	NA	NA	NA
Hancock County, MS	28045	NA	NA	NA	NA	NA	NA
Orleans Parish, LA	22071	NA	NA	NA	NA	NA	NA
St. Bernard Parish, LA	22087	NA	NA	NA	NA	NA	NA
Plaquemines Parish, LA	22075	NA	NA	NA	NA	NA	NA
Jefferson Parish, LA	22051	NA	NA	NA	NA	NA	NA
Lafourche Parish, LA	22057	NA	NA	NA	NA	NA	NA
Terrebone Parish, LA	22109	NA	NA	NA	NA	NA	NA
St. Mary Parish, LA	22101	NA	NA	NA	NA	NA	NA
Iberia Parish, LA	22045	NA	NA	NA	NA	NA	NA
Vermilion Parish, LA	22113	NA	NA	NA	NA	NA	NA
Cameron Parish, LA	22023	NA	NA	NA	NA	NA	NA
Jefferson County, TX	48245	NA	NA	NA	NA	NA	NA
Chambers County, TX	48071	NA	NA	NA	NA	NA	NA
Galveston County, TX	48167	NA	NA	NA	NA	NA	NA
Brazoria County, TX	48039	NA	NA	NA	NA	NA	NA
Matagorda County, TX	48321	NA	NA	NA	NA	NA	NA
Calhoun County, TX	48057	NA	NA	NA	NA	NA	NA
Aransas County, TX	48007	NA	NA	NA	NA	NA	NA
Nueces County, TX	48355	NA	NA	NA	NA	NA	NA
Kleberg County, TX	48273	NA	NA	NA	NA	NA	NA
Kenedy County, TX	48261	NA	NA	NA	NA	NA	NA
Willacy County, TX	48489	NA	NA	NA	NA	NA	NA
Cameron County, TX	48061	NA	NA	NA	NA	NA	NA
Alaminos Canyon	99001	NA	NA	NA	NA	NA	NA
Atwater Valley	99005	1,408	357.3	15.6	39.6	2.1	22.8
Brazos	99007	NA	NA	NA	NA	NA	NA
Brazos South Addition	99009	NA	NA	NA	NA	NA	NA
Breton Sound	99011	NA	NA	NA	NA	NA	NA
Chandeleur	99013	NA	NA	NA	NA	NA	NA
Chandeleur East Addition	99015	NA	NA	NA	NA	NA	NA
Corpus Christi	99017	NA	NA	NA	NA	NA	NA
East Breaks	99023	NA	NA	NA	NA	NA	NA
East Cameron	99025	NA	NA	NA	NA	NA	NA

TABLE C-2. Continued.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr	Total Emissions by Pollutant (in tons/year) NOx	HC	CO	SOx	TSP
East Cameron South Addition	99027	NA	NA	NA	NA	NA	NA
Eugene Island	99029	NA	NA	NA	NA	NA	NA
Eugene Island South Addition	99031	NA	NA	NA	NA	NA	NA
Ewing Bank	99033	NA	NA	NA	NA	NA	NA
Galveston	99037	NA	NA	NA	NA	NA	NA
Galveston South Addition	99039	NA	NA	NA	NA	NA	NA
Garden Banks	99041	NA	NA	NA	NA	NA	NA
Grand Isle	99043	10,885	127.2	12.8	15.6	3.5	7.8
Grand Isle South Addition	99045	NA	NA	NA	NA	NA	NA
Green Canyon	99047	NA	NA	NA	NA	NA	NA
High Island	99049	NA	NA	NA	NA	NA	NA
High Island East Addtion	99051	NA	NA	NA	NA	NA	NA
High Island East Add. South Ext.	99053	NA	NA	NA	NA	NA	NA
High Island South Addition	99055	NA	NA	NA	NA	NA	NA
Keathley Canyon	99059	NA	NA	NA	NA	NA	NA
Main Pass	99063	NA	NA	NA	NA	NA	NA
Main Pass South and East Addition	99065	NA	NA	NA	NA	NA	NA
Matagorda Island	99067	NA	NA	NA	NA	NA	NA
Mississippi Canyon	99069	1,543	391.6	17.0	43.4	2.3	25.0
Mobile	99071	NA	NA	NA	NA	NA	NA
Mustang Island	99073	NA	NA	NA	NA	NA	NA
Mustang Island East Addition	99075	NA	NA	NA	NA	NA	NA
NG 15-8	99077	NA	NA	NA	NA	NA	NA
NG 15-9	99079	NA	NA	NA	NA	NA	NA
NG 16-4	99081	752	190.9	8.3	21.2	1.1	12.2
NG 16-7	99085	146	37.0	1.6	4.1	0.2	2.4
North Padre Island	99087	NA	NA	NA	NA	NA	NA
North Padre Island East Addition	99089	NA	NA	NA	NA	NA	NA
Port Isabel	99093	NA	NA	NA	NA	NA	NA
Sabine Pass	99097	NA	NA	NA	NA	NA	NA
Ship Shoal	99099	NA	NA	NA	NA	NA	NA
Ship Shoal South Addition	99101	NA	NA	NA	NA	NA	NA
South Marsh Island	99103	NA	NA	NA	NA	NA	NA
South Marsh Island North Addition	99105	NA	NA	NA	NA	NA	NA
South Marsh Island South Addition	99107	NA	NA	NA	NA	NA	NA
South Padre Island	99109	NA	NA	NA	NA	NA	NA
South Padre Island East Addition	99111	NA	NA	NA	NA	NA	NA

TABLE C-2. Concluded.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr	Total Emissions by Pollutant (in tons/year)				
			NOx	HC	CO	SOx	TSP
South Pass	99113	NA	NA	NA	NA	NA	NA
South Pass East Addition	99115	NA	NA	NA	NA	NA	NA
South Pass South Addition	99117	102	25.8	1.1	2.9	0.2	1.6
South Pelto	99119	NA	NA	NA	NA	NA	NA
South Timbalier	99121	NA	NA	NA	NA	NA	NA
South Timbalier South Addition	99123	NA	NA	NA	NA	NA	NA
Vermilion	99127	NA	NA	NA	NA	NA	NA
Vermilion South Addition	99129	NA	NA	NA	NA	NA	NA
Viosca Knoll	99133	NA	NA	NA	NA	NA	NA
Walker Ridge	99135	NA	NA	NA	NA	NA	NA
West Cameron	99137	NA	NA	NA	NA	NA	NA
West Cameron South Addition	99139	NA	NA	NA	NA	NA	NA
West Cameron West Addition	99141	NA	NA	NA	NA	NA	NA
West Delta	99143	NA	NA	NA	NA	NA	NA
West Delta South Addition	99145	211	53.6	2.3	5.9	0.3	3.4
WX-1	99147	NA	NA	NA	NA	NA	NA
Apalachicola	99149	NA	NA	NA	NA	NA	NA
DeSoto Canyon	99151	NA	NA	NA	NA	NA	NA
Destin Dome	99153	NA	NA	NA	NA	NA	NA
Florida Middle Ground	99155	NA	NA	NA	NA	NA	NA
Howell Hook	99157	NA	NA	NA	NA	NA	NA
Lloyd Ridge	99159	NA	NA	NA	NA	NA	NA
NG 16-5	99161	NA	NA	NA	NA	NA	NA
Pensacola	99163	NA	NA	NA	NA	NA	NA
Rankin	99165	NA	NA	NA	NA	NA	NA
The Elbow	99167	NA	NA	NA	NA	NA	NA
Vernon Basin	99169	NA	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: CARB, 1991a,b; Caterpillar, 1993; Lloyd's Maritime Information Services, 1992; LOOP, Inc., 1993; MMS, 1982; and EPA, 1985 and 1991.

The emissions shown in Table C-2 for Grand Isle only represent emissions resulting from tanker engine operation. These emissions are considered area source emissions because the vessels travel through various parts of the Grand Isle lease area. Sources of other emissions related to LOOP activities are ballast operations, platform pump engine operation, and platform generator operation. These emissions are treated point source emissions in the Grand Isle lease area because they are emitted only from the LOOP facilities. The following table identifies the four emission sources in the Grand Isle lease area, shows whether these emissions sources are area or point sources, and presents the total emissions (in tons per year) for each pollutant type.

Emissions Source	Source Type		Emissions by Pollutant (ton/yr)					
				HC				
	Area	Point	NO_x	THC	VOC	CO	SO_x	TSP
Tanker Engines	×		127.2	12.8	NA	15.6	3.5	7.8
Ballast Operations		×	NA	NA	542.5	NA	NA	NA
Platform Pump Engines		×	1,166.8	50.9	NA	129.3	6.7	69.9
Platform Generators		×	153.3	42.9	NA	25.2	14.1	8.9

NA = Not applicable.

For the ballasting operation, the baseline emissions were derived by multiplying the number of tankers using the LOOP during 1990 (255 tankers) by the VOC emission rate of 2.13 tons per tanker. For the diesel pump engines, the baseline emissions (by pollutant) were derived by multiplying the average number of hours the engines were in operation (13,500 hours) by the associated emission factors shown in Table C-1. For the diesel platform generator, the five baseline emissions (by pollutant) were derived by multiplying the number of hours in a year (8,736 hours), since the generator operates continuously, by the associated emission factors shown in Table C-1. These same processes were repeated for 1988, 1991, and 1993, 1995, and 2000.

The table below indicates the forecast adjustment factors used for the future projections of emissions from the LOOP. The projected activity levels for 1993, 1995, and 2000 were based on an average of the annual vessel traffic between 1987 and 1991. The average number of vessels from previous years was used as the best indication for future traffic levels at the LOOP for the following reasons: 1) no expansion of the LOOP facilities are expected before the year 2000; 2) the number of tankers per year using the LOOP fluctuated an average of 9 percent per year from 1987 to 1991, with both upward and downward movement; 3) no direct correlation exists between the amount of throughput each year and the number of vessels using the port because tankers of various capacities use the port (e.g., during 1989 the average throughput was 847,000 barrels per day delivered by 282 tankers during the year, whereas, in 1990 the average throughput increased to 909,000 barrels per day, but was delivered by only 255 tankers)

Year	Activity Level (Annual Vessel Traffic)	Adjustment Factor
1987*	271	1.063
1988*	248	0.973
1990*	255	-
1991*	269	1.055
1993**	265	1.039
1995**	265	1.039
2000**	265	1.039

* Activity level based on actual LOOP vessel traffic.
** Activity level based on projected LOOP vessel traffic derived from the average of historical vessel traffic data.

(LOOP, Inc., 1993); and 4) the facility is operating near its effective annual operating capacity, thus precluding substantial growth.

Since deep draft tankers are a subset of the commercial shipping industry, no adjustments have been made to account for time of day or seasonal differences in vessel traffic. The nature of deep draft shipping includes consistent levels of operation during every hour, day, and month. The EIS for LOOP describes the port arrival times of tankers to be completely unpredictable and random (USCG, 1976). There are intervals when no tankers are moored at the LOOP and other times when the port is working at full capacity. These peak periods, however, do not follow a schedule and can not be predicted. The emissions related to ballast activities and platform pump engine operations also do not require seasonal adjustments. The ballast activity and pump engine operation is related to the tanker traffic, so the operating times are just as random. As stated previously, the generator runs continuously throughout the year, thus requiring no seasonal, annual, time-of-day, or day-of-week adjustment.

Section References

CARB. 1991a. California Air Resources Board. Notice of Public Meeting to Consider a Plan for the Control of Emission from Marine Vessels (Mailout #90-58), Staff Report, September.

CARB. 1991b. California Air Resources Board. Regulatory Strategies for Reducing Emissions from Marine Vessels in California Waters, prepared by Sierra Research, Inc., October.

CARB. 1993. California Air Resources Board. Personal communication with R. Abachi, Mobile Source Division, Off-Road Controls Section, January.

Caterpillar. 1993. Personal communication with A. Kludjian, Authorized Dealer, Peterson Power Systems Inc., San Leandro, California, January.

EPA. 1985. U.S. Environmental Protection Agency. Compilation of Air Emission Factors, Volume II, EPA Report No. AP-42, Fourth Edition, Research Triangle Park, North Carolina, Office of Air Quality Planning and Standards.

EPA. 1991. U.S. Environmental Protection Agency. Commercial Marine Vessel Contributions to Emission Inventories, Final Report prepared by Booz, Allen, and Hamilton, Inc., Los Angeles, California, October.

EPA. 1993a. U.S. Environmental Protection Agency. Personal communication with J. Carbiness, Office of Mobile Sources.

EPA. 1993b. U.S. Environmental Protection Agency. Personal communication with J. Somers, Emission Planning and Strategies Division, Office of Mobile Sources, Ann Arbor, Michigan, January.

Lloyd's Maritime Information Services. 1992. Lloyd's Register Statistical Tables. June.

Louisiana Offshore Oil Port (LOOP), Inc. 1993. Personal communication with D. Rollins, New Orleans, Louisiana. January.

MMS. 1982. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. Areas of Multiple Use, Visual 11. New Orleans, Louisiana. August.

MMS. 1992. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. Gulf of Mexico Sales 142 and 143: Central and Western Planning Areas. Final Environmental Impact Statement. Volume I. New Orleans, Louisiana. November.

USCG. 1976. U.S. Department of Transportation, Coast Guard. Draft Environmental Impact/4(f) Statement, LOOP Deepwater Port License Application. Office of Marine Environment and Systems, Deepwater Ports Project. Washington, DC.

ATTACHMENT D: RECREATIONAL BOATING

Description of the Sector

Recreational boating in the Gulf of Mexico can be broken into two basic types of activities, recreational boating and recreational fishing. Recreational fishing and boating are conducted using privately owned boats, as well as any of a large number of charter companies which may be hired. Recreational boating activities include cruising, racing, waterskiing, diving, and swimming (USCG, 1987). Fishing activities in the Gulf of Mexico occur under a wide variety of conditions. A large proportion of fishing is coastal-oriented, with activity occurring near shore. Deep sea fishing occurs farther offshore, in highly-productive fishing grounds or near the large number of artificial fishing reefs which are scattered throughout the Gulf. Given the large number of fishing and recreational boating activities which take place in the Gulf of Mexico, similar diversity is found in the types of boats which operate in this area.

Emission Factors

Recreational vessels are typically powered by three types of engines: 2-stroke gasoline outboards; 4-stroke gasoline inboard/sterndrives; and diesel inboards. For this analysis, emission factors were derived for recreational vessels using both gasoline and diesel fuel.

Recreational boats using 2-stroke gasoline outboard engines commonly have an average available horsepower of about 25 (EPA, 1985). Average fuel consumption for a gasoline outboard engine of this size, running at 75 percent of full power, is estimated to be approximately 3.06 gallons of fuel per hour (EPA, 1991).

Recreational boats using 4-stroke gasoline inboard engines and gasoline inboards with sterndrive typically have an average available horsepower of about 162 (EPA, 1991). Average fuel consumption for such engines of this size, running at 75 percent of full power, is estimated to be approximately 12.2 gallons of fuel per hour (EPA, 1991).

Recreational boats using diesel inboard engines typically have an average available horsepower of about 172 (EPA, 1991). Average fuel consumption for diesel inboard engines of this size, running at 75 percent of full power, is estimated to be approximately 8.5 gallons of fuel per hour (EPA, 1991).

The primary pollutants emitted by gasoline and diesel engines while in service to recreational vessels include nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), sulfur oxides (SO_x), and particulates (PM) (EPA, 1985, 1991). Total particulate matter equates to total suspended particulate (TSP) and is referred to as TSP in the model and the remainder of this analysis. The emission factors for the primary pollutants are provided in terms of grams per gallon of fuel used. Table D-1 summarizes the emission factors for recreational vessels by engine type for all five pollutants.

TABLE D-1. Emission factors for recreational boating.

Engine Type	Pollutant (kg/liter)					Fuel Consumption (liters/hour at 75% power)	Pollutant (k/hour)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Gasoline 2 - Stroke Outboard (average 25 HP)	0.003	0.262	0.381	0.001	0.013	11.60	0.04	3.03	4.42	0.01	0.15
4 - Stroke Inboard (average 162 HP)	0.012	0.029	0.431	0.001	0.0002	46.24	0.54	1.35	19.95	0.04	0.01
Diesel Inbound (average 172 HP)	0.046	0.006	0.010	0.003	0.003	32.25	1.47	0.21	0.32	0.10	0.09

Source: EPA, 1991.

In order to estimate total emission factors by fuel type, emission factor data for each gasoline engine type were aggregated to represent a composite data set for all gasoline engines. To derive these data, the emission factor data for each gasoline engine type (as shown in the last five columns of Table D-1) were weighted based on the percentage of recreational boats classified as gasoline outboard, inboard, and inboard/sterndrive (USCG, 1991a). Based on available data on the classification of recreational boats by type of gasoline engine, it was estimated that gasoline outboards represent 75.7 percent of the total; gasoline inboards represent 13.1 percent of the total; and gasoline inboard/sterndrives represent 11.2 percent of the total.[3] The adjusted emission factors for recreational boating activity by fuel type are shown in Table D-2.

TABLE D-2. Adjusted emission factors for recreational boating.*

Engine Type	Pollutant (g/hour)				
	NO_x	HC	CO	SO_x	TSP
Gasoline	158.27	2624.87	8190.59	15.31	113.61
Diesel	1468.40	207.64	315.04	103.82	92.67

* *Adjusted for gasoline engines based on percentage of engine type in use. See text for derivation.*

Source: Derived from Exhibit 9-1; USCG, 1991; Texas Parks and Wildlife Department, 1993.

[3] Data on the number of inboard engines used for recreational activity, as presented in USCG (1991a), were adjusted downward by approximately 13 percent to factor out the number of inboard engines classified as diesel (Texas Parks and Wildlife Department, 1993).

Methodology

Annual emissions from recreational boating in the Gulf of Mexico were estimated using the following formula:

Annual Fuel Consumption (L/yr) × Emission Factors by Pollutant (kg/L) × 0.0011 ton/kg = Total Emissions by Pollutant (ton/yr)

Annual fuel consumption in each county or area was estimated based on the following:

- Total fuel use within each State was taken from the *National Recreational Boating Survey* (U.S. Fish and Wildlife Service and U.S. Coast Guard, 1992).

- Marine fuel consumption (i.e., in saltwater boating) was estimated by adjusting the fuel consumption within each State by the proportion of registered boats located in coastal counties (Alabama Department of Conservation and Natural Resources, 1993; Louisiana Department of Wildlife and Fisheries, 1993; Mississippi Department of Wildlife, Fisheries, and Parks, 1993; Texas Parks and Wildlife Department, 1993).

- The percentage of fuel used in recreational boating was extrapolated based on an estimate that approximately 58 percent of Gulf of Mexico recreational boat trips are for recreational fishing (i.e., 42 percent are for recreational boating) (Nichols and Goldbloom, 1989).

- Marine fuel consumption was allocated within each State to each county based on the percentage of coastal boats registered in each county.

- Since recreational boating activities typically take place near shore, all recreational boating was predicted to take place within State waters.

- About 68.8 percent of each county's fishing fuel consumption was allocated to that county, based on recreational fishing catch estimates (National Marine Fisheries Service, 1992).

- The remaining 31.2 percent of fishing fuel consumption was assigned to other areas based on the probability that fishing trips originating from each county would reach that area. Fishing "draw zones" were determined based on artificial fishing reef and fishing resource information (Sport Fishing Institute n.d; MMS, 1983). The distribution of fishing activity by distance from shore in the Gulf of Mexico was determined using the results of a Minerals Management Service study of fishing near offshore platforms in the Gulf of Mexico (MMS, 1984).

The air emission data for recreational boating activities were derived from the 1991 EPA report titled *Nonroad Engine and Vehicle Emission Study, Final Report* (Office of Air and Radiation, November). This report presents the most recent data on air emission factors for several nonroad emission sources, including recreational marine sources. Air emission factor data were derived from this source for the five primary pollutants associated with recreational boating activities by engine type.

Baseline

Table D-3 presents the annual baseline emissions by county and area for recreational boating and fishing. Emissions are highest in the coastal parishes in Louisiana. Although a larger number of hours are spent boating and fishing in Texas than in Louisiana, Mississippi, and Alabama, emissions are not as high in Texas counties. This is because the boating activity is spread over a larger geographic area in Texas.

Since the level of recreational boating varies greatly according to season and the day of week (i.e., activity is higher in summer and weekends), the following factors may be used to adjust pollutant levels to reflect seasonality or day of the week. Seasonality factors were estimated using Nichols and Goldbloom (1989) and MMS (1984), which present the percentage of fishing activity observed by month in Texas and the Central Gulf of Mexico respectively. The peak boating season is expected to occur from May through August. The "shoulder" season, so named because these frequencies lie to either side of the peak of the boating frequency distribution, occurs in March, April, September, and October. The off season runs from November through February.

Recreational Fishing and Boating Seasonality Multipliers

Season	*Multiplier*
Peak Boating	0.462
Shoulder Season	0.332
Off Season	0.205

Day-of-the-week factors were taken from the MMS (1984), which reports the daily level of offshore fishing activity in the Central Gulf of Mexico.

Recreational Fishing and Boating Day-of-the-Week Multipliers

Day	*Multiplier*
Monday	0.144
Tuesday	0.135
Wednesday	0.129
Thursday	0.131
Friday	0.149
Saturday	0.161
Sunday	0.151

TABLE D-3. Baseline emissions, recreational boating.

County/Area Name	County Code (FIPS)	Annual Fuel Consumpt	Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	871,024	20	739	1,416	3	35
Mobile County, AL	01097	1,848,022	43	1,569	3,005	6	74
Jackson County, MS	28059	1,023,663	24	869	1,665	3	41
Harrison County, MS	28047	1,017,615	24	864	1,655	3	41
Hancock County, MS	28045	268,914	6	228	437	1	11
Orleans Parish, LA	22071	701,731	16	596	1,141	2	28
St. Bernard Parish, LA	22087	437,242	10	371	711	1	18
Plaquemines Parish, LA	22075	324,155	8	275	527	1	13
Jefferson Parish, LA	22051	1,901,890	44	1,614	3,093	6	76
Lafourche Parish, LA	22057	883,430	21	750	1,437	3	35
Terrebone Parish, LA	22109	1,062,766	25	902	1,728	4	43
St. Mary Parish, LA	22101	599,615	14	509	975	2	24
Iberia Parish, LA	22045	537,417	12	456	874	2	22
Vermilion Parish, LA	22113	376,226	9	319	612	1	15
Cameron Parish, LA	22023	139,671	3	119	227	0	6
Calcasieu Parish, LA	22019	1,268,349	29	1,077	2,062	4	51
Orange County, TX	48361	540,517	13	459	879	2	22
Jefferson County, TX	48245	906,691	21	770	1,474	3	36
Chambers County, TX	48071	92,287	2	78	150	0	4
Harris County, TX	48201	5,282,464	123	4,484	8,590	17	212
Galveston County, TX	48167	713,615	17	606	1,160	2	29
Brazoria County, TX	48039	689,074	16	585	1,120	2	28
Matagorda County, TX	48321	136,114	3	116	221	0	5
Calhoun County, TX	48057	109,292	3	93	178	0	4
Jackson County, TX	48239	64,220	1	55	104	0	3
Refugio County, TX	48391	32,283	1	27	52	0	1
Aransas County, TX	48007	126,851	3	108	206	0	5
San Patricio County, TX	48409	192,800	4	164	314	1	8
Nueces County, TX	48355	593,055	14	503	964	2	24
Kleberg County, TX	48273	41,339	1	35	67	0	2
Kenedy County, TX	48261	899	0	1	1	0	0
Willacy County, TX	48489	27,098	1	23	44	0	1
Cameron County, TX	48061	266,975	6	227	434	1	11
Alaminos Canyon	99001	NA	NA	NA	NA	NA	NA
Atwater Valley	99005	8,188	0	7	13	0	0
Brazos	99007	285,284	7	242	464	1	11
Brazos South Addition	99009	41,402	1	35	67	0	2
Breton Sound	99011	NA	NA	NA	NA	NA	NA

TABLE D-3. Continued.

County/Area Name	County Code (FIPS)	Annual Fuel Consumpt	Total Emissions by Pollutant (tons/yr) NOx	HC	CO	SOx	TSP
Chandeleur	99013	NA	NA	NA	NA	NA	NA
Chandeleur East Addition	99015	NA	NA	NA	NA	NA	NA
Corpus Christi	99017	NA	NA	NA	NA	NA	NA
East Breaks	99023	17,698	0	15	29	0	1
East Cameron	99025	NA	NA	NA	NA	NA	NA
East Cameron South Addition	99027	NA	NA	NA	NA	NA	NA
Eugene Island	99029	NA	NA	NA	NA	NA	NA
Eugene Island South Addition	99031	NA	NA	NA	NA	NA	NA
Ewing Bank	99033	NA	NA	NA	NA	NA	NA
Galveston	99037	1,513,122	35	1,284	2,460	5	61
Galveston South Addition	99039	NA	NA	NA	NA	NA	NA
Garden Banks	99041	NA	NA	NA	NA	NA	NA
Grand Isle	99043	NA	NA	NA	NA	NA	NA
Grand Isle South Addition	99045	NA	NA	NA	NA	NA	NA
Green Canyon	99047	NA	NA	NA	NA	NA	NA
High Island	99049	NA	NA	NA	NA	NA	NA
High Island East Addtion	99051	NA	NA	NA	NA	NA	NA
High Island East Add. South Ext.	99053	24,169	1	21	39	0	1
High Island South Addition	99055	71,339	2	61	116	0	3
Keathley Canyon	99059	NA	NA	NA	NA	NA	NA
Main Pass	99063	NA	NA	NA	NA	NA	NA
Main Pass South and East Addition	99065	191,166	4	162	311	1	8
Matagorda Island	99067	99,096	2	84	161	0	4
Mississippi Canyon	99069	122,811	3	104	200	0	5
Mobile	99071	672,393	16	571	1,093	2	27
Mustang Island	99073	90,012	2	76	146	0	4
Mustang Island East Addition	99075	28,717	1	24	47	0	1
NG 15-8	99077	NA	NA	NA	NA	NA	NA
NG 15-9	99079	NA	NA	NA	NA	NA	NA
NG 16-4	99081	NA	NA	NA	NA	NA	NA
NG 16-7	99085	NA	NA	NA	NA	NA	NA
North Padre Island	99087	58,818	1	50	96	0	2
North Padre Island East Addition	99089	NA	NA	NA	NA	NA	NA
Port Isabel	99093	NA	NA	NA	NA	NA	NA
Sabine Pass	99097	NA	NA	NA	NA	NA	NA
Ship Shoal	99099	271,868	6	231	442	1	11
Ship Shoal South Addition	99101	44,140	1	37	72	0	2
South Marsh Island	99103	200,863	5	171	327	1	8

TABLE D-3. Concluded.

County/Area Name	County Code (FIPS)	Annual Fuel Consumpt	Total Emissions by Pollutant (tons/yr) NOx	HC	CO	SOx	TSP
South Marsh Island North Addition	99105	NA	NA	NA	NA	NA	NA
South Marsh Island South Addition	99107	30,627	1	26	50	0	1
South Padre Island	99109	30,054	1	26	49	0	1
South Padre Island East Addition	99111	NA	NA	NA	NA	NA	NA
South Pass	99113	NA	NA	NA	NA	NA	NA
South Pass East Addition	99115	NA	NA	NA	NA	NA	NA
South Pass South Addition	99117	NA	NA	NA	NA	NA	NA
South Pelto	99119	NA	NA	NA	NA	NA	NA
South Timbalier	99121	304,418	7	258	495	1	12
South Timbalier South Addition	99123	NA	NA	NA	NA	NA	NA
Vermilion	99127	NA	NA	NA	NA	NA	NA
Vermilion South Addition	99129	15,784	0	13	26	0	1
Viosca Knoll	99133	NA	NA	NA	NA	NA	NA
Walker Ridge	99135	NA	NA	NA	NA	NA	NA
West Cameron	99137	NA	NA	NA	NA	NA	NA
West Cameron South Addition	99139	205,871	5	175	335	1	8
West Cameron West Addition	99141	NA	NA	NA	NA	NA	NA
West Delta	99143	211,719	5	180	344	1	8
West Delta South Addition	99145	67,136	2	57	109	0	3
WX-1	99147	241,267	6	205	392	1	10
Apalachicola	99149	NA	NA	NA	NA	NA	NA
DeSoto Canyon	99151	NA	NA	NA	NA	NA	NA
Destin Dome	99153	178,014	4	151	289	1	7
Florida Middle Ground	99155	NA	NA	NA	NA	NA	NA
Howell Hook	99157	NA	NA	NA	NA	NA	NA
Lloyd Ridge	99159	NA	NA	NA	NA	NA	NA
NG 16-5	99161	NA	NA	NA	NA	NA	NA
Pensacola	99163	72,761	2	62	118	0	3
Rankin	99165	NA	NA	NA	NA	NA	NA
The Elbow	99167	NA	NA	NA	NA	NA	NA
Vernon Basin	99169	NA	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: MMS, 1983, 1984, and 1992; NMFS, 1992; Nichols and Goldbloom, 1989; Mississippi Department of Wildlife, Fisheries, and Parks, 1993; Louisiana Department of Wildlife and Fisheries, 1993; Alabama Department of Conservation and Natural Resources, 1993; Texas Parks and Wildlife Department, 1993; Sport Fishing Institute, n.d.

Similarly, the following factors were calculated to reflect future increases in recreational boating activity. A range of factors was calculated to represent low and high ranges of expected growth. The low range is calculated using a seven-year trend line estimated using U.S. Coast Guard recreational boat registration statistics for the Gulf region (USCG, 1987-1992). The high range represents estimates of recreational fishing and boating based on the expected growth of these activities in Texas over the 1985 to 1995 period (Nichols and Goldbloom, 1989). These factors are multipliers which may be applied to the baseline emission estimates shown in Table D-3 to extrapolate expected annual emissions from recreational boats.

Recreational Fishing and Boating Annual Activity Multipliers

Year	*Low Estimate*	*High Estimate*
1985	1.00	1.00
1987	1.01	1.03
1988	1.01	1.05
1990	1.02	1.09
1991	1.03	1.10
1993	1.04	1.14
1995	1.04	1.17
2000	1.07	1.26

Adjusted to reflect the base year of 1990, adjustment factors are as follows:

Year	Activity Level (Number of registered recreational boats)	Adjustment Factors
1987	1,255,382	0.959
1988	1,272,320	0.972
1990*	1,309,316	1.000
1991	1,310,788	1.001
1993	1,311,658	1.002
1995	1,322,889	1.010
2000	1,350,969	1.032

* Most recent fuel use data were used to derive pollutant emissions (U.S. Fish and Wildlife Service and U.S. Coast Guard, 1992). Although fuel use is the "driver" in determining pollutants from recreational boating, it is expected that fuel use is determined largely by the number of boats. Therefore, activity levels are chosen based on regional boat registration for 1987 to 1991, and are estimated for 1993, 1995, and 2000 based on the seven-year trend line.

Section References

Alabama Department of Conservation and Natural Resources, Marine Police Division. 1993. Personal communication with R. Thorndale, Montgomery, Alabama. January.

EPA. 1985. U.S. Environmental Protection Agency. Compilation of Air Emission Factors, Volume II, EPA Report No. AP-42, Fourth Edition, Research Triangle Park, North Carolina, Office of Air Quality Planning and Standards.

EPA. 1991. U.S. Environmental Protection Agency. Nonroad Engine and Vehicle Emission Study, Report and Appendices, EPA-21A-2001, Washington, D.C., Office of Air and Radiation, November.

Louisiana Department of Wildlife and Fisheries, 1993. Personal communication. Baton Rouge. January.

Mississippi Department of Wildlife, Fisheries, and Parks. 1993. Personal communication with S. Jordan, Jackson, Mississippi. January.

MMS. 1983. U.S. Department of the Interior, Minerals Management Service. Recreation. Visual No. 4-II. Gulf of Mexico Regional Office.

MMS. 1984. U.S. Department of the Interior, Minerals Management Service. Fishing Offshore Platforms Central Gulf of Mexico: An Analysis of Recreational and Commercial Fishing Use at 164 Major Offshore Petroleum Structures. Gulf of Mexico Regional Office. OCS Monograph MMS 84-0006. April.

MMS. 1992. U.S. Department of the Interior, Minerals Management Service. Gulf of Mexico Sales 142 and 143: Central and Western Planning Areas. Final Environmental Impact Statement. Volume I: Sections I through IV.C. Gulf of Mexico OCS Region. New Orleans. November.

Nichols, K.N. and A.P. Goldbloom, 1989. Texans Outdoors: An Analysis of 1985 Participation in Outdoor Recreation Activities. Texas Parks and Wildlife Department. Comprehensive Planning Branch, Parks Division. Austin. November.

NMFS. 1992. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1990-1991. Current Fisheries Statistics Number 9204. Silver Spring, Maryland. September.

Sport Fishing Institute, n.d. Artificial Reefs in the Gulf of Mexico. Washington, D.C.

Texas Parks and Wildlife Department. 1993. Personal communication with P. Allen, Austin, Texas. January.

USCG. 1987. U.S. Department of Transportation, Coast Guard. Boating Statistics: 1986. June.

USCG. 1988. U.S. Department of Transportation, Coast Guard. Boating Statistics: 1987. June.

USCG. 1989. U.S. Department of Transportation, Coast Guard. Boating Statistics: 1988. June.

USCG. 1990. U.S. Department of Transportation, Coast Guard. Boating Statistics: 1989. June.

USCG. 1991a. U.S. Department of Transportation, Coast Guard. American Red Cross National Boating Survey: A Study of Recreational Boats, Boaters, and Accidents in the United States. Prepared by the American Red Cross.

USCG. 1991b. U.S. Department of Transportation, Coast Guard. Boating Statistics: 1990. June.

USCG. 1992. U.S. Department of Transportation, Coast Guard. Boating Statistics: 1991. June.

U.S. Fish and Wildlife Service and the U.S. Coast Guard. 1992. National Recreational Boating Survey: Draft Final Report, Volume 1 of 2. Prepared by Price Waterborne under Contract #14-16-0009-90-006. March.

ATTACHMENT E: DEEP DRAFT COMMERCIAL SHIPPING

Description of the Sector

Deep draft commercial shipping refers to cargo carrying, oceangoing steam and motor vessels of 1,000 gross tons or more. These vessels include freighters, bulk carriers, and tankers.

Freighters accounted for about 52.5 percent of the world's fleet at the beginning of 1992, but comprised only 18.8 percent of deadweight tons (MARAD, 1992). The freighter fleet includes five classes: general cargo carriers, full containerships, partial containerships, roll-on/roll-off (RO/ROs) vessels, and barge carriers. Bulk carriers are designed to carry dry bulk cargo. They accounted for 22.9 percent of the world's fleet at the beginning of 1992 and 38.0 percent of the deadweight tons. Categories of bulk carriers include: general bulk, special bulk, collier, ore, ore/oil, and ore/bulk/oil. The tanker fleet includes general tankers, chemical tankers, and liquid natural gas (LNG) and liquid petroleum gas (LPG) tankers. Tankers accounted for 23.1 percent of the world's fleet at the beginning of 1992 and 43.0 percent of the deadweight tons. (The remaining vessels in the world merchant fleet are combination passenger and cargo vessels. They accounted for less than 2 percent of the world's fleet and just over 2 percent of the deadweight tons at the beginning of 1992.)

Commercial shipping in the Gulf of Mexico includes domestic and foreign trade vessels. Domestic oceanborne trade includes noncontiguous trade, coastwise trade, and intercoastal trade. Noncontiguous trade is trade between the U.S. mainland and Alaska, Hawaii, Puerto Rico, Virgin Islands, Guam, Wake, and Midway Islands. Coastwise trade refers to trade within the Atlantic, Gulf, and Pacific coasts and trade between the Great Lakes, Atlantic, and Gulf coasts. Intercoastal trade is trade between the Atlantic or Gulf and Pacific coasts by way of the Panama Canal (MARAD, 1991). Domestic trade is conducted by U.S. flag vessels. Both U.S. and foreign flag vessels conduct oceanborne foreign trade.

Commercial shipping includes scheduled and non-scheduled operations. The liner fleet operates on a predetermined and fixed itinerary over a specific route, at relatively regular intervals, and at published tariffs. This fleet includes various types of freighters (Transportation Institute, 1992). Tramp service is a non-liner service which operates on an irregular or non-scheduled basis. A tramp vessel can operate anywhere on any terms.

Bulk carriers typically operate on an as-needed basis and transport a specific commodity. Cargoes are shipped unpackaged either dry such as grain and ore, or liquid such as petroleum products (Transportation Institute, 1992).

Emission Factors

Oceangoing commercial vessels are powered by two types of engines: steam or diesel propulsion systems. The propulsion systems of steam-powered vessels consist of a boiler with steam or gas turbines. Steam propulsion systems are typically found in older vessels (i.e., cargo vessels and tankers built prior to 1982) whose engines range from about 5,000 to 26,000 horsepower (CARB, 1991b). Based on this range, an average steamship in commercial service would be rated at approximately 15,500 horsepower. At full power, a steamship of this horsepower rating would consume fuel at the rate of approximately 3,440 liters per hour (907 gallons per hour) (EPA, 1991).

Steam-powered vessels are increasingly being outnumbered by diesel motorships because new vessels tend to be powered by the more efficient diesel engines (CARB, 1991a, 1991b). Deep draft commercial vessels (e.g., tankers and bulk carriers) using diesel engines are typically powered by large, low-speed diesel engines which commonly burn residual or bunker fuel oil. Low-speed two-stroke engines range in size from about

1,350 to 67,000 horsepower (CARB, 1991a). A typical modern low-speed diesel engine in commercial service would be rated at 10,000 horsepower (CARB, 1991a). At full power, a motorship of this horsepower would consume fuel at the rate of approximately 2,170 liters per hour (572 gallons per hour) (EPA, 1991).

All vessels normally operate at just below full power while cruising at sea and at much lower loads while hotelling at berth (CARB, 1991b). Fuel consumption for the cruise and hotelling operating modes was estimated using a ratio of the total fuel consumption when operating at full power. The ratios were based on reported data for commercial steamships which estimate the percentage of full power used for other operating modes (EPA, 1985). The hotelling mode is estimated to use about 10 percent of available power.[4] The cruise mode may require 35 to 75 percent of available power (EPA, 1985). In this analysis, the cruise mode is estimated to use 55 percent of available power.

The primary pollutants emitted by both steam and diesel engines in any mode of operation include the following: nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), sulfur oxides (SO_x), and particulates (PM) (EPA, 1985). Total particulate matter equates to total suspended particulate (TSP) and is referred to as TSP in the model and the remainder of this analysis. HC refers to total hydrocarbon emissions, not just the volatile component of these emissions. The primary emission factors are derived in terms of kilograms per 1,000 liters of fuel used. Historical emission factors for each pollutant by engine type and mode of operation were multiplied by the associated fuel consumption rate (in terms of 1,000 liters per hour of use) to estimate the level of emissions generated from commercial shipping vessels per hour of use. Adjusted emission factors are, therefore, derived in terms of kilograms per hour of use. The adjusted emission factors for commercial shipping vessels are shown in Table E-1.

Methodology

Annual emissions from deep draft commercial shipping were estimated using the following formula:

$$\text{Annual Vessel Hours (hr/yr)} \times \text{Emission Factors by Pollutant (kg/hr)} \times 0.0011 \text{ (ton/kg)} = \text{Total Emissions by Pollutant (ton/yr)}$$

Annual vessel hours in each county or area were estimated based on the following:

[4] The exception is the hotelling mode for diesel vessels. It is common for a diesel powered vessel to be powered while at berth by auxiliary diesel-powered electrical generators. The fuel consumption rate for this engine type was derived from industry data (Caterpillar, 1993).

TABLE E-1. Emission factors for deep draft commercial shipping.

Operating Mode	Pollutant (kg/1,000 liters of fuel)					Fuel Consumption (1,000 liters/hour)	Pollutant (kg/hour)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Steam Propulsion											
Hotelling	4.37	0.380	0.000	0.382	1.20	0.340	1.486	0.129	0.000	0.130	0.408
Maneuver/Cruise	6.70	0.082	0.414	0.382	2.40	1.890	12.660	0.155	0.782	0.722	4.540
Full Power	7.63	0.206	0.872	0.382	6.78	3.440	26.250	0.709	3.000	1.314	23.320
Diesel Motor Propulsion											
Hotelling Auxillary Diesel Engines 500kw (50% load)	35.10	9.80	5.76	3.20	2.03	0.08	2.81	0.78	0.46	0.26	0.16
Maneuver/Cruise	65.81	2.87	7.30	0.38	3.95	1.19	78.45	3.42	8.70	0.45	4.71
Full Power	65.81	2.87	7.30	0.38	3.95	2.17	142.68	6.23	15.82	0.81	8.56

Source: EPA, 1985 and 1991; CARB, 1991a,b; Caterpillar, 1993.

- Shipping lane length in the FIPS area. The length (in nautical miles) of shipping lanes in each FIPS area was estimated using safety fairways shown in Chart Kits for Region 16: New Orleans, LA to Panama City, FL and Region 18: Texas Coast and Offshore published by the Better Boating Association, Inc. (1988a and 1988b) and in the MMS Outer Continental Shelf Natural Gas and Oil Resource Management Comprehensive Program (1992-1997) map (MMS, 1991). Shipping lanes which begin or end in open waters away from shore were assigned to handle vessels on international routes and were predicted to continue in the same direction once beyond the formal safety fairway designation. Those lanes that connect closer to shore or lead to a port area were assigned to handle vessels on domestic and international routes.

- Number of vessels. The number of vessels calling at Gulf of Mexico ports was determined from the *Waterborne Commerce of the United States* prepared by the U.S. Department of the Army, Corps of Engineers (COE, 1991a) and *United States Foreign Trade Vessel Entrances and Clearances* prepared by the Bureau of the Census (1990). The Corps of Engineers statistics include vessels on domestic routes and the Bureau of the Census data for vessels coming from and leaving for international areas. The Corps of Engineers data, using self-propelled dry cargo/passenger and tankers of more than 18 feet, were assigned to areas based on the location of shipping lanes and inland water routes leading to major ports on the Gulf of Mexico. The Bureau of the Census data were assigned to the shipping lanes designated as international routes.

- Rate of speed. The average speed for the worldwide merchant fleet, 15 knots (nautical miles per hour), was provided by MARAD (1987) and was estimated to be the speed at full power. The cruising speed was estimated to be 8.25 knots.

- Operating mode. Vessels assigned to designated safety fairways as shown in the Better Boating Association Chart Kits and the MMS OCS Natural Gas and Oil Resource Management Comprehensive Program map were predicted to be operating at a cruising/maneuvering speed of 8.25 knots (55 percent of full speed). Those vessels assigned to shipping lanes beyond those shown in the charts and maps were predicted to be operating at full power, or 15 knots. Hotelling, which occurs when a vessel is at berth and running auxiliary motors, was estimated to occur for a 24-hour period during which cargo and supplies are unloaded and loaded at each port of call. The annual vessel hours associated with hotelling were assigned to the county or parish in which a port is located.

- Propulsion type. Deep draft commercial vessels are powered by either steam or diesel engines. According to *Lloyd's Register Statistical Tables* (Lloyd's Maritime Information Services, 1992), approximately 98 percent of the world's merchant fleet is powered by diesel engines. The proportion of steam-powered vessels in the world fleet, currently almost 2 percent, will become even smaller since diesel engines have been the preferred deep draft vessel power source for the last decade. Because these two engine types emit varying levels of emissions, these proportions were used in the analysis to determine the annual vessel hours for each type of engine to correspond with the related emission factors.

The emission factors used to determine total annual pollutant emissions associated with commercial shipping activity were derived from several sources. The primary source document used in this analysis was *Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources* (hereafter referred to as Report AP-42) prepared by the U.S. Environmental Protection Agency (EPA, 1985). This document identifies emission factors for various types of engines used for marine vessel applications. It is currently the primary source of data on air emission factors used by regulatory agencies (EPA, 1993). The derivation of emission factors for steam and diesel engines is described below.

- Emission factors for steam-powered commercial vessels. Data on air pollutant factors for steam-powered commercial vessels were derived from Report AP-42 (EPA, 1985). Personal communication with regulatory agency personnel and a review of recent publications were used to confirm that this document provides the best available source of emission data for steamships (EPA, 1993; CARB, 1993; EPA, 1991; CARB, 1991b).

- Emission factors for all pollutants, except SO_x, were taken from Report AP-42 (EPA, 1985; Table II-3-2). Emissions factors for SO_x are typically represented by a variable which can be converted to a numerical estimate based on the percentage of sulfur present in the type of fuel used. For steamship vessel operations, a common fuel used is residual fuel oil. This type of fuel contains, on average, a 2 percent sulfur content (EPA, 1991; CARB, 1991a). SO_x emission factors were calculated using this percentage. All emission factors were derived in terms of kilograms per 1,000 liters of fuel. Note that this is substantially higher than for other types of vessels, because of the different fuel (bunker fuel oil vs. low sulfur diesel) used by steamships.

- Emission factors for diesel motorships. Data on air pollutant factors for diesel motorships were derived primarily from *Commercial Marine Vessel Emission Contributions to Emission Inventories* (EPA, 1991; Exhibit 2). Additional sources used include: Report AP-42 (EPA, 1985); Notice of Public Meeting to Consider a Plan for the Control of Emissions from Marine Vessels (CARB, 1991a). SO_x emission factors were calculated in the same way as they were for steam-powered commercial vessels.

Baseline

Table E-2 presents the baseline emissions by county and area for deep draft commercial shipping. The largest concentration of vessel hours within a county or parish occurs in

TABLE E-2. Baseline emissions, deep-draft commercial shipping.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr	Total Emissions by Pollutant (in tons/year)				
			NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	NA	NA	NA	NA	NA	NA
Mobile County, AL	01097	41,861	656.0	53.8	78.2	13.3	39.8
Jackson County, MS	28059	31,572	180.5	29.6	24.8	9.2	10.8
Harrison County, MS	28047	14,140	63.4	12.7	9.2	4.1	3.8
Hancock County, MS	28045	NA	NA	NA	NA	NA	NA
Orleans Parish, LA	22071	189,649	1,337.3	186.6	176.4	55.8	80.6
St. Bernard Parish, LA	22087	9,217	783.7	34.1	86.8	4.6	47.8
Plaquemines Parish, LA	22075	117,519	9,992.1	434.6	1,106.5	59.0	609.7
Jefferson Parish, LA	22051	9,374	797.0	34.7	88.3	4.7	48.6
St. Charles Parish, LA	22089	16,267	700.6	36.4	78.9	6.3	42.7
Lafourche Parish, LA	22057	NA	NA	NA	NA	NA	NA
St. John the Baptist Parish, LA	22095	6,504	553.0	24.1	61.2	3.3	33.7
St. James County, LA	22093	46,883	673.8	58.1	81.0	14.7	40.9
Ascension Parish, LA	22005	4,937	419.8	18.3	46.5	2.5	25.6
Iberville Parish, LA	22047	6,912	587.7	25.6	65.1	3.5	35.9
West Baton Rouge Parish, LA	22121	66,775	555.6	68.7	71.3	19.9	33.6
Terrebone Parish, LA	22109	NA	NA	NA	NA	NA	NA
St. Mary Parish, LA	22101	NA	NA	NA	NA	NA	NA
Iberia Parish, LA	22045	NA	NA	NA	NA	NA	NA
Vermilion Parish, LA	22113	NA	NA	NA	NA	NA	NA
Calcasieu Parish, LA	22019	31,437	249.6	31.9	32.3	9.3	15.1
Cameron Parish, LA	22023	3,037	258.2	11.2	28.6	1.5	15.8
Orange County, TX	48361	283	2.4	0.3	0.3	0.1	0.1
Jefferson County, TX	48245	93,497	1,724.1	129.1	202.9	30.4	104.8
Chambers County, TX	48071	17,182	1,460.9	63.5	161.8	8.6	89.1
Harris County, TX	48201	175,001	1,919.2	196.1	237.4	53.3	116.3
Galveston County, TX	48167	74,907	1,835.1	119.2	211.9	25.5	111.7
Brazoria County, TX	48039	23,982	227.5	25.6	28.7	7.2	13.8
Matagorda County, TX	48321	NA	NA	NA	NA	NA	NA
Calhoun County, TX	48057	6,132	86.7	7.5	10.4	1.9	5.3
Aransas County, TX	48007	NA	NA	NA	NA	NA	NA
Nueces County, TX	48355	59,139	1,053.0	80.3	124.2	19.1	64.0
Kleberg County, TX	48273	NA	NA	NA	NA	NA	NA
Kenedy County, TX	48261	NA	NA	NA	NA	NA	NA
Willacy County, TX	48489	NA	NA	NA	NA	NA	NA

TABLE E-2. Continued.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr	Total Emissions by Pollutant (in tons/year) NOx	HC	CO	SOx	TSP
Cameron County, TX	48061	20,460	288.0	25.1	34.7	6.4	17.5
Alaminos Canyon	99001	8,108	1,254.4	54.7	139.1	7.3	79.1
Atwater Valley	99005	38,366	5,935.7	258.8	658.2	34.7	374.5
Brazos	99007	3,139	266.9	11.6	29.6	1.6	16.3
Brazos South Addition	99009	3,932	334.4	14.5	37.0	2.0	20.4
Breton Sound	99011	461	39.2	1.7	4.3	0.2	2.4
Chandeleur	99013	844	71.8	3.1	7.9	0.4	4.4
Chandeleur East Addition	99015	NA	NA	NA	NA	NA	NA
Corpus Christi	99017	3,168	269.3	11.7	29.8	1.6	16.4
East Breaks	99023	33,143	3,285.9	143.0	364.0	19.3	202.7
East Cameron	99025	NA	NA	NA	NA	NA	NA
East Cameron South Addition	99027	42,153	3,584.1	155.9	396.9	21.2	218.7
Eugene Island	99029	NA	NA	NA	NA	NA	NA
Eugene Island South Addition	99031	NA	NA	NA	NA	NA	NA
Ewing Bank	99033	128,632	10,937.0	475.7	1,211.1	64.6	667.4
Galveston	99037	72,882	6,196.8	269.5	686.2	36.6	378.1
Galveston South Addition	99039	5,943	505.3	22.0	56.0	3.0	30.8
Garden Banks	99041	124,174	10,557.9	459.2	1,169.2	62.3	644.2
Grand Isle	99043	NA	NA	NA	NA	NA	NA
Grand Isle South Addition	99045	NA	NA	NA	NA	NA	NA
Green Canyon	99047	90,881	7,727.2	336.1	855.7	45.6	471.5
High Island	99049	74,349	6,321.5	274.9	700.0	37.3	385.7
High Island East Addtion	99051	24,448	2,078.7	90.4	230.2	12.3	126.8
High Island East Add. South Ext.	99053	NA	NA	NA	NA	NA	NA
High Island South Addition	99055	3,706	315.1	13.7	34.9	1.9	19.2
Keathley Canyon	99059	4,825	746.4	32.5	82.8	4.4	47.1
Main Pass	99063	2,478	210.7	9.2	23.3	1.2	12.9
Main Pass South and East Addition	99065	538	45.8	2.0	5.1	0.3	2.8
Matagorda Island	99067	8,149	692.9	30.1	76.7	4.1	42.3
Mississippi Canyon	99069	66,332	5,639.9	245.3	624.5	33.3	344.1
Mobile	99071	1,757	149.4	6.5	16.5	0.9	9.1
Mustang Island	99073	10,328	878.1	38.2	97.2	5.2	53.6
Mustang Island East Addition	99075	8,189	696.3	30.3	77.1	4.1	42.5
NG 15-8	99077	3,618	559.8	24.4	62.1	3.3	35.3
NG 15-9	99079	NA	NA	NA	NA	NA	NA

TABLE E-2. Continued.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr	Total Emissions by Pollutant (in tons/year)				
			NOx	HC	CO	SOx	TSP
NG 16-4	99081	38,807	6,003.9	261.8	665.8	35.1	378.8
NG 16-7	99085	8,820	1,364.5	59.5	151.3	8.0	86.1
North Padre Island	99087	903	76.8	3.3	8.5	0.5	4.7
North Padre Island East Addition	99089	NA	NA	NA	NA	NA	NA
Port Isabel	99093	1,634	138.9	6.0	15.4	0.8	8.5
Sabine Pass	99097	7,004	595.5	25.9	65.9	3.5	36.3
Ship Shoal	99099	NA	NA	NA	NA	NA	NA
Ship Shoal South Addition	99101	NA	NA	NA	NA	NA	NA
South Marsh Island	99103	NA	NA	NA	NA	NA	NA
South Marsh Island North Addition	99105	NA	NA	NA	NA	NA	NA
South Marsh Island South Addition	99107	NA	NA	NA	NA	NA	NA
South Padre Island	99109	1,990	169.2	7.4	18.7	1.0	10.3
South Padre Island East Addition	99111	1,723	146.5	6.4	16.2	0.9	8.9
South Pass	99113	1,924	163.6	7.1	18.1	1.0	10.0
South Pass East Addition	99115	891	75.8	3.3	8.4	0.4	4.6
South Pass South Addition	99117	475	40.4	1.8	4.5	0.2	2.5
South Pelto	99119	NA	NA	NA	NA	NA	NA
South Timbalier	99121	NA	NA	NA	NA	NA	NA
South Timbalier South Addition	99123	NA	NA	NA	NA	NA	NA
Vermilion	99127	NA	NA	NA	NA	NA	NA
Vermilion South Addition	99129	NA	NA	NA	NA	NA	NA
Viosca Knoll	99133	NA	NA	NA	NA	NA	NA
Walker Ridge	99135	NA	NA	NA	NA	NA	NA
West Cameron	99137	9,260	787.3	34.2	87.2	4.6	48.0
West Cameron South Addition	99139	52,109	4,430.5	192.7	490.6	26.2	270.3
West Cameron West Addition	99141	25,179	2,140.9	93.1	237.1	12.6	130.6
West Delta	99143	NA	NA	NA	NA	NA	NA
West Delta South Addition	99145	NA	NA	NA	NA	NA	NA
WX-1	99147	2,062	175.3	7.6	19.4	1.0	10.7
Apalachicola	99149	NA	NA	NA	NA	NA	NA
DeSoto Canyon	99151	NA	NA	NA	NA	NA	NA
Destin Dome	99153	NA	NA	NA	NA	NA	NA
Florida Middle Ground	99155	NA	NA	NA	NA	NA	NA
Howell Hook	99157	NA	NA	NA	NA	NA	NA
Lloyd Ridge	99159	NA	NA	NA	NA	NA	NA

TABLE E-2. Concluded.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr	Total Emissions by Pollutant (in tons/year)				
			NOx	HC	CO	SOx	TSP
NG 16-5	99161	NA	NA	NA	NA	NA	NA
Pensacola	99163	NA	NA	NA	NA	NA	NA
Rankin	99165	NA	NA	NA	NA	NA	NA
The Elbow	99167	NA	NA	NA	NA	NA	NA
Vernon Basin	99169	NA	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: Better Boating Association, 1988a,b; CARB, 1991a,b; Caterpillar, 1993; COE, 1991a; Bureau of the Census, 1990; Lloyd's Maritime Information Services, 1992; MMS, 1989 and 1991; MARAD, 1987; EPA, 1985 and 1991.

the Louisiana parishes of Orleans, Plaquemines, and West Baton Rouge and the Texas counties of Jefferson, Harris, Galveston, and Nueces. Plaquemines Parish has many vessel hours because the Mississippi River, a major route for vessel traffic to the ports of New Orleans and Baton Rouge, runs the maximum length of the parish, approximately 100 miles. The other parishes and counties have high annual vessel hours because a major port is located within their boundaries. In general, most of these hours represent vessels in the hotelling mode, which has lower emission levels than the other modes of operation. Therefore, the corresponding emission levels are not directly related to the number of annual vessel hours.

For the offshore areas in the Gulf of Mexico, significant levels of annual vessel hours occur in Ewing Bank, Galveston, Garden Banks, Green Canyon, High Island, Mississippi Canyon, and West Cameron South Addition. Four of these areas, Ewing Bank, Garden Banks, Green Canyon, and Mississippi Canyon, contain the major East-West shipping route between Mobile and New Orleans and Brownsville, Corpus Christi, Freeport, Galveston, Houston, Port Arthur, and Beaumont. The high traffic volume on this route results in a high number of vessel hours. The other three areas with high activity, Galveston, High Island, and West Cameron South Addition, are in proximity to the busy safety fairways surrounding the Galveston, Texas City, Houston, Port Arthur, and Beaumont ports. Unlike the emission levels predicted for the counties and parishes, these vessel hours directly correlate with the total level of emissions because the low-emission hotelling mode does not occur in these areas.

The table also indicates a relatively high level of NO_x. This is the result of the compounding and interaction of four factors -- higher emissions per unit of fuel by this industry, a high hourly fuel consumption rate, use of bunker fuel oil (vs. low sulfur diesel), and long periods of idling in port. These are explained more fully below.NO_x emissions from the large low-RPM type of engines (i.e., typically commercial shipping vessels propulsion) are much higher than for the smaller diesels used by other sectors.

Second, and most important, commercial shipping consumes larger quantities of fuel relative to other marine vessel sectors, which translates into very high relative emissions per hour of operation. Thus, while the commercial ship hours of operation are comparable to those found in the other sectors, they often produce 20 to 30 times the volume of NO_x per hour of operation.

Third, the commercial shipping estimates include 24 hours of hotelling for each port call. The substantial amount of time spent in the hotelling mode produces an emission pattern which is distinct from the emission characteristics found in many of the other boating sectors. For example, in the hotelling mode HC emissions are estimated at 9.8 kg/1,000 liters compared to 35.10 kg/1,000 liters for NO_x. While periods of engine idling are built into some of the other sectors, none of them include the 24 hours of hotelling time found in shipping.

Fourth, commercial shipping (and the LOOP tankers) are the only sector burning residual fuel oil, which has an estimated 2 percent sulfur content. The sulfur emissions from any sector using residual fuel oil rather than marine diesel would be substantially higher than these using alternative fuels.

Since deep draft shipping is a commercial form of transportation, no adjustments have been made to account for time-of-day, day-of-week, or seasonal differences in vessel traffic. The nature of deep draft shipping includes consistent levels of operation during every hour, day, and month.

Similarly, no adjustments have been made to reflect future growth or decline in vessel traffic. According to the *Waterborne Commerce of the United States* (COE, 1991b.), the average annual change in foreign and domestic waterborne commerce was approximately 4.2 percent from 1985 and 1989. While foreign trade is predicted to grow, emissions are expected to remain fairly level due to advancements in vessel and propulsion design. These include increased vessel size, improvements in efficiency as a result of newer, more efficient vessels, improved port operations and containerization which dramatically reduces port time. The baseline, therefore, also represents the projections.

The most recent year for which all necessary data were available was 1989. These data were used to develop the 1990 base year activity level. The annual reported vessel hours were 1,983,994. The adjustment factors for the years 1987 through 2000 is 1.0.

Section References

Better Boating Association, Inc. 1988a. Chart Kit, New Orleans to Panama City, FL: Region 16. Needham, MA.

Better Boating Association, Inc. 1988b. Chart Kit, Texas Coast and Offshore: Region 18. Needham, MA.

Bureau of the Census. 1990. U.S. Department of Commerce. United States Foreign Trade Vessel Entrances and Clearances, 1988 Annual Report. FT975-88. Issued February.

CARB. 1991a. California Air Resources Board. Notice of Public Meeting to Consider a Plan for the Control of Emission from Marine Vessels (Mailout #90-58). Staff Report. September.

CARB. 1991b. California Air Resources Board. Regulatory Strategies for Reducing Emissions from Marine Vessels in California Waters. Prepared by Sierra Research, Inc. October.

CARB. 1993. California Air Resources Board. Personal communication with R. Abachi, Mobile Source Division, Off-Road Controls Section. January.

Caterpillar. 1993. Personal communication with A. Kludjian, Authorized Dealer, Peterson Power Systems, Inc. San Leandro, California. January.

COE. 1991a. U.S. Department of the Army, Corps of Engineers. Waterborne Commerce of the United States, Calendar Year 1989, Part 2 Gulf Coast, Mississippi River System, and Antilles.

COE. 1991b. U.S. Department of the Army, Corps of Engineers. Waterborne Commerce of the United States, Calendar Year 1989, Part 5 National Summaries.

EPA. 1985. U.S. Environmental Protection Agency. Compilation of Air Emission Factors, Volume II, EPA Report No. AP-42, Fourth Edition. Research Triangle Park, North Carolina, Office of Air Quality Planning and Standards.

EPA. 1991. U.S. Environmental Protection Agency. Commercial Marine Vessel Contributions to Emission Inventories. Prepared by Booz, Allen, and Hamilton, Inc. Los Angeles, California. October.

EPA. 1993. U.S. Environmental Protection Agency. Personal communication with J. Somers, Emission Planning and Strategies Division, Office of Mobile Sources, Ann Arbor, Michigan. January.

Lloyd's Maritime Information Services. 1992. *Lloyd's Register Statistical Tables.* June.

MARAD. 1987. U.S. Department of Transportation, Maritime Administration, Office of Trade Analysis and Insurance. Oceangoing Merchant Type Vessels of 1,000 Gross Tons and Over Showing Number, Percent, Average Age, Speed & Draft by Type of Vessel and County of Registration as of December 31, 1985.

MARAD. 1991. U.S. Department of Transportation, Maritime Administration. Domestic Waterborne Trade of the United States, 1987-1989. November.

MARAD. 1992. U.S. Department of Transportation, Maritime Administration. Merchant Fleets of the World, Oceangoing Steam and Motor Ships of 1,000 Gross Tons and Over as of January 1. 1992.

MMS. 1989. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office. Historic Leasing and Infrastructure, Visual 1. March.

MMS. 1991. U.S. Department of the Interior, Minerals Management Service. Outer Continental Shelf Natural Gas and Oil Resource Management Comprehensive Program (1992-1997), Visual I. June.

Transportation Institute. 1992. The U.S.-Flag Merchant Marine: An Introduction.

ATTACHMENT F: COMMERCIAL FISHING

Description of the Sector

Commercial fishing is an important component of the total amount of vessel traffic in the waters of the Gulf of Mexico. Commercial fishing takes place both in the open waters of the Gulf of Mexico as well as the inshore waters of the bays and estuaries along the coastline. The major fisheries of the area and around which this analysis was organized include these components:

- Offshore and inshore shrimp fishery
- Offshore reef fish fishery
- Offshore pelagic line fishery
- Inshore oyster fishery
- Inshore crab fishery
- Inshore fishery for miscellaneous finfish.

The shrimp fishery is the predominant fishery in the area. Offshore shrimping is conducted using shrimp trawl vessels with typical sizes ranging from an overall length of 36 to 80 feet. These are almost exclusively diesel powered vessels with typical horsepowers ranging up to 500 horsepower. Open water shrimp trawling is conducted in open waters from near shore out to 200 to 600 miles from shore along the whole length of the Gulf of Mexico coastline. Inshore shrimping is conducted in bays and estuaries in the region. While the larger vessels may occasionally trawl for shrimp in the inshore areas, much of the inshore shrimping activity is conducted by smaller trawl vessels, a large proportion of which are under 36 feet.

The offshore reef fishery is conducted using vessels which fish with power hand lines or long lines. Typical vessel lengths range from 30 to 70 feet. Snapper and grouper are the primary target species. The general fishing areas are similar to those for shrimp. These vessels are almost exclusively diesel powered.

The offshore pelagic line fishery targets species such as swordfish, yellowfin tuna, bluefin tuna, shark and various other pelagic species. This fishery is frequently conducted further from shore than the other fisheries and tends to range throughout the whole Gulf of Mexico area. However, the bulk of the fishing activity in the Gulf of Mexico takes place north of a line running from the Texas/Mexican boarder to the tip of Florida. Vessels in this fishery range from 40 to 70 feet in length and are almost exclusively diesel powered. Many of these vessels are converted from former shrimp vessels.

The inshore oyster fishery is conducted in bays and estuaries almost exclusively within 3 miles of the shoreline. Typical fishing gear used includes dredges and tongs. Roughly half the craft in this fishery are boats under 27 feet in length, which may be powered by gasoline outboard or inboard engines. The other half of the vessels in this fishery are larger ranging up to 45 feet or more in length. These vessels are powered with either gasoline or diesel inboard engines.

The inshore crab fishery is conducted using crab pots in the bays and estuaries within 3 miles of shore. While a variety of vessels engage in this fishery, the majority are small boats typically under 30 feet in length. These are most frequently powered by gasoline outboard or inboard engines.

The miscellaneous finfish fishery targets species such as croaker, mullet, and sea trout. Within the Western and Central OCS Planning Area, this fishery is concentrated off the States of Alabama and Mississippi within 3 miles of shore. This fishery is conducted from small boats which are typically powered by gasoline outboard motors, using gill nets or trammel nets.

Emission Factors

Fishing vessels have a wide variety of sizes, types, and operating characteristic. Even within a given fishery, there will be a significant range in operating characteristics such as the number of days fished per year, the number of hours fished per day, the amount of time spent idling, at slow speed or at high speed cruise. Based on available data, it was concluded that the most appropriate method to estimate emissions, was to estimate the amount of fuel consumed in each fishery, and to apply data on the amount of emissions per unit of fuel.

Commercial fishing vessels are powered by three types of engines: 2-stroke gasoline outboards; 4-stroke gasoline inboards; and diesel propulsion systems. Commercial fishing vessels using 2-stroke gasoline outboard engines typically have a horsepower rating from 36 to over 150 horsepower. Commercial fishing vessels using 4-stroke gasoline inboard engines generally range in size from 120 to 200 horsepower. Commercial fishing vessels using diesel engines are often powered by smaller, high-speed diesel engines which commonly burn marine diesel fuel oil. The majority of diesel engines typically used on commercial fishing vessels in the Gulf of Mexico range in size from about 100 to 500 horsepower.

The primary pollutants emitted by both gasoline and diesel engines while in service on commercial fishing vessels include the following: nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), sulfur oxides (SO_x), and particulates (PM). Total particulate matter equates to total suspended particulate (TSP) and is referred to as TSP in the model and the remainder of this analysis. HC are total hydrocarbons, not just VOC emissions. The emission factors for these pollutants are provided in terms of grams per liter of fuel used. Table F-1 summarizes the emission factors related to commercial fishing vessels for all five pollutants.

The emission factors used to determine total annual pollutant emissions associated with commercial fishing activity were derived from *Commercial Marine Vessel Emission Contributions to Emission Inventories* (EPA, 1991a); and *Nonroad Engine and Vehicle Emission Study, Final Report* (EPA, 1991b).

Emission factors for NO_x, HC, and CO for 2-stroke outboard gasoline engines with typical horsepower ranges of 36 to 150 horsepower were derived from EPA (1991b/Table I-11a). For each pollutant, the emission factor data presented for each horsepower rating in the range of 36-150 (grams/hour) were averaged to estimate a composite emission factor data set for this engine type. The emission factor data presented for each pollutant were converted to grams per liter for this analysis. Gasoline outboard emission factors for SO_x and TSP were also provided in EPA (1991b/Table 2-07e). The emission factors for HC and CO were further adjusted (up) by a factor of 1.2 to reflect in-use impacts on emissions from engine malfunctions, improper maintenance, and engine wear. It was determined that adjustments need not be made to emission factors for NO_x, SO_x, and TSP (EPA, 1991b).

Commercial fishing vessels using 4-stroke gasoline inboard engines and inboard/sterndrive engines commonly range in horsepower from 120 to 200 horsepower. Emission factors for all five pollutants for inboard gasoline engines of this size were derived from EPA (1991b/Table 2-07c). The emission factors for HC and CO were further adjusted (up) by a factor of 1.5 and 1.3, respectively, to reflect in-use impacts on

TABLE F-1. Emission factors for commercial fishing vessels.

Engine Type	Pollutant (kg/liter of fuel)					Source
	NO_x	HC	CO	SO_x	TSP	
2-Stroke Outboard • Gasoline (avg. 36-150+ HP)	0.002	0.226	0.434	0.001	0.013	EPA, 1991b; Tables 2-07e, I-11a.
4-Stroke Inboard/ Sterndrive • Gasoline (avg. 120-200 HP)	0.012	0.029	0.416	0.001	0.0002	EPA, 1991b; Table 2-07c.
Diesel • Cruise Mode						
– <500 HP	0.047	0.006	0.006	0.0002*	0.0002*	EPA, 1991a; Exhibit 3.
– 500-1,000 HP	0.036	0.002	0.010	0.0002*	0.0002*	EPA, 1991a; Exhibit 3.
– 1,000-1,500 HP	0.036	0.003	0.007	0.0002*	0.0002*	EPA, 1991a; Exhibit 3.

***Calculated based on sulfur content of 0.80 percent for marine diesel fuel.**

emissions from engine malfunctions, improper maintenance, and engine wear. It was determined that adjustments need not be made to emission factors for NO_x, SO_x, and PM (EPA, 1991b).

Data on air pollutant emission factors for diesel powered commercial fishing vessels were derived from *Commercial Marine Vessel Emission Contributions to Emission Inventories* (EPA, 1991a). Emission factors for SO_x are typically represented by a variable which can be converted into a numerical estimate based on the percentage of sulfur present in the type of fuel used. For commercial fishing operations, a common fuel used is marine diesel fuel. This type of fuel contains, on average, a 0.8 percent sulfur content. Therefore, SO_x emission factors were calculated using this percentage.

Methodology

Annual emissions from commercial fishing operations were estimated using the following formula:

Annual Fuel Usage (L/yr) × Emission Factors by Pollutant (g/L)
× 0.0000011 ton/g = Total Emissions by Pollutant (ton/yr)

Annual fuel usage in each county or offshore area for the various commercial fisheries was estimated based on the following:

- For the offshore shrimp fishery, data were obtained from the National Marine Fisheries Service (NMFS) on the number of operating days by shrimp trawlers for NMFS Gulf of Mexico Fishery Offshore Reporting Grid Numbers 10 through 21 (NMFS, 1993b). These grids range along the coast from Alabama through Texas from shore to a point roughly 200 to 600 miles offshore. Operating days were averaged for the years 1990 through 1991. Operating days by NMFS Grid Number were allocated to Minerals Management Service (MMS) offshore areas by taking the relative proportion of area (i.e., if 25 percent of Grid 21 was in MMS area x, and 10 percent of Grid 20 was in MMS area x; MMS area x was allocated 25 percent of the fishing days in Grid 21 and 10 percent of the fishing days in Grid 20). Average fuel usage per day was estimated from operating profiles of typical Gulf of Mexico offshore shrimp vessels (Roberts and Sass, 1979) Emissions data were taken from Table F-1 for diesel vessels under 500 horsepower.

- For the offshore reef fish fishery, total number of operating hours were estimated based on the estimated number of vessels and average number of operating hours (Poffenberger, 1985). These were allocated to NMFS Grid Number based on the distribution of the 1972-1986 commercial red snapper (the primary target species) catch (NMFS, 1988). Operating days by NMFS Grid Number were allocated to MMS offshore areas by taking the relative proportion of area. Fuel usage per day was estimated from operating profiles of typical Gulf of Mexico reef fish vessels (Poffenberger, 1985). Emissions data were taken from Table F-1 for diesel vessels under 500 horsepower.

- For the offshore pelagic line fishery, data were obtained from NMFS on the total number of operating days in the Gulf of Mexico (NMFS, 1993a). According to this source, about 80 percent of these operating days would be expected to be north of a line from the Texas/Mexico border to the tip of Florida. Within that area, operating days were allocated to MMS lease areas, based on the relative proportion of area, since fishing activity in this fishery is widespread and can reasonably be assumed to be randomly distributed. Fuel usage per day was estimated to be similar to that of reef fish vessels. Emissions data were taken from Table F-1 for diesel vessels under 500 horsepower.

- For the inshore shrimp, oyster, crab and miscellaneous finfish fishery, no specific data were available on activity levels by vessel operating areas. Thus, activity estimates by county were made by taking the catch in pounds by state (unpublished catch data supplied by NMFS), and allocating it to coastal counties.

This was done for catch data for the year 1988, which was assumed to be typical. Data were allocated to counties based on the relative proportion of inshore fishing area (within 3 miles of shore). Fuel usage per pound of fish caught was then estimated for the inshore shrimp, oyster, crab and finfish fisheries, respectively. The fuel usage figures were taken from operating vessel profiles for typical vessels in the respective fisheries from COE (1985) and Roberts and Thompson (1982). These fuel usage factors were applied to the county catch estimates to estimate fuel usage by county. Estimates were made of the relative mix of diesel, gasoline inboard and gasoline outboard engines. Emissions data were taken from Table F-1 for the various engine types and applied to the fuel usage estimates.

Baseline

Table F-2 presents the annual baseline emissions by county and offshore MMS area for commercial fishing operations. These were calculated by summing the emissions for the six offshore and inshore fisheries described above.

These major fisheries in the Gulf of Mexico are essentially stable in terms of growth. This is because they are fully developed and further growth is precluded due to limitations imposed by biological and economic factors. Thus, the emissions in future years can be essentially characterized by activity levels in the recent past. While there is substantial annual variability in the harvests of these fisheries, this variability is not readily predicted. Complex factors such as habitat loss, seasonal weather conditions, oceanographic conditions, and market prices for various fishery products substantially affect harvests. Further, emissions are related to levels of fishing activity, not actual catch, further complicating any forecasts of hours of operations. Because these fisheries are fully developed, the total hours of fishing effort is likely to remain relatively constant independent of actual harvest.

For the inshore fisheries (within 3 miles of shore) 1988 data for Alabama, Louisiana, Mississippi, and Texas were used. For the offshore fisheries (beyond 3 miles of shore), the average operating days in 1990 and 1991 were used. The offshore fishery is dominated by shrimp. The 194,600 operating days represent only the shrimp fishery since each zone can have more than one type of fishing present. The actual data used reflects the differences by zone in the type of fishing that is present. The inshore fishery activity level is reported as 255 million pounds of fish. These activity data are assumed applicable for the years 1987 through 2000, therefore the adjustment factor for these years is 1.0.

Because fishing activity tends to be dictated by weather and trip logistics, emissions levels should not vary significantly by time-of-day or day-of-week. Commercial fishermen tend to spread their activity throughout weekday and weekend periods.

TABLE F-2. Baseline emissions, commercial fishing vessels.

County/Area Name	County Code (FIPS)	Annual Fuel Consumption (1,000 liters)	Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	2,952.8	133.6	23.6	56.4	0.50	6.02
Mobile County, AL	01097	3,534.0	167.0	28.2	52.7	0.60	7.54
Jackson County, MS	28059	3,816.7	180.3	30.5	56.9	0.64	8.14
Harrison County, MS	28047	13,915.8	625.1	115.3	276.1	2.37	28.47
Hancock County, MS	28045	4,605.8	193.3	40.0	120.2	0.79	8.91
St. Bernard Parish, LA	22087	16,887.8	708.9	146.5	440.6	2.91	32.66
Plaquemines Parish, LA	22075	43,017.1	1,768.4	376.9	1,200.9	7.43	81.71
Jefferson Parish, LA	22051	4,918.8	199.0	43.4	144.0	0.85	9.22
Lafourche Parish, LA	22057	8,198.0	331.7	72.4	240.1	1.42	15.36
Terrebone Parish, LA	22109	21,314.8	862.4	188.2	624.2	3.69	39.93
St. Mary Parish, LA	22101	3,279.2	132.7	28.9	96.0	0.57	6.14
Iberia Parish, LA	22045	8,198.0	331.7	72.4	240.1	1.42	15.36
Vermilion Parish, LA	22113	14,756.4	597.1	130.3	432.1	2.56	27.65
Cameron Parish, LA	22023	24,200.9	981.1	213.2	704.6	4.19	45.40
Jefferson County, TX	48245	4,444.1	184.1	38.2	120.8	0.77	8.46
Chambers County, TX	48071	219.2	9.4	1.8	5.2	0.04	0.43
Galveston County, TX	48167	4,384.2	188.7	36.0	104.0	0.75	8.57
Brazoria County, TX	48039	3,507.4	151.0	28.8	83.2	0.60	6.85
Matagorda County, TX	48321	4,822.6	207.6	39.6	114.4	0.83	9.42
Calhoun County, TX	48057	2,630.5	113.2	21.6	62.4	0.45	5.14
Aransas County, TX	48007	2,630.5	113.2	21.6	62.4	0.45	5.14
San Patricio County, TX	48409	1,052.2	45.3	8.6	25.0	0.18	2.06
Nueces County, TX	48355	701.5	30.2	5.8	16.6	0.12	1.37
Kleberg County, TX	48273	1,753.7	75.5	14.4	41.6	0.30	3.43
Kenedy County, TX	48261	3,945.8	169.9	32.4	93.6	0.68	7.71
Willacy County, TX	48489	1,315.3	56.6	10.8	31.2	0.23	2.57
Cameron County, TX	48061	2,192.1	94.4	18.0	52.0	0.38	4.28
Alaminos Canyon	99001	37.8	1.9	0.3	0.2	0.01	0.08
Atwater Valley	99005	37.8	1.9	0.3	0.2	0.01	0.08
Brazos	99007	3,059.3	156.8	20.6	19.0	0.51	6.85
Brazos South Addition	99009	1,312.0	67.2	8.8	8.2	0.22	2.94
Breton Sound	99011	148.2	7.6	1.0	0.9	0.02	0.33
Chandeleur	99013	359.5	18.4	2.4	2.2	0.06	0.80
Chandeleur East Addition	99015	138.3	7.1	0.9	0.9	0.02	0.31
Corpus Christi	99017	4.5	0.2	0.0	0.0	0.00	0.01
East Breaks	99023	33.0	1.7	0.2	0.2	0.01	0.07

TABLE F-2. Continued.

County/Area Name	County Code (FIPS)	Annual Fuel Consumption (1,000 liters)	Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
East Cameron	99025	1,785.9	91.5	12.0	11.1	0.30	4.00
East Cameron South Addition	99027	1,083.0	55.5	7.3	6.7	0.18	2.42
Eugene Island	99029	3,263.6	167.2	21.9	20.3	0.54	7.30
Eugene Island South Addition	99031	1,629.2	83.5	11.0	10.1	0.27	3.65
Ewing Bank	99033	924.7	47.4	6.2	5.8	0.15	2.07
Galveston	99037	3,527.7	180.8	23.7	22.0	0.58	7.89
Galveston South Addition	99039	1,260.7	64.6	8.5	7.8	0.21	2.82
Garden Banks	99041	34.8	1.8	0.2	0.2	0.01	0.08
Grand Isle	99043	1,890.9	96.9	12.7	11.8	0.31	4.23
Grand Isle South Addition	99045	1,921.8	98.5	12.9	12.0	0.32	4.30
Green Canyon	99047	37.8	1.9	0.3	0.2	0.01	0.08
High Island	99049	3,178.7	162.9	21.4	19.8	0.53	7.11
High Island East Addtion	99051	1,053.5	54.0	7.1	6.6	0.17	2.36
High Island East Add. South Ext.	99053	1,051.9	53.9	7.1	6.5	0.17	2.35
High Island South Addition	99055	1,718.9	88.1	11.6	10.7	0.28	3.85
Keathley Canyon	99059	37.8	1.9	0.3	0.2	0.01	0.08
Main Pass	99063	1,282.4	65.7	8.6	8.0	0.21	2.87
Main Pass South and East Add.	99065	2,060.2	105.6	13.9	12.8	0.34	4.61
Matagorda Island	99067	2,181.5	111.8	14.7	13.6	0.36	4.88
Mississippi Canyon	99069	33.1	1.7	0.2	0.2	0.01	0.07
Mobile	99071	1,103.2	56.5	7.4	6.9	0.18	2.47
Mustang Island	99073	1,076.5	55.2	7.2	6.7	0.18	2.41
Mustang Island East Addition	99075	1,993.3	102.1	13.4	12.4	0.33	4.46
NG 15-8	99077	7.0	0.4	0.0	0.0	0.00	0.02
NG 15-9	99079	9.1	0.5	0.1	0.1	0.00	0.02
NG 16-4	99081	37.8	1.9	0.3	0.2	0.01	0.08
NG 16-7	99085	9.2	0.5	0.1	0.1	0.00	0.02
North Padre Island	99087	1,193.7	61.2	8.0	7.4	0.20	2.67
North Padre Island East Addition	99089	2,238.1	114.7	15.1	13.9	0.37	5.01
Port Isabel	99093	10.0	0.5	0.1	0.1	0.00	0.02
Sabine Pass	99097	143.6	7.4	1.0	0.9	0.02	0.32
Ship Shoal	99099	2,740.5	140.4	18.4	17.1	0.45	6.13
Ship Shoal South Addition	99101	1,822.4	93.4	12.3	11.3	0.30	4.08
South Marsh Island	99103	713.0	36.5	4.8	4.4	0.12	1.60
South Marsh Island North Addition	99105	778.1	39.9	5.2	4.8	0.13	1.74
South Marsh Island South Addition	99107	1,064.8	54.6	7.2	6.6	0.18	2.38

TABLE F-2. Concluded.

County/Area Name	County Code (FIPS)	Annual Fuel Consumption (1,000 liters)	Total Emissions by Pollutant (tons/yr)				
			NOx	HC	CO	SOx	TSP
South Padre Island	99109	1,093.4	56.0	7.4	6.8	0.18	2.45
South Padre Island East Addition	99111	1,479.6	75.8	10.0	9.2	0.24	3.31
South Pass	99113	680.5	34.9	4.6	4.2	0.11	1.52
South Pass East Addition	99115	65.3	3.3	0.4	0.4	0.01	0.15
South Pass South Addition	99117	716.3	36.7	4.8	4.5	0.12	1.60
South Pelto	99119	378.3	19.4	2.5	2.4	0.06	0.85
South Timbalier	99121	2,686.8	137.7	18.1	16.7	0.44	6.01
South Timbalier South Addition	99123	1,652.2	84.7	11.1	10.3	0.27	3.70
Vermilion	99127	2,061.1	105.6	13.9	12.8	0.34	4.61
Vermilion South Addition	99129	1,236.4	63.4	8.3	7.7	0.20	2.77
Viosca Knoll	99133	1,078.5	55.3	7.3	6.7	0.18	2.41
Walker Ridge	99135	38.7	2.0	0.3	0.2	0.01	0.09
West Cameron	99137	2,243.4	115.0	15.1	14.0	0.37	5.02
West Cameron South Addition	99139	2,111.0	108.2	14.2	13.1	0.35	4.72
West Cameron West Addition	99141	1,859.8	95.3	12.5	11.6	0.31	4.16
West Delta	99143	3,241.2	166.1	21.8	20.2	0.54	7.25
West Delta South Addition	99145	1,611.7	82.6	10.8	10.0	0.27	3.61
WX−1	99147	583.4	29.9	3.9	3.6	0.10	1.31

Sources: COE, 1985; MFS, 1988; Poffenberger, 1985; Roberts and Sass, 1979; Roberts and Thompson, 1982; EPA, 1991a,b; unpublished statistical data from National Marine Fisheries Service.

Commercial fishing activity in the Gulf of Mexico does, however, vary by fishing season. Since the shrimp fishery tends to dominate the emissions estimate, an adjustment factor for monthly emissions was calculated from the relative monthly fishing effort in the shrimp fishery for the years 1990 and 1991 (NMFS, 1993b). These monthly activity multipliers are as follows:

Commercial Fishing Monthly Activity Multiplier

Month	*Multiplier*
January	0.028
February	0.029
March	0.023
April	0.044
May	0.102
June	0.080
July	0.117
August	0.121
September	0.120
October	0.141
November	0.106
December	0.091
Total	1.000

Section References

COE. 1985. U.S. Department of the Army, Corps of Engineers. Commercial Fishing Cost Return Profiles for Gulf Coast Areas. Prepared by Centaur Associates, Inc.

EPA. 1991a. U.S. Environmental Protection Agency. Commercial Marine Vessel Contributions to Emission Inventories, Final Report prepared by Booz, Allen, and Hamilton, Inc., Los Angeles, California, October.

EPA. 1991b. U.S. Environmental Protection Agency. Nonroad Engine and Vehicle Emission Study, Report and Appendices, EPA-21A-2001, Washington, D.C., Office of Air and Radiation, November.

NMFS. 1988. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1988 NMFS Reef Fish Assessments for the Gulf of Mexico. NMFS Southeast Fisheries Center, Miami, Florida.

NMFS. 1993a. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Center. Personal communication with J. Creamer. Miami, Florida. January.

NMFS. 1993b. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center. Personal communication with J. Nance, Galveston, Texas. January.

Poffenberger, J.R. 1985. Operational and Financial Characteristics of Reef Fish Vessels in the South Atlantic and Gulf of Mexico Areas. North American Journal of Fisheries Management 5:379-388.

Roberts, K.J. and M.E. Sass. 1979. Financial Aspects of Louisiana Shrimp Vessels, 1978. Louisiana State University Sea Grant Publication No. LSU-TL-79-007.

Roberts, K.J. and M.E. Thompson. 1982. Economic Elements of Commercial Crabbing in Lake Pontchartrain and Lake Borgne. Louisiana State University Sea Grant Publication No. LSU-TL-82-001.

ATTACHMENT G: INTRACOASTAL BARGE TRAFFIC

Description of the Sector

Cargo is moved on the navigable internal waterways of the Gulf coast, including the Gulf Intracoastal Waterway, and the nation's other major inland waterways by unmanned barges lashed together into a single unit called a tow. Barges generally are moved by towing vessels, typically a towboat pushing them ahead or a tug pulling them on a hawser, but there are some self-propelled barges. Since 9 feet is generally the controlling depth of channels on the inland waterway system, most equipment will draw 9 feet when fully loaded. Barge shipping is also referred to as shallow draft shipping. There are several types of barges. Open hopper barges are used primarily for dry bulk commodities not susceptible to weather damage such as coal, rock, or sand. Covered hopper barges are used for commodities that need protection such as grain. Deck barges are used to transport vehicles and equipment. Petroleum and chemicals are carried in tank barges (MARAD, 1991).

Historically, many river operations operated like a way train railroad operation, that is moving between two points with many intermediate stops to drop off or add barges. This type of operation requires a high degree of equipment standardization. An alternative type of operation is the integrated tow which carries high volumes of traffic between fixed origins and destinations. Integrated tows are used extensively by tank barge operators on the Gulf Intracoastal Waterway.

When the river barge operation is not an integrated tow operation, barges pass through fleeting areas for consolidating and breaking apart barges to form tows that are suitable for the river segments to be traveled. Fleeting areas are found at key river junctions, near terminals, and in major ports for temporary storage of barges in transit.

There is some ocean trade using oceangoing barges, but it is small. An important type of equipment used in this type of trade is the integrated tug-barge, which couples a towboat and a barge in such a way that they behave in seas as if they were a single vessel. Oceangoing barges have drafts greater than 9 feet.

Emission Factors

Tugs and towboats that provide power for barges are typically powered by diesel engines. For these applications, diesel engines range from 200 to 6,000 horsepower (EPA, 1985). Barge traffic is powered by medium- to high-speed diesel engines. These engines tend to be used in smaller vessels and are commonly lighter and more compact than their low-speed counterparts at equivalent horsepower ratings (CARB, 1991).

For this analysis, emission factors were derived for inland and oceangoing barges. The average horsepower ratings used to derive emission factors for inland and oceangoing barge traffic are 1,200 and 6,000, respectively. At full power, the power vessel for an inland barge with a horsepower rating of 1,200 would typically consume fuel at the rate of approximately 120 liters per hour (32 gal/hr) (EPA, 1991). The power vessel for an oceangoing barge at full power with a horsepower rating of 6,000 would typically consume fuel at the rate of approximately 165 liters per hour (44 gal/hr).

Barge traffic normally operates at just below full power while cruising (EPA, 1991). Fuel consumption for the cruise operating mode was estimated using a ratio of the total fuel consumption when operating at full power. The ratio was based on reported data for commercial steamships, which estimate the percentage of full power used for other operating modes. The cruise mode may require 35 to 75 percent of available power (EPA, 1985). In this analysis, the cruise mode is assumed to use 55 percent of available power.

The primary pollutants emitted by diesel engines in any mode of operation include nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), sulfur oxides (SO_x), and particulates (PM). Total particulate matter equates to total suspended particulate (TSP) and is referred to as TSP in the model and the remainder of this analysis. These emission factors are derived in terms of kilograms per 1,000 liters of fuel used. Historical emission factors for each pollutant by mode of operation were multiplied by the associated fuel consumption rate (in terms of 1,000 liters per hour of use) to estimate the level of emissions generated from intracoastal barge traffic per hour of use. Adjusted emission factors are, therefore, derived in terms of kilograms per hour of use. The adjusted emission factors for intracoastal barge traffic are shown in Table G-1.

TABLE G-1. Emission factors for intracoastal barge traffic.

Vessel Type by Operating Mode	Pollutant (kg/1,000 liters of fuel)					Fuel Consumption (1,000 liters/hour)	Pollutant (kg/hour)				
	NO_x	HC	CO	SO_x	TSP		NO_x	HC	CO	SO_x	TSP
Inland Tugboats/Tows (1,200 hp)											
Hotelling	35.90	2.87	7.30	0.15	2.03	0.01	0.36	0.03	0.07	0.00	0.02
Maneuver/Cruise	35.90	2.87	7.30	0.15	2.03	0.07	2.51	0.20	0.51	0.01	0.14
Full Power	35.90	2.87	7.30	0.15	2.03	0.12	4.31	0.34	0.88	0.02	0.24
Ocean-Going Tugboats/Tows (6,000 hp)											
Hotelling	50.21	2.70	7.16	0.15	2.03	0.02	1.00	0.05	0.14	0.00	0.04
Maneuver/Cruise	46.87	2.01	9.37	0.15	2.03	0.09	4.22	0.18	0.84	0.01	0.18
Full Power	47.82	2.55	11.48	0.15	2.03	0.16	7.65	0.41	1.84	0.02	0.33

Source: EPA, 1991.

Methodology

Annual emissions from intracoastal barge traffic were estimated using the following formula:

Annual Vessel Hours (hr/yr) × Emission Factors by Pollutant (kg/hr) × 0.0011 ton/kg = Total Emissions by Pollutant (ton/yr)

Annual vessel hours in each county or area were estimated based on the following:

- Distance travelled in the FIPS area. The distance of the Gulf Intracoastal Waterway travelled within each coastal county or parish was estimated based on the Minerals Management Service (MMS) Historic Leasing and Infrastructure map (1989). The distance travelled on the waterway is expressed in nautical miles.

  For the purpose of determining the effect of oceangoing barge traffic emanating from the Gulf Intracoastal Waterway, the length of each waterway joining the Gulf of Mexico and the Intracoastal Waterway was obtained from data provided in *Waterborne Commerce of the United States* prepared by the U.S. Army Corps of Engineers (COE, 1991a, b). Where lengths of the waterways were not provided, the distance was measured from the MMS Historic Leasing and Infrastructure map. Links between the waterway and the Gulf exist in Louisiana and Texas. The length of the waterways is expressed in nautical miles. In addition, a distance of 3 statute miles (converted to nautical miles) was added to the length of each segment in Louisiana State waters so as to include barge traffic in State waters. A distance of 9 nautical miles was added to the length of each segment in Texas state waters so as to include barge traffic in State waters.

  After tracking the path of the oceangoing barges to the Gulf of Mexico, the barges were assumed to act in a similar manner to other deep draft vessels. The distance from the entrance of the barge into the Gulf to the nearest safety fairway, or shipping lane, was measured. This distance was determined by safety fairways shown in Chart Kits for Region 16: New Orleans, LA to Panama City, FL and Region 18: Texas Coast and Offshore published by the Better Boating Association, Inc. (1988a and 1988b) and in the MMS Outer Continental Shelf Natural Gas and Oil Resource Management Comprehensive Program (1992-1997) map (MMS, 1991). Once the barges were linked up to a safety fairway, the most direct route toward international ports, within the safety fairways where provided, was assumed to be the distance travelled within the Gulf of Mexico by oceangoing barges.

- Number of vessels. Trips along the Gulf of Mexico Intracoastal Waterway and routes joining the Intracoastal with the Gulf were obtained from *Waterborne Commerce of the United States* (COE, 1991a). Self-propelled towboat and tugboat trips for vessels with drafts of 18 feet or less were classified as intracoastal barge trips. Totals for each segment of the Gulf Intracoastal Waterway were included in the estimate of number of vessel trips.

Total oceangoing towboat and tugboat trips were also obtained from *Waterborne Commerce of the United States* (COE, 1991a, b). Self-propelled towboats and tugboats with a draft greater than 18 feet were classified as oceangoing. Oceangoing routes for these vessels were assumed to be those that link the intracoastal waterway with the Gulf of Mexico. In general, oceangoing traffic constituted a small percentage of the total amount of barge traffic in the Gulf of Mexico area.

- Rate of speed. Full power for the intracoastal waterway traffic was assumed to be 5 knots, or 5 nautical miles per hour (Canal Barge Line, 1993). Oceangoing barges were assumed to travel at 7 knots (Tidewater Marine, 1993). These assumed full power speeds were adjusted to 2.75 and 3.85 knots for intracoastal and oceangoing barges, respectively, when in the maneuver/cruise mode.

  The inverted rates of speed for towboats and tugs (hours per nautical mile) for intracoastal travel were used in the calculations of annual vessel hours in each FIPS area.

- Operating mode. Barges travelling via the Gulf Intracoastal Waterway were assumed to be operating at full capacity, or 5 knots, for a majority of the distance. In proximity to busy ports, the barges are assumed to slow to a cruising or maneuvering level of 55 percent of full speed, or 2.75 knots.

  The oceangoing barges, which are larger and demand more power, are assumed to operate at full capacity, or 7 knots, once they are beyond the established safety fairways in the Gulf. However, while the barges are either travelling between the Gulf Intracoastal Waterway and the safety fairways or within the safety fairways, they are assumed to operate at an estimated 55 percent of full power, or 3.85 knots.

  These two operating modes, full and cruise/maneuver, were used to determine the rate of speed at which the barges were travelling within the segments of the Gulf Intracoastal Waterway and the Gulf of Mexico.

The air pollutant emission factors used to determine total annual pollutant emissions associated with intracoastal barge traffic were provided in *Commercial Marine Vessel Contributions to Emission Inventories* prepared by the U.S. Environmental Protection Agency (1991). This document provides data which are representative of harbor vessels, which includes barge traffic, and was used for all air emission pollutants except SO_x. Emission factors for SO_x are typically represented by a variable which can be converted to a numerical estimate based on the percentage of sulfur present in the type of fuel used. For intracoastal barge traffic, a common fuel used is marine diesel fuel. This type of fuel contains, on average, a 0.8 percent sulfur content (EPA, 1991). The SO_x emission factor was calculated using this percentage. All emission factors were derived in terms of kilograms per 1,000 liters of fuel.

Baseline

Table G-2 presents the baseline emissions by county and area for intracoastal barge traffic. The greatest concentration of vessel hours, and therefore pollutant emissions, is in parishes in Louisiana. The Gulf Intracoastal Waterway passes through these parishes. A second concentration of vessel hours is in eastern Texas, from about the border with Louisiana to the Colorado River. Again, the Gulf Intracoastal Waterway passes through these counties.

Also note that there are no barge emission reported predicted for the coastal counties of Harrison, San Patricio, Jackson, and Refugio (Texas). This is because barge emissions were predicted for major ports and activity along the intracoastal waterway, the principal route used by barges in the Gulf. Refugio and Jackson counties are not directly on the coast of Texas and are classified as a coastal county because of a small shoreline on an inland bays. In this way, the intracoastal water way does not pass through Jackson or Refugio counties, and thus no barge emissions were forecast for these locations. Barge emissions were also not predicted for San Patricio because the waterway goes away from the coast as it approaches this county. Barge emissions for Harris County (Houston area) were attributed to the primary segment of the waterway in the area and are thus included with those reported for the County of Galveston.

Since intracoastal barge traffic is a commercial form of transportation, no adjustments have been made to account for time-of-day, day-of-week, or seasonal differences in vessel traffic. Similarly, no adjustments have been made to reflect future growth or decline in vessel traffic. The annual vessel hours activity level is reported at 3,046,067 hours. This is because the barge industry is a mature industry and no future growth is anticipated. Future efficiency improvements, while possible, are anticipated to be very minor or in terms of their effect on emissions. The baseline, therefore, also represents the projections.

Section References

Better Boating Association, Inc. 1988a. Chart Kit, New Orleans to Panama City, FL: Region 16. Needham, MA.

Better Boating Association, Inc. 1988b. Chart Kit, Texas Coast and Offshore: Region 18. Needham, MA.

TABLE G-2. Baseline emissions, intracoastal barge traffic.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr.	Total Emissions by Pollutant (in tons/year) NOx	HC	CO	SOx	TSP
Baldwin County, AL	01003	15,018	71.3	5.6	14.6	0.3	4.0
Mobile County, AL	01097	51,007	225.3	17.8	46.0	1.0	12.5
Jackson County, MS	28059	52,703	232.8	18.4	47.5	1.1	13.0
Harrison County, MS	28047	68,004	300.4	23.7	61.3	1.4	16.7
Hancock County, MS	28045	21,999	104.5	8.2	21.3	0.5	5.8
Orleans Parish, LA	22071	18,692	82.6	6.5	16.9	0.4	4.6
St. Bernard Parish, LA	22087	NA	NA	NA	NA	NA	NA
Plaquemines Parish, LA	22075	28,684	136.3	10.7	27.8	0.6	7.6
Jefferson Parish, LA	22051	80,024	380.2	30.0	77.6	1.8	21.2
Lafourche Parish, LA	22057	221,333	1,051.1	82.2	214.5	4.8	58.3
Terrebone Parish, LA	22109	253,793	1,121.2	88.5	228.8	5.1	62.4
St. Mary Parish, LA	22101	349,272	1,659.3	130.8	338.8	7.7	92.4
Iberia Parish, LA	22045	102,897	488.9	38.6	99.8	2.3	27.2
Vermilion Parish, LA	22113	297,285	1,412.4	111.4	288.4	6.6	78.6
Cameron Parish, LA	22023	314,573	1,494.5	117.9	305.1	6.9	83.2
Calcasieu Parish, LA	22019	217,261	1,032.2	81.4	210.7	4.8	57.5
Orange County, TX	48361	29,003	137.8	10.9	28.1	0.6	7.7
Jefferson County, TX	48245	142,114	628.0	49.4	128.1	2.9	34.9
Chambers County, TX	48071	18,157	86.3	6.8	17.6	0.4	4.8
Galveston County, TX	48167	226,468	936.6	73.7	191.0	4.2	52.0
Brazoria County, TX	48039	109,202	482.4	38.1	98.4	2.2	26.9
Matagorda County, TX	48321	148,446	705.3	55.6	144.0	3.3	39.3
Calhoun County, TX	48057	79,159	376.1	29.7	76.8	1.7	20.9
Aransas County, TX	48007	61,348	291.5	23.0	59.5	1.4	16.2
Nueces County, TX	48355	55,815	246.6	19.4	50.3	1.1	13.7
Kleberg County, TX	48273	3,043	14.5	1.1	3.0	0.1	0.8
Kenedy County, TX	48261	6,519	31.0	2.4	6.3	0.1	1.7
Willacy County, TX	48489	1,847	8.8	0.7	1.8	0.0	0.5
Cameron County, TX	48061	6,164	27.2	2.1	5.6	0.1	1.5
Alaminos Canyon	99001	344	2.9	0.2	0.7	0.0	0.1
Atwater Valley	99005	6,698	56.5	3.0	13.6	0.1	2.4
Brazos	99007	NA	NA	NA	NA	NA	NA
Brazos South Addition	99009	NA	NA	NA	NA	NA	NA
Breton Sound	99011	NA	NA	NA	NA	NA	NA
Chandeleur	99013	NA	NA	NA	NA	NA	NA
Chandeleur East Addition	99015	NA	NA	NA	NA	NA	NA
Corpus Christi	99017	134	0.6	0.0	0.1	0.0	0.0

TABLE G-2. Continued.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr.	Total Emissions by Pollutant (in tons/year)				
			NOx	HC	CO	SOx	TSP
East Breaks	99023	339	1.8	0.1	0.4	0.0	0.1
East Cameron	99025	NA	NA	NA	NA	NA	NA
East Cameron South Addition	99027	2,656	12.4	0.5	2.5	0.0	0.5
Eugene Island	99029	1,188	5.5	0.2	1.1	0.0	0.2
Eugene Island South Addition	99031	640	3.0	0.1	0.6	0.0	0.1
Ewing Bank	99033	10,071	46.8	2.0	9.3	0.1	2.0
Galveston	99037	4,381	20.4	0.9	4.1	0.0	0.9
Galveston South Addition	99039	377	1.8	0.1	0.3	0.0	0.1
Garden Banks	99041	5,931	27.6	1.2	5.5	0.1	1.2
Grand Isle	99043	NA	NA	NA	NA	NA	NA
Grand Isle South Addition	99045	NA	NA	NA	NA	NA	NA
Green Canyon	99047	4,943	23.0	1.0	4.6	0.1	1.0
High Island	99049	4,523	21.0	0.9	4.2	0.0	0.9
High Island East Addtion	99051	1,541	7.2	0.3	1.4	0.0	0.3
High Island East Add. South Ext.	99053	NA	NA	NA	NA	NA	NA
High Island South Addition	99055	7	0.0	0.0	0.0	0.0	0.0
Keathley Canyon	99059	205	1.7	0.1	0.4	0.0	0.1
Main Pass	99063	NA	NA	NA	NA	NA	NA
Main Pass South and East Addition	99065	NA	NA	NA	NA	NA	NA
Matagorda Island	99067	NA	NA	NA	NA	NA	NA
Mississippi Canyon	99069	3,522	16.4	0.7	3.3	0.0	0.7
Mobile	99071	NA	NA	NA	NA	NA	NA
Mustang Island	99073	244	1.1	0.0	0.2	0.0	0.0
Mustang Island East Addition	99075	148	0.7	0.0	0.1	0.0	0.0
NG 15-8	99077	153	1.3	0.1	0.3	0.0	0.1
NG 15-9	99079	NA	NA	NA	NA	NA	NA
NG 16-4	99081	6,775	57.1	3.1	13.7	0.1	2.5
NG 16-7	99085	1,539	13.0	0.7	3.1	0.0	0.6
North Padre Island	99087	NA	NA	NA	NA	NA	NA
North Padre Island East Addition	99089	NA	NA	NA	NA	NA	NA
Port Isabel	99093	19	0.1	0.0	0.0	0.0	0.0
Sabine Pass	99097	453	2.1	0.1	0.4	0.0	0.1
Ship Shoal	99099	NA	NA	NA	NA	NA	NA
Ship Shoal South Addition	99101	NA	NA	NA	NA	NA	NA
South Marsh Island	99103	NA	NA	NA	NA	NA	NA
South Marsh Island North Addition	99105	NA	NA	NA	NA	NA	NA
South Marsh Island South Addition	99107	NA	NA	NA	NA	NA	NA

TABLE G-2. Concluded.

County/Area Name	County Code (FIPS)	Total Vessel Hours/Yr.	Total Emissions by Pollutant (in tons/year) NOx	HC	CO	SOx	TSP
South Padre Island	99109	12	0.1	0.0	0.0	0.0	0.0
South Padre Island East Addition	99111	20	0.1	0.0	0.0	0.0	0.0
South Pass	99113	NA	NA	NA	NA	NA	NA
South Pass East Addition	99115	1	0.0	0.0	0.0	0.0	0.0
South Pass South Addition	99117	NA	NA	NA	NA	NA	NA
South Pelto	99119	71	0.3	0.0	0.1	0.0	0.0
South Timbalier	99121	2,569	12.0	0.5	2.4	0.0	0.5
South Timbalier South Addition	99123	1,288	6.0	0.3	1.2	0.0	0.3
Vermilion	99127	NA	NA	NA	NA	NA	NA
Vermilion South Addition	99129	NA	NA	NA	NA	NA	NA
Viosca Knoll	99133	NA	NA	NA	NA	NA	NA
Walker Ridge	99135	NA	NA	NA	NA	NA	NA
West Cameron	99137	301	1.4	0.1	0.3	0.0	0.1
West Cameron South Addition	99139	3,388	15.8	0.7	3.1	0.0	0.7
West Cameron West Addition	99141	1,754	8.2	0.3	1.6	0.0	0.3
West Delta	99143	NA	NA	NA	NA	NA	NA
West Delta South Addition	99145	NA	NA	NA	NA	NA	NA
WX−1	99147	NA	NA	NA	NA	NA	NA
Apalachicola	99149	NA	NA	NA	NA	NA	NA
DeSoto Canyon	99151	NA	NA	NA	NA	NA	NA
Destin Dome	99153	NA	NA	NA	NA	NA	NA
Florida Middle Ground	99155	NA	NA	NA	NA	NA	NA
Howell Hook	99157	NA	NA	NA	NA	NA	NA
Lloyd Ridge	99159	NA	NA	NA	NA	NA	NA
NG 16−5	99161	NA	NA	NA	NA	NA	NA
Pensacola	99163	NA	NA	NA	NA	NA	NA
Rankin	99165	NA	NA	NA	NA	NA	NA
The Elbow	99167	NA	NA	NA	NA	NA	NA
Vernon Basin	99169	NA	NA	NA	NA	NA	NA

NA = Not applicable.

Sources: COE, 1991a; MMS, 1989 and 1991; EPA, 1991; Canal Barge Line, 1993; Tidewater Marine, 1993; and Better Boating Association, 1988a,b.

CARB. 1991. California Air Resources Board. Notice of Public Meeting to Consider a Plan for the Control of Emission from Marine Vessels (Mailout #90-58). Staff Report. September.

Canal Barge Line. 1993. Personal communication with engineering representative. January.

COE. 1981. U.S. Department of the Army, Corps of Engineers. National Waterways Study: Overview of the Transportation Industry. Prepared by A.T. Kearney, Inc.

COE. 1991a. U.S. Department of the Army, Corps of Engineers. Waterborne Commerce of the United States, Calendar Year 1989, Part 2 Gulf Coast, Mississippi River System, and Antilles.

COE, 1991b. U.S. Department of the Army, Corps of Engineers. Waterborne Commerce of the United States, Calendar Year 1989, Part 5 National Summaries.

EPA. 1985. U.S. Environmental Protection Agency. Compilation of Air Emission Factors, Volume II, EPA Report No. AP-42, Fourth Edition. Research Triangle Park, North Carolina, Office of Air Quality Planning and Standards.

EPA. 1991. U.S. Environmental Protection Agency. Commercial Marine Vessel Contributions to Emission Inventories. Prepared by Booz, Allen, and Hamilton, Inc. Los Angeles, California. October.

MARAD. 1991. U.S. Department of Transportation, Maritime Administration. Domestic Waterborne Trade of the United States, 1987-1989. November.

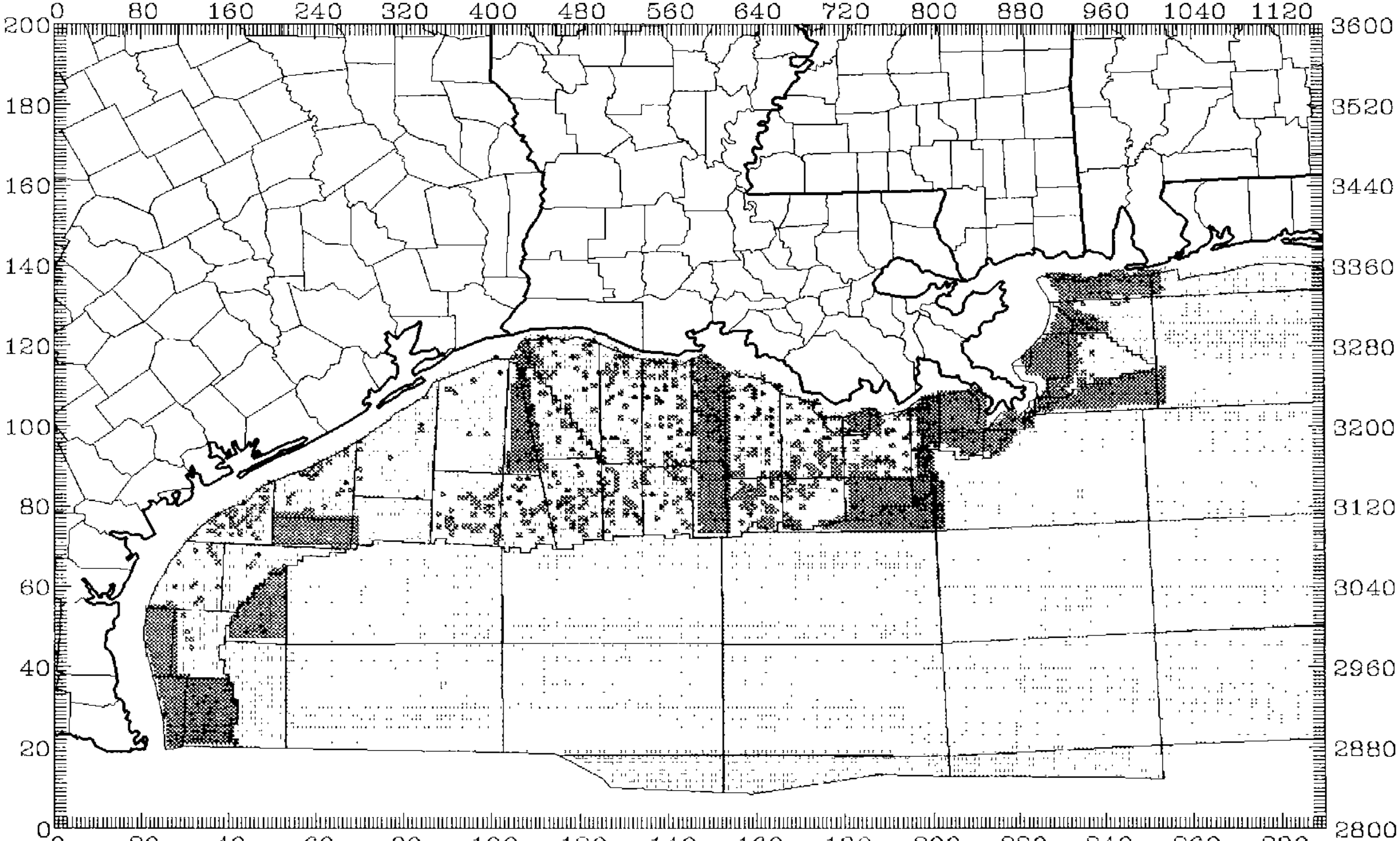
MMS. 1989. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office. Historic Leasing and Infrastructure, Visual 1. March.

MMS. 1991. U.S. Department of the Interior, Minerals Management Service. Outer Continental Shelf Natural Gas and Oil Resource Management Comprehensive Program (1992-1997), Visual I. June.

Tidewater Marine. 1993. Personal communication with C. Annessa, engineering representative. January.

APPENDIX O

SPATIAL SURROGATES



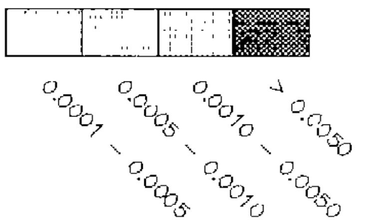
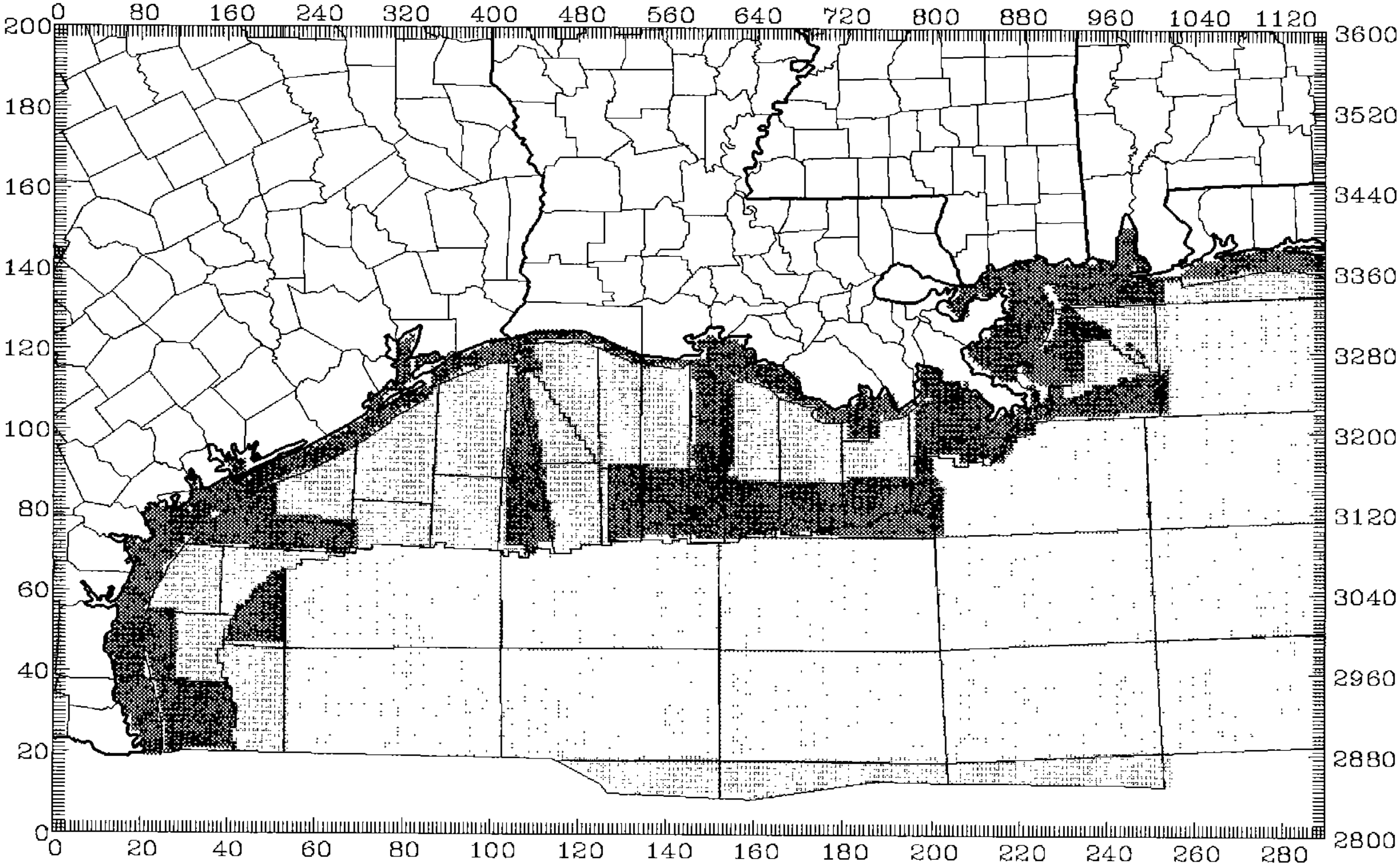


FIGURE O-1. Graphical representation of spatial surrogate based on lease block surface area and platform density



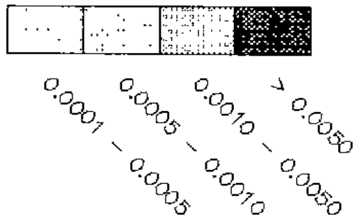


FIGURE O-2. Graphical representation of spatial surrogate based on lease block and state water surface area.

95013

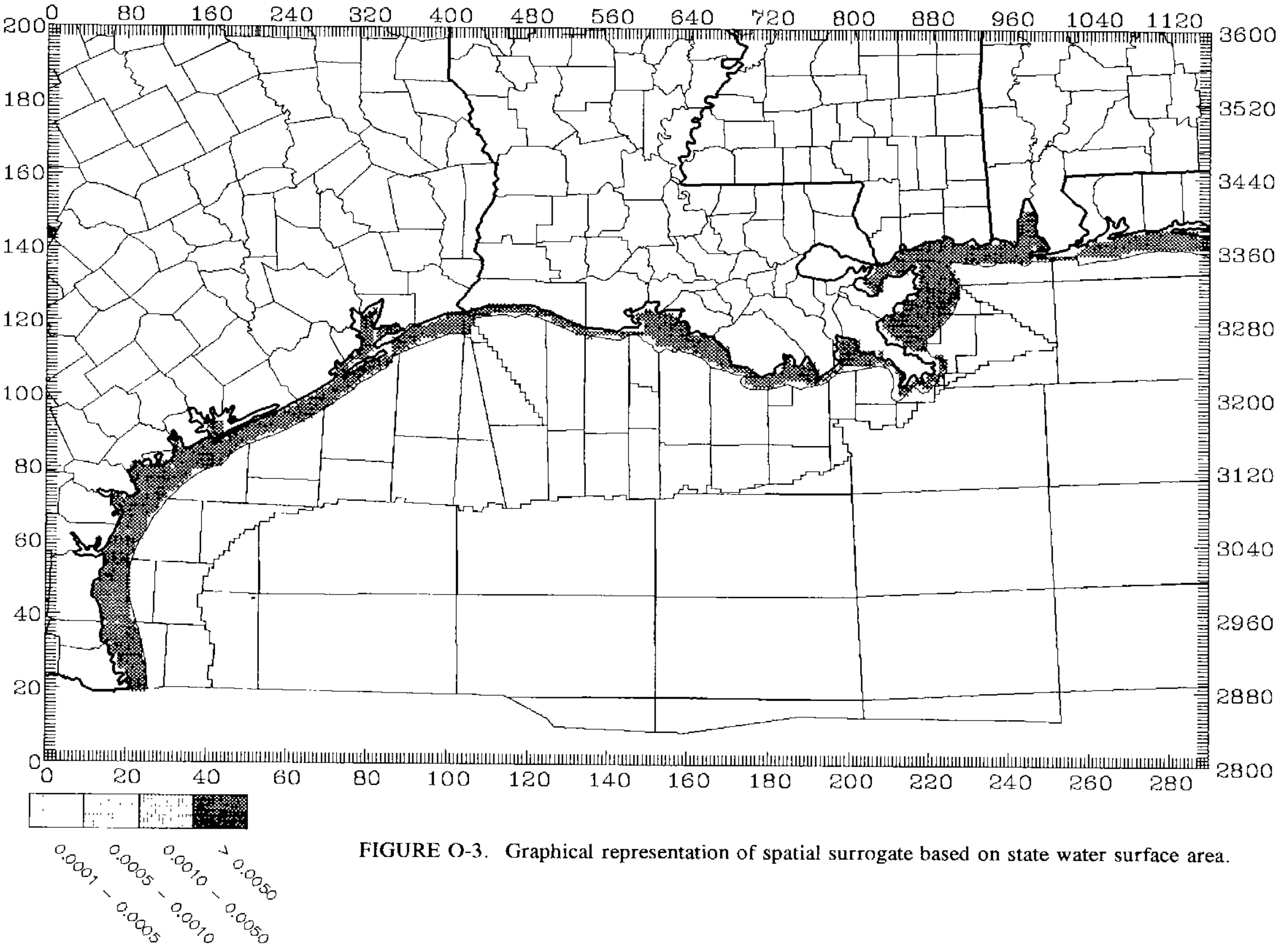


FIGURE O-3. Graphical representation of spatial surrogate based on state water surface area.

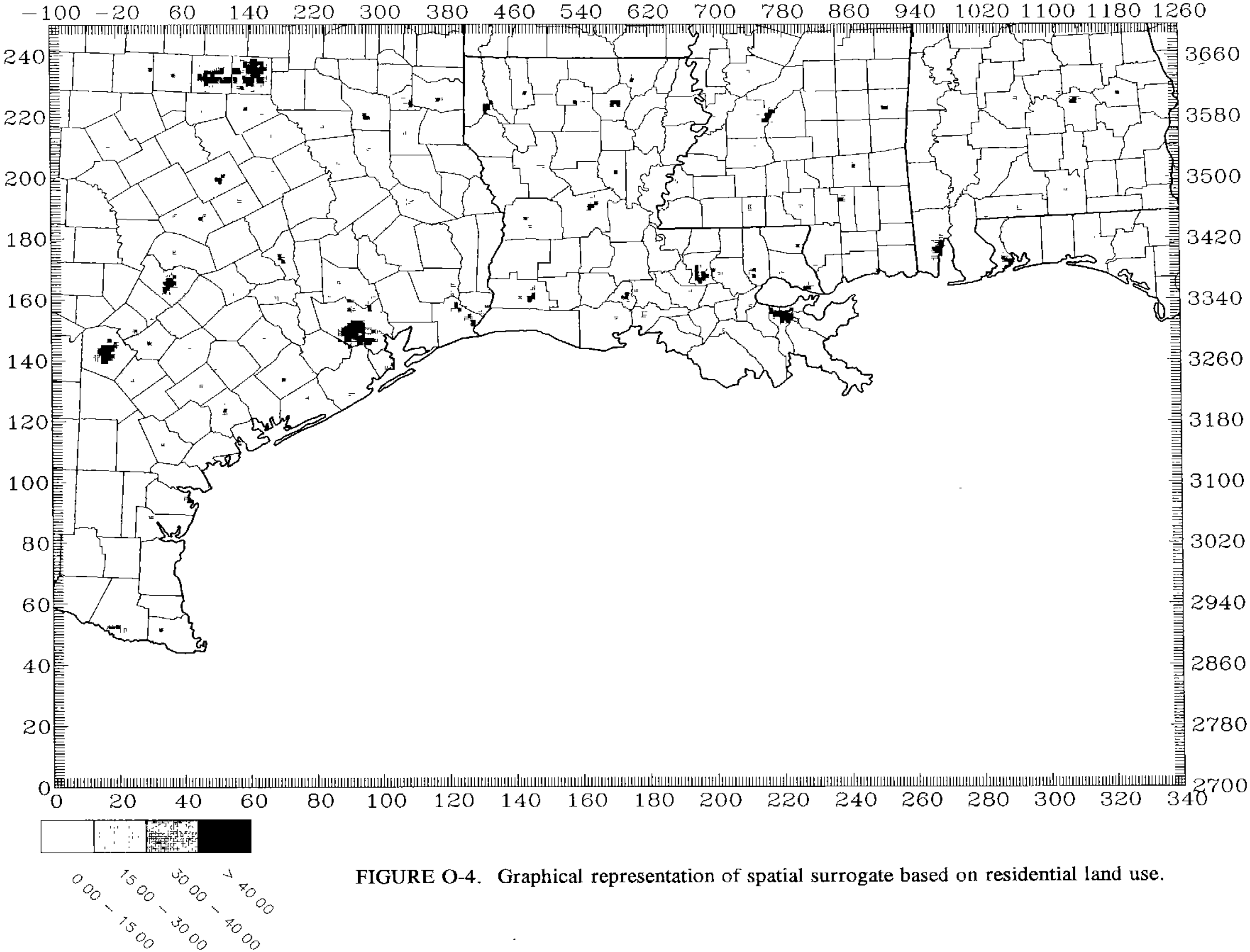


FIGURE O-4. Graphical representation of spatial surrogate based on residential land use.

95013

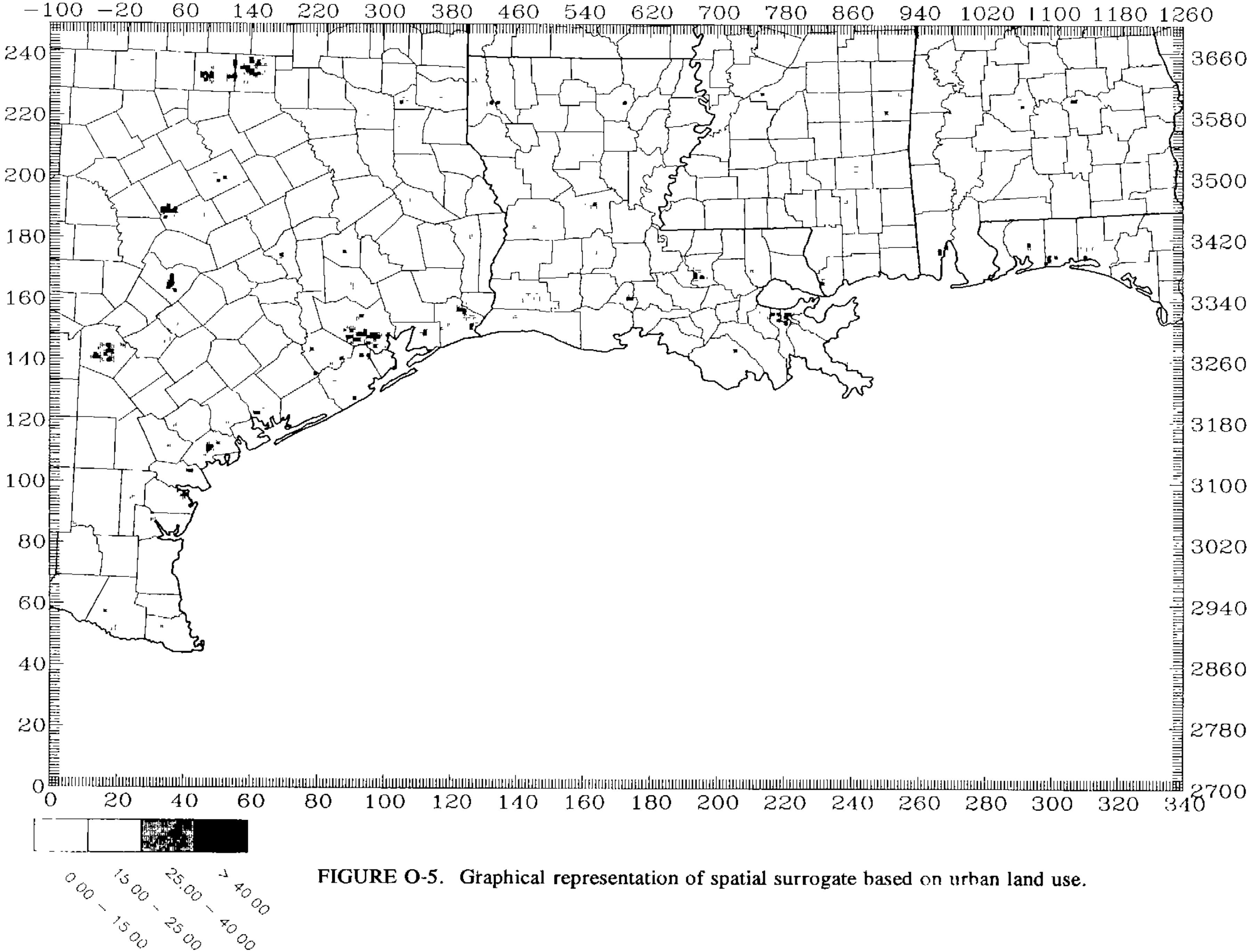
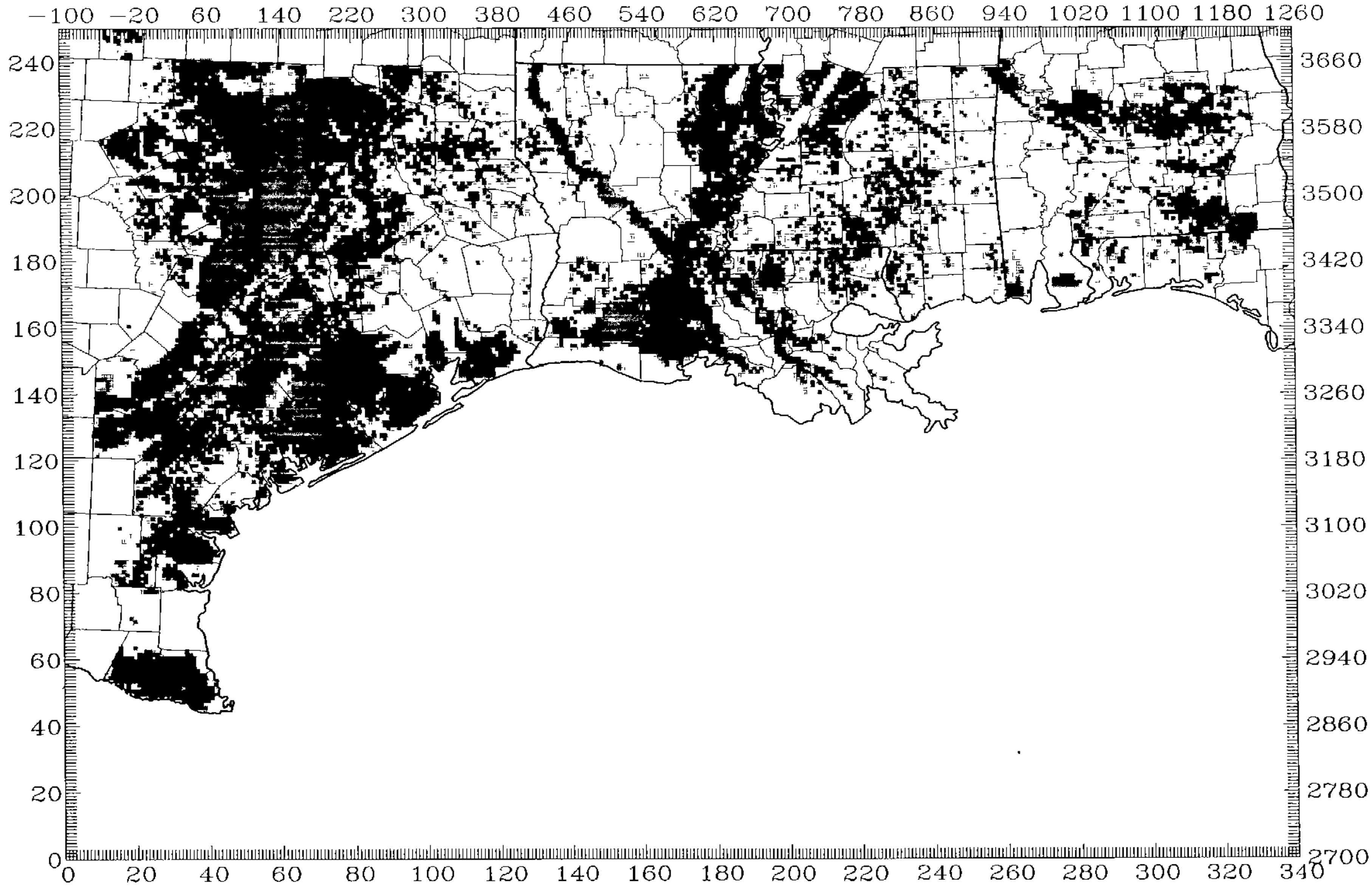


FIGURE O-5. Graphical representation of spatial surrogate based on urban land use.



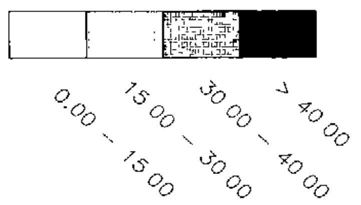
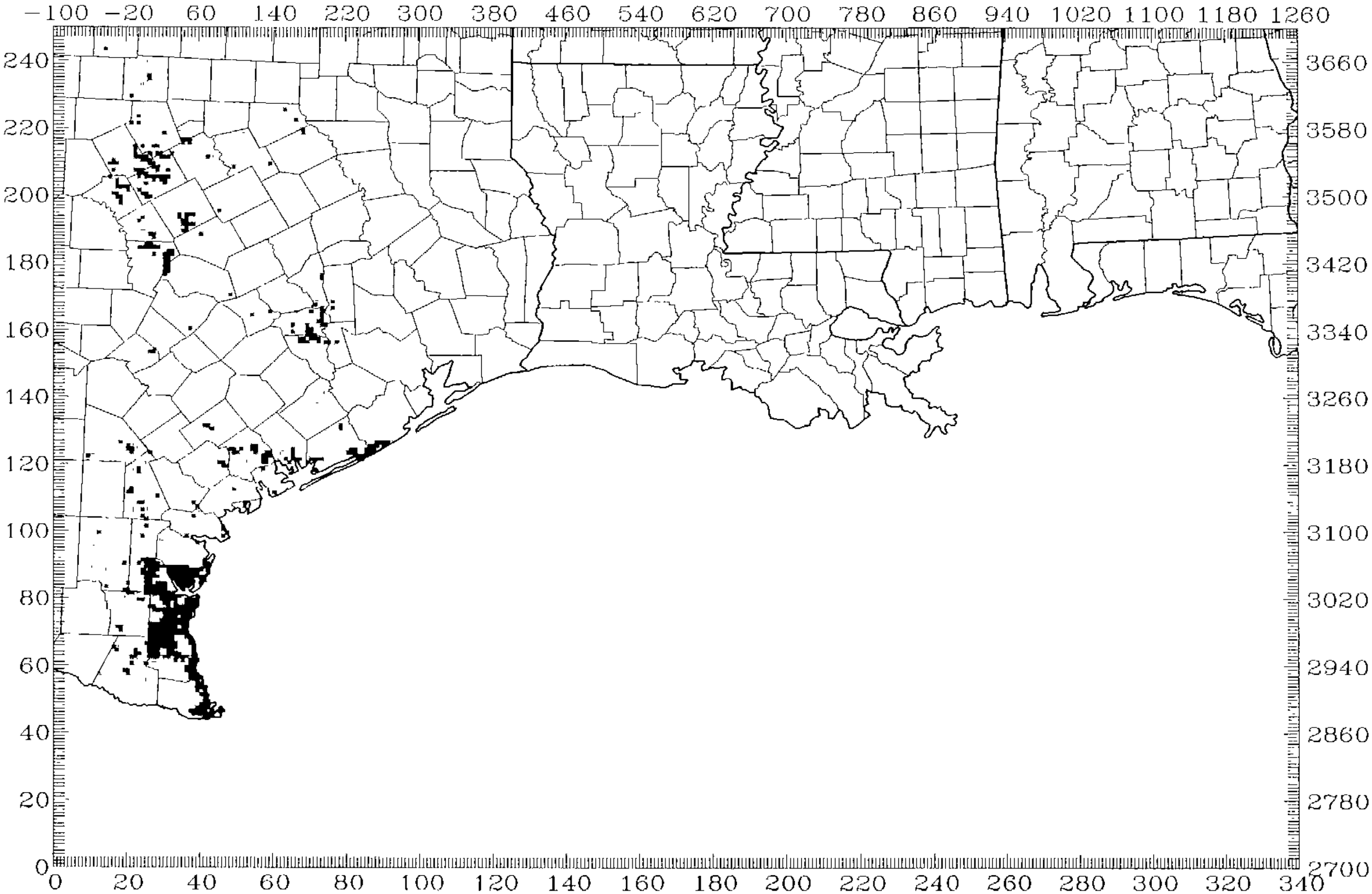


FIGURE O-6. Graphical representation of spatial surrogate based on agricultural land use.



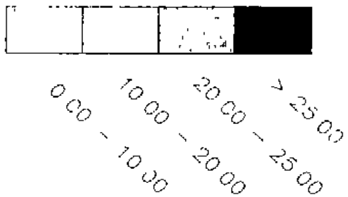


FIGURE O-7. Graphical representation of spatial surrogate based on range land use.

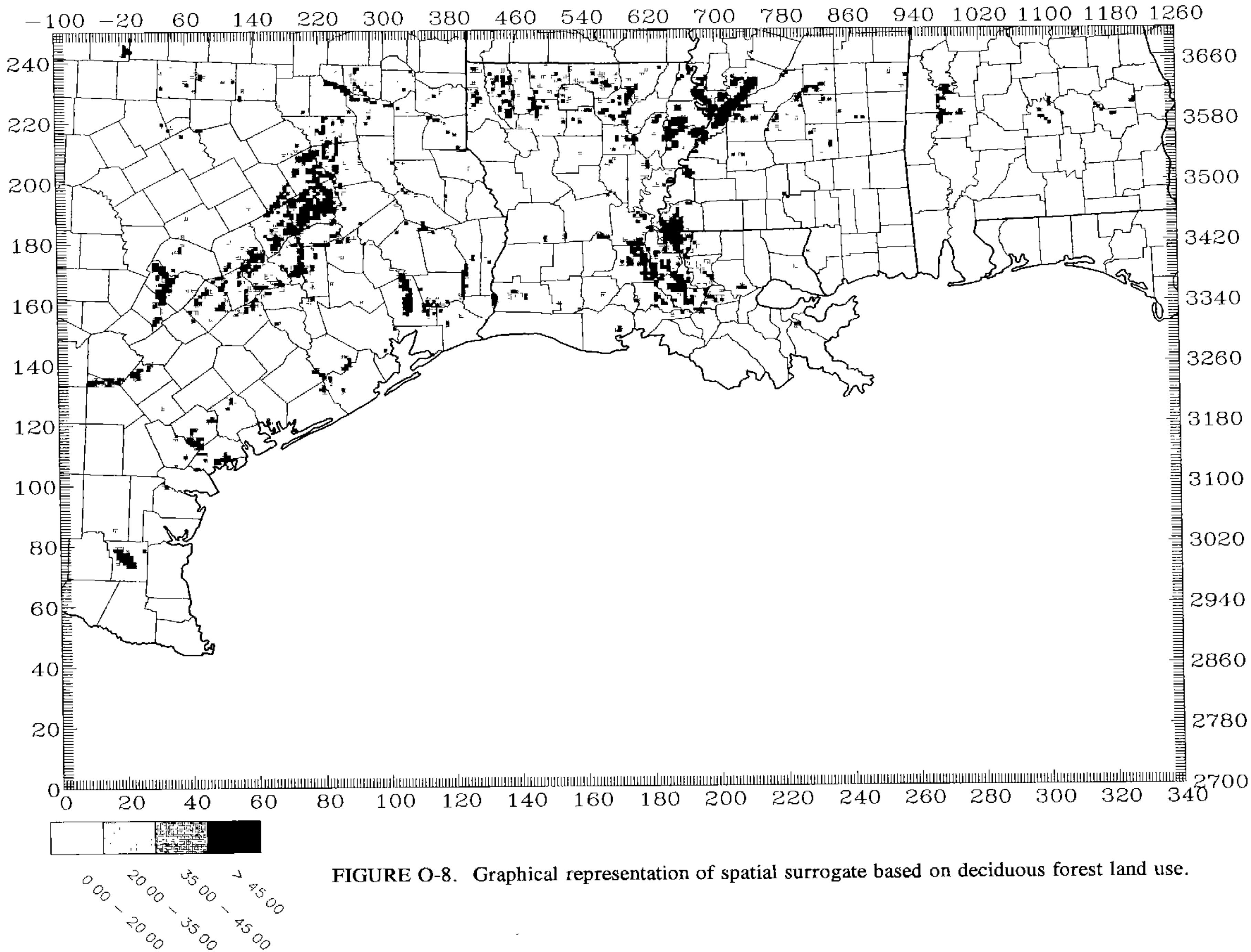


FIGURE O-8. Graphical representation of spatial surrogate based on deciduous forest land use.

95013

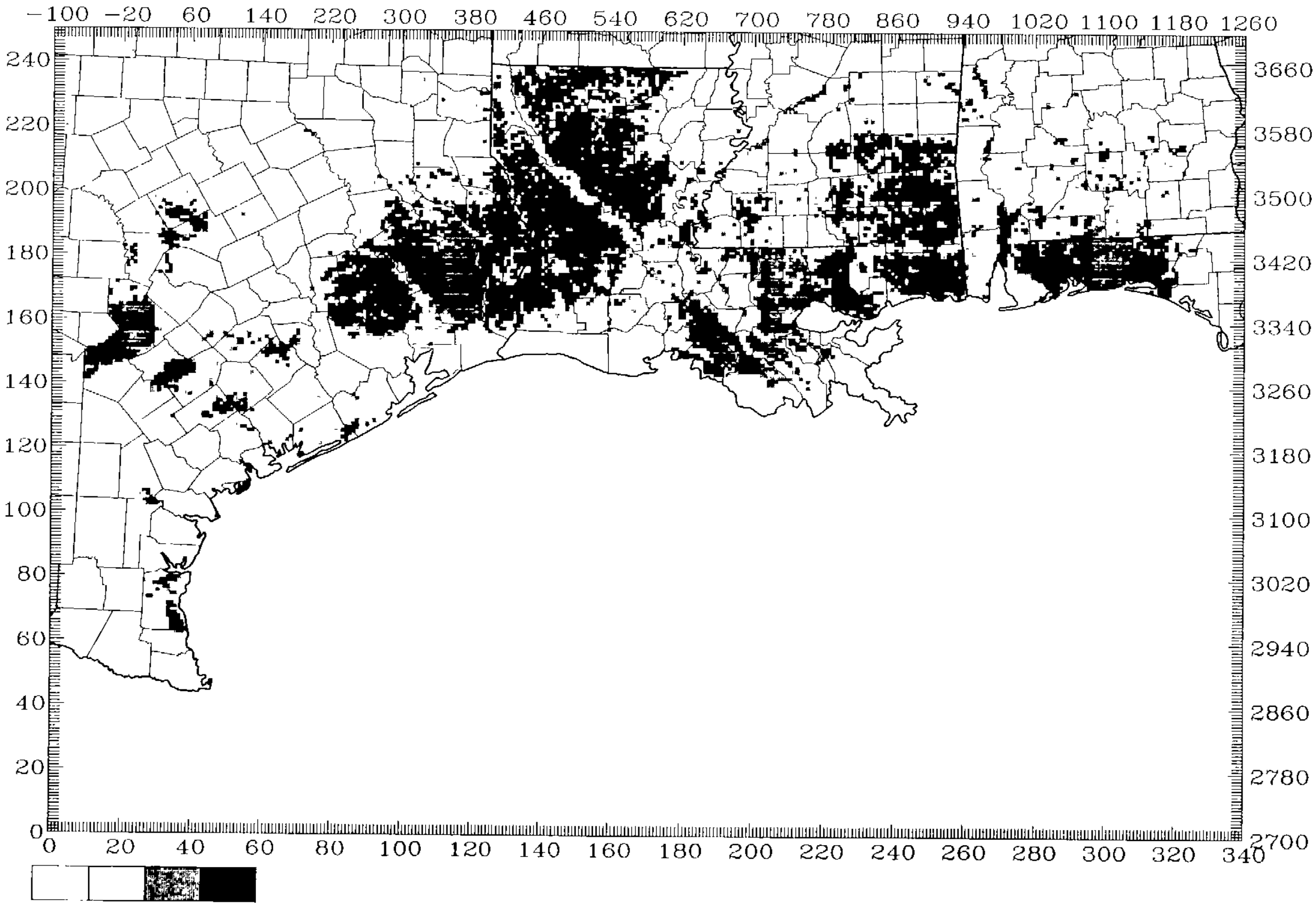


FIGURE O-9. Graphical representation of spatial surrogate based on coniferous forest land use.

95013

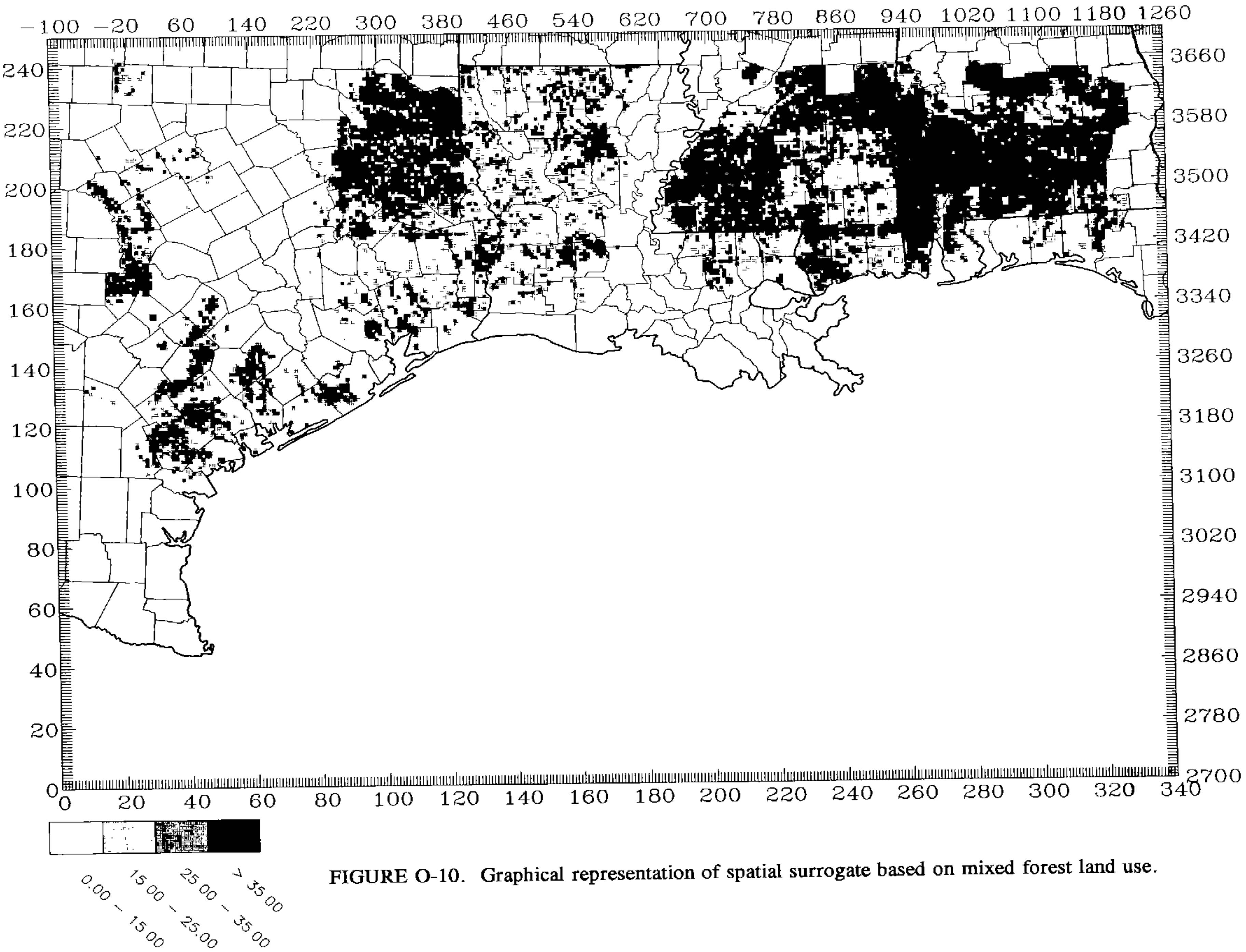
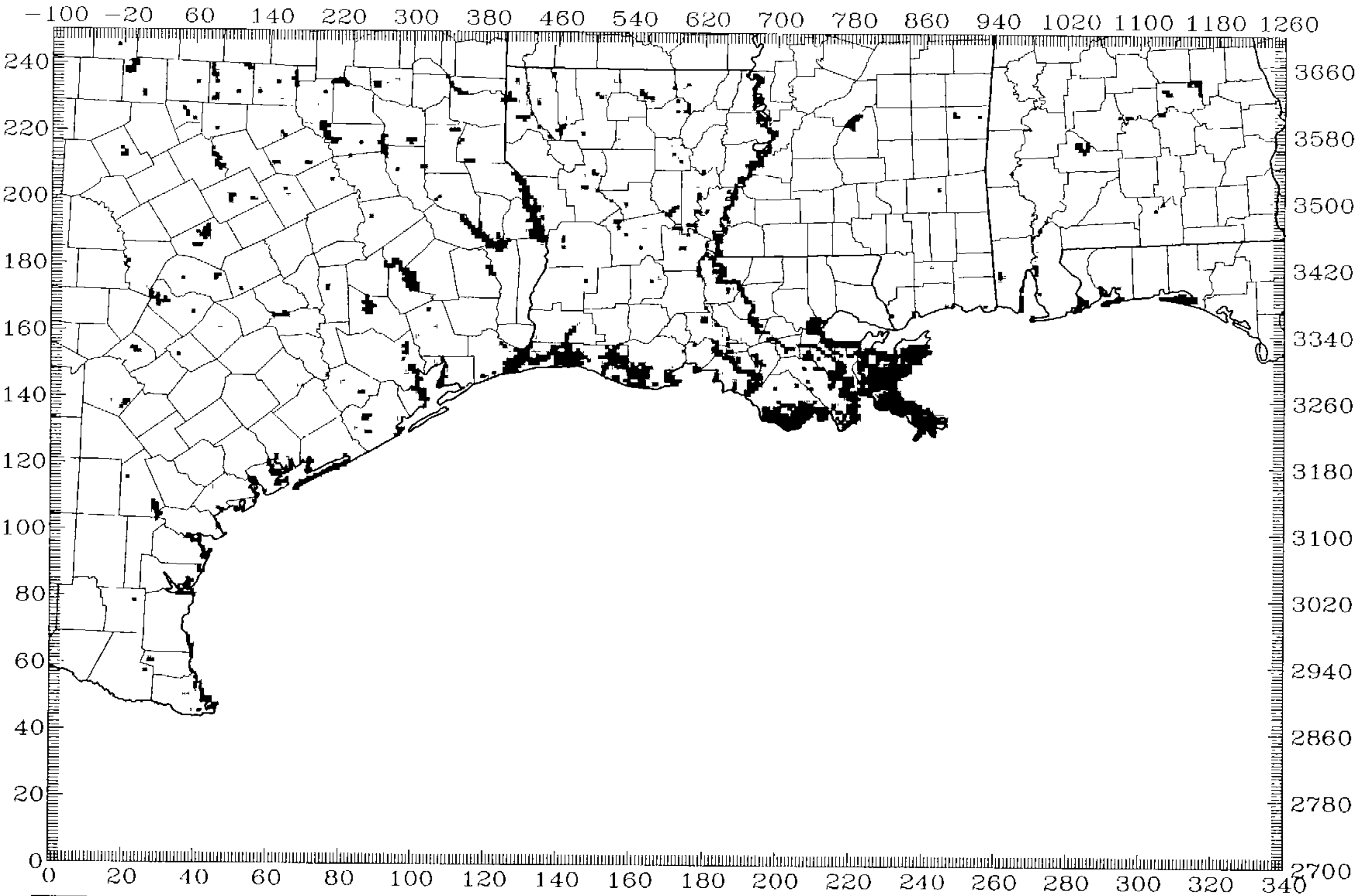


FIGURE O-10. Graphical representation of spatial surrogate based on mixed forest land use.



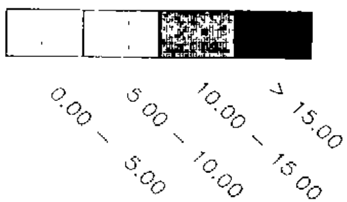
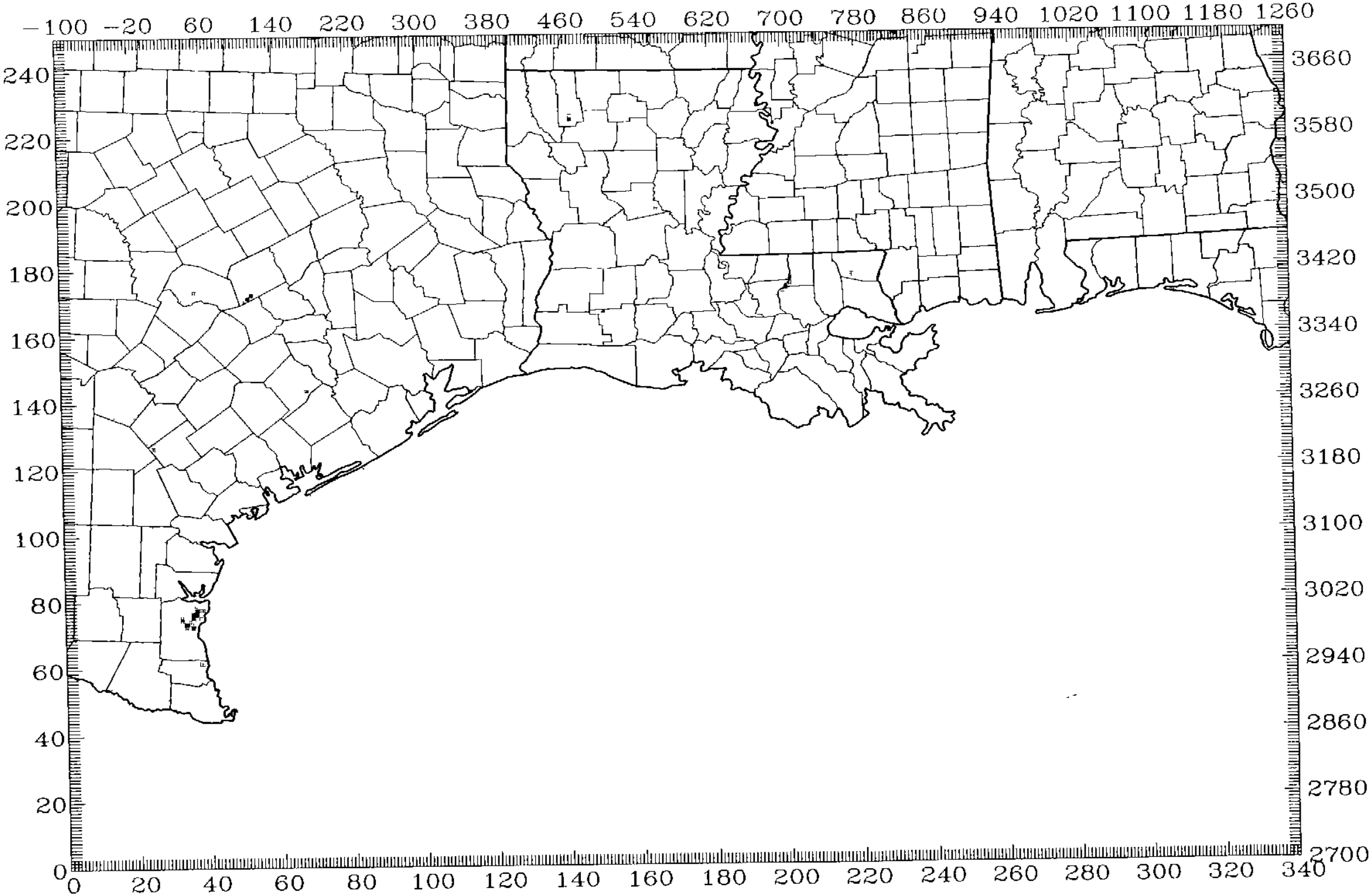


FIGURE O-11. Graphical representation of spatial surrogate based on water land use.



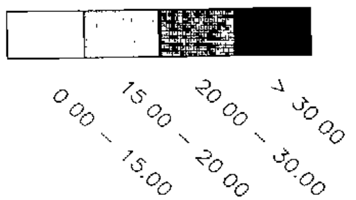


FIGURE O-12. Graphical representation of spatial surrogate based on barren land use.

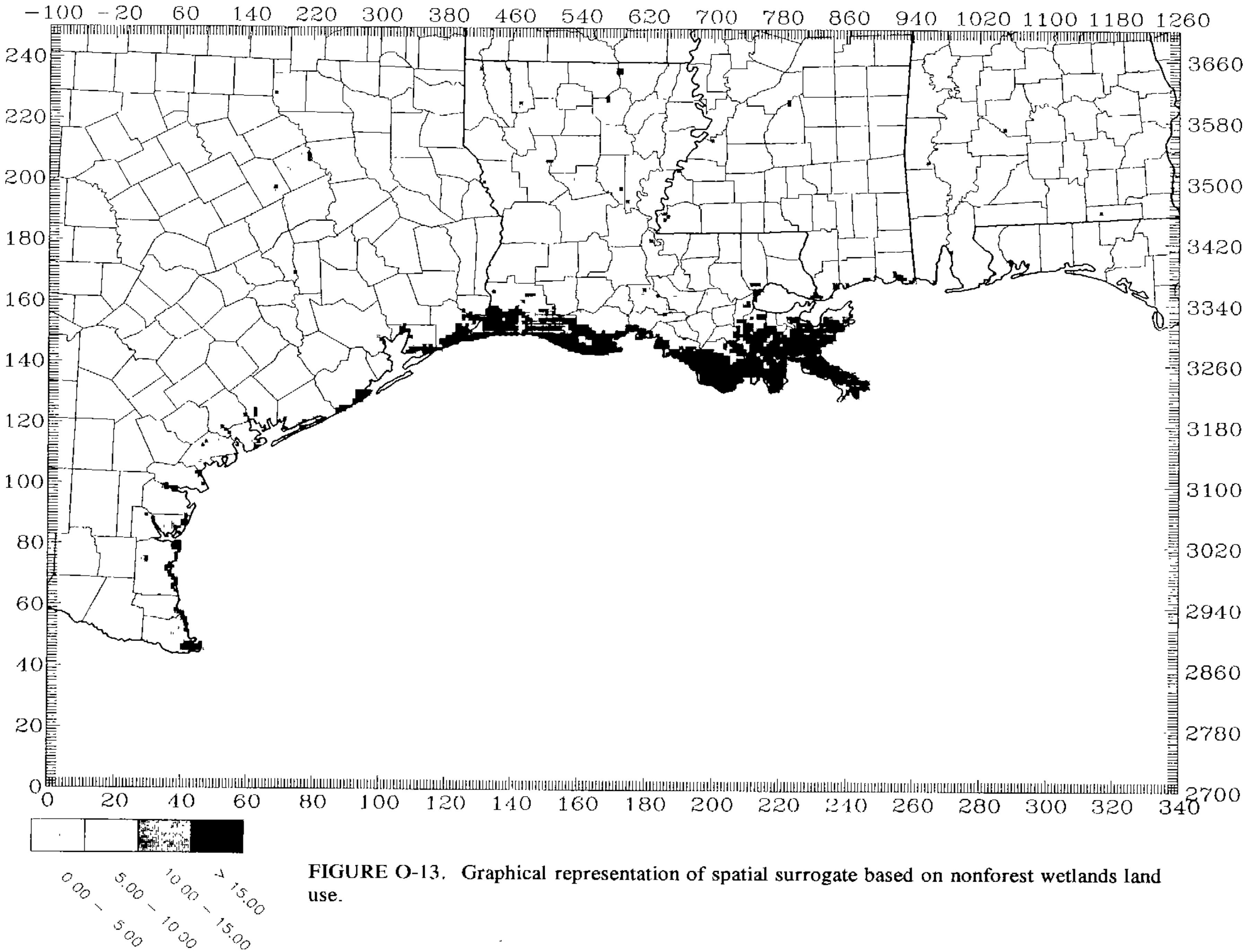
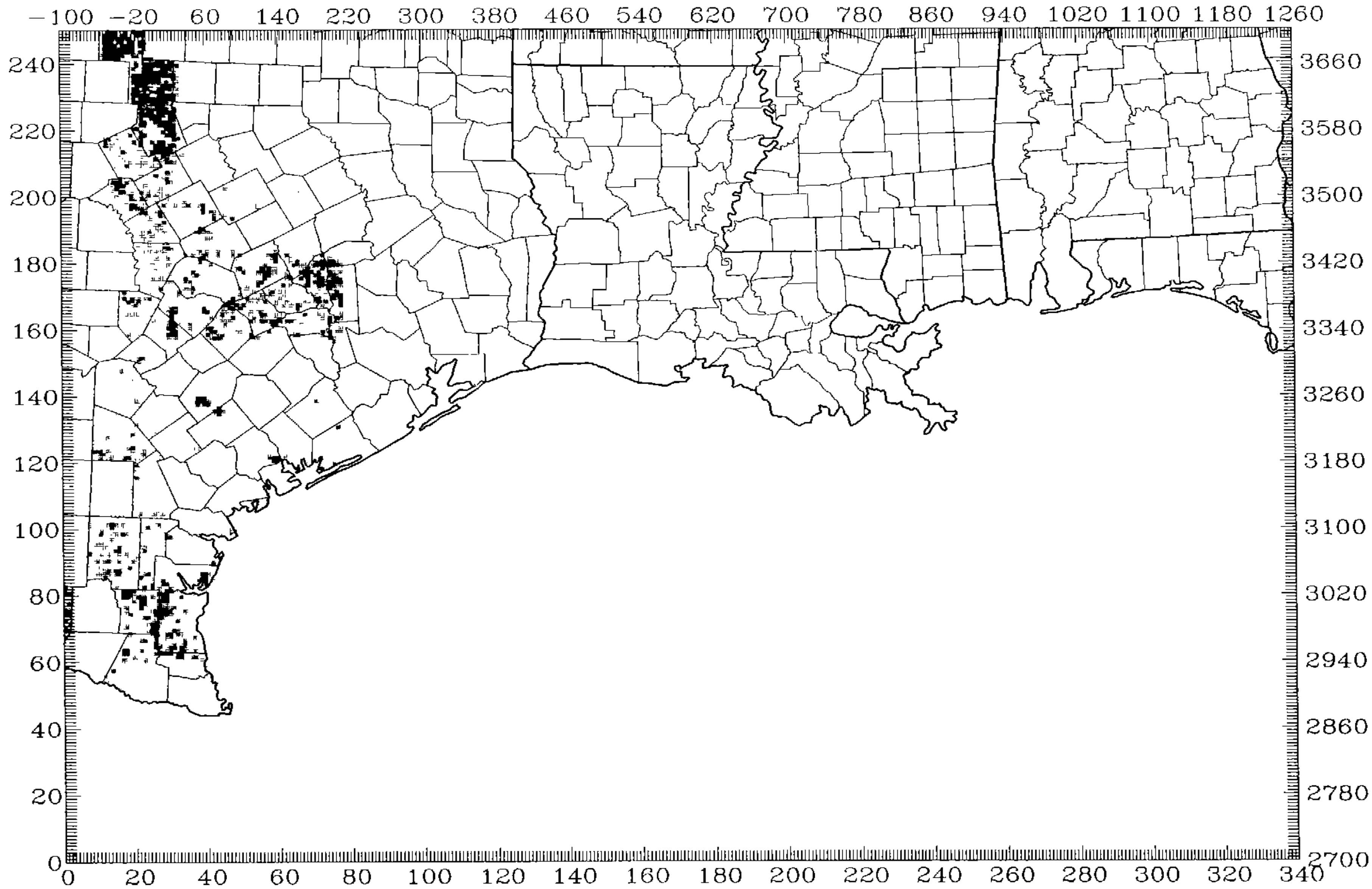


FIGURE O-13. Graphical representation of spatial surrogate based on nonforest wetlands land use.



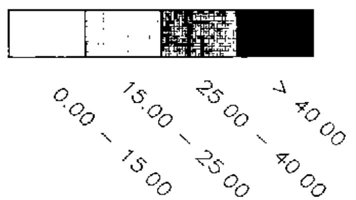


FIGURE O-14. Graphical representation of spatial surrogate based on mixed agricultural/range land use.

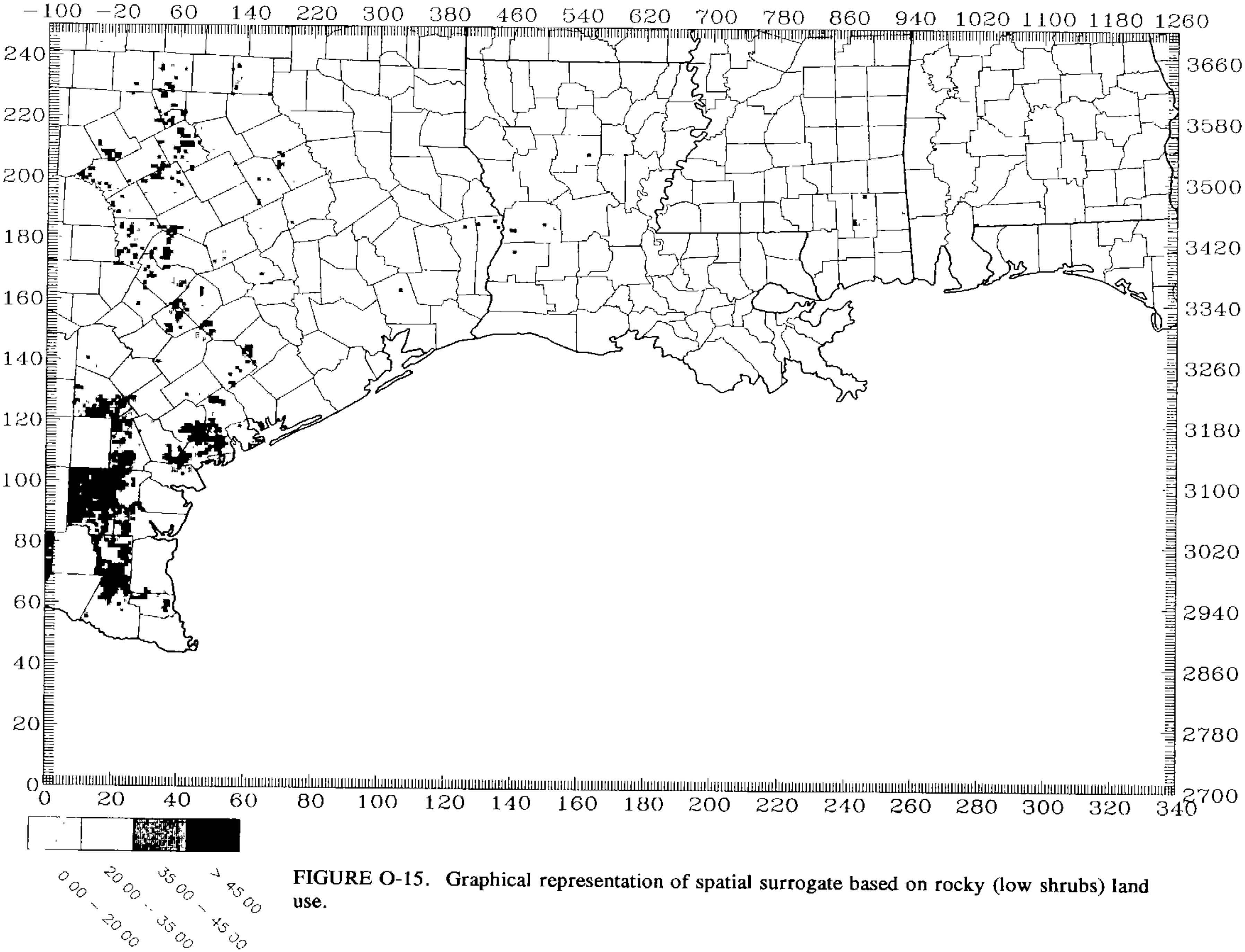
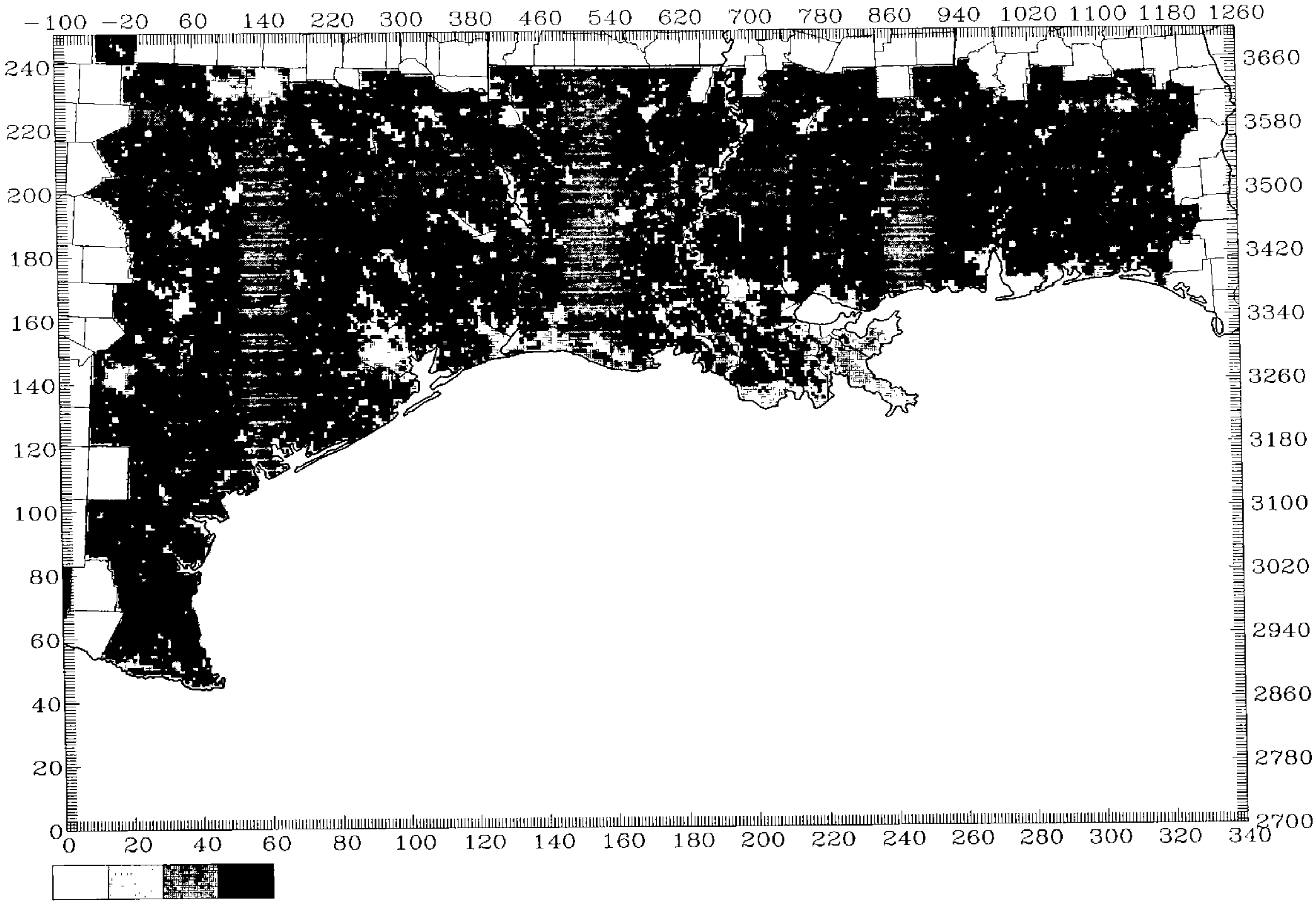


FIGURE O-15. Graphical representation of spatial surrogate based on rocky (low shrubs) land use.



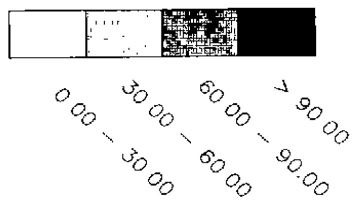
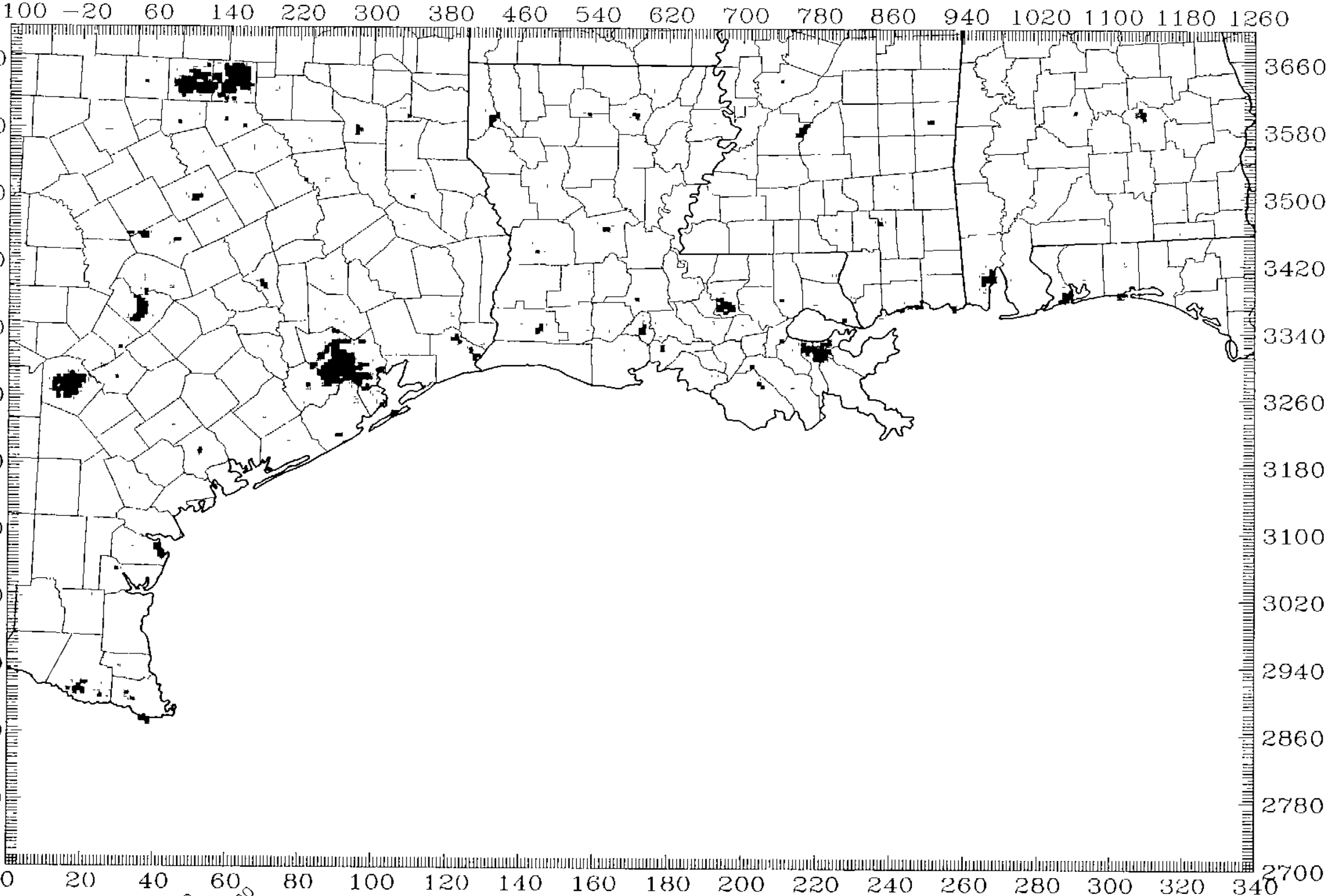


FIGURE O-16. Graphical representation of spatial surrogate based on rural land use.

95013



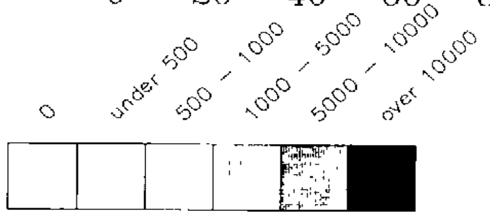


FIGURE O-17. Graphical representation of spatial surrogate based on population gridding.

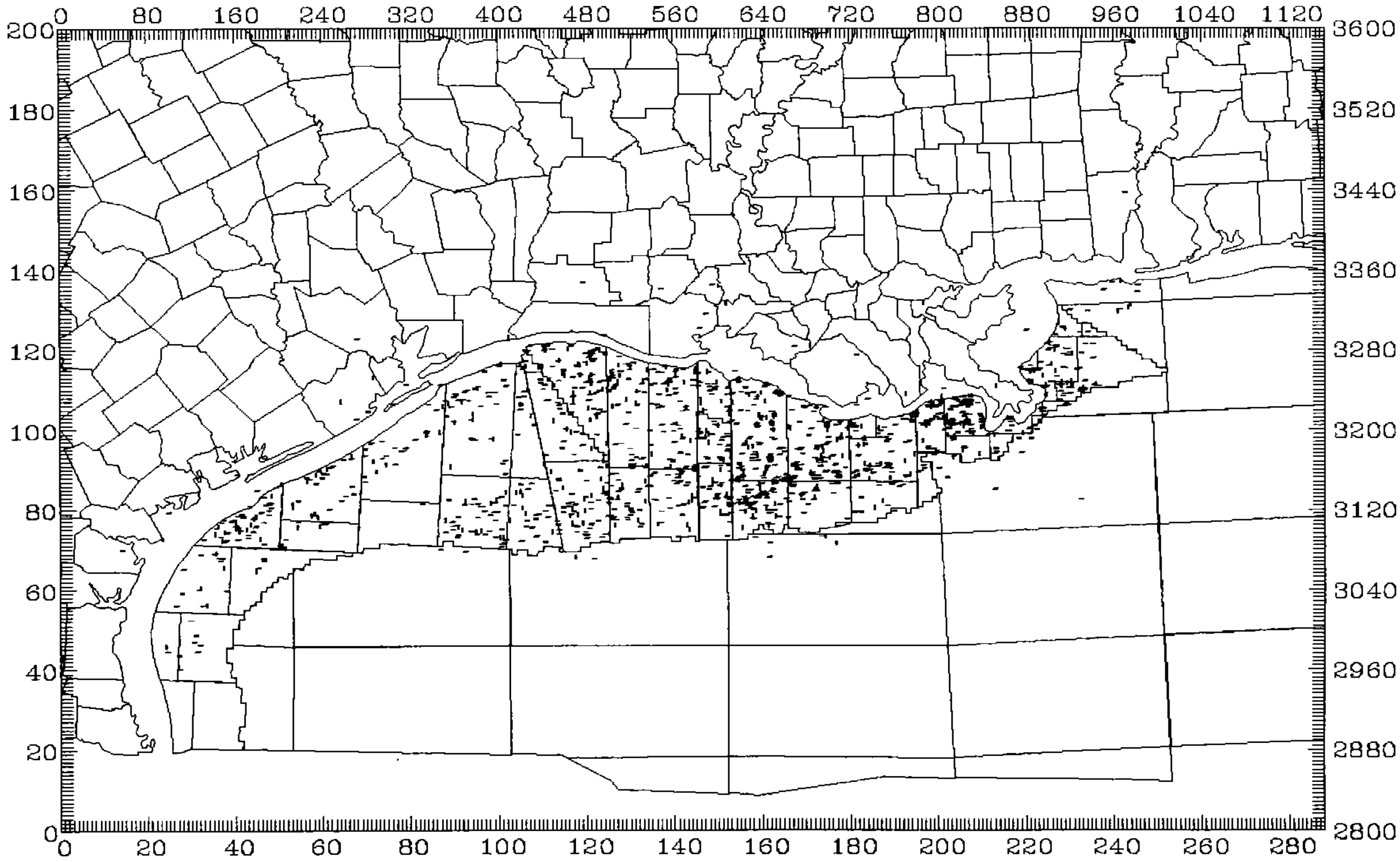


FIGURE O-18. Link data for spatial allocation of helicopter landings and take-offs.

95013

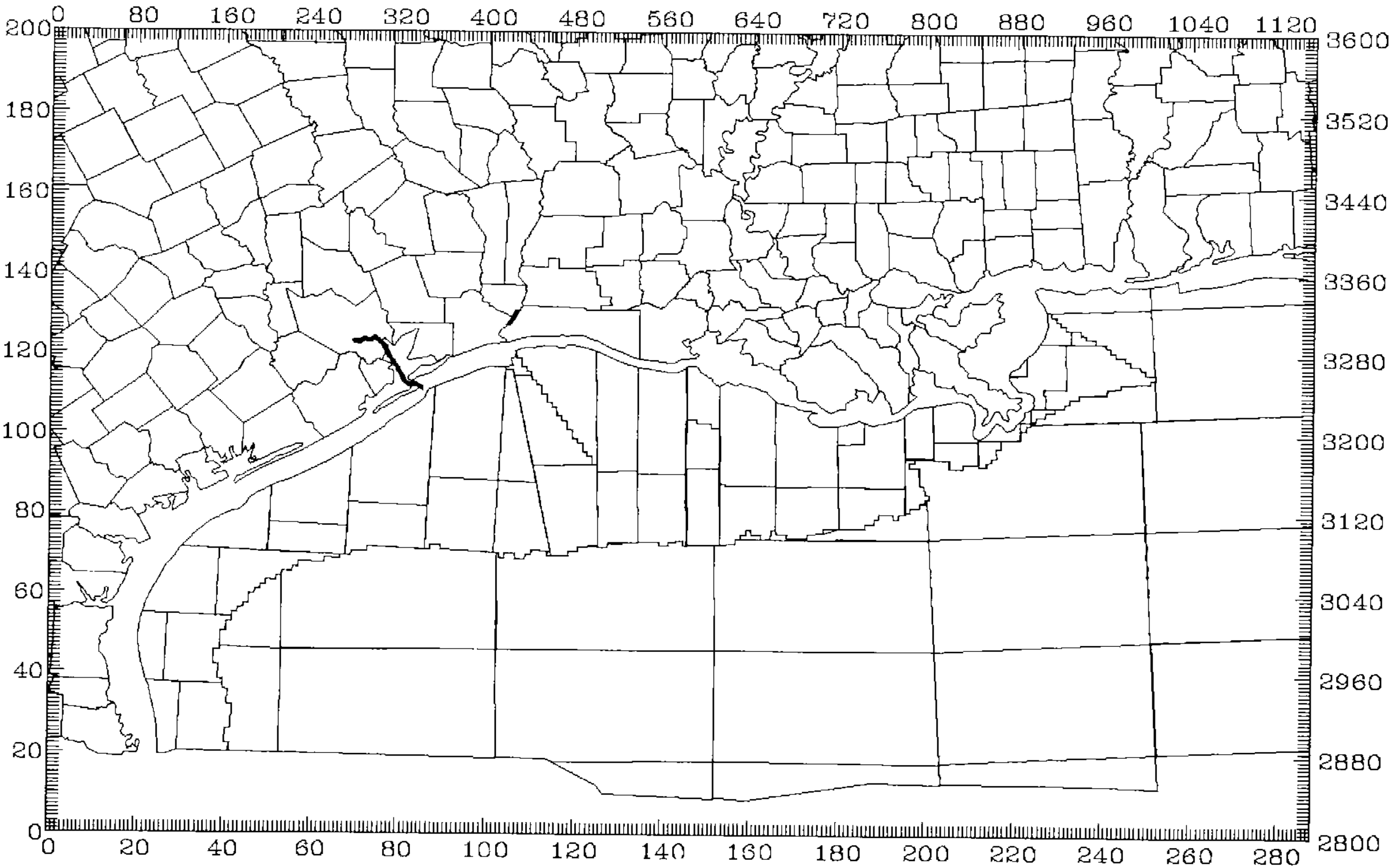
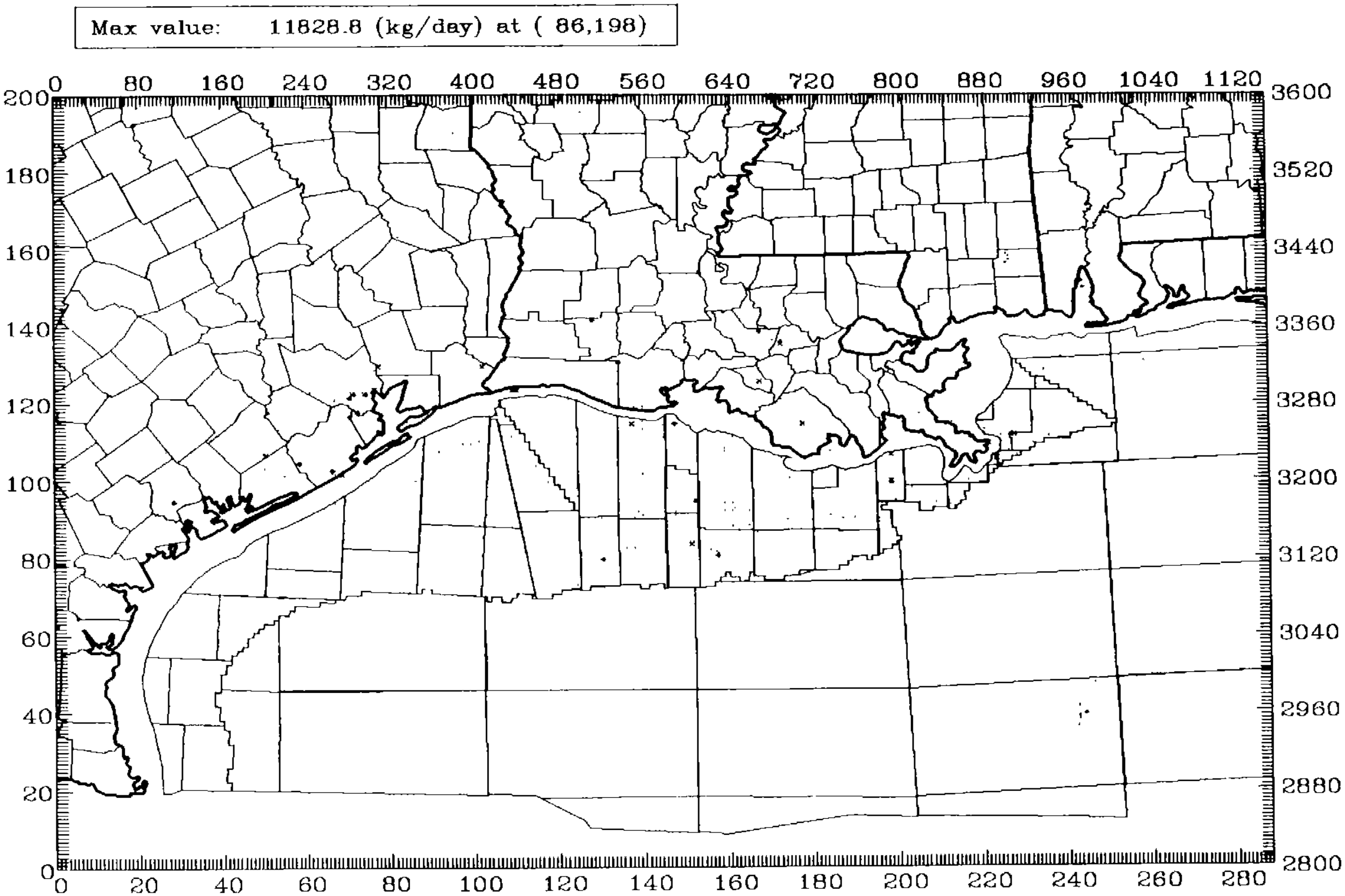


FIGURE O-19. Link data of shipping channels in the Houston/Galveston and Beaumont/Port Arthur nonattainment areas.

APPENDIX P

SPATIAL DENSITY PLOTS BY MAJOR SOURCE CATEGORY FOR AUGUST 17, 1993



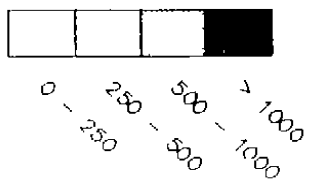


FIGURE P-1a. Spatial density of baseline low-level point NO_x emissions for August 17, 1993.

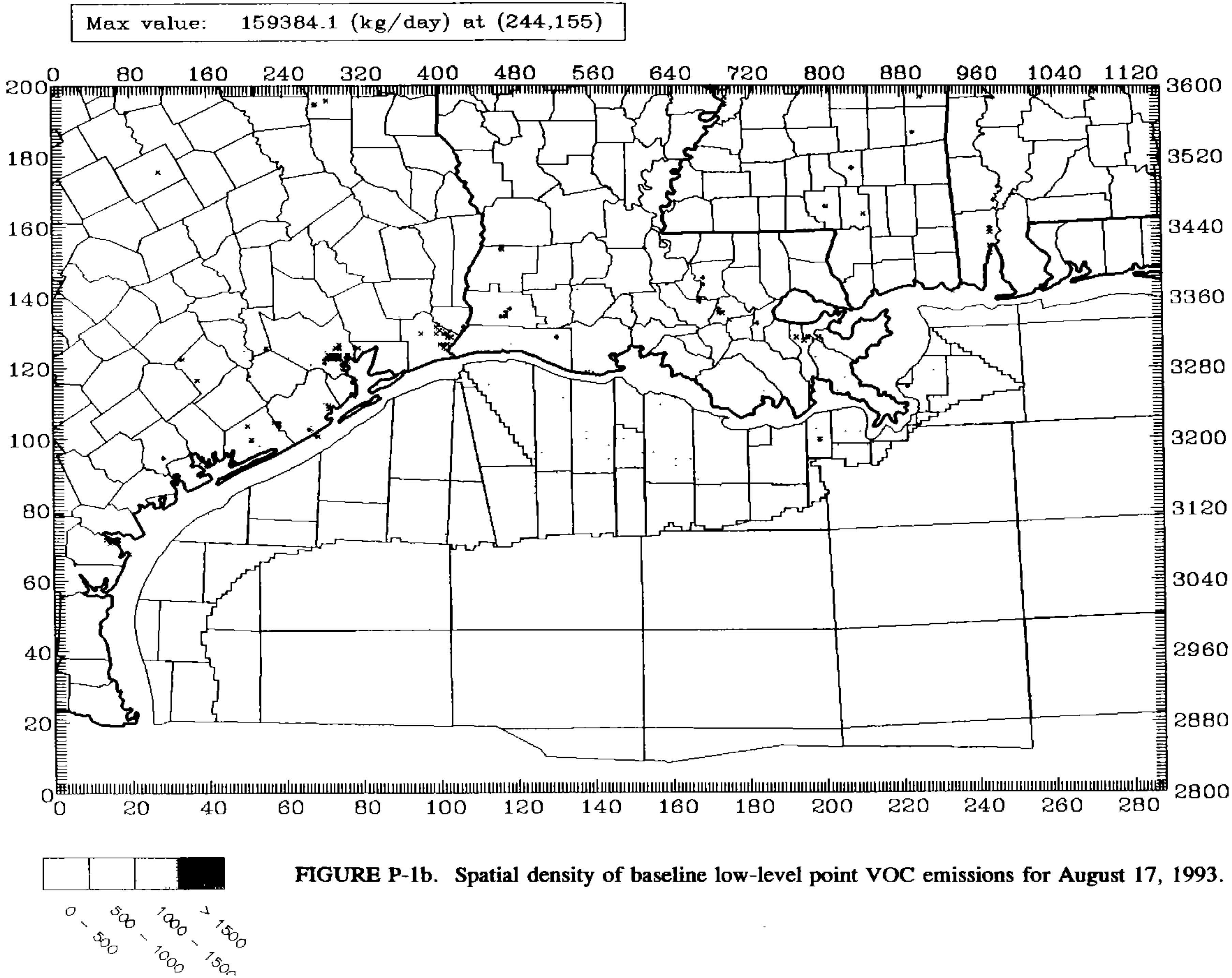


FIGURE P-1b. Spatial density of baseline low-level point VOC emissions for August 17, 1993.

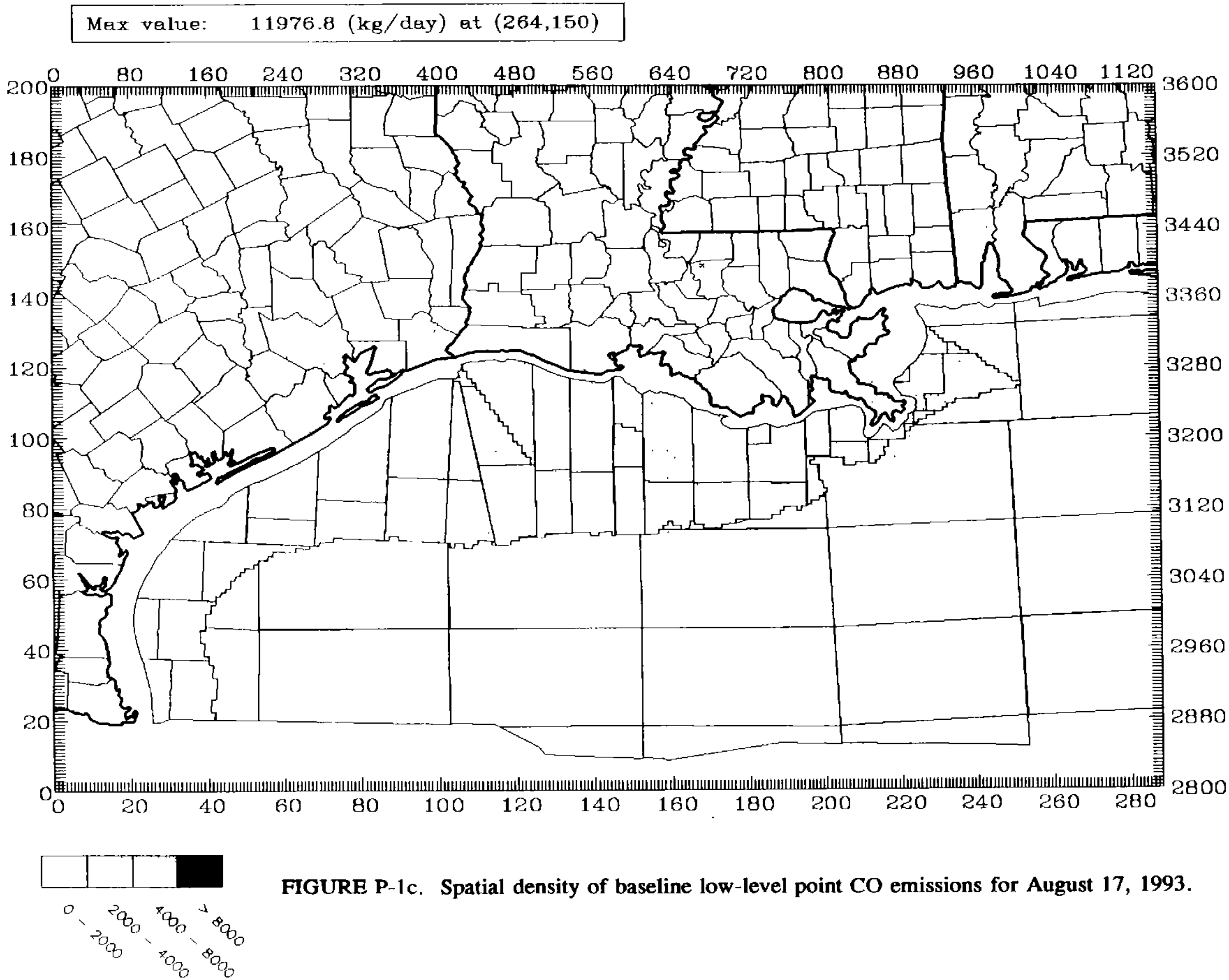
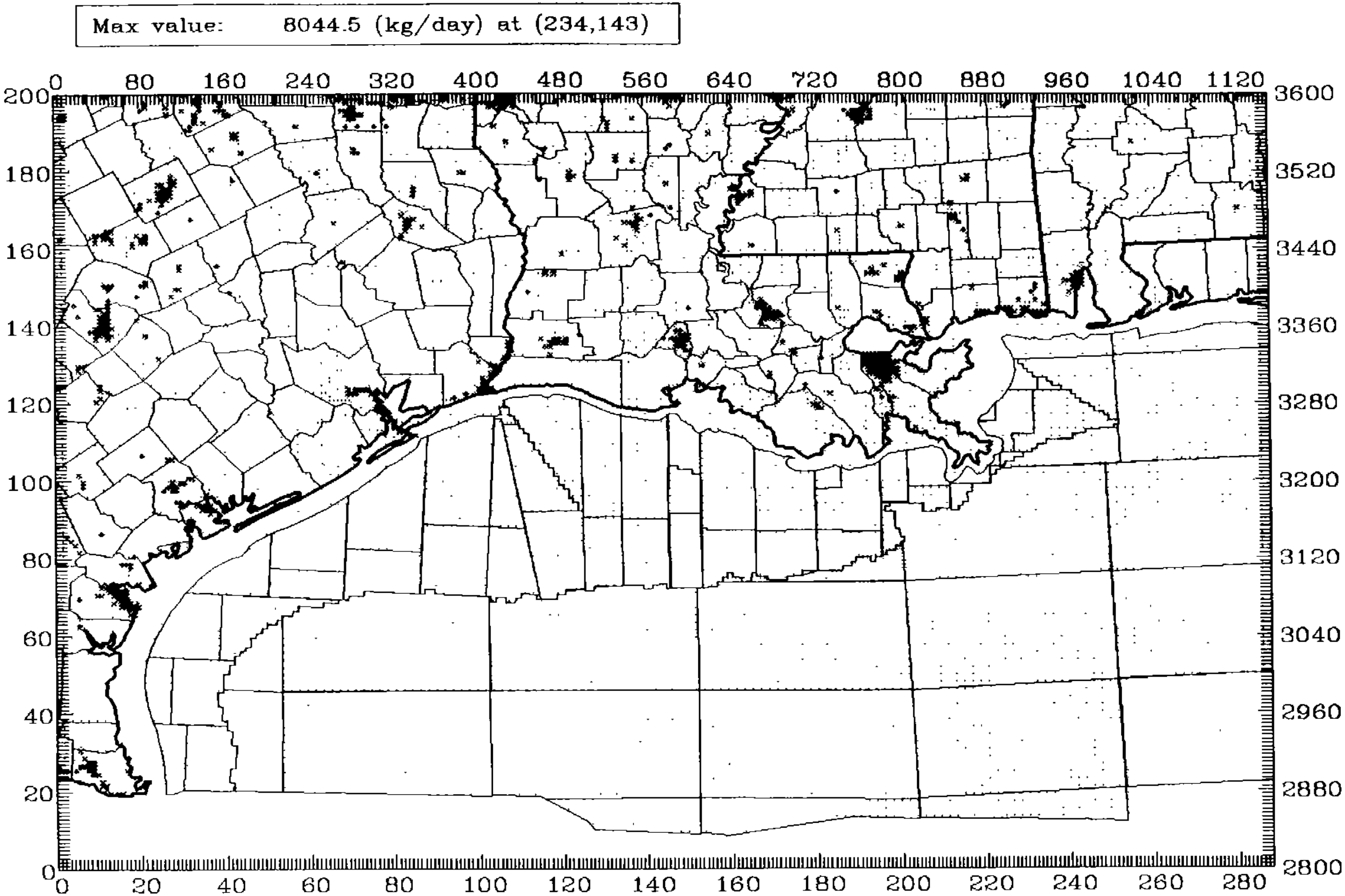


FIGURE P-1c. Spatial density of baseline low-level point CO emissions for August 17, 1993.



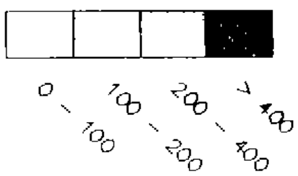


FIGURE P-2a. Spatial density of baseline area NO_x emissions for August 17, 1993.

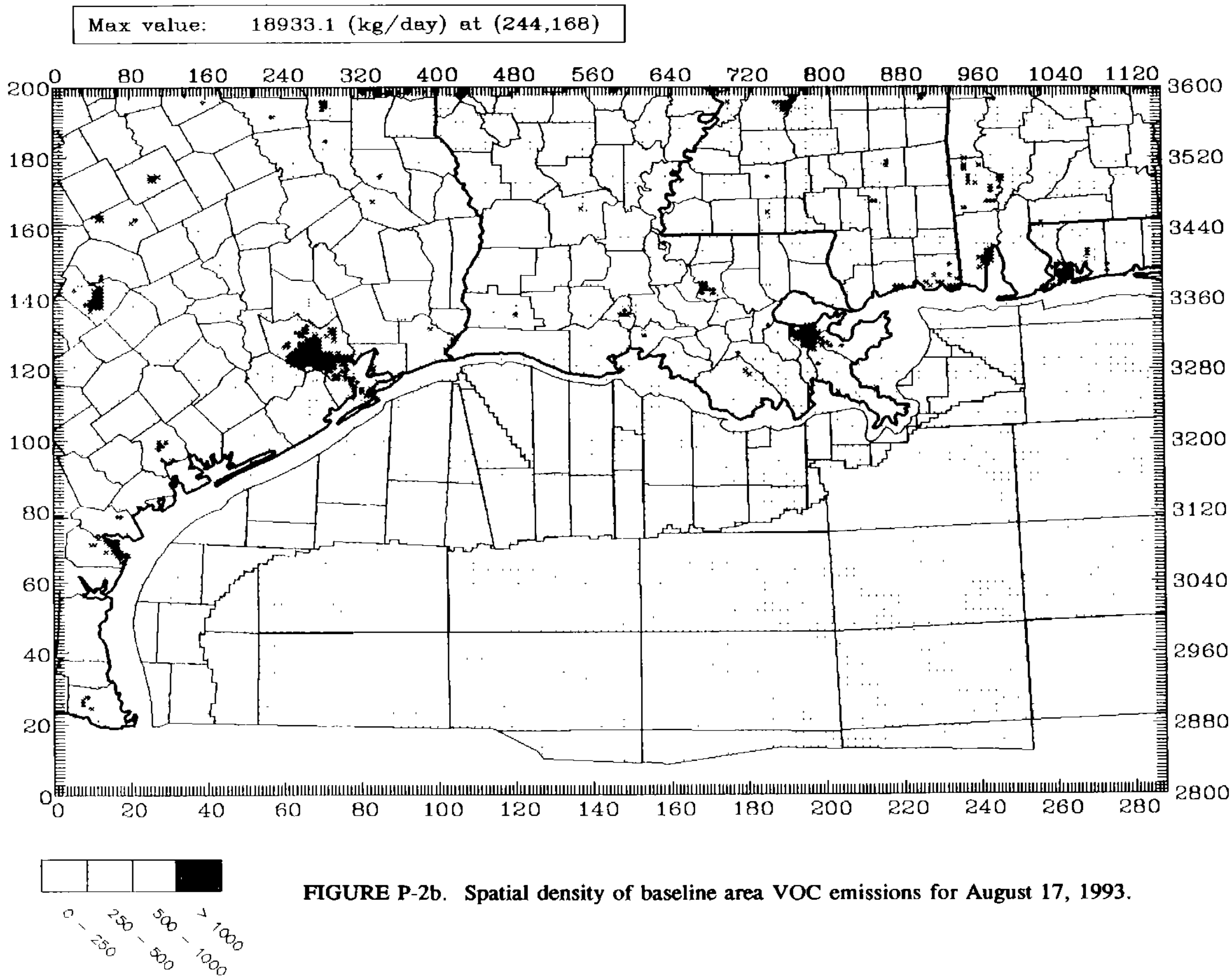
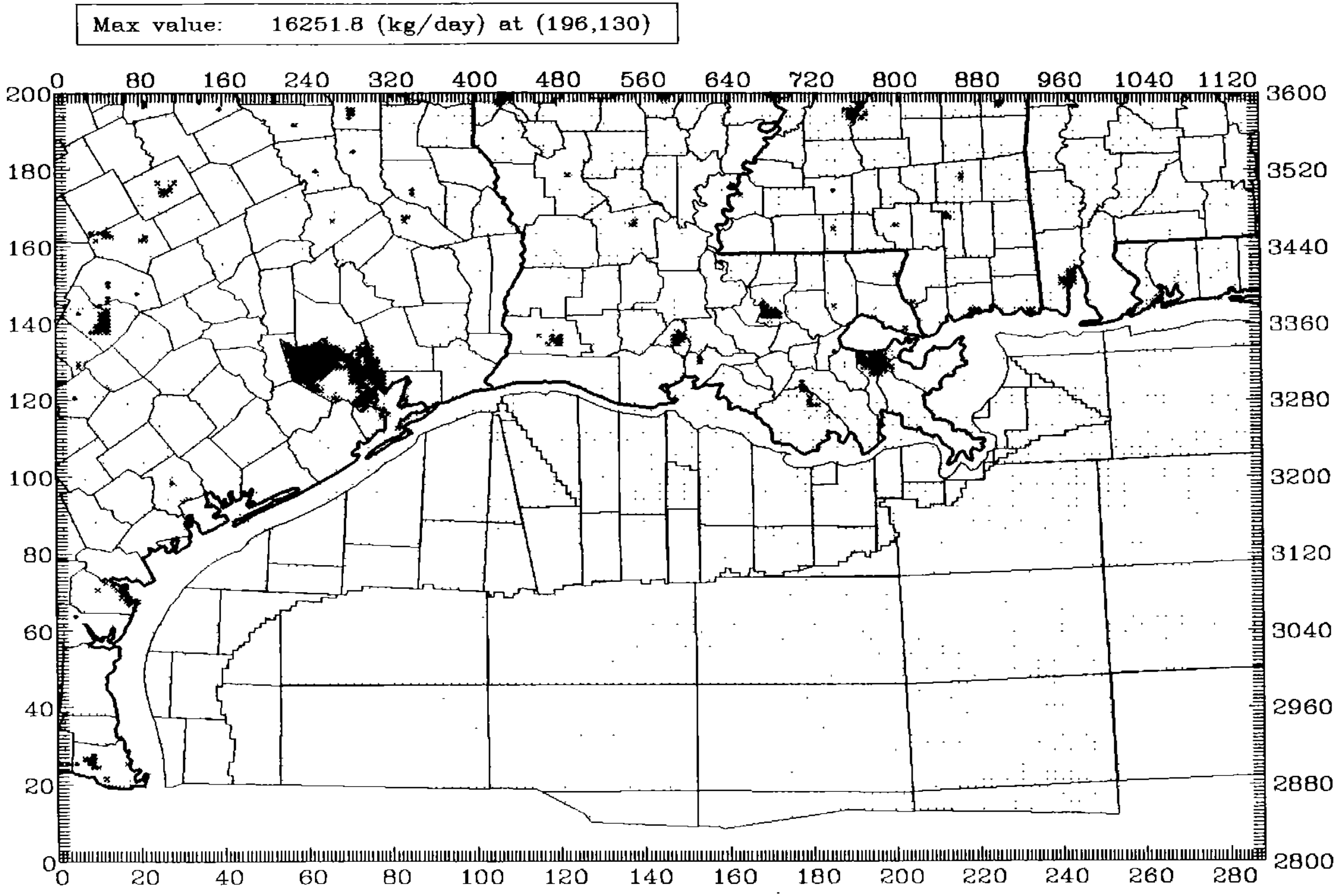


FIGURE P-2b. Spatial density of baseline area VOC emissions for August 17, 1993.



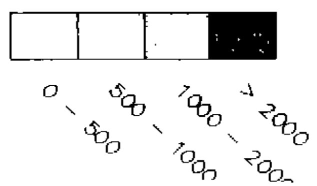
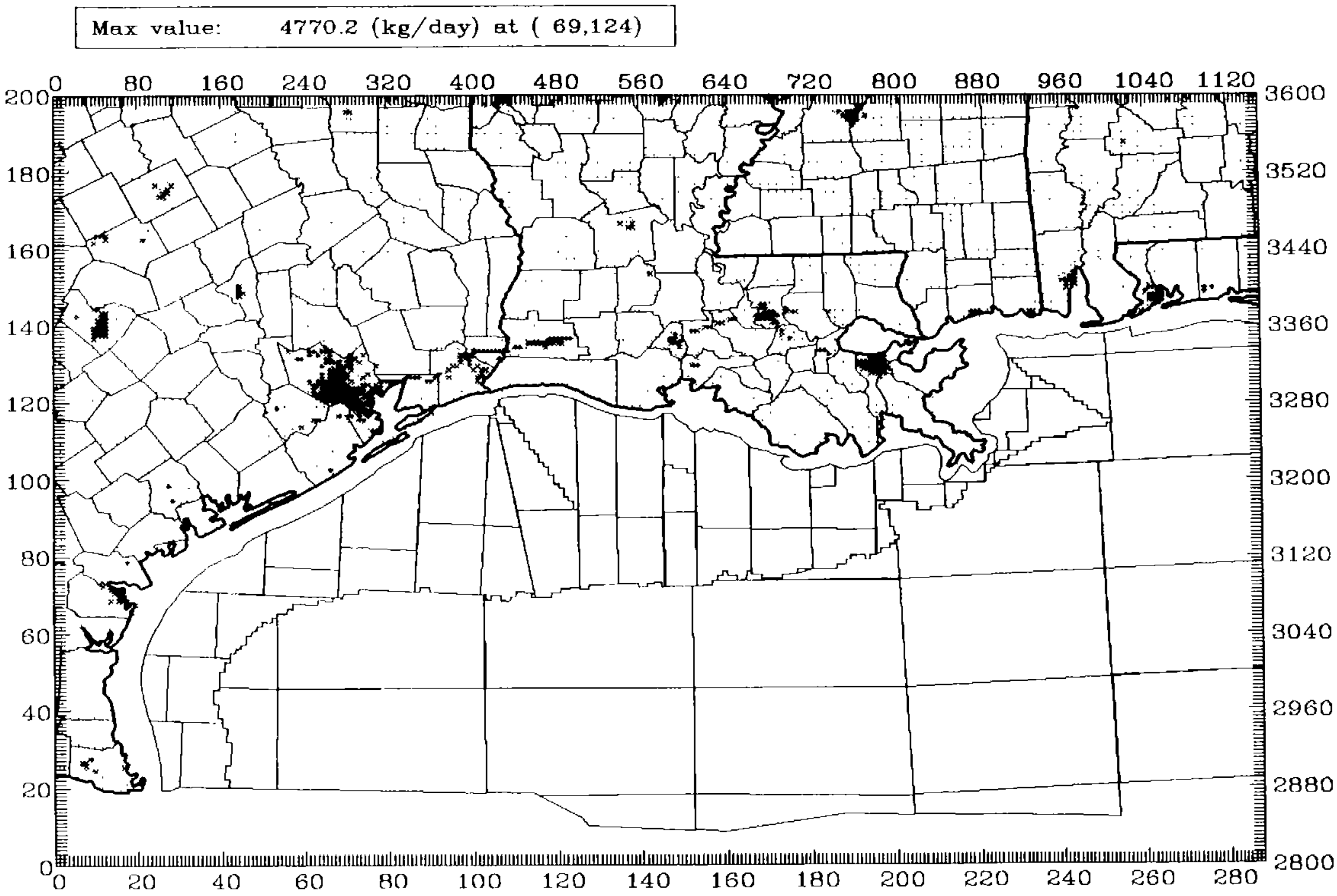


FIGURE P-2c. Spatial density of baseline area CO emissions for August 17, 1993.



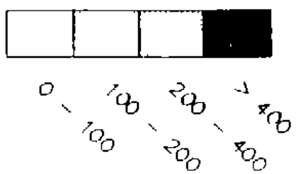


FIGURE P-3a. Spatial density of onroad mobile NO_x emissions for August 17, 1993.

95013

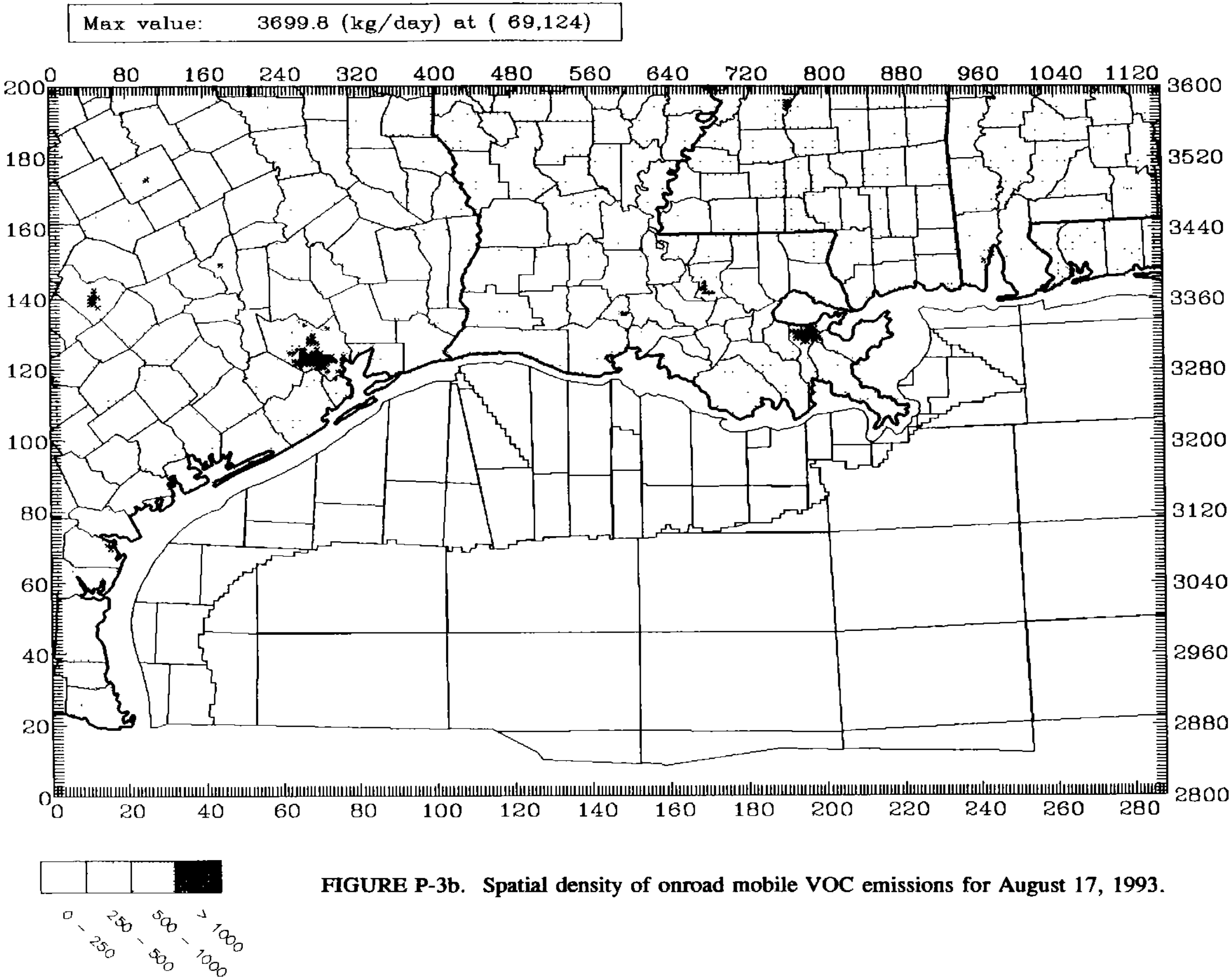
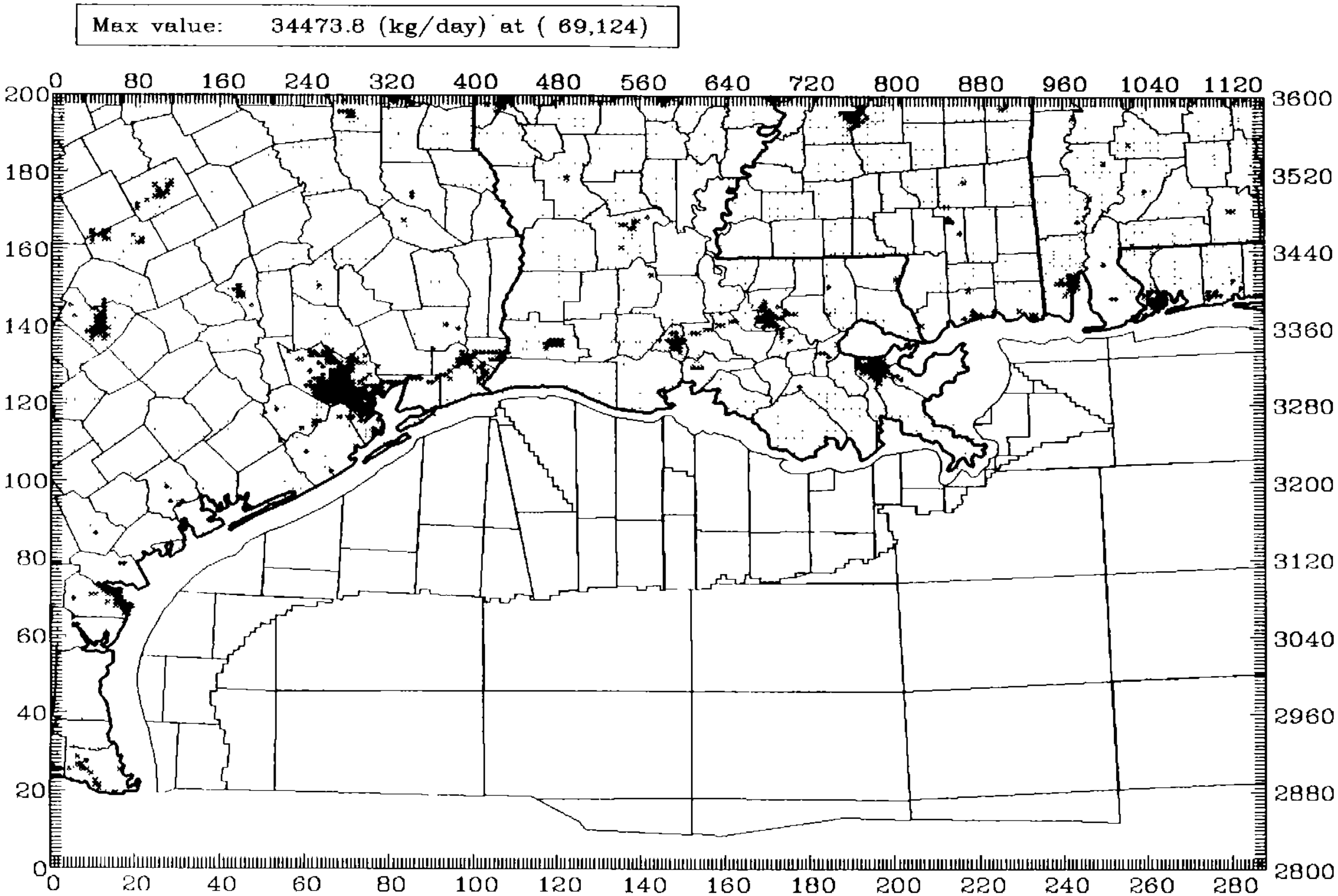


FIGURE P-3b. Spatial density of onroad mobile VOC emissions for August 17, 1993.



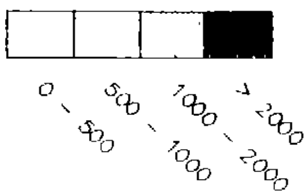
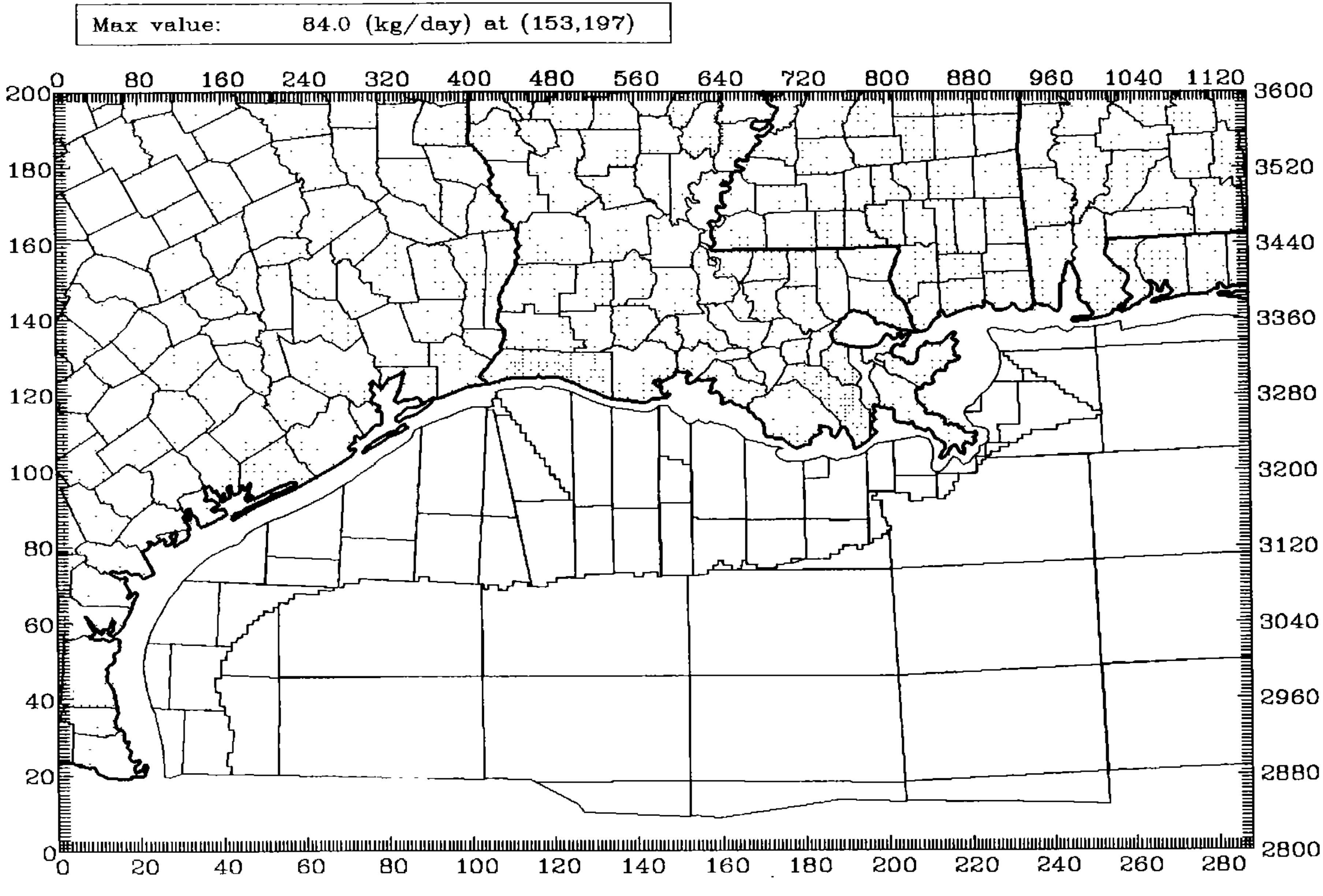


FIGURE P-3c. Spatial density of onroad mobile CO emissions for August 17, 1993.



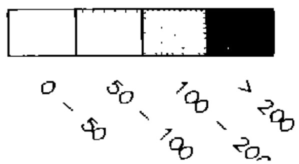
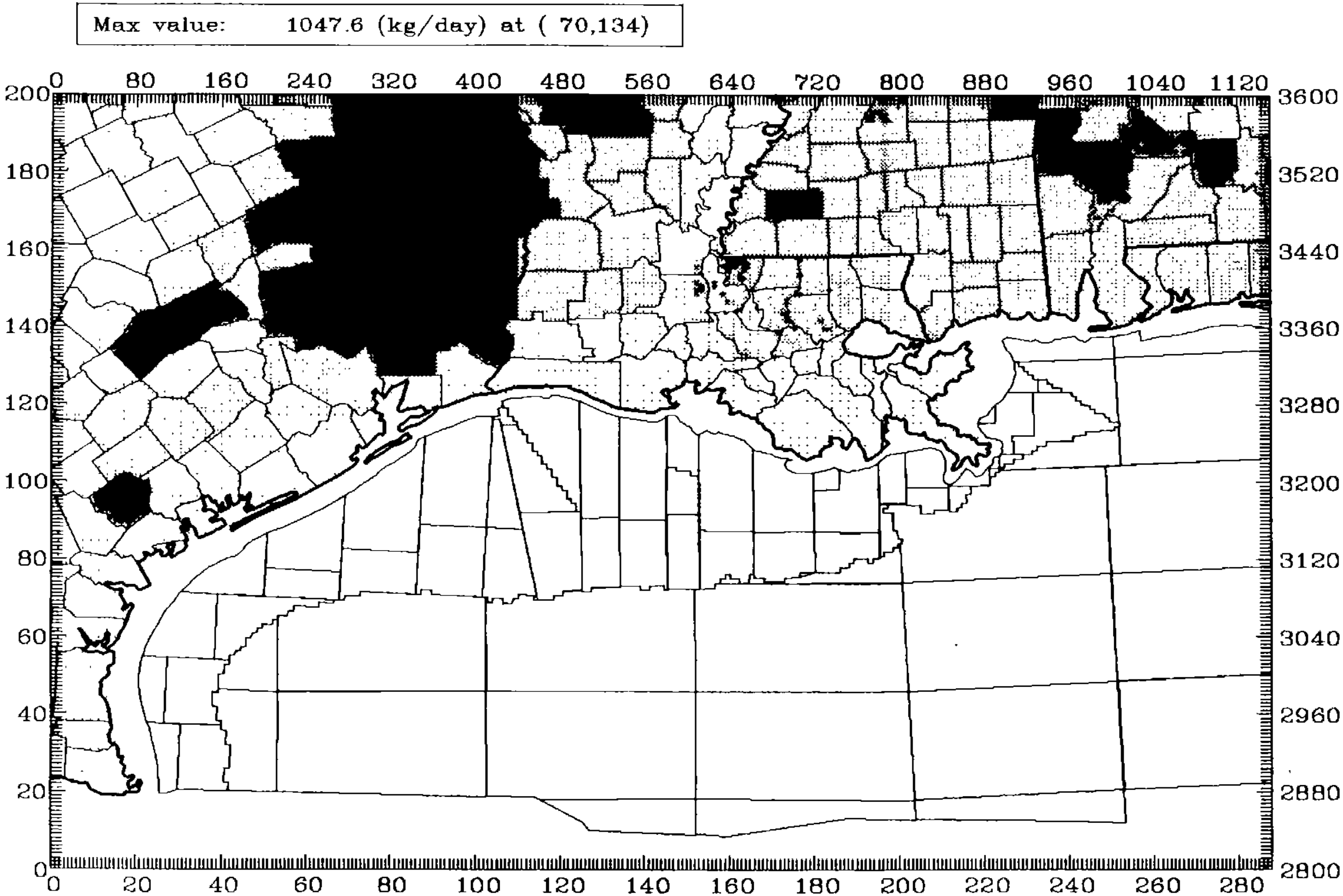


FIGURE P-4a. Biogenic NO emissions (reported as NO_x) adjusted in subregion 1 for August 17, 1993: total 4433 tons/day.



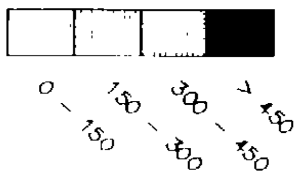
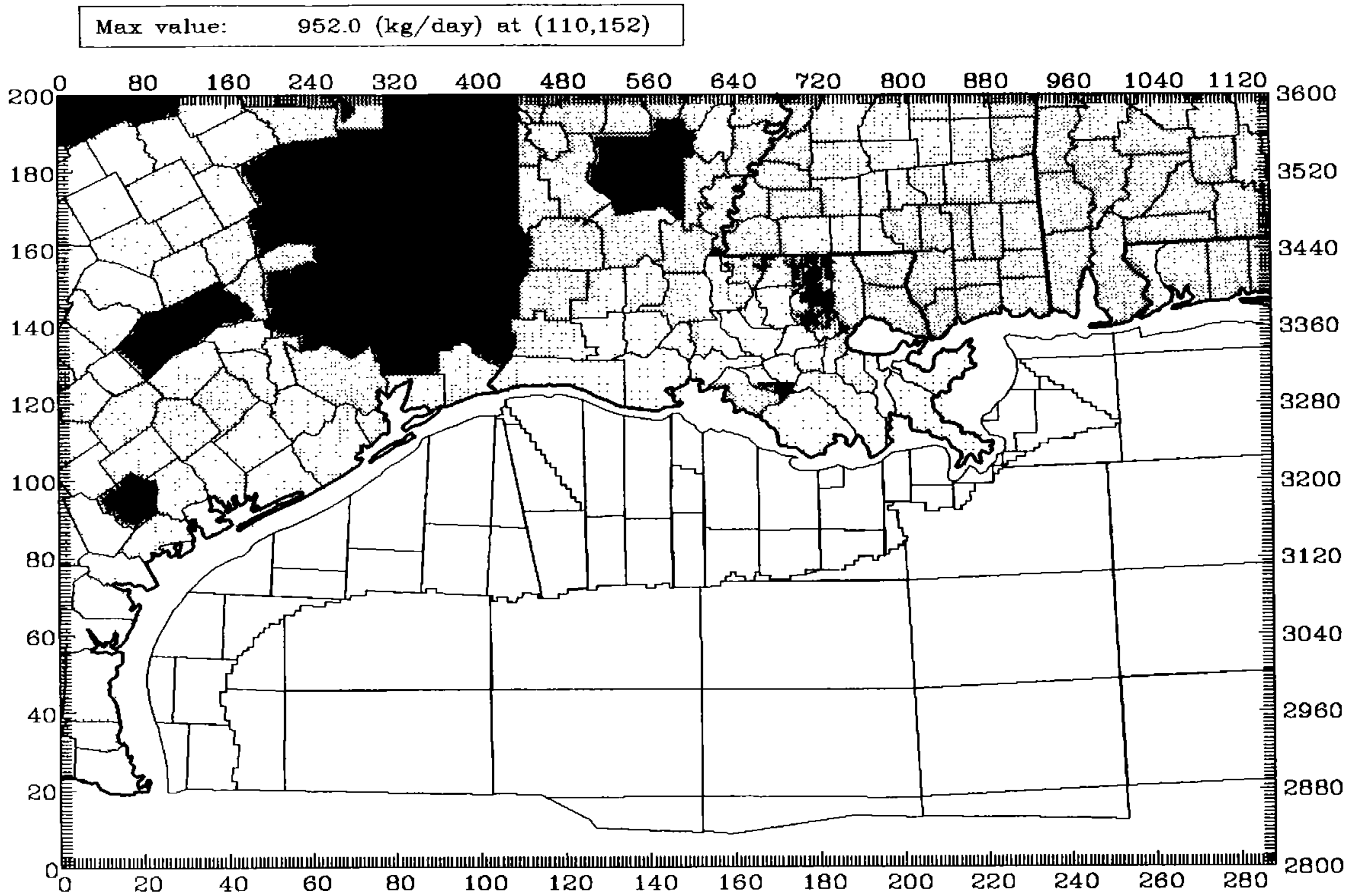


FIGURE P-4b. Biogenic isoprene emissions (reported as methane) adjusted in subregion 1 for August 17, 1993: total 8233.3 ton/day.

95013



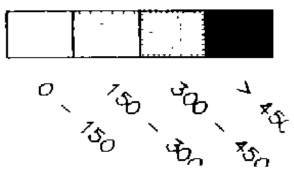
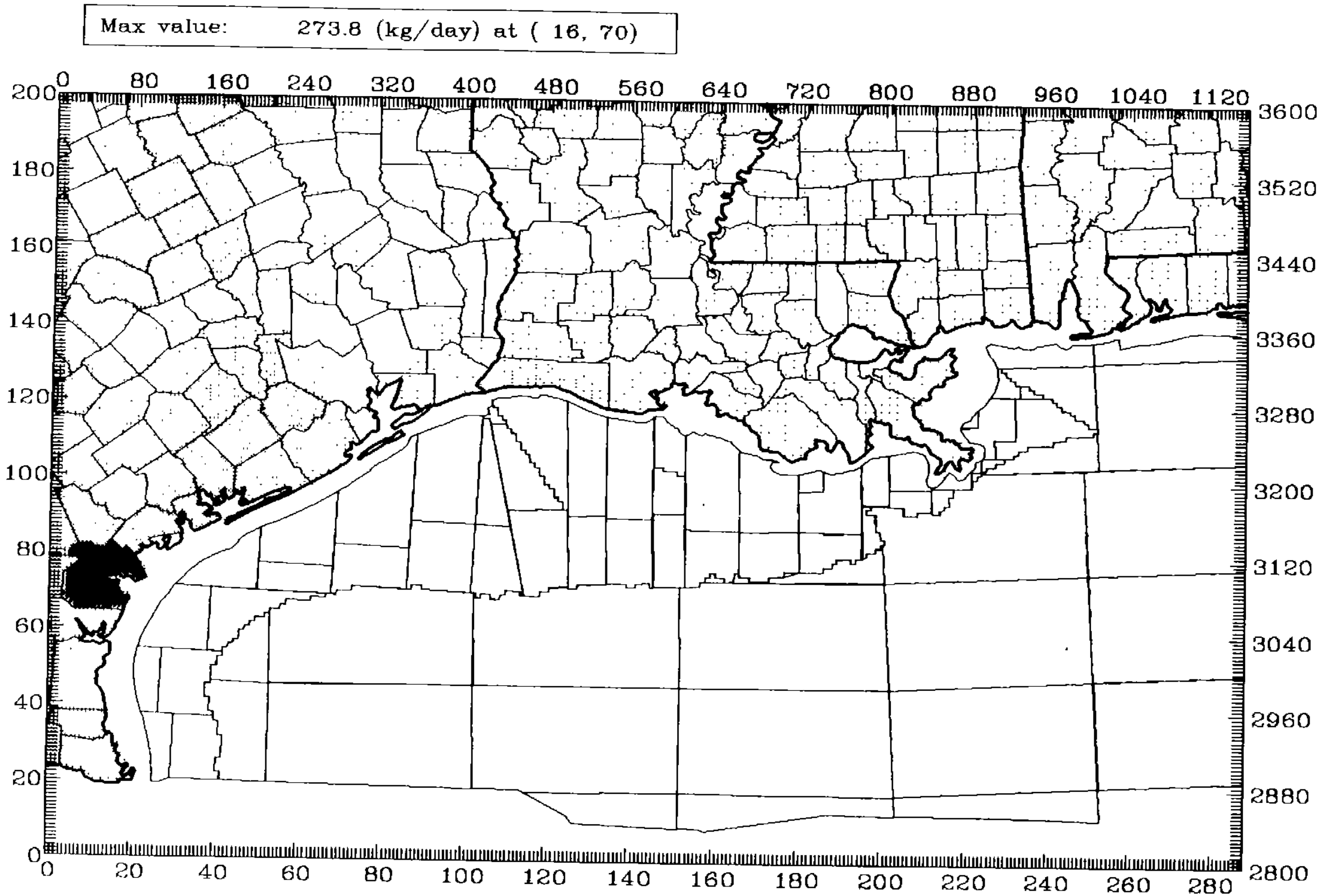


FIGURE P-4c. Other biogenic monoterpene emissions adjusted in subregion 1 for August 17, 1993: total 8233.3 tons/day.



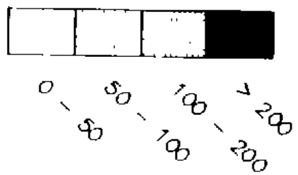


FIGURE P-5a. Biogenic NO emissions (reported as NO_x) for September 6, 1993: total 1138.1 ton/day.

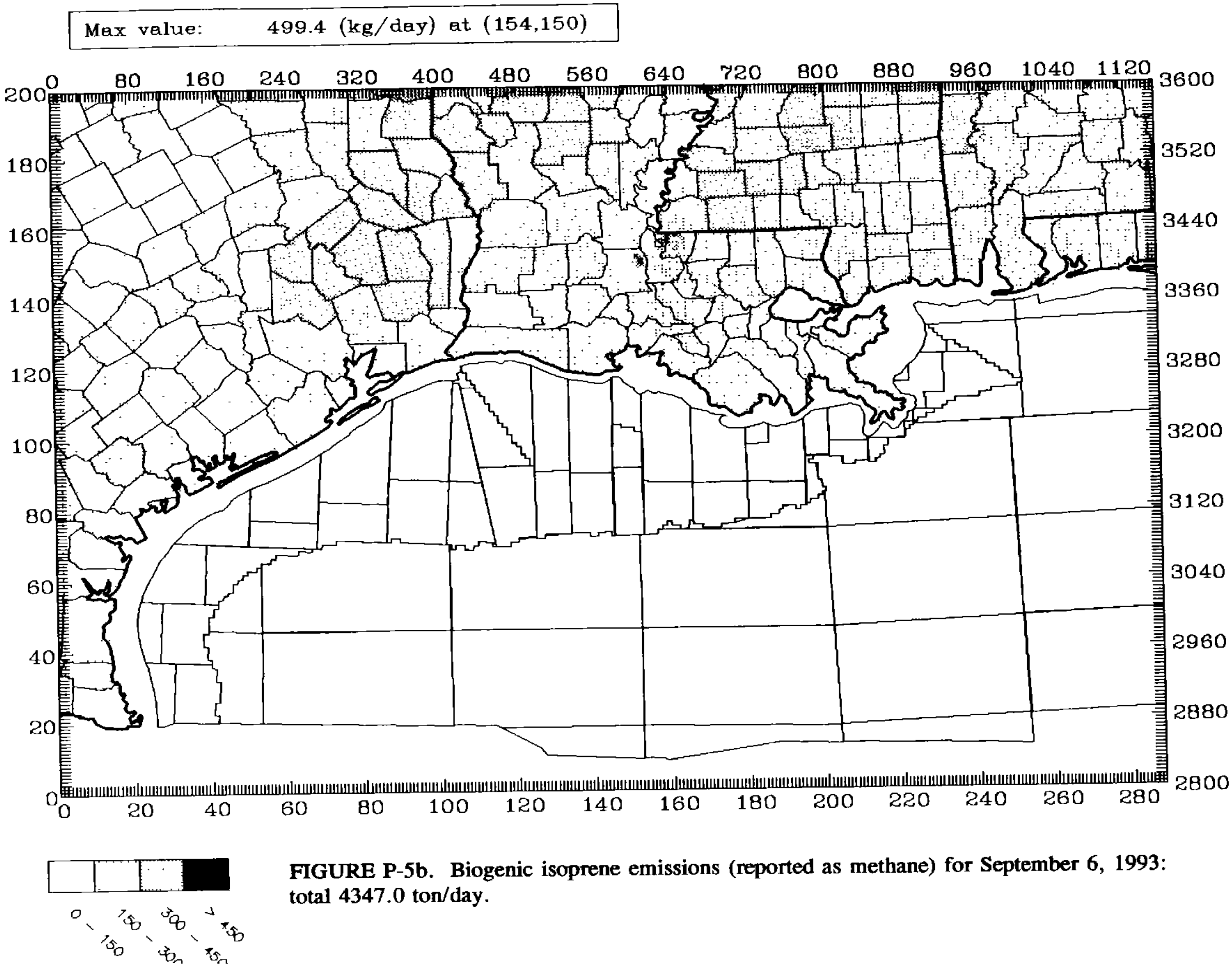
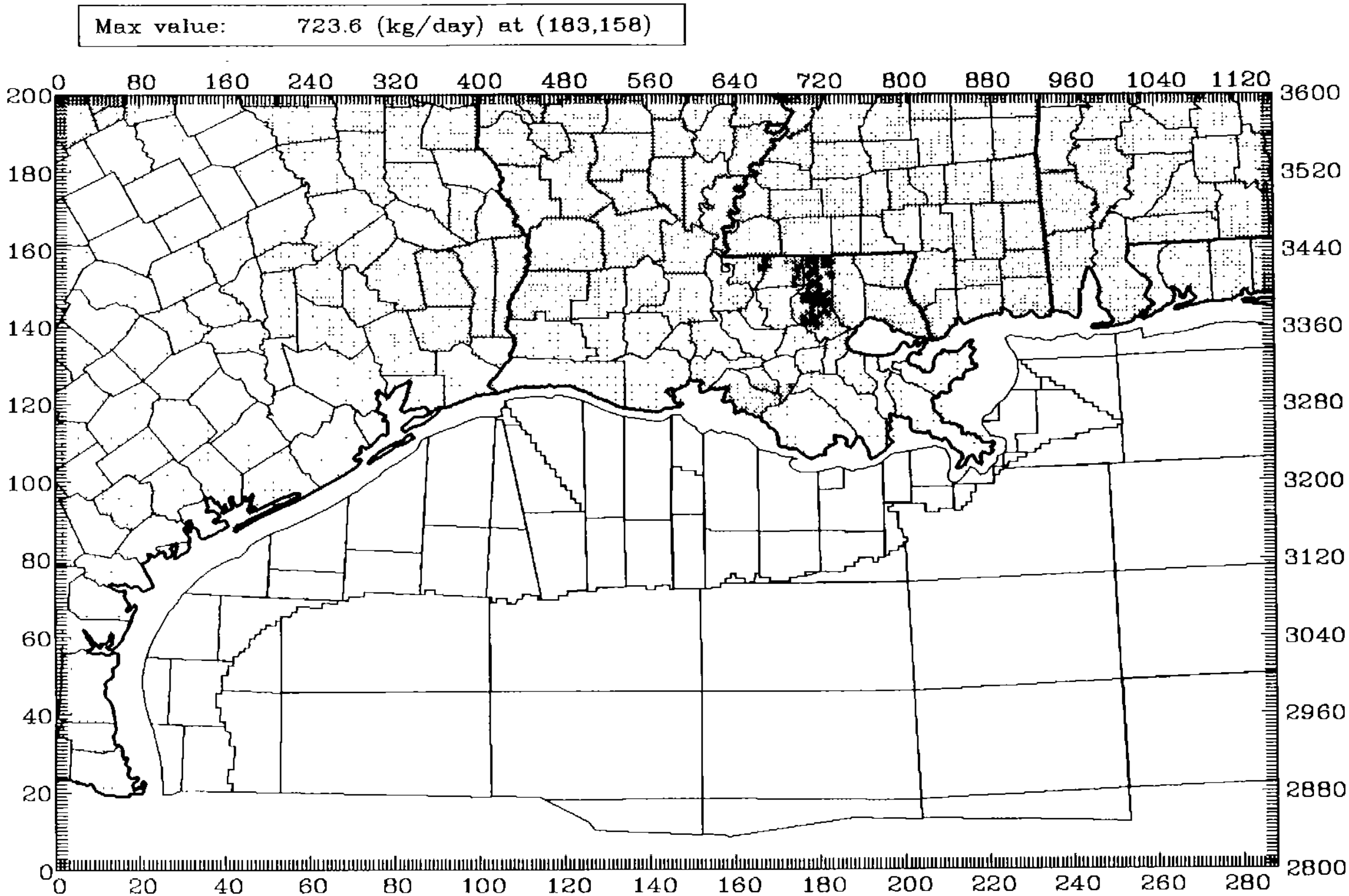


FIGURE P-5b. Biogenic isoprene emissions (reported as methane) for September 6, 1993: total 4347.0 ton/day.



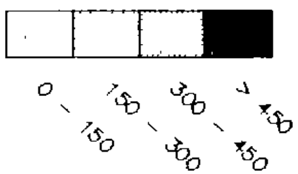


FIGURE P-5c. Other biogenic monoterpene emissions for September 6, 1993: total 5333.0 ton/day.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.