Estimation and evaluation of cancer risks attributed to air pollution in southwest Chicago final summary report

Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southwest Chicago

Final Summary Report

Submitted To:

U.S. EPA Region 5
Air and Radiation Division

By:

ViGYAN Inc.

April 1993

ESTIMATION AND EVALUATION OF CANCER RISKS ATTRIBUTED TO AIR POLLUTION IN SOUTHWEST CHICAGO

Final Summary Report

Prepared For:

Ms. Patricia Morris, Air and Radiation Division

U.S. Environmental Protection Agency, Region 5

Under EPA Contract No. 68-D0-0018
Work Assignment No. II-13

By:

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April 1993

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DISCLAIMER

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VíGYAN would like to acknowledge the role of U.S. EPA Region 5's Southeast Chicago study and Transboundary study. The basic approach utilized by Region 5 for risk assessment in the Southeast Chicago study, including assumptions and emissions inventory, was used in this report. While the results discussed in this report are the work of VíGYAN, some parts of this report have been taken from Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southeast Chicago (Summerhays, 1989) and The Transboundary Air Toxics Study (Blakley, 1990). Additionally, the Executive Summary and Chapter I of this report were prepared by the Region 5 Technical Representative.

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August 4, 1990

Valdas V. Adamkus
Regional Administrator
United States Environmental Protection Agency
230 S. Dearborn
Chicago, IL 60604

Dear Mr. Adamkus,

I am writing this letter regarding concerns which I have about the air quality in part of the Congressional district which I represent. In light of these concerns, I am respectfully requesting that the United States Environmental Protection Agency conduct a detailed air toxins study in the Chicago area encompassed by Archer Ave. on the north, 65th st. on the south, Harlem Ave. on the west and Cicero Ave. on the East.

The reason I am requesting this detailed air toxins study, for this community, is because this area is a highly residential and is currently burdened by a number of heavy industries. In addition the aforementioned area has been targeted for additional incinerators and chemical boilers.

The community for which I have requested the air quality study is already shouldering its fair share of the burden of coping with the byproducts of our modern technological society. This area is directly adjacent to the Metropolitan Sanitary District of Chicago and thus most cope with the foul odors that it, as well as a number of closely located industrial facilities, emit into the air each and every day. Further, this area must cope with the toxins emitted into the air by the large volume of trucks and autos which use closely located Interstate 55 and the many airplanes which use nearby Midway Airport. Immediately north of this area, Koppers Inc. has been newly licensed to operate a hazardous waste incinerator. As if all the previously sources of pollution is not enough, the General Electric Corporation has applied for a license to operate a PCB Recovery operation facility.

Having a PCB recover operation facility located immediately adjacent to a highly residential community causes me great concern. PCBs are strongly suspected to be linked to cancer and birth defects. I do not believe that it is fair to subject the people of this residential area and their families to these risks. To have such a facility in this area would greatly reduce their quality of life. Further, I am very concerned by the potential disaster that could happen if an industrial accident occurred with a compound as dangerous as PCBs. Hence, I am also respectfully requesting the I am provided with a detailed account of all the safety records for the General Electric Corporation.

In addition to the concerns for the health of the people of this community and nearby affected communities there are very genuine environmental issues involved. In regard to General Electric's proposed PCB recovery operation facility, the controversial chemical freon is also a byproduct of the process. Freon is known to promote the deterioration of the earth's ozone layer, thus reducing our protection freon dangerous ultraviolet lights.

Please keep my Chief of Staff James Laski informed of the status of my requests. You can contact Mr. Laski at my District office 312-582-7323. Thank your for your cooperation.

As always, I remain,

Sincerely,

William O. Lipinski
Member of Congress

EXECUTIVE SUMMARY

This report estimates the cancer risks associated with 30 air pollutants in the Southwest Chicago area. The study area, approximately 16 square miles including Midway Airport and neighboring suburbs, is bordered on the north by Pershing Road, on the south by 70th Street, Harlem Avenue on the west, and Pulaski Avenue on the east. About 93,854 people live in the study area.

Significant uncertainties are associated with estimating risk. These are due to data limitations and assumptions inherent in our current risk assessment methodology. The numerical estimates presented in this report should be viewed only as rough indications of the potential for cancer risk caused by a limited group of pollutants found in the ambient air. A detailed discussion of uncertainties inherent in this study is contained in Chapter V.

The study's purpose is to estimate cancer risks that may be attributed to toxicants in the ambient air in Southwest Chicago. U.S. EPA estimated risks for 30 air pollutants, including 7 known human carcinogens, 21 probable human carcinogens and 2 possible human carcinogens.

According to statistics from the American Cancer Society, about one in three Americans will contract cancer over the course of an average lifetime. Of the approximately 31,000 cancer cases that can reasonably be projected for this population, the report finds that 20 (or about one case every three and a half years) may be caused by the air pollutants studied. There are known and suspected risk factors that can increase the likelihood of contracting the disease (including both voluntary and involuntary exposures to carcinogens).

This cancer risk from toxic air pollution is of the magnitude of 2 chances in 10,000. This is consistent with other urban area studies that have estimated cancer risks from air pollution. These other studies reported risks ranging from a low of 1 in 10,000 to a high of 10 in 10,000.

Cars, trucks, buses, and trains are the major contributors of carcinogens accounting for about 25% of the total estimated cancer cases. Background concentrations of formaldehyde and carbon tetrachloride account for 19%. The third major contributor in the area is chrome plating operations accounting for about 16% of the total estimated cancer cases. Other significant contributors are aircraft engine emissions from Midway Airport and nonroad mobile sources (such as lawn mowers and snowblowers). Each of these two sources contributes approximately 11% of the total estimated cancer cases. These combined sources account for 81% of the estimated air-pollution-related cancer risks in the area.

Based on U.S. EPA unit risks used in this study, 1,3-butadiene is the most significant pollutant that contributes to cancer risk in the area. The second highest pollutant contributor is polycyclic organic compounds (POM). Both these two pollutant contributors are emitted mostly from mobile sources such as automobile, aircraft, and nonroad equipment engines. Other major pollutant contributors are hexavalent chromium (commonly used in the chrome-plating process) and formaldehyde (generated mostly by photochemical reactions).

CONCLUSION

The cancer risks from air pollutants estimated in this study are consistent with the risks found in other large urban areas. The study's findings parallel similar studies in other major urban areas of the United States and are typical of highly industrialized communities.

U.S. EPA recognizes the air quality in urban areas must be improved and is taking steps to address the air pollutants that adversely affect human health. The 1990 amendments to the Clean Air Act specifically address many of the sources of air pollution common to urban areas. Generally speaking, the Chicago metropolitan area as a whole should experience a dramatic and visible improvement in air quality as many specific provisions of the new Federal law are implemented.

U.S. EPA's actions include stricter regulation and enforcement of emissions of air toxicants including many of those studied in this report. Transportation control measures, use of cleaner fuels, vapor recovery at gas stations, and stricter controls on consumer solvents are only a few of the changes that will soon affect every person in the metropolitan area.

CHAPTER I
INTRODUCTION

I.1 BACKGROUND

This summary report presents the results of our assessment of the carcinogenic risks attributed to air pollution in Southwest Chicago, impacted by the urban air toxics emitted from the surrounding area. This study assists the U.S. Environmental Protection Agency (U.S. EPA) Region 5 in estimating and evaluating the cancer risks attributed to air pollution in the Southwest Chicago area.

This study may be considered in the context of the national concern about urban air toxics issues. A 1985 U.S. EPA report entitled The Air Toxics Problem in the United States: An Analysis of Cancer Risks for Selected Pollutants estimated that as many as 1,800 to 2,400 cancer cases per year may be attributed nationally to air pollution (not including indoor radon). This report indicates that while individual industrial operations may lead to high localized risks, a much greater share of the cumulative risk from air toxicants comes from activities that are more population-oriented, such as driving motor vehicles and heating with fireplaces and woodstoves. In fact, limited monitoring data in some large cities indicated that even in residential and commercial areas, health risks approach those found near the highest risk industrial facilities. These risks arise from the multiple sources of emissions and multiple pollutants that exist in all urban areas. Since 61% of the United States population lives in urbanized areas, and the exposure to high urban toxics extends throughout these urban areas, urban air toxics exposure appears to be the major risk factor for cases of cancer attributable to air pollution. Various studies suggest that cancer risks from air pollution throughout urban areas are commonly in the range of 1×10^{-3} (*i.e.*, 1 case per thousand people exposed for a lifetime) to 1×10^{-4} (1 case in 10,000). Given the general national picture of urban air toxics risks, the purpose of the Southwest Chicago study is to define in more detail the relative contributions of various source types and pollutants to that risk in this geographic area.

This study focused on atmospheric emission of 30 pollutants which U.S. EPA considers to be carcinogens. Some of these pollutants have been shown to be carcinogenic based on human exposure data and others have been implicated by animal studies.

The National Academy of Sciences has defined risk assessment as a 4 step process: hazard identification, exposure assessment, assessment of dose-response relationships, and risk characterization. The hazard identified for assessment in this study is cancer due to ambient air contaminants. The exposure assessment principally involves estimating ambient atmospheric concentration, that for most pollutants were estimated by deriving an inventory of emissions, and then estimating atmospheric dispersion of these emissions. The assessment of dose-response

relationships involves derivation of a unit risk factor, that expresses the probability or risk of contracting cancer that is associated with exposure to a unit concentration of air pollution.

Finally, risk characterization involves deriving various measures of risk. The simplest measure is individual risk representing the risk attributable to air contaminants at a specific geographic location. An alternative and more appropriate measure of risk is the number of cancer cases estimated to occur among the population in the study area attributable to air contaminants. In addition to estimating these general measures of cancer risk, this study also investigated the origins of these risks and incidences. For example, which source types and which pollutants are the most probable causes of these individual and area-wide risks estimated to result from air pollution in the Southwest Chicago area.

Using the Agency's well-established dispersion models, such as the Industrial Source Complex -- Long Term (ISCLT) and Climatological Dispersion Model (CDM), with carefully selected meteorological and emissions inventory data, air toxics concentrations in the receptor grid network from various point and area sources can be predicted. Based on the estimated concentrations, environmental hazard indices such as lifetime individual risks and lifetime cancer incidences can be calculated at the receptors to support urban toxics and risk assessment studies for the designated study area.

It must be noted that the risk estimates presented in this report should be regarded as only rough approximations of total cancer cases and individual lifetime risks, and are best used in a relative sense. Estimates for individual pollutants are highly uncertain and should be used with particular caution.

I.2 LIMITATIONS

To put the air toxics risk in perspective, cancer risks due to other forms of environmental pollution must be considered. Other exposure routes include exposure through drinking water, skin contact, eating fish from or swimming in lakes that may contain contaminants, and exposure to indoor air contaminants including radon. This study however focused on air pollution risks and did not evaluate risks from other forms of exposure to environmental contamination. Also, other air pollutants that cannot be quantitatively evaluated may cause significant risks.

CHAPTER II
STUDY DESIGN

II.1 GEOGRAPHIC COVERAGE

The target area of the study is encompassed approximately by Pershing Road on the north, 70th Street on the south, Harlem Avenue on the west, and Pulaski Avenue on the east. To ensure that this area was included in the study in its entirety, a slightly larger area was determined to construct our receptor grid network system. In Universal Transverse Mercator (UTM) coordinates, the designated receptor grid network extends from 4623.62 to 4630.12 kilometers northing and from 433.24 to 440.04 kilometers easting in zone 16. The uniform distances between two adjacent receptors are 0.8125 kilometers on the UTM north (UTMY) axis and 0.85 kilometers on the UTM east (UTMX) axis. This receptor grid network comprises 64 (8 x 8) rectangular grids. Figures 1 to 3 portray the geographic coverage of the study area.

For purposes of this study, the "Southwest Chicago" receptor area was defined as an area that is approximately a 4-mile square, having a total area of 16 square miles. This area covers populated areas around Midway Airport. The total population of the receptor area is approximately 93,854 persons.

II.2 POLLUTANTS

Not all pollutants recorded in applicable emissions inventories were included in the study. Only 30 carcinogenic pollutants were studied for their hazardous impacts over the study area. Among these 30, several represent mixtures of compounds. Polycyclic organic matter (POM) represents a class of compounds including benzo(a)pyrene (B(a)P). POM is itself a component of the solvent extractable fraction of particulate matter. Dioxins represent a class of 75 chlorinated dibenzo-dioxins and 135 chlorinated dibenzo-furans. Other mixtures of compounds in this study are coke oven emissions, gasoline vapors, and polychlorinated biphenyls (PCBs). The cancer causing air toxics considered in this study and their carcinogenic measures are listed in Tables 1 and 2. For more details on the pollutants studied, please refer to Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southeast Chicago (Summerhays, 1989). Other potentially hazardous air pollutants such as mercury and lead are not included either because they are considered not to be carcinogens or because quantifiable unit risk factors are not available. For example, there is no current evidence that mercury is a carcinogen. Animal studies have concluded that lead is a probable human carcinogen, however, the cancer risk is not quantifiable.

Southwest Chicago Study

Study Area and Neighboring Counties

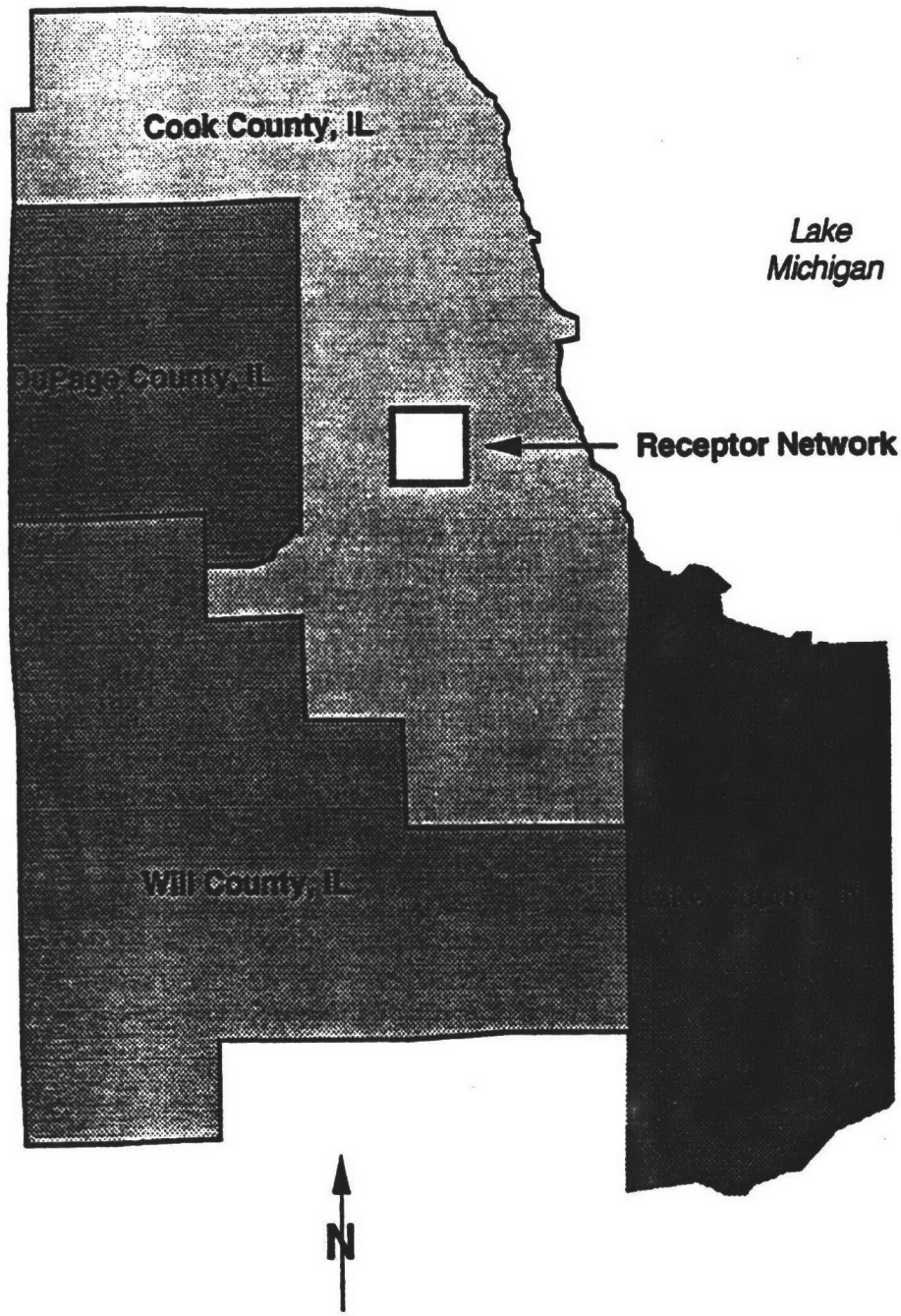


FIGURE 1

Southwest Chicago Study
Study Area and Vicinity

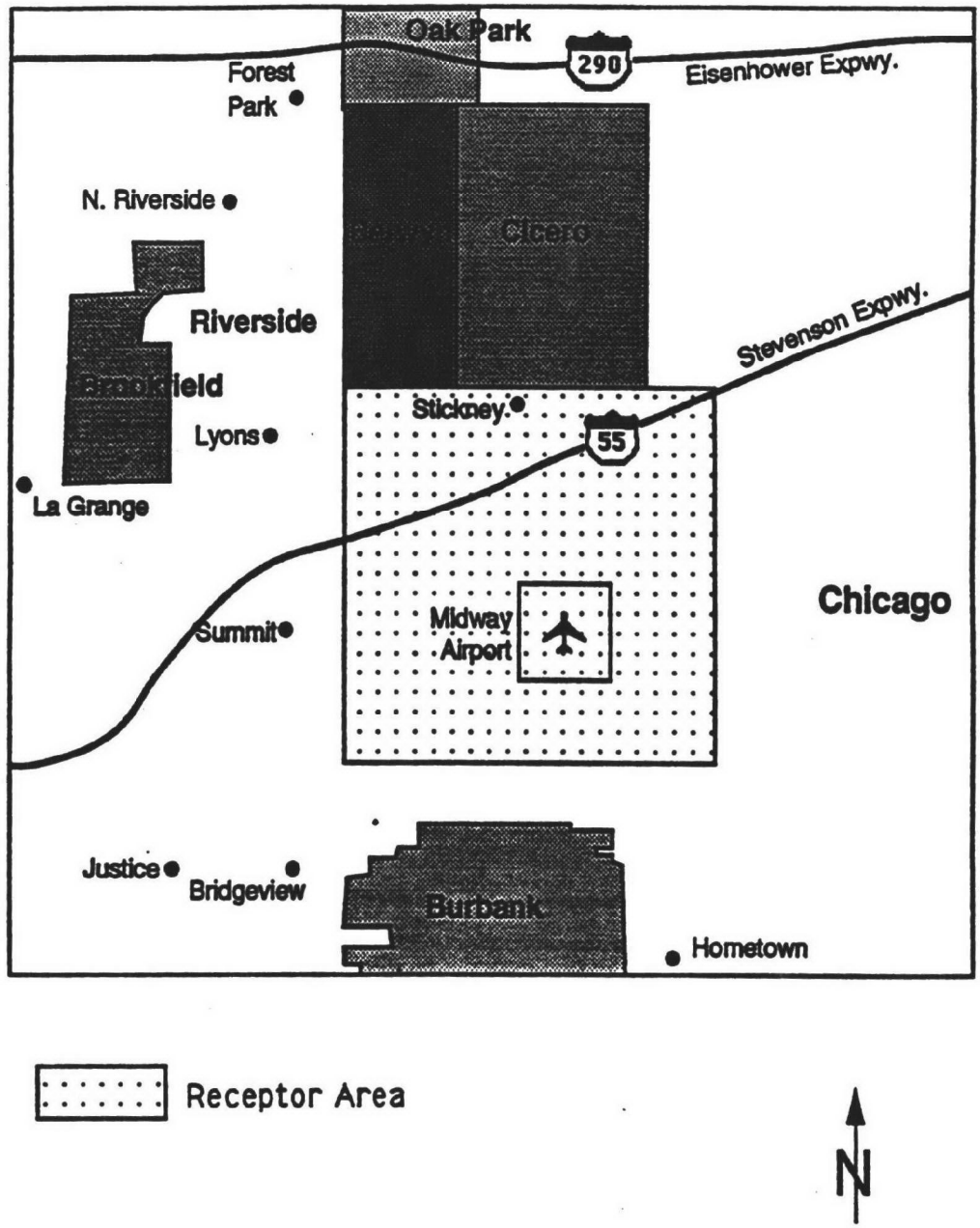


FIGURE 2

Southwest Chicago Study
Receptor Grid Network

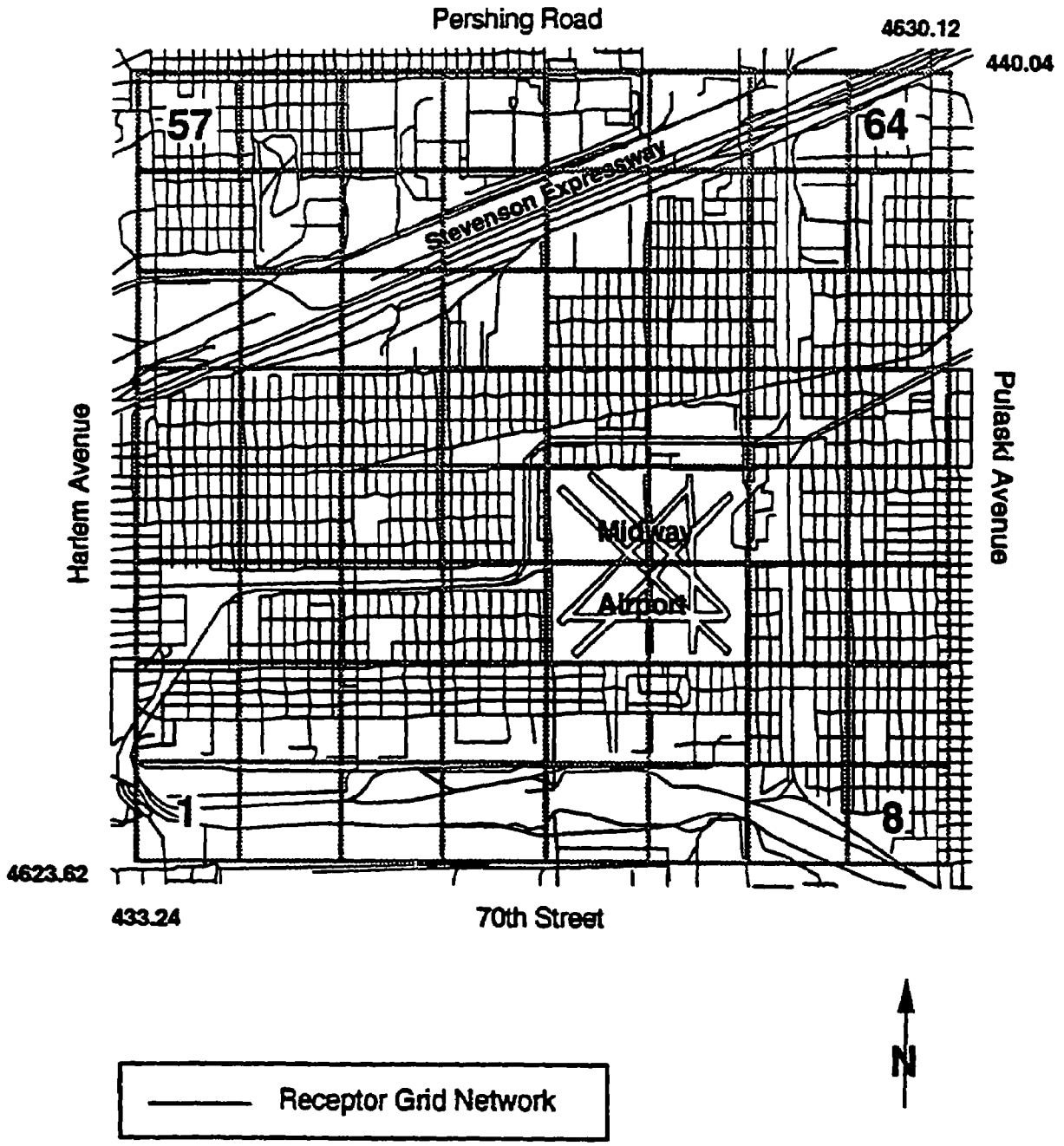


FIGURE 3

II.3 UNIT RISK FACTORS

The unit risk factor is defined as an estimate of the probability that an individual will develop cancer when continuously exposed to a pollutant at an ambient concentration of one microgram per cubic meter (ug/m^3) for 70 years. The cancer risk estimates are based on upper bound estimates of unit risk, except for class A carcinogens. Unit risks for class A carcinogens are based on human data. The estimate of cancer risk for each pollutant, considering the unit risk factor alone, is conservative, that is, while the actual risk may be higher, it is more likely to be lower and may even be as low as zero. Thus, the cancer risk estimates are not meant to be representative of actual risks. Instead they are meant to be used in a comparative sense to compare risks.

The weight-of-evidence that a pollutant causes cancer varies from proven human carcinogen (*e.g.*, benzene) to probable human carcinogen (*e.g.*, 1,3-butadiene) to possible human carcinogen (*e.g.*, vinylidene chloride). The weight-of-evidence rating is based on the most current studies; human data are used when available, but data is more often drawn from animal studies. The unit risk factors and weight-of-evidence ratings remain uncertain to varying degrees and are subject to change as further evidence is obtained and the significance of preliminary data is reviewed.

For many substances, the unit risk factor is probably the greatest potential source of uncertainty in estimating cancer risk. This is a significant issue and of particular concern for particulate matter and POM. The diesel particulate matter unit risk estimate used in the study is 1.7×10^{-5} (Table 2). This U.S. EPA estimate (Pepelko and Ris, 1992) has not been peer reviewed and is subject to change. The unit risk estimate attributes carcinogenicity to the particle itself rather than POM adsorbed to the surface of diesel particles. The gasoline particulate matter, woodstove, and residential heating oil unit risk estimates used in this study, on the other hands, are based on the comparative potency method (Lewtas, 1991) and use epidemiological data from coke oven emissions, roofing tar emissions, and cigarette smoke to develop a correlation with the organics based on the relative potencies in the skin tumor initiation assay. These unit risk estimates are given in Table 2. The unit risk estimates based on the comparative potency method are not official U.S. EPA estimates, and are highly uncertain. For particulate matter emission sources in this study, particulate matter unit risk estimates were used when available. Since no cancer potencies exist for aircraft particulate emissions, the U.S. EPA Office of Mobile Sources (OMS) recommended using the unit risk factor for non-catalyst light-duty vehicles (1.6×10^{-5}, Lewtas) for piston aircraft and the diesel particulate unit risk factor of 1.7×10^{-5} (Pepelko and Ris) for turboprop and turbofan aircraft.

For other sources, the benzo(a)pyrene (B(a)P) surrogate approach was used to assess cancer risks. In the surrogate approach, POM is assumed to have the same cancer risk factor as B(a)P. Since B(a)P is among the most potent of the carcinogenic compounds included as POM, and since not all POM is carcinogenic, the use of this value is likely to overestimate risk from the POM mixture. A similar overestimate may result from the use of the unit risk factor for the most potent dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin) as a surrogate for all dioxins. Finally, the estimates for gasoline vapors from gasoline marketing are uncertain because the fraction of vapors that is carcinogenic is not absolutely verified.

Data on synergistic or antagonistic effects are almost never available, so cancer risks from various chemicals in a mixture are assumed to be additive. It should be noted that the assumption of additivity can lead to substantial errors in risk estimates if synergistic or antagonistic interactions occur. Although dose additivity has been shown to predict the acute toxicity of many mixtures of similar and dissimilar compounds, some marked exceptions have been identified. In some cases, risks would be either greatly overestimated or, in other cases, greatly underestimated. The available data are insufficient for estimating the magnitude of these errors.

For a discussion of how U.S. EPA evaluates suspect carcinogens and more information on these classifications, refer to Guidelines for Carcinogenic Risk Assessment (51 Federal Register 33992).

TABLE 1. CARCINOGENICITY OF POLLUTANT LIFETIME EXPOSURE TO A UNIT POLLUTANT CONCENTRATION

Pollutant	Unit Risk Factor $(ug/m^3)^{-1}$ [a]	Weight of Evidence Rating	Source of Data
Acrylamide	0.0013	B2	IRIS
Acrylonitrile	0.000068	B1	IRIS
Arsenic	0.0043	A	IRIS
Asbestos	0 0076	A	IRIS
Benzene	0 0000083	A	IRIS
Benzo(a)pyrene (B(a)P)[b]	0 0017	B2	OAQPS
Beryllium	0 0024	B2	IRIS
1,3-Butadiene	0.00028	B2	IRIS
Cadmium	0.0018	B1	IRIS
Carbon Tetrachloride	0 000015	B2	IRIS
Chloroform	0.000023	B2	IRIS
Hexavalent Chromium	0.012	A	IRIS
Coke Oven Emissions	0.00062	A	IRIS
Dioxins (2,3,7,8-TCDD)[c]	33.0	B2	OHEA
Epichlorohydrin	0.0000012	B2	IRIS
Ethylene Dibromide	0.00022	B2	IRIS
Ethylene Dichloride	0.000026	B2	IRIS
Ethylene Oxide	0.0001	B1-B2	OHEA
Formaldehyde	0.000013	B1	IRIS
Gasoline Vapors	0.00000066	B2	OAQPS
Hexachlorobenzene	0.00046	B2	IRIS
Methyl Chloride	0.0000018	C	OHEA
Methylene Chloride	0.00000047	B2	IRIS
Perchloroethylene	0.00000058	B2	OHEA
Polychlorinated byphenyls (PCBs)	0.0022	B2	OHEA
Propylene Oxide	0.0000037	B2	IRIS
Styrene	0.00000057	B2	OHEA
Trichloroethylene	0.0000017	B2	OHEA
Vinyl Chloride	0.000084	A	OHEA
Vinylidene Chloride	0.00005	C	IRIS

A	-	Known human carcinogen	B	-	Probable human Carcinogen
B1	-	Based on "limited" human data	B2	-	Based on "sufficient" animal data
C	-	Possible human carcinogen			

HERL	Health Effects Research Laboratory	IRIS:	Integrated Risk Information System
OAQPS	Office of Air Quality Planning and Standards	OHEA	Office of Health and Environmental Assessment

[a] The unit risk factor is defined as an estimate of the probability that an individual will develop cancer when exposed to a pollutant at an ambient concentration of one microgram per cubic meter (ug/m^3) for 70 years These unit risk factors are either upper-bound values or maximum likelihood values

[b] Surrogate unit factor to represent the polycyclic organic matter (POM) mixture when no POM unit risk factor derived by comparative potency approach is available for the source

[c] 2,3,7,8-TCDD surrogate unit factor to represent the dioxin mixture

TABLE 2
POM/PARTICULATE MATTER CARCINOGENICITY DERIVED BY COMPARATIVE POTENCY APPROACH

Pollutant	Combustion Source	Unit Risk Factor $(ug/m^3)^{-1}$	Weight of Evidence Rating	Source of Data
POM	Residential Woodstoves	0.000029	nd[b]	HERL[c]
Particulate Matter[a]	Residential Heating (Oil)	0.000009	nd	HERL
	Diesel Vehicles	0.000017	B2	AWMA[d]
	Gasoline Road Vehicles	0.000051	nd	HERL
	Gasoline Nonroad Engines	0.000016	nd	HERL
	Piston Aircraft Engines	0.000016	nd	HERL
	Turbine Aircraft Engines	0.000017	B2	AWMA

[a] These factors have been adjusted such that they are applied to the total particle concentration to estimate risk from the POM fraction of the particulate matter

[b] "nd" indicates "not determined". Lewtas (1991) recommends class A ratings, but these unit risk estimates have not been officially classified by U.S. EPA.

[c] Indicates the U.S. EPA Health Effects Research Laboratory

[d] Indicates information extracted from the Air and Waste Management Association (AWMA) publication by Pepelko and Ris (1992)

CHAPTER III
STUDY METHODOLOGY

III.1 EMISSIONS INVENTORY

III.1.1 *SOUTHEAST CHICAGO INVENTORY*

The emissions inventory used in the Southeast Chicago Study was utilized as the primary emissions inventory in this study. The emissions inventory is described in detail in separate reports. A detailed description of the inventory is given in a July 1987 report entitled Air Toxics Emissions Inventory for the Southeast Chicago Area, authored by John Summerhays and Harriet Croke. This report documents emission estimates for a wide range of source types, including source types that are traditionally inventoried in air pollution studies as well as some source types that are not traditionally inventoried such as volatilization from wastewater at sewage treatment plants. An addendum to this report (dated August 1989) updates it by describing limited revisions to the previously described inventory. The addendum describes procedures and results of estimating air emissions from various waste handling sources including facilities for the treatment, storage, and disposal of hazardous waste, abandoned hazardous waste sites, and landfills storing municipal waste. Further details on the estimation of air emissions from the handling of hazardous and nonhazardous waste are provided in two reports by the Midwest Research Institute: Estimation of Hazardous Air Emissions in Southeast Chicago Contributed by TSDFs, covering air emissions from the treatment, storage, and disposal of hazardous waste facilities and Estimation of Hazardous Air Emissions from Sanitary Landfills, covering air emissions from landfills for ordinary municipal solid waste. Further details for abandoned waste sites are given in a report by Alliance Technologies Corporation entitled Estimation of Air Emissions from Abandoned Waste Sites in the Southeast Chicago Area. The reader interested in more details on the procedures, data sources, and emissions should consult these separate reports.

There are 174 industrial point sources contained in the point source emissions inventory previously prepared for the Southeast Chicago study. These point sources were grouped under four major industry categories: Steel Mills, Wastewater Treatment Facilities, Chrome Platers, and Other Industrial Point Sources. The groupings were done to provide a basis for risk analysis by major industrial source types.

Emissions from the Treatment, Storage, and Disposal Facilities (TSDFs) were considered as well. Among all 75 TSDF point sources inventoried, three major source categories were assigned to distinguish their industrial types. The three source categories were the Resource Conservation and Recovery Act (RCRA)-regulated Hazardous Waste Sites, Municipal Waste Landfills, and Other Hazardous Waste TSDFs.

Because of the nature of the industry and emissions, some source categories included in the study can only be inventoried as area sources. These source categories are as follows,

- Road Vehicles
- Gasoline Marketing
- Barge Loading
- Industrial Heating
- Commercial Heating
- Residential Heating
- Residential Wood Combustion
- Dry Cleaners
- Degreasing
- Surface Coating
- Hospitals
- Paint Strippers
- Demolition
- Chrome Platers (in Lake County, Indiana only)
- Per Capita Area Sources

Examples of per capita area sources inventoried are aerosol cans, paint stripping, and chlorinated drinking water.

III.1.2 *ADDITIONAL POINT SOURCES*

A search of the Toxic Release Inventory (TRI) database was conducted for new or additional sources to add to the inventory. Most of the sources listed in the TRI database were already included in the Southeast Chicago inventory. Sources of concern to the community were particularly scrutinized. Two proposed sources (Robbins Incinerator and Sun Chemical Incinerator) were added to the inventory to assess potential impact. In addition to the TRI database, information from RCRA permits and Illinois Environmental Protection Agency (IEPA) records were obtained. Six point sources were identified and added to the inventory. A detailed description of these additional sources is included in Appendix A. A list of the additional point sources and Midway Airport, as well as the emissions considered in the cancer risk assessment is provided in Table 3.

Mercury, considered non-carcinogenic in this study, from the proposed Robbins Incinerator was initially estimated at 2.2 tons per year. However, Robbins Incinerator is now committed to carbon injection to control Mercury. Pursuant to consent decree, emissions must not exceed 0.44 tons per year. The records on the General Electric PCB Reclamation facility were scrutinized for any actual or potential PCB emissions. U.S. EPA PCB inspectors found no PCB emissions from this facility.

TABLE 3
ADDITIONAL SOURCES AND ESTIMATED EMISSIONS

Facility Name	Pollutant	Emissions
KOPPERS, INC.		
From State permit	Styrene	0.4 tons/yr
CORN PRODUCTS		
From the final report of Air Toxics Emission Inventories for the Lake Michigan Region	Arsenic	36.0 lbs/yr
	Cadmium	3.8 lbs/yr
	Total Chromium	33 4 lbs/yr
	Formaldehyde	548.8 lbs/yr
	Benzene	4.0 lbs/yr
GE PCB RECLAMATION FACILITY		
From RCRA, EPA ID ILD070015714	Tetrachloroethylene	0 002 lbs/yr
GRACE SPECIALTY CHEMICALS		
From TRI data	Formaldehyde	230 lbs/yr
SUN CHEMICAL		
From RCRA (Proposed incinerator, project has been withdrawn by the company)	Arsenic	0.142 lbs/yr
	Benzene	2.212 lbs/yr
	Beryllium	0.030 lbs/yr
	Cadmium	0.048 lbs/yr
	Chromium	7.048 lbs/yr
ROBBINS INCINERATOR[a]		
From State permit (Proposed)	Arsenic	20.148 lbs/yr
	Cadmium	16.644 lbs/yr
	Total Chromium	289.080 lbs/yr
	Dioxins	2.000 ng/m^3
AIRCRAFT EMISSIONS AT MIDWAY AIRPORT	Benzene	8.99 tons/yr
	1,3-Butadiene	7.60 tons/yr
	Formaldehyde	62.86 tons/yr
	Particulate Matter (Piston Engines)	1.23 tons/yr
	Particulate Matter (Turbojet/Turboprop Engines)	48.87 tons/yr
ROAD VEHICLE EMISSIONS FROM PARKING LOTS AT MIDWAY AIRPORT	Benzene	0.332 tons/yr
	1,3-Butadiene	0.055 tons/yr
	Formaldehyde	0.118 tons/yr
	Particulate Matter (Diesel Vehicles)	0.190 tons/yr
	Particulate Matter (Gasoline Vehicles)	0.068 tons/yr

The first four point sources listed in Table 3 were classified as Other Industrial Point Sources and appended to the Southeast Chicago point source emissions inventory. Sun Chemical Incinerator and Robbins Incinerator, two proposed facilities, were not considered when the aggregated cancer cases in the Southwest Chicago area were analyzed even though they were inventoried. Instead, these two facilities were singled out and the risk assessment for each of them was conducted separately. The results of the study are not significantly affected by either facility.

III.1.3 *EMISSIONS AT MIDWAY AIRPORT*

Midway Airport is located within the target 8 x 8 receptor grid network. An area source inventory was set up to scrutinize the estimated emissions from mobile sources at Midway. Based on the technical directives from OMS, the emissions inventory of the Midway Airport area source compasses a 1.7 kilometer x 1.7 kilometer square with the southwest corner of (UTMY,UTMX) = (4625.2,436.64). The main focus of the Midway emissions inventory is emissions from aircraft engines. Emissions by aviation category from all phases of the landing and takeoff (LTO) cycle (approach, taxi/idle, takeoff, and climbout) among all aircraft in 1990 were estimated. Twenty-five 340-meter by 340-meter emission grids were arbitrarily assigned covering the Midway Airport area for use in CDM modeling.

The last source listed in Table 3, the estimated vehicular emissions, occurred in three parking lots and the passenger pick-up and drop-off lane (Helen Mikols Drive) at Midway. The methodologies utilized to estimate air pollution from mobile sources at Midway in greater detail in Appendix B. Figure 4 provides a general layout of Midway Airport and assigned emission grids in the study. A detailed layout of Midway can be found in Appendix B as well.

III.1.4 *NONROAD MOBILE SOURCE EMISSIONS INVENTORY*

Nonroad mobile sources such as lawn mowers and snowblowers usually contribute significantly to air pollution in a highly populated area and , if feasible, must be accounted for in an adequate risk assessment. Based on Nonroad Engine Emission Inventories for CO and Ozone Nonattainment Boundaries - Chicago CMSA (1992) provided by OMS, emissions from nonroad engines were estimated for the study. The source report was prepared for OMS in response to calls for the nonattainment area emissions inventory development. It provides the county emissions per person per criteria pollutant data computed using an equipment's population in a given region, the average load factor at which the equipment's engine is operated, the average annual hours of use and the horsepower rating of the engine, and the emission factor attributable to the engine. For this Southwest Chicago risk assessment study, the county emissions per person data were used in conjunction with the available population data to calculate

the total annual hydrocarbons (THC) and particulate matter emissions in the inventoried portion of each of the four counties. Emissions of benzene, 1,3-butadiene, and formaldehyde were prepared using the toxic/THC fractions suggested by OMS in Table 4.

TABLE 4
NONROAD MOBILE SOURCE TOXIC FRACTIONS OF THC

Pollutant	Toxic/THC Fraction
Benzene	3.0% of Exhaust THC (including Crankcase THC) + 1.7% of Evaporative THC
1,3-Butadiene	1.3% of Exhaust THC (including Crankcase THC)
Formaldehyde	1.1% of Exhaust THC (including Crankcase THC)

Estimated annual emissions from nonroad mobile sources in the study area are presented in Table 5. It must be noted that nonroad mobile sources operated at Midway were also included in these estimates as stated in the source report.

TABLE 5
NONROAD MOBILE SOURCE EMISSIONS INVENTORY
(Emissions in tons/yr)

County	Benzene	1,3-Butadiene	Formaldehyde	Gasoline[a] Particulate	Diesel Particulate
Cook	157.67	66.18	56.00	82.61	668.98
Du Page	4.07	1.71	1.45	2.13	17.28
Will	4.10	1.72	1.45	2.15	17.38
Lake, IN	29.43	12.48	10.56	17.15	82.24

[a] Includes particulate matter emissions from both 2-stroke and 4-stroke engines

Southwest Chicago Study

Midway Area Source Emission Grids

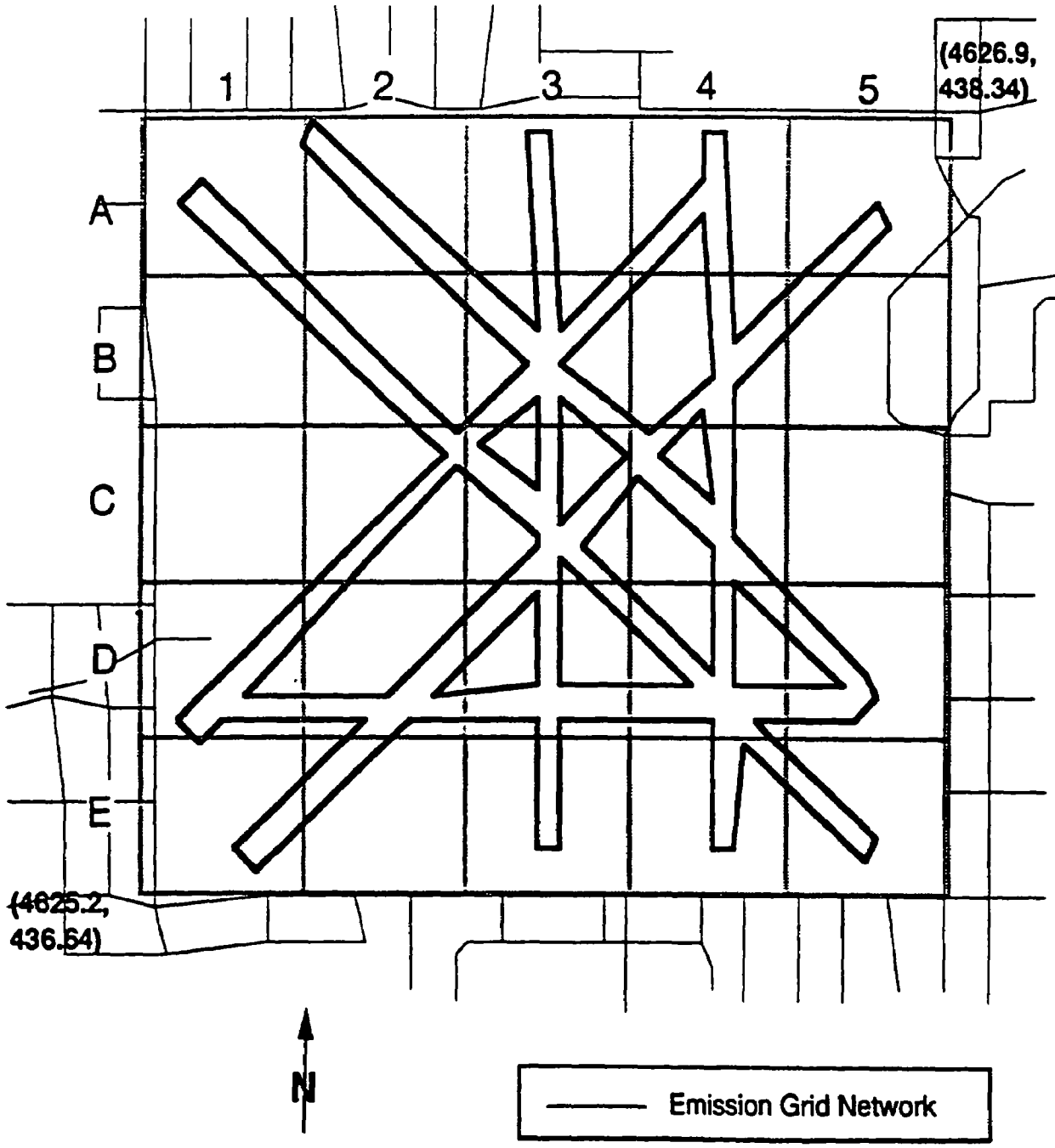


FIGURE 4

III.1.5 *EMISSIONS TO THE NORTH OF THE RECEPTOR AREA*

The original Southeast Chicago study area did not include sources to the north of the receptor area. For this study, carcinogenic air emissions as far as 16 kilometers (10 miles) to the north of the Southwest Chicago receptor area were estimated for both point sources and area sources. Point source emission were taken from the Aerometric Information and Retrieval System Facility Subsystem (AIRS/AFS). This data system contains all point sources which emit at least 100 tons per year of volatile organic compounds (VOCs) and/or particulate matter. The emissions data were speciated, by accessing the U.S. EPA SPECIATE database system, to reflect metals from particulate matter and various organics from the VOC data. The total number of facilities that emit the pollutants studied in the northern area is 34. Area source data were estimated using the area source data from the Southeast Chicago inventory. The population was calculated using U.S. Census' Block Group/Enumeration Districts (BGED) centroid data of 1980, at 2-kilometer by 2-kilometer grid cells and overall emissions in the northern area were proportioned based on the percentage of the population at individual grid cells to the total number of people residing in the northern area. The assumption was made that emissions from source categories were distributed based mainly on population density. To be consistent with the Southeast Chicago study, BGED data of 1980 were chosen rather than the recently released 1990 U.S. Census population data. Area source emissions in the area north to the receptor area covered every source type inventoried in the Southeast Chicago inventory, except barge loading.

To avoid any duplication in the northern area emissions inventory, point source emissions from two types of processes, surface coating and degreasing, were subtracted from emissions estimated for the corresponding area source categories. Figure 5 shows the relative location of the northern area to the receptor network and area emission grids defined within it.

III.1.6 *REVISIONS TO THE SOUTHEAST CHICAGO VEHICULAR EMISSIONS INVENTORY*

The Southeast Chicago road vehicle emissions inventory was revisited in this study to take into account vehicular emissions information available in the 1990 Baseline Emissions Inventory prepared by IEPA using MOBILE4.1. With the OMS-suggested emission factors and toxic fractions, vehicular emissions considered in the study area were updated based on vehicle mix in the 1990 fleet, vehicle miles travelled (VMT), and VOC/total organic gases (TOG) emissions.

Particulate matter emission estimates, replacing the previous POM emission estimates, were divided into diesel and gasoline particulate matter emissions for a more specific particulate matter assessment. Conversely, emissions of dioxins, ethylene dibromide, and gasoline vapors were deleted since emission factors of these carcinogens calculating emissions based on VOC amounts are very uncertain for this emission source. Other carcinogens included in the inventory

are formaldehyde, benzene, and 1,3-butadiene. Approaches and assumptions used to revise the road vehicle emissions inventory and related data sources and contents are further explained in Appendix C.

III.1.7 *REVISIONS TO THE SOUTHEAST CHICAGO PARTICULATE MATTER EMISSIONS INVENTORY*

The unit risk factor for POM previously used in the Southwest Chicago Study for residential heating and woodstoves is 1.7×10^{-3}. This unit risk factor was chosen based on the assumption that all POM could be represented by a surrogate compound, benzo(a)pyrene, or B(a)P. This approach is often referred to as the B(a)P surrogate approach. Recent U.S. EPA publications recommend the use of the comparative potency approach that applies a cancer unit risk factor to the entire mixture of POM or particulate matter emitted by each source category rather than to a particular surrogate compound. To be in line with U.S. EPA practices in risk assessment, the Southeast Chicago emissions inventory was revisited to adapt the comparative potency approach.

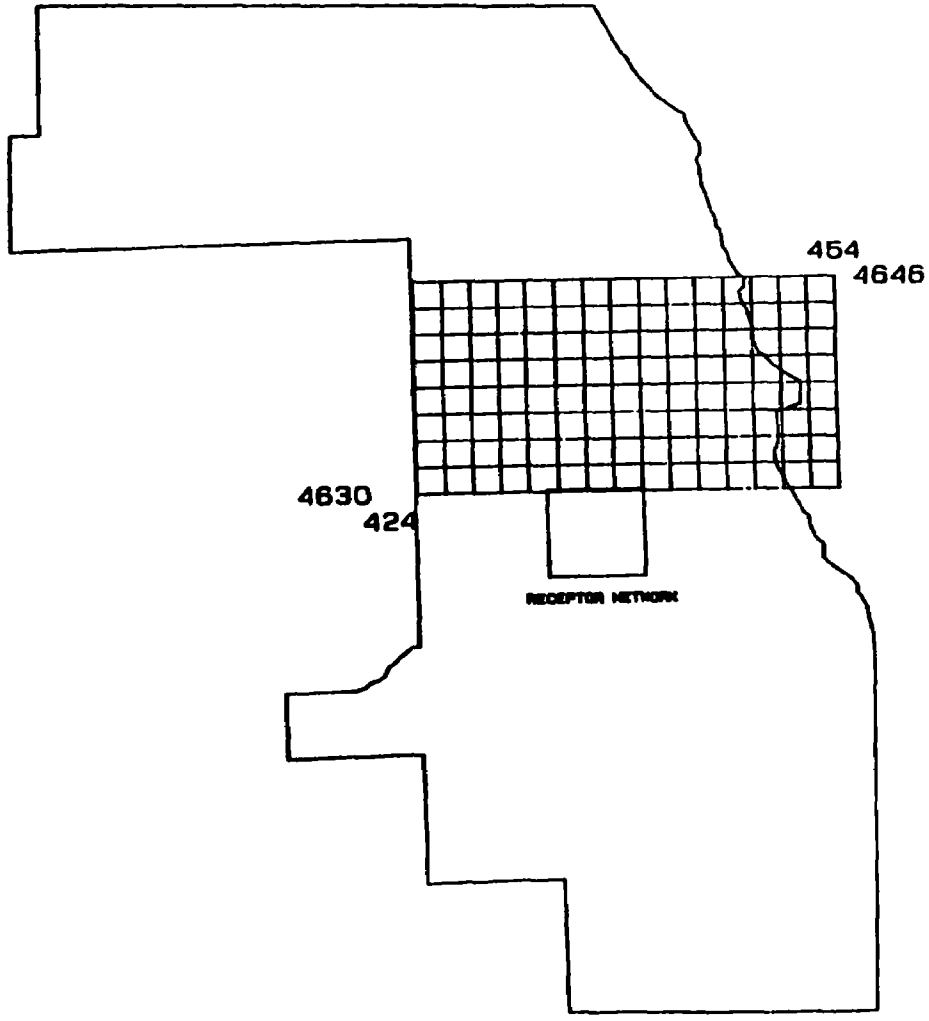
Emissions from residential heating were further broken down to particulate emissions from residential heating using distillate oil and POM emissions from residential heating using natural gas. The former has a cancer unit risk factor (0.9×10^{-5}) derived by the comparative potency approach available and the latter can only use the B(a)P surrogate unit risk factor to for cancer assessment. For residential woodstoves, POM emission amounts were not updated. However, their cancer risks were assessed based on the unit risk factor (2.9×10^{-5}) derived using the comparative potency approach in the study. Appendix D contains the technical information on approaches used in the study to analyze the POM emission sources.

III.1.8 *A NOTE ON CHROMIUM EMISSIONS*

Chromium exists in various forms with various toxicities. It is known that hexavalent chromium is the most toxic form, but it is usually not clear what mix of valence states is present in any set of emissions. In general, the Southeast Chicago emissions inventory conservatively assumed that all chromium was in the most toxic form. An exception was for point sources such as steel furnaces where a factor of 0.1% was estimated. As much as possible, the Southwest Chicago emissions inventory followed the assumptions and estimates used for the Southeast Chicago study.

The summarized air toxic releases scenario indicating the emission amounts of carcinogenic pollutants across all source categories is included in Appendix E. The total annual amount of carcinogenic air pollution analyzed in the study is about 26,832 tons per year. Information on emissions by source category is shown in Figure 6.

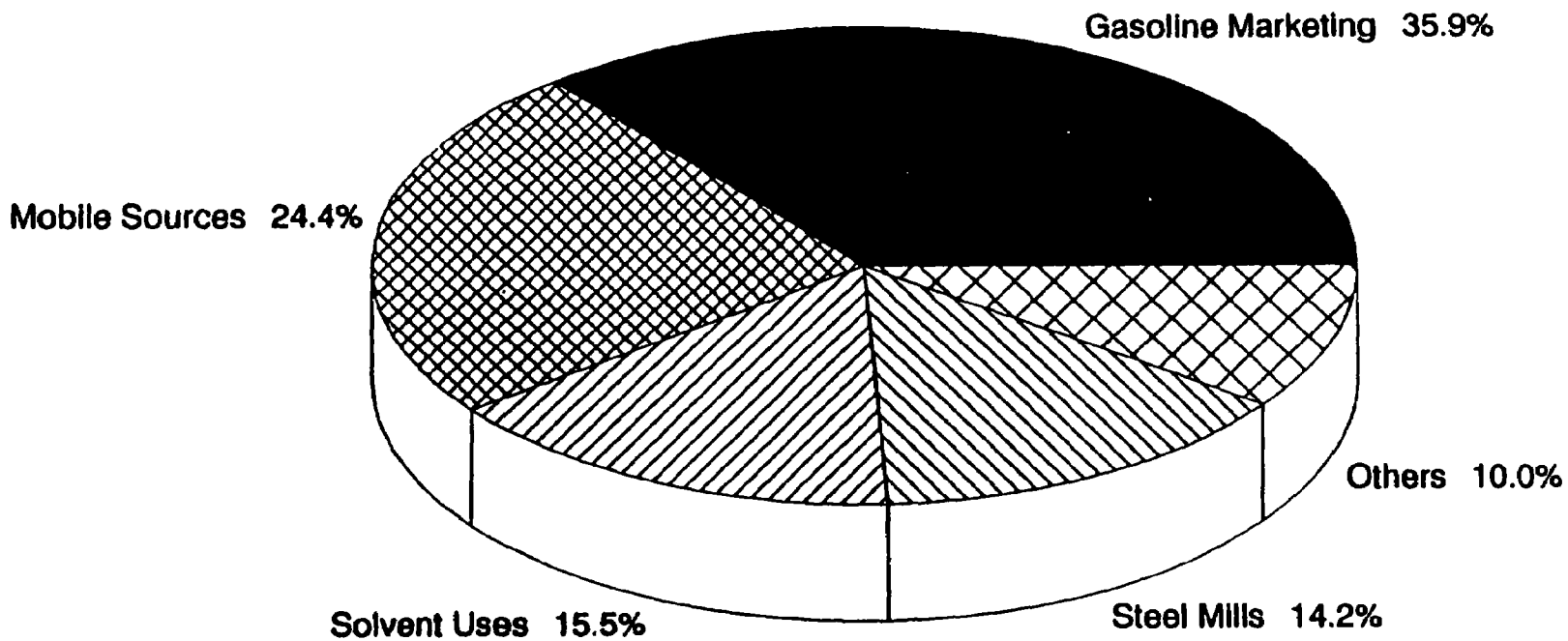
SOUTHWEST CHICAGO STUDY
2 KM BY 2 KM AREA EMISSION GRIDS IN THE NORTHERN BOUNDARY



POLITICAL BOUNDARY SHOWN
INDICATES COOK COUNTY

FIGURE 5

SOUTHWEST CHICAGO STUDY
TOXIC EMISSIONS BY SOURCE CATEGORY



TOTAL EMISSIONS = 26,832 Tons/Yr.

* Emissions are Apportioned on a Mass Basis
* Mobile Sources Include Road Vehicles, Nonroad Engines, and Aircraft Engines
* Solvent Uses Include Paint Strippers, Surface Coating, Degreasing, and Dry Cleaners
* Gasoline Marketing Toxic Emissions are Comprised Mostly of Gas Vapors

FIGURE 6

III.2 AIR DISPERSION MODELING

A risk assessment needs population, a measure of the degree of risk a particular pollutant poses (a unit risk factor), and a concentration of that pollutant. Ambient concentrations are based on the combination of the point source contribution, the area source contribution, and the background concentration which is determined and assumed. In this study, modeling techniques and methodologies used to estimate these three sources' contributions to ambient concentrations were the same as the ones applied to the Southeast Chicago study.

The Program Integration Project -- Queries Using Interactive Command (PIPQUIC) system, implemented on the U.S. EPA IBM 3090 mainframe, allows a user to access two of the U.S. EPA air dispersion models: Industrial Source Complex -- Long Term (ISCLT) and Climatological Dispersion Model (CDM). While ISCLT well serves the need for predicting concentrations from point sources, CDM gains recognition in its capability for modeling area source emissions and resulting concentrations.

PIPQUIC was accessed to proceed with the dispersion modeling tasks. However, if PIPQUIC could not provide the needed capability, customized procedures outside of PIPQUIC were established. Appendix F further describes the air dispersion modeling methodology applied to this study.

III.2.1 *BACKGROUND CONCENTRATIONS*

It is documented in the Southeast Chicago study report (Summerhays, 1989) that formaldehyde and carbon tetrachloride concentrations may be attributed to origins other than current emissions. Specifically, formaldehyde may be generated by photochemical reactions and carbon tetrachloride may be attributed to atmospheric accumulations. Since studies show that background concentrations of these two pollutants are fairly uniformly distributed, formaldehyde was assumed to have a background concentration of 2.23 ug/m^3 and carbon tetrachloride was assumed to have a background concentration of 0.76 ug/m^3, as indicated in the Southeast Chicago study report and The Transboundary Air Toxics Study (Blakley, 1990). Other than formaldehyde and carbon tetrachloride, this study considered background concentrations and inflow from area outside of the study area to be zero.

III.3 MONITORED CONCENTRATION VS. MODELED CONCENTRATION

Available monitored concentrations were compared to modeled concentrations to assess the quality of modeled outcomes. The monitored concentrations listed in Illinois Annual Air Quality Reports of 1988 and 1991 (for particulate toxicants) and 1988/89 Toxic Air Monitoring Station (TAMS) Report (for organic toxicants) were extracted for monitoring sites in or close to the receptor network. The extracted monitored data were then compared to the modeled concentrations. Results of this comparison are displayed in Tables 6 and 7.

TABLE 6

COMPARISON OF MONITORED AND MODELED CONCENTRATIONS FOR PARTICULATE TOXICANTS (concentration in ug/m³)

Pollutant	Monitoring Site	No. of Samples	Annual Arith. Mean of Monitored Concentration	Reporting Year of Monitored Data	Modeled Concentration
Arsenic	Summit[a]	57	0.002	1988	0.00074[c]
	Bedford Park[b]	58	0.001	1991	0.00064[d]
Cadmium	Summit	57	0.003	1988	0.00034[c]

[a] Located at 60th Street and 70th Avenue
[b] Located at 7800 W. 65th Street, south of Midway Airport
[c] Highest value among receptor grids No. 17-18 and 25-26, which are located in or close to the Summit monitoring site
[d] Highest value among receptor grids No. 3-8 and 11-16, which are located in or close to the Bedford Park monitoring site

TABLE 7

COMPARISON OF MONITORED AND MODELED CONCENTRATIONS
FOR ORGANIC TOXICANTS
(concentration in ug/m^3)

Pollutant	No. of Samples 1988/1989[a]	Arithmetic Mean of Monitored Concentration	Highest Modeled Concentration at Receptors[b]	Average Modeled Concentration at Receptors[c]
Benzene	22/23	6.26	0.99	0.88
Carbon Tetrachloride[d]	21/23	0.69	0.76	0.76
Formaldehyde[d]	14/-	2 43	2.81	2.65
Methyl Chloride	21/23	1.28	0 010	0.008
Methylene Chloride	21/23	2.50	1.90	1.39
Perchloroethylene	21/23	1 83	2.31	1.40
Styrene	21/23	2.13	0.0035	0.0032
Trichloroethylene	21/23	0.75	0.70	0.52

[a] TAMS Monitoring site selected is the Bedford Park site which located at 7800 W. 65th Street, south of Midway Airport.

[b] Highest value among receptor grids No. 3-8 and 11-16, which are located in or close to the Bedford Park monitoring site

[c] Average value among receptor grids No. 3-8 and 11-16, which are located in or close to the Bedford Park monitoring site

[d] Includes assumed background concentrations in the modeled data. The assumed background concentrations for carbon tetrachloride and formaldehyde are 0.76 ug/m^3 and 2.23 ug/m^3, respectively.

Please refer to the source reports for detection limits, sampling intervals, and monitoring device used at the selected monitored sites. Figures 7 and 8 display the modeled annual concentrations of arsenic and benzene, respectively, at receptor grids. By comparing the modeled concentrations at the receptors in vicinity of the monitoring sites to the monitored concentrations, this study finds that modeled concentrations are, in general, close to or less than monitored concentrations. For most pollutants, the modeled and monitored concentrations agree reasonably well (*e.g.*, same order of magnitude). In most cases, monitored data show higher concentrations than modeled data. These differences suggest that these modeled pollutant concentrations are

underestimated when compared to actual ambient concentrations. It is possible that the emissions inventory may underestimate emissions affecting the study area. This could occur by underestimating emissions at identified facilities or area sources, or by failing to identify some sources of emissions. For example, the differences between modeled and monitored concentrations for particulate toxicants may be caused by the exclusion of pollution in the form of fugitive dust in the modeling outcomes. For benzene, the difference between the modeled and monitored concentrations may be due to the long residence time of benzene in the atmosphere. Significant day-to-day carryover of benzene concentrations would be expected, but is not included in the modeled concentration. For carbon tetrachloride and formaldehyde, modeled concentrations show the slightly higher values than monitored concentrations. The potential cause of the overestimation of modeled concentrations for these two pollutants may be the assumption of the uniform background emissions in the study area since background emissions are the primary source of the modeled concentrations. Finally, yearly variation of meteorological conditions in the study area was generalized for dispersion modeling. This generalization approach may also be a contributing factor for the differences in modeled and monitored concentrations.

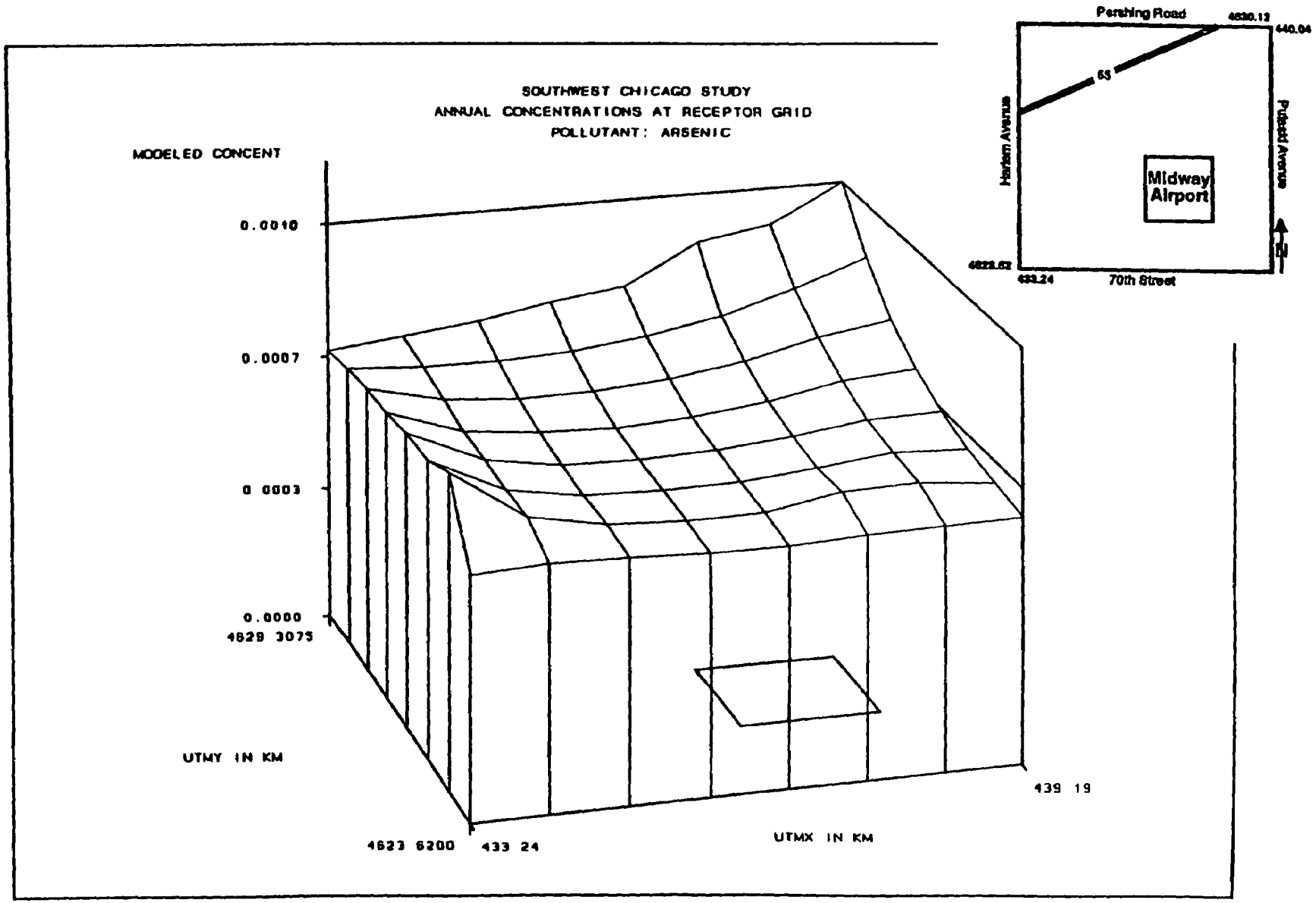

SOUTHWEST CHICAGO STUDY
ANNUAL CONCENTRATIONS AT RECEPTOR GRID
POLLUTANT: ARSENIC
MODELED CONCENT
0.0010
0.0007
0.0003
0.0000
4629 3075
UTMY IN KM
4623 6200
433 24
UTMX IN KM
439 19
Pershing Road
440.04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
N
433.24
70th Street

FIGURE 7

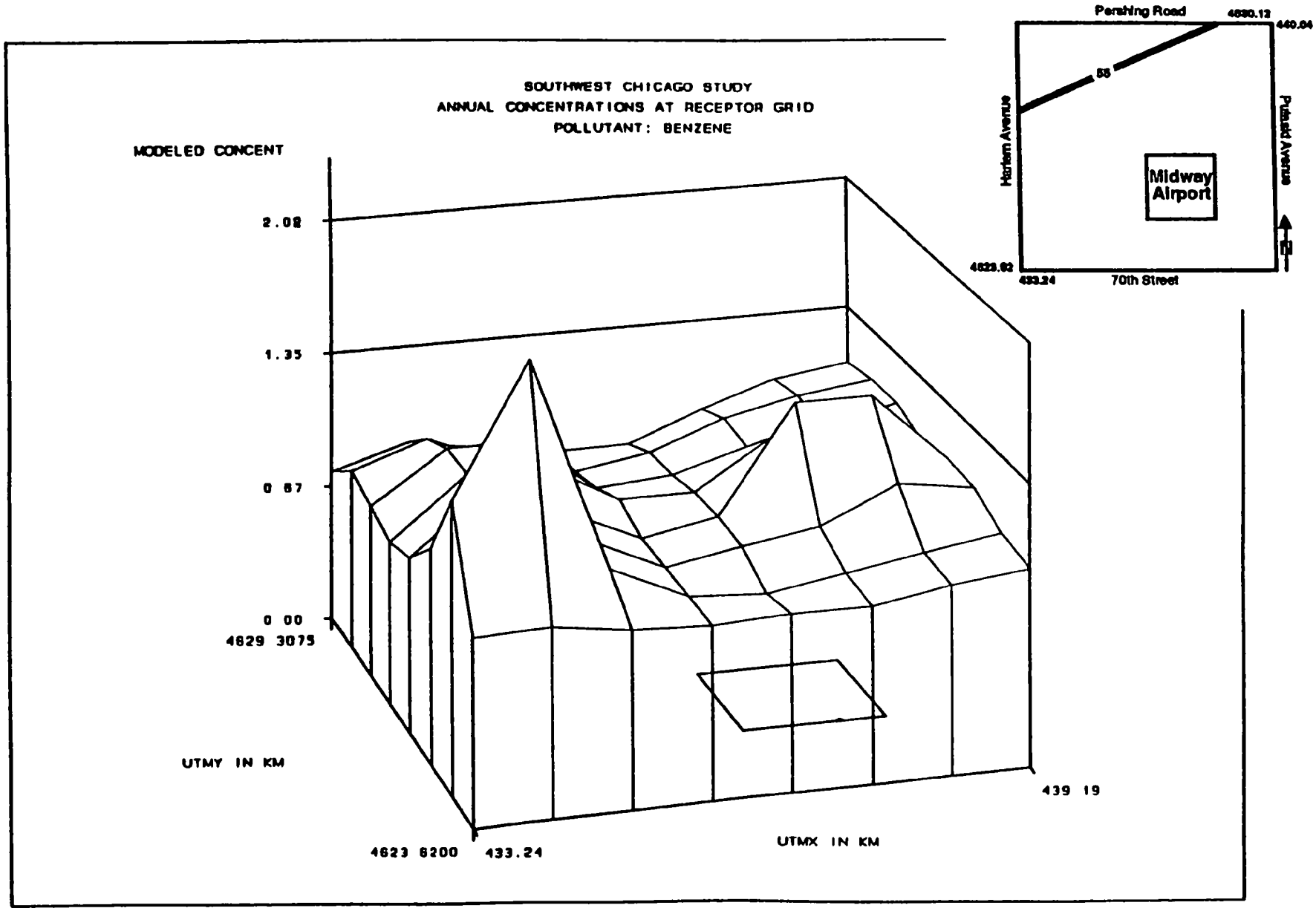

SOUTHWEST CHICAGO STUDY
ANNUAL CONCENTRATIONS AT RECEPTOR GRID
POLLUTANT: BENZENE
MODELED CONCENT
2.02
1.35
0.67
0.00
4629.3075
UTMY IN KM
4623.6200
433.24
UTMX IN KM
439.19
Pershing Road
55
Harlem Avenue
Pulaski Avenue
Midway Airport
70th Street
N

FIGURE 8

CHAPTER IV
RISK ASSESSMENT

IV.1 RISK ASSESSMENT METHODOLOGY

Once the concentration at a given receptor has been modeled for a pollutant, risk is computed as the product of the population residing in the receptor area, the concentration to which the population is exposed, and the unit risk associated with the pollutant. Dispersion models used in the study estimate average concentrations at targeted receptors. They do not have the capability for predicting maximum concentrations at receptors. The technical approaches used to conduct the risk assessment in this study are further detailed in Appendix F. The population profile and its distribution at the receptor grid network is displayed in Figure 9.

Cancer incidences presented in this report are based on the assumption that emission levels and ambient levels for each pollutant either "average out" over a 70-year period to equal the concentrations used in the calculations of annual incidence or remain constant for that period of time. In reality, emissions and air quality will vary from year to year. Because the amount and direction of variation is unknown, it is unclear how much this assumption affects the results.

As a result of the limitations and uncertainties identified throughout this report, the numerical estimates presented in this report should be viewed only as a rough indication of the potential for cancer risk caused by a limited group of pollutants found in the ambient air. While the modeled concentrations at receptors were averages, unit risk estimates are upper bound estimates. Many of the risks cited in this report are almost certainly inaccurate in an absolute sense. The best use of the risk estimates is in describing the broad nature of cancer risk posed by these air toxics and by making relative comparisons of risks across pollutants and sources.

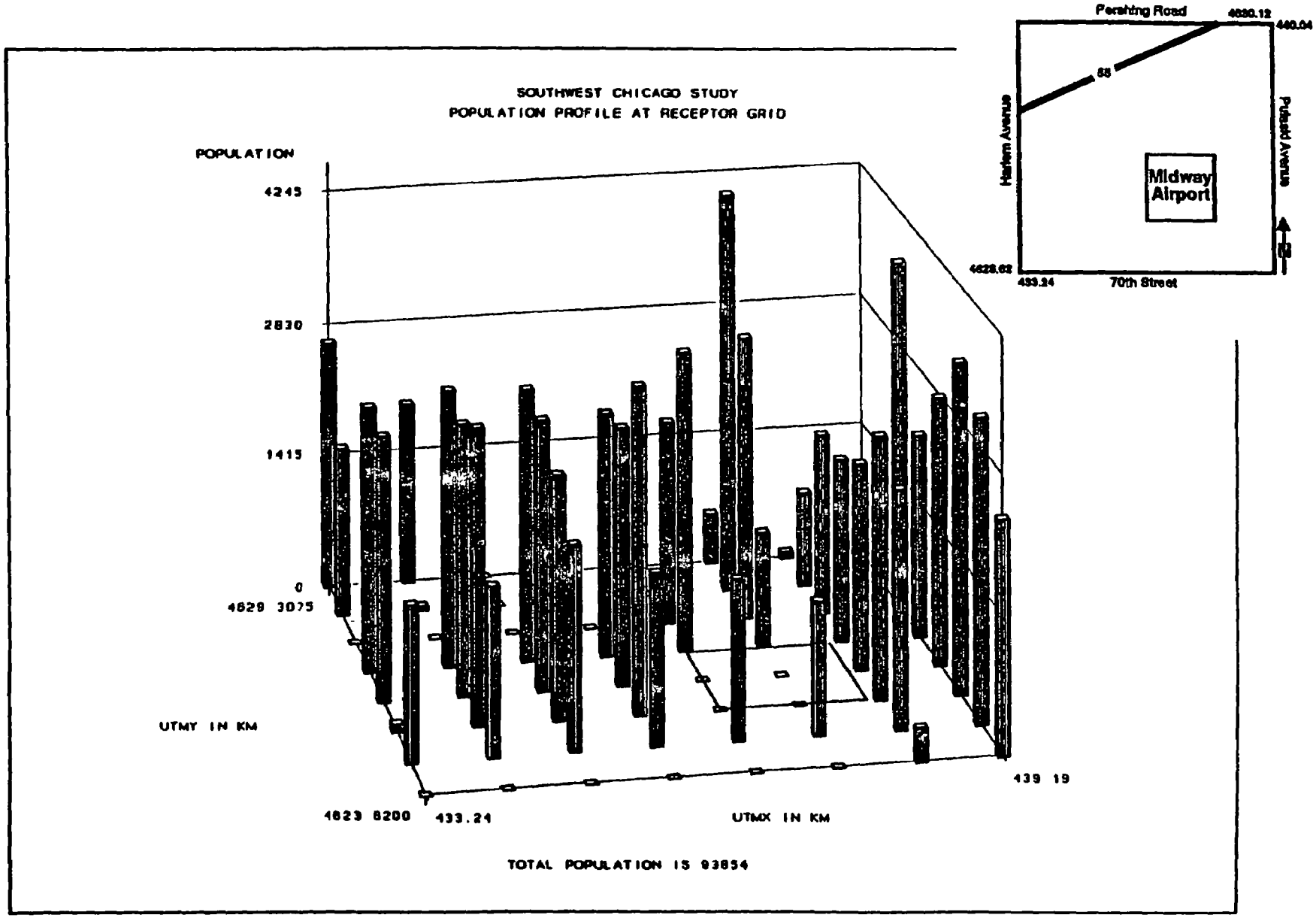

SOUTHWEST CHICAGO STUDY
POPULATION PROFILE AT RECEPTOR GRID
POPULATION
4245
2830
1415
0
4629 3075
UTMY IN KM
4623 8200
433.24
UTMX IN KM
439 19
TOTAL POPULATION IS 93854
Pershing Road
Harlem Avenue
Pulaski Avenue
70th Street
Midway Airport
55
433.24
440.04

FIGURE 9

IV.2 ESTIMATED HAZARD INDICES

IV.2.1 *OVERALL RISK ASSESSMENT RESULTS*

By summing up lifetime individual risks and lifetime cancer cases over all 64 receptors from all pollutants and source categories, the overall risk estimates within the target area can be estimated. The cumulative total number of cancer cases that this study estimated to be attributable to air pollution is about 20 cases over 70 years or about one over three and a half years. The study area for which exposure was assessed has a population of 93,854 residents. Therefore, the average risk across the area due to air pollution as estimated by this study is approximately 2.1×10^{-4}, which is very close to the average of 2.2×10^{-4} estimated in the Southeast Chicago study. This similarity in average risk may result from the high degree of urbanization in both study areas.

Also, by examining the individual lifetime risk estimated at each receptor, this study finds that the individual lifetime risk ranges from 1.3×10^{-4} to 4.2×10^{-4}. This range is in agreement with the average individual lifetime risk of 2.1×10^{-4} with no difference in the order of magnitude (order of negative 4, or 10^{-4}). This observation suggests that, throughout the study area, approximately 1 to 4 in every 10,000 people would be likely to contract cancer in their lifetimes due to being continuously exposed to toxic air pollution. The distributions of lifetime individual risks and cancer cases at the receptor grid network are shown in Table 8.

To better portray the aggregated risk scenarios in the study, Figures 10 and 11 are included to identify the distributions of the estimated hazard indices. Among all 64 receptor grids, the cumulative lifetime individual risk reaches the maximum at the receptor (UTMY,UTMX) = (4626.06,437.49), located at the middle of Midway Airport. Since no population resides on this grid, the highest number of cancer cases is estimated at the receptor grid (UTMY,UTMX) = (4626.06,434.09). The origins of lifetime cancer cases were further investigated and are described in the next two sections.

TABLE 8. AGGREGATE HAZARD INDICES AT RECEPTOR GRID[a]

Grid ID	Receptor Location (Southwest Corner)	Lifetime Individual Risks	Population	Lifetime Cancer Cases	Percent Cancer Cases
1	4623.62 433.24	1.47E-04	0	0	0
2	4623.62 434.09	1.50E-04	0	0	0
3	4623.62 434.94	1.54E-04	0	0	0
4	4623.62 435.79	1.56E-04	0	0	0
5	4623.62 436.64	1.62E-04	0	0	0
6	4623.62 437.49	1.66E-04	0	0	0
7	4623.62 438.34	1.76E-04	351	0.062	0.31
8	4623.62 439.19	1.79E-04	2396	0.43	2.13
9	4624.43 433.24	1.61E-04	1614	0.26	1.30
10	4624.43 434.09	1.88E-04	1749	0.33	1.64
11	4624.43 434.94	1.97E-04	2105	0.41	2.07
12	4624.43 435.79	1.77E-04	1775	0.31	1.56
13	4624.43 436.64	1.72E-04	1662	0.29	1.42
14	4624.43 437.49	1.80E-04	1384	0.25	1.24
15	4624.43 438.34	1.85E-04	2453	0.45	2.26
16	4624.43 439.19	1.89E-04	3159	0.60	2.98
17	4625.25 433.24	1.73E-04	91	0.015	0.078
18	4625.25 434.09	2.68E-04	3056	0.82	4.08
19	4625.25 434.94	2.69E-04	2518	0.68	3.37
20	4625.25 435.79	1.87E-04	3391	0.63	3.16
21	4625.25 436.64	2.08E-04	0	0	0
22	4625.25 437.49	2.18E-04	0	0	0
23	4625.25 438.34	2.72E-04	2723	0.74	3.69
24	4625.25 439.19	2.10E-04	3451	0.72	3.61
25	4626.06 433.24	1.74E-04	2735	0.48	2.37
26	4626.06 434.09[b]	3.64E-04	2818	1.03	5.11
27	4626.06 434.94	2.30E-04	2814	0.65	3.22
28	4626.06 435.79	1.86E-04	2680	0.50	2.48
29	4626.06 436.64	2.05E-04	0	0	0
30	4626.06 437.49	4.16E-04	0	0	0
31	4626.06 438.34	3.96E-04	2151	0.85	4.24
32	4626.06 439.19	2.21E-04	2807	0.62	3.09

[a] Aggregated over all pollutants and all source categories
[b] The grid where peak lifetime cancer cases occur

TABLE 8. AGGREGATE HAZARD INDICES AT RECEPTOR GRID (CONT'D)

Grid ID	Receptor Location (Southwest Corner)	Lifetime Individual Risks	Population	Lifetime Cancer Cases	Percent Cancer Cases
33	4626.87 433.24	1.60E-04	2769	0.44	2.21
34	4626.87 434.09	2.05E-04	2895	0.59	2.95
35	4626.87 434.94	2.33E-04	2860	0.67	3.33
36	4626.87 435.79	1.94E-04	2557	0.50	2.47
37	4626.87 436.64	1.97E-04	3154	0.62	3.10
38	4626.87 437.49	2.83E-04	1201	0.34	1.69
39	4626.87 438.34	2.66E-04	1913	0.51	2.54
40	4626.87 439.19	2.12E-04	2126	0.45	2.24
41	4627.68 433.24	1.53E-04	0	0	0
42	4627.68 434.09	1.89E-04	0	0	0
43	4627.68 434.94	2.16E-04	0	0	0
44	4627.68 435.79	2.83E-04	0	0	0
45	4627.68 436.64	2.07E-04	2138	0.44	2.21
46	4627.68 437.49	2.10E-04	2997	0.63	3.13
47	4627.68 438.34	2.19E-04	1900	0.42	2.07
48	4627.68 439.19	2.24E-04	3698	0.83	4.13
49	4628.50 433.24	1.45E-04	1767	0.26	1.28
50	4628.50 434.09	1.56E-04	48	0.0075	0.037
51	4628.50 434.94	1.69E-04	0	0	0
52	4628.50 435.79	1.95E-04	0	0	0
53	4628.50 436.64	2.03E-04	0	0	0
54	4628.50 437.49	2.14E-04	4245	0.91	4.52
55	4628.50 438.34	2.22E-04	990	0.22	1.10
56	4628.50 439.19	2.25E-04	1552	0.35	1.74
57	4629.31 433.24	1.41E-04	2638	0.37	1.86
58	4629.31 434.09	1.47E-04	1928	0.28	1.42
59	4629.31 434.94	1.57E-04	0	0	0
60	4629.31 435.79	1.78E-04	0	0	0
61	4629.31 436.64	1.79E-04	0	0	0
62	4629.31 437.49	1.93E-04	525	0.10	0.50
63	4629.31 438.34	2.08E-04	67	0.014	0.069
64	4629.31 439.19	2.14E-04	3	0.00064	0.003
Total			*93,854*	*20.07*	

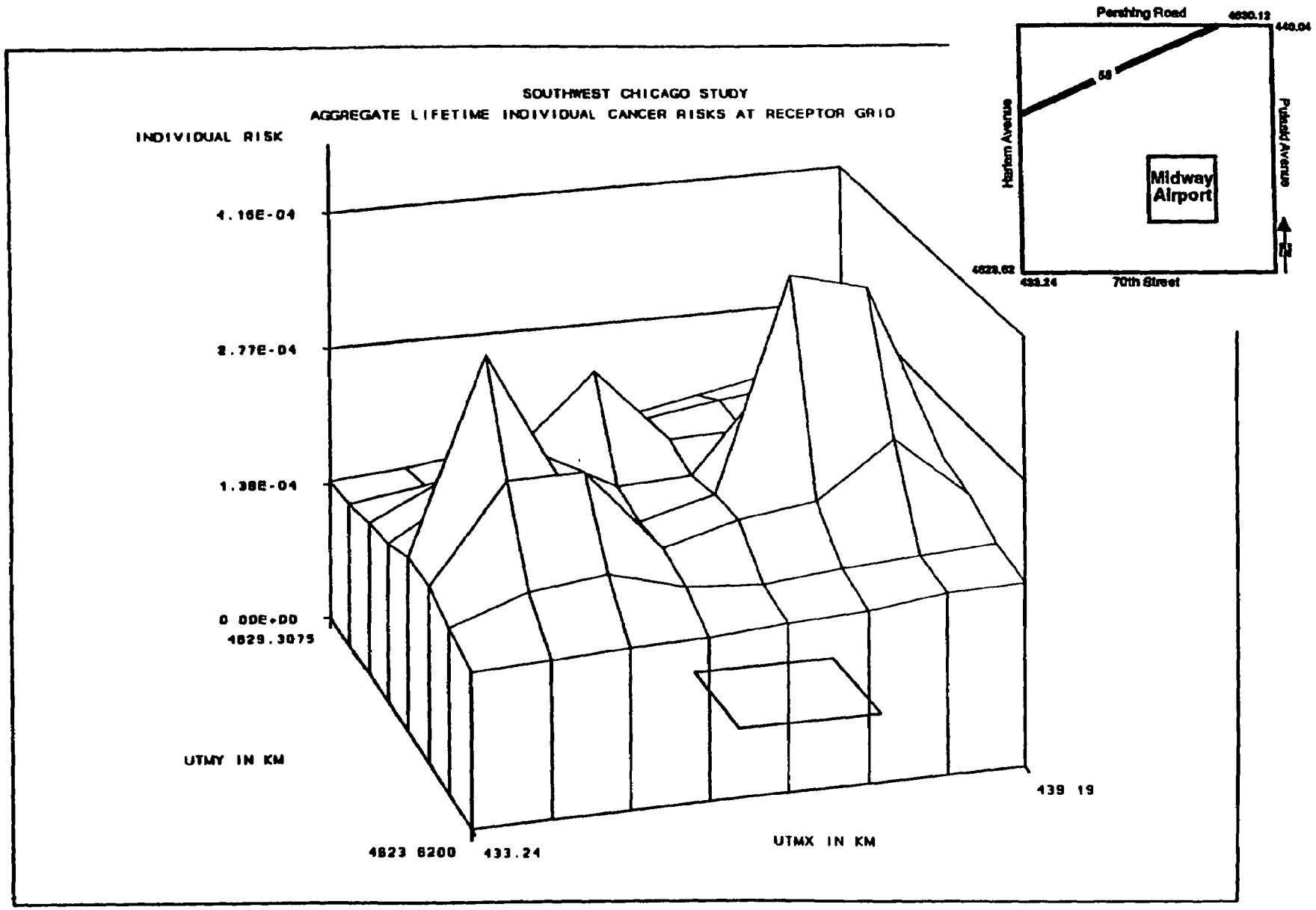

SOUTHWEST CHICAGO STUDY
AGGREGATE LIFETIME INDIVIDUAL CANCER RISKS AT RECEPTOR GRID
INDIVIDUAL RISK
4.16E-04
2.77E-04
1.38E-04
0.00E+00
4829.3075
UTMY IN KM
4823.6200
433.24
UTMX IN KM
439.19
Pershing Road
4830.12
440.04
58
Harlem Avenue
Pulaski Avenue
Midway Airport
N
4828.62
433.24
70th Street

FIGURE 10

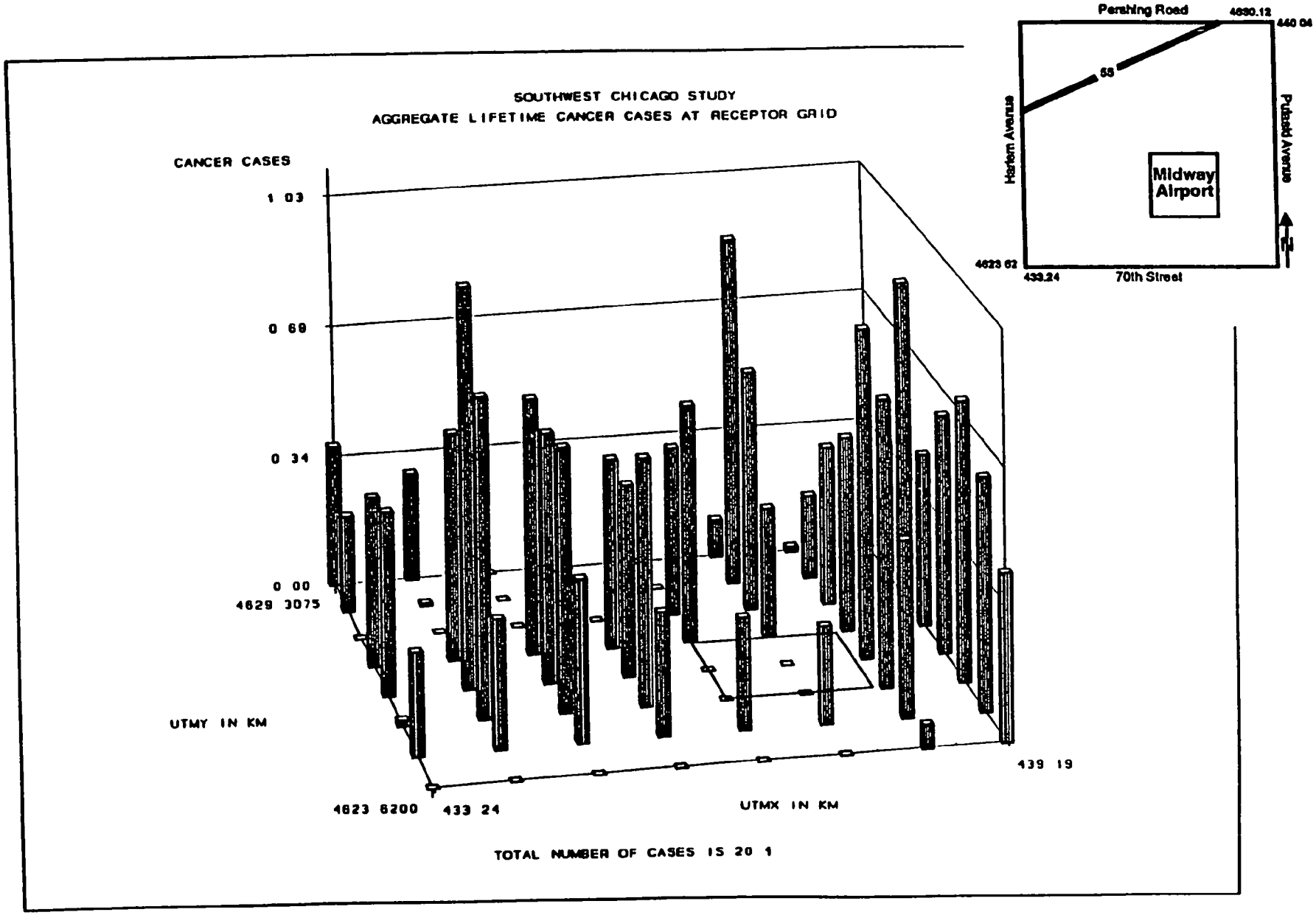

SOUTHWEST CHICAGO STUDY
AGGREGATE LIFETIME CANCER CASES AT RECEPTOR GRID
CANCER CASES
1 03
0 69
0 34
0 00
4629 3075
UTMY IN KM
4623 6200
433 24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 20 1
Pershing Road
4630.12
440 04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4623 62
433.24
70th Street
N

FIGURE 11

IV.2.2 *RISK ASSESSMENT BY SOURCE CATEGORY*

The estimated risk by source category was examined to determine some of the major contributors to cancer risk in this particular area. Table 9 indicates the contributions to risks by source category. The top five source categories (each contributes at least ten percent of the cumulative cancer cases) account for 81% (about 16 cancer cases) of the cumulative total number of estimated lifetime cancer cases (Figure 12). For many of the sources, the 1990 Clean Air Act (CAA) Amendments will regulate the air toxic emissions and reduce the consequent cancer risks.

This study finds that the major contributor to risk is the road vehicles in the study area, which contributes an estimated 5 cases over 70 years or about 25% of the total. Road vehicle emissions include emissions originated from arterial exhaust, freeway exhaust, and evaporation. Because of the high traffic and sophisticated public transportation system within and surrounding the target area, lifetime individual risks impacted by emissions from road vehicles are fairly distributed among all receptors and cancer cases vary based on population (Figure 13).

Background concentrations contribute an estimated 4 cases over 70 years or about 19% of the total. This source type consists of air pollution not caused by current emissions. As mentioned before, only formaldehyde concentrations caused by photochemical reactions and carbon tetrachloride caused by atmospheric accumulations are considered to be background concentrations in the study. Among the two pollutants, formaldehyde (close to 3 cases) generates lifetime cancer cases two and half times higher than carbon tetrachloride (1 case). Please note that the magnitude of cancer impact by background concentrations is exactly a proportioned reflection of population in the receptor area. This situation is due to the uniform annual concentration assumed at each receptor.

This study also finds that hexavalent chromium emissions emitted by electroplater job shops contribute an estimated 3 cancer cases over 70 years or about 16% of the total. The carcinogenic impact over the study area from chrome platers is portrayed in Figure 14.

Emissions from nonroad mobile sources and emissions from aircraft engines at Midway are both major contributing sources of cancer risks in the area. Each source contributes approximately 2 cancer cases over 70 years (or about 11% of the total) in the study area. For the source of nonroad engines, this result may suggest that the frequent uses of nonroad equipment correlates positively with the local population (Figure 15). Also, due to the location of Midway Airport located within the receptor grid network, it is no surprise that emissions from aircraft engines may have a significant impact on residents living in the study area, especially to people living at receptors adjacent to the airport (Figure 16). Finally, carcinogenic impacts caused by the top five source categories and emitted air toxics are described in Appendix G.

TABLE 9
AGGREGATE HAZARD INDICES BY SOURCE CATEGORY[a]

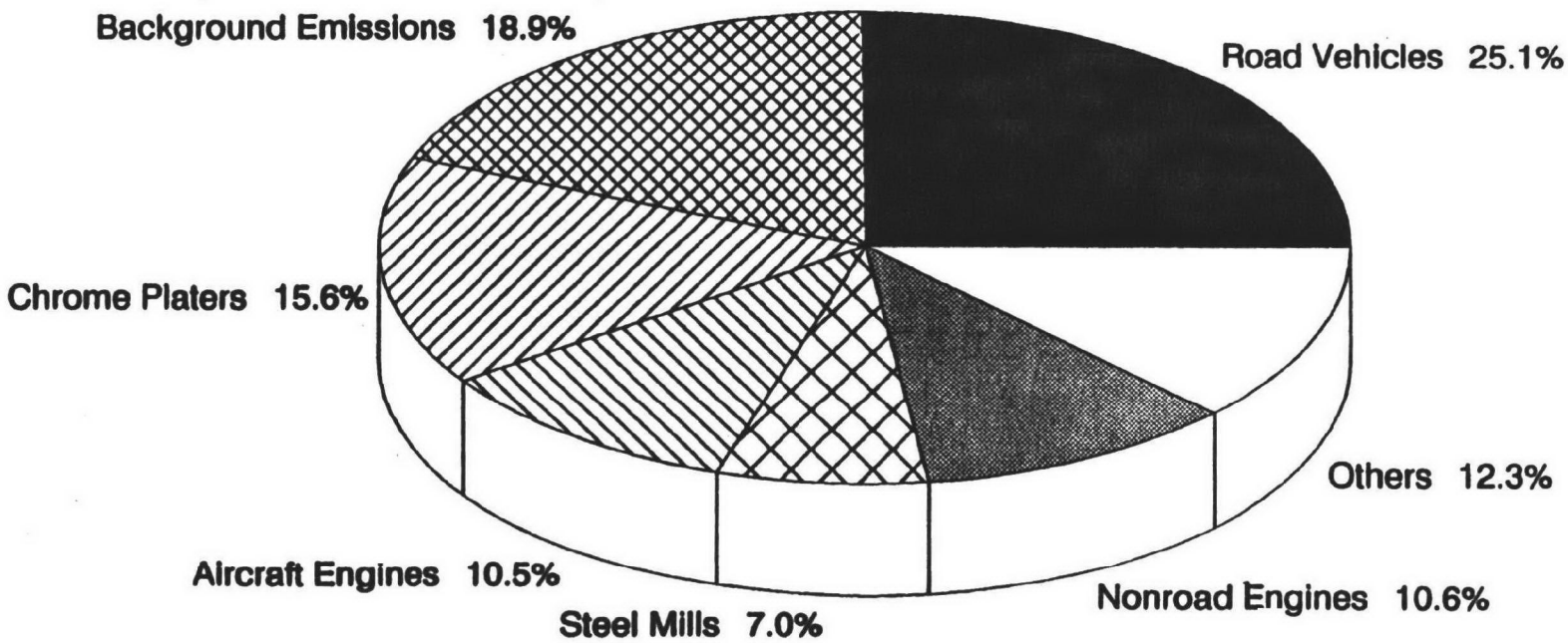
Source Category	Lifetime Individual Risks	Lifetime Cancer Cases	Percent Cancer Cases
Road Vehicles[b]	3.34E-03	5.03	25.08
Background Concentration	2.58E-03	3.79	18.88
Chrome Platers	1.78E-03	3.13	15.60
Nonroad Engines	1.34E-03	2.14	10.65
Aircraft Engines	1.42E-03	2.11	10.52
Steel Mills	9.50E-04	1.41	7.03
Other Industrial Points	4.62E-04	0.68	3.41
Cooling Towers	3.00E-04	0.45	2.24
Residential Heating	1.99E-04	0.31	1.54
Gasoline Marketing	1.66E-04	0.26	1.28
Industrial Heating	9.47E-05	0.14	0.70
Wastewater Treatment	1.72E-04	0.13	0.63
Per Capita Area Sources	7.94E-05	0.12	0.62
Commercial Heating	7.94E-05	0.12	0.61
Degreasing	6.99E-05	0.10	0.52
Hospitals	3.27E-05	0.049	0.25
Dry Cleaners	2.54E-05	0.039	0.19
Paint Strippers	1.05E-05	0.016	-[c]
Other Hazardous Waste TSDFs	7.82E-06	0.012	-
Surface Coating	6.36E-06	0.010	-
Demolition	6.28E-06	0.0098	-
Residential Wood Combustion	2.96E-06	0.0044	-
Municipal Landfills	8.94E-07	0.0013	-
RCRA Hazardous Sites	2.28E-07	0.00034	-
Barge Loading	1.17E-07	0.00017	-

[a] Aggregated over all pollutants among all receptor grids

[b] Including vehicular emissions from parking lots and Helen Mikols Drive at Midway Airport

[c] "-" indicates less than 0.1%

SOUTHWEST CHICAGO STUDY
CONTRIBUTIONS TO CANCER RISK
BY SOURCE CATEGORY



TOTAL NUMBER OF CASES = 20.1

FIGURE 12

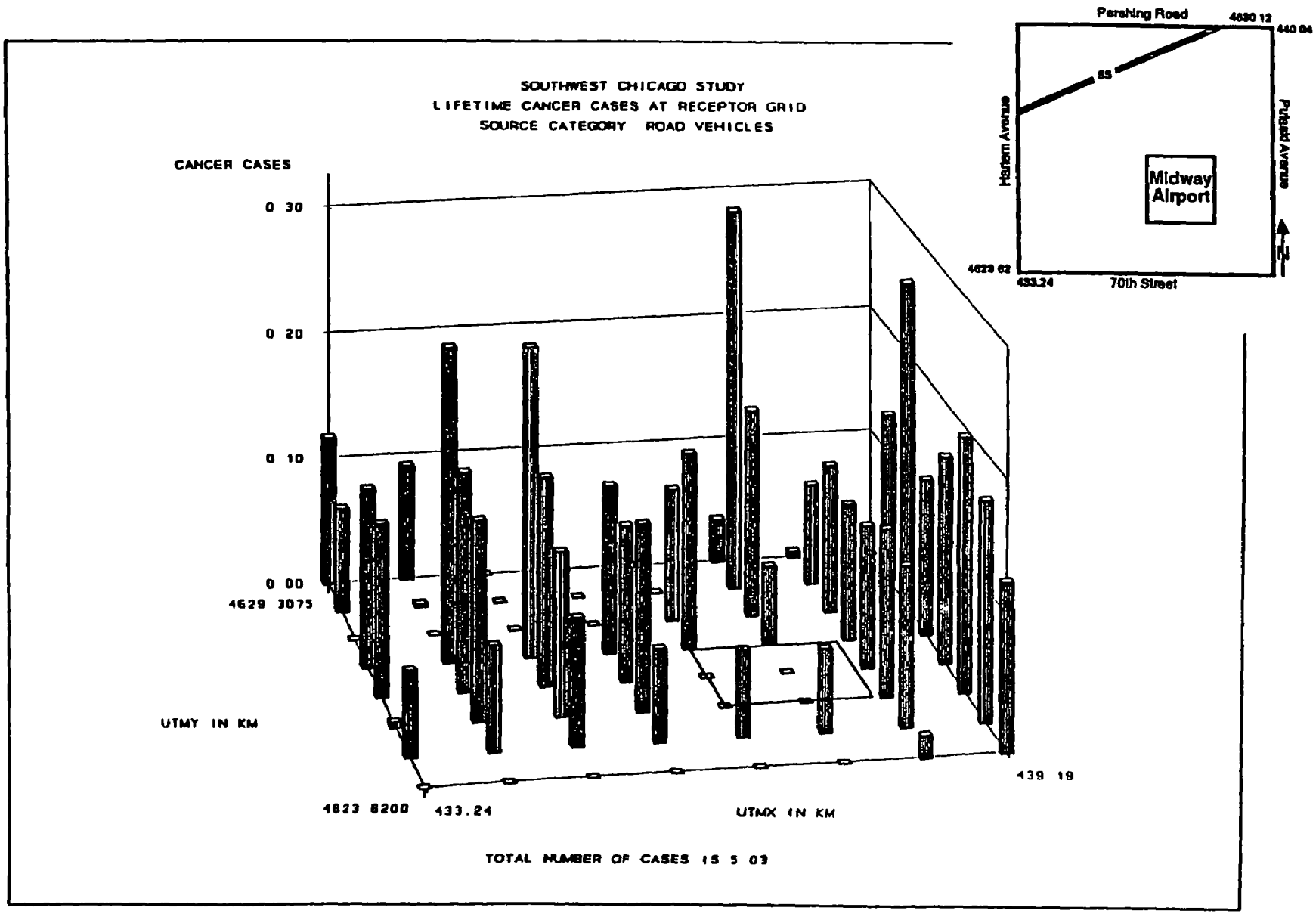

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
SOURCE CATEGORY ROAD VEHICLES
CANCER CASES
0 30
0 20
0 10
0 00
4629 3075
UTMY IN KM
4623 8200
433.24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES 15 5 03
Pershing Road
4630 12
440 04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4623 62
433.24
70th Street

FIGURE 13

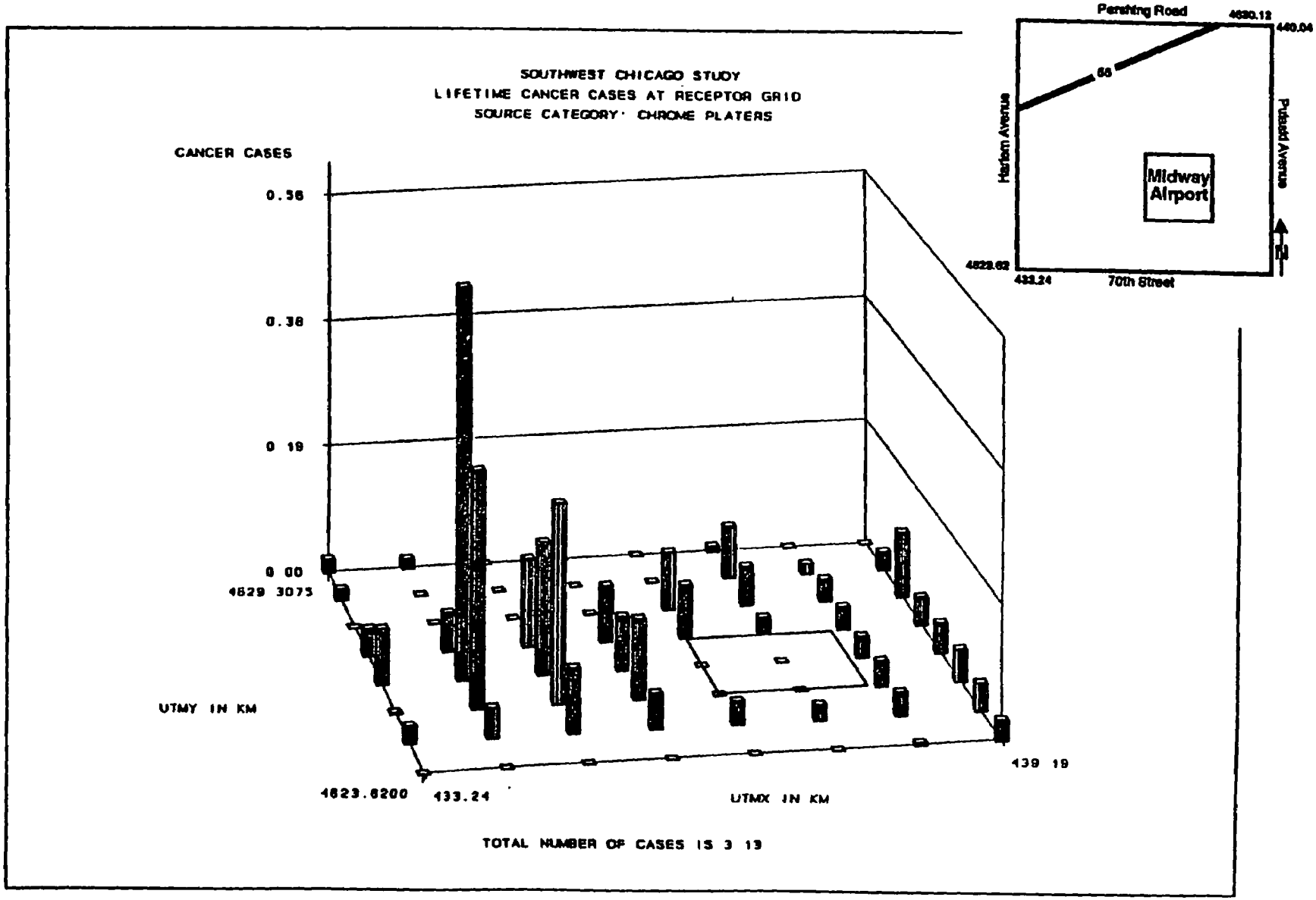

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
SOURCE CATEGORY: CHROME PLATERS
CANCER CASES
0.56
0.38
0 19
0 00
4829 3075
UTMY IN KM
4823.6200
433.24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 3 19
Pershing Road
4830.12
440.04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4828.62
433.24
70th Street
N

FIGURE 14

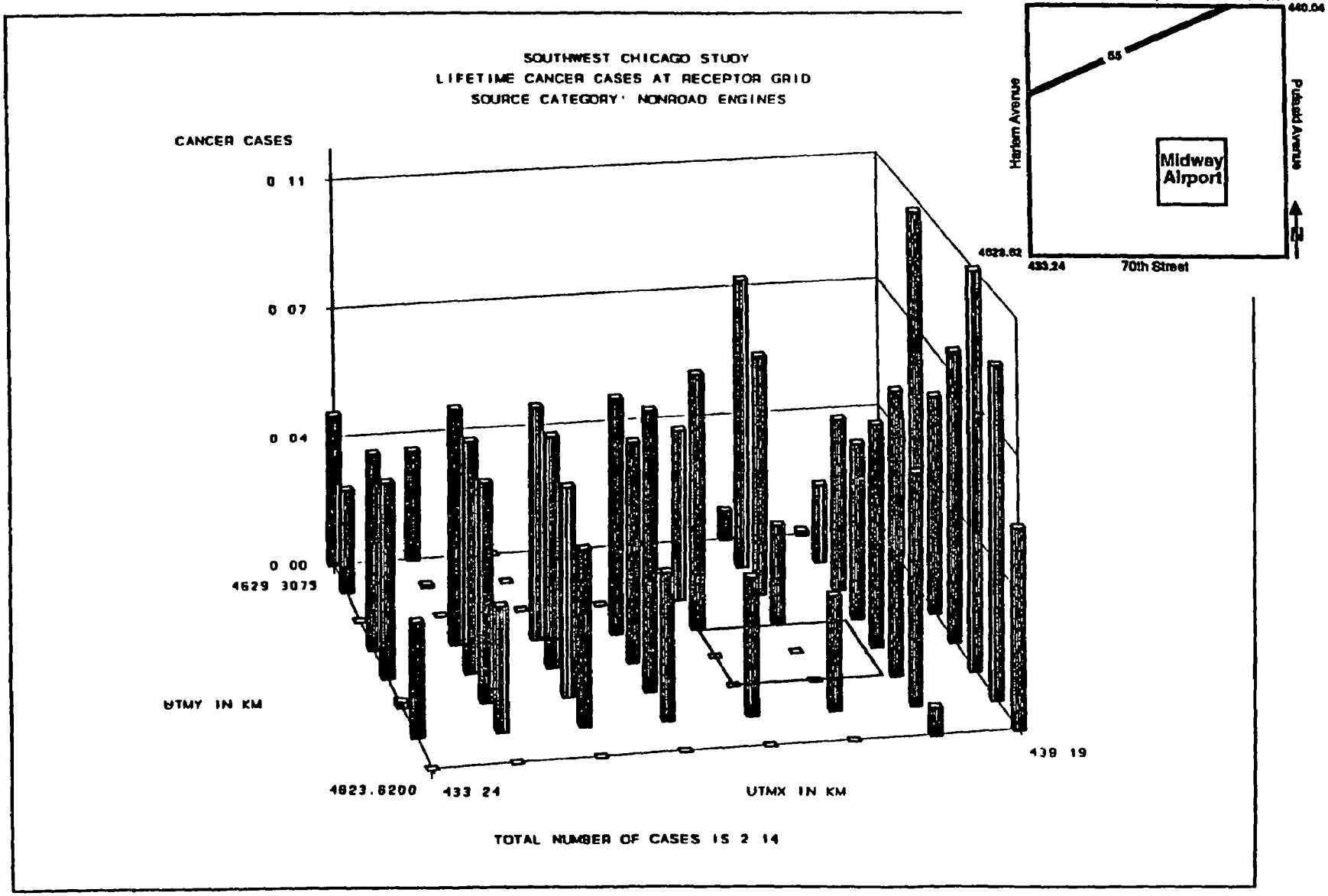

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
SOURCE CATEGORY: NONROAD ENGINES
CANCER CASES
0 11
0 07
0 04
0 00
4629 3075
UTMY IN KM
4623.6200
433 24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 2 14
Pershing Road
4630.12
440.04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4623.62
433.24
70th Street

FIGURE 15

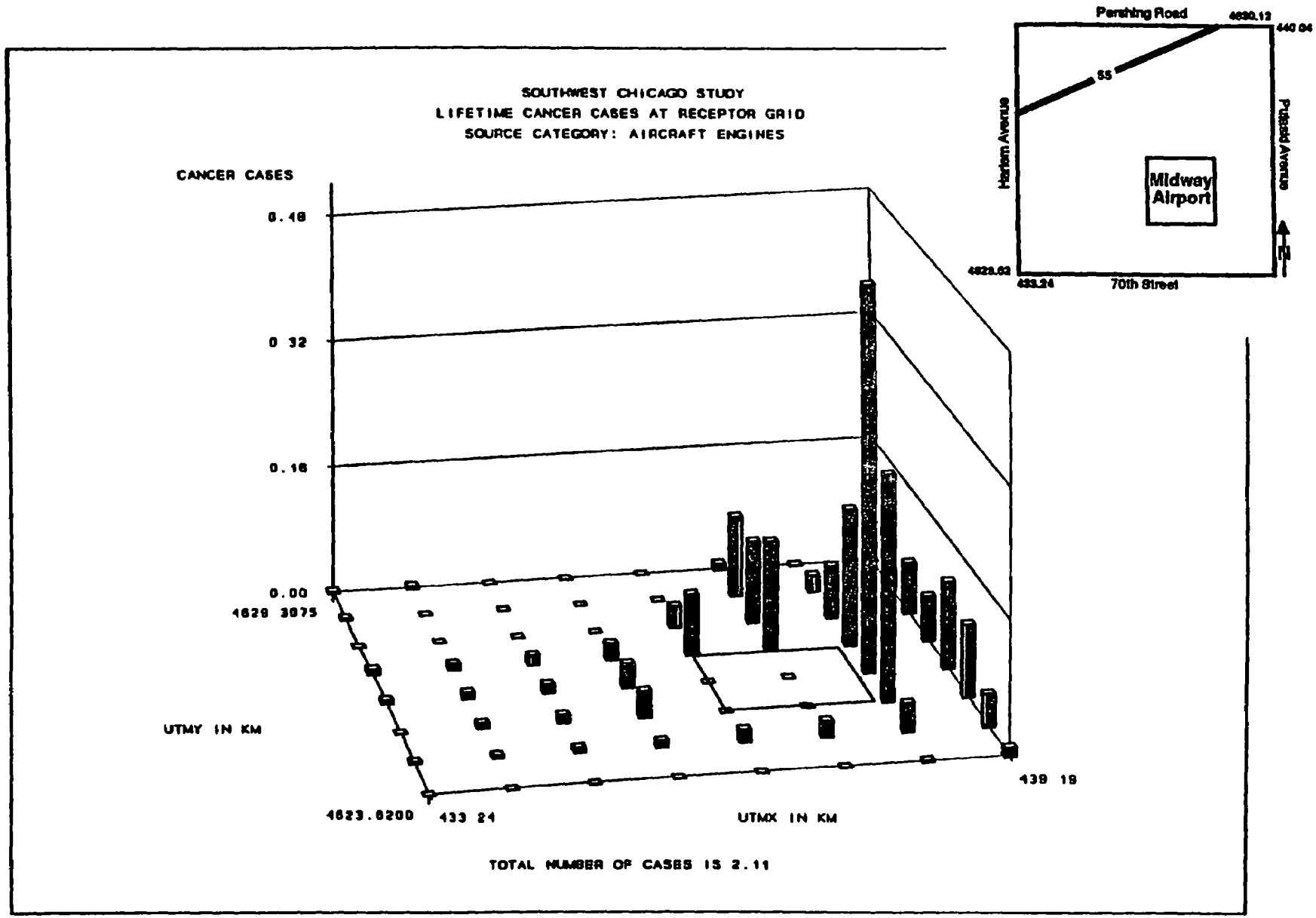

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
SOURCE CATEGORY: AIRCRAFT ENGINES
CANCER CASES
0.48
0 32
0.16
0.00
4628 3075
UTMY IN KM
4623.6200
433 24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 2.11
Pershing Road
55
Harlem Avenue
Pulaski Avenue
Midway Airport
70th Street
N

FIGURE 16

IV.2.3 *RISK ASSESSMENT BY POLLUTANT*

Because of the difference in emission amounts and unit risk values, some pollutants may dominantly contribute to the risk estimates within the Southwest Chicago area. The contributions to risks by pollutant are depicted in Table 10. Table 11 further breaks down cancer cases attributed to POM pollution by emitting origin to reflect different unit risk factors used. In the case of population lifetime risks, the top four pollutants, whose individual contributions to the cumulative cancer cases exceed ten percent, make up 79% (about 16 cancer cases) of the total number of cancer cases (Figure 17).

The primary contributor in terms of pollutant risk is 1,3-butadiene, which contributes 4 and a half cancer cases over a lifetime or about 23% of the total. Among all the sources emitting 1,3-butadiene, an estimated 4 lifetime cancer cases are attributed to emissions from mobile sources: road vehicles (2 cancer cases), aircraft engines (1 cancer case), and nonroad mobile sources (1 cancer case).

POM and particulate emissions in the study area contribute approximately 4 cancer cases over a lifetime or about 19% of the total number of cases. Prominent POM emission sources in the study area are mobile sources such as road vehicles, nonroad engines, and aircraft engines. Particulate emissions from road vehicles contribute about 2 cancer cases, and are primarily attributable to the diesel-fueled vehicle fleet. Approximately one cancer case is attributed to particulate matter emissions from nonroad mobile sources, and only about a half cancer case is attributed to particulate matter emissions from aircraft.

The third largest contributor in the area in terms of pollutant risk is hexavalent chromium. Estimated cancer cases caused by hexavalent chromium emissions account for roughly 18% of the total number of cases, or about 4 cancer cases over 70 years. The major source of emissions is chromium electroplaters, which alone results in about 3 cancer cases over a lifetime.

Emissions of formaldehyde are another significant contributor to risk. An estimated 3 and a half cancer cases over 70 years or about 18% of the total are caused by formaldehyde. About 3 cancer cases are attributed to the formaldehyde background concentrations. This assessment result is consistent with the findings stated in the previous section *Risk Assessment by Source Category* pertaining to background concentrations. Since background concentrations dominate the risks posed by formaldehyde, the relative magnitude of cancer cases estimated at receptors are very much in line with the magnitude of population at receptors. Figures 18 to 21 highlight the carcinogenic impact attributed to 1,3-butadiene, POM, hexavalent chromium, and formaldehyde in sequence. Cross contributions of the top four pollutants and their respective emission sources were examined and can be found in Appendix H.

TABLE 10
AGGREGATE HAZARD INDICES BY POLLUTANTS[a]

Pollutant	Individual Concentrations (ug/m³)	Lifetime Individual Risks	Lifetime Cancer Cases	Percent Cancer Cases
1,3-Butadiene	1 09E+01	3.06E-03	4.69	23.36
POM[b]	1 24E+02	2.50E-03	3.78	18.83
Hexavalent Chromium	1 79E-01	2.15E-03	3.69	18.38
Formaldehyde	1 87E+02	2.44E-03	3.60	17.94
Coke Oven Emissions	1 30E+00	8 05E-04	1.20	5.96
Carbon Tetrachloride	4 87E+01	7 30E-04	1.07	5.33
Benzene	6 29E+01	5.22E-04	0.80	3.96
Arsenic	4 37E-02	1.88E-04	0.27	1.35
Gasoline Vapors	2.35E+02	1.55E-04	0.24	1.19
Ethylene Oxide	1.29E+00	1.29E-04	0.19	0.94
Hexachlorobenzene	3 68E-01	1.69E-04	0.13	0.66
Trichloroethylene	3 07E+01	5.22E-05	0.077	0.38
Perchloroethylene	8.12E+01	4.71E-05	0.074	0.37
Cadmium	2.36E-02	4.25E-05	0.062	0.31
Methylene Chloride	8.25E+01	3.88E-05	0.058	0.29
Chloroform	1.68E+00	3.86E-05	0.057	0.28
Asbestos	3.03E-03	2.30E-05	0.035	0.17
Dioxins	4.34E-07	1.43E-05	0.021	0.11
Vinyl Chloride	8.61E-02	7.23E-06	0.010	-[c]
Ethylene Dichloride	3.21E-01	8.34E-06	0.0087	-
Ethylene Dibromide	2.28E-02	5.02E-06	0.0067	-
Vinylidene Chloride	4.98E-02	2.49E-06	0.0038	-
Acrylonitrile	3.90E-02	2.65E-06	0.0037	-
Methyl Chloride	5.31E-01	9.56E-07	0.0015	-
Styrene	6.58E-01	3.75E-07	0.00041	-
Acrylamide	4.34E-05	5.64E-08	0.000083	-
Epichlorohydrin	3.51E-02	4.21E-08	0.000071	-
Propylene Oxide	8.46E-03	3.13E-08	0.000045	-
PCBs	8.76E-06	1.93E-08	0.000027	-
Beryllium	1.59E-06	3.82E-09	0.0000057	-

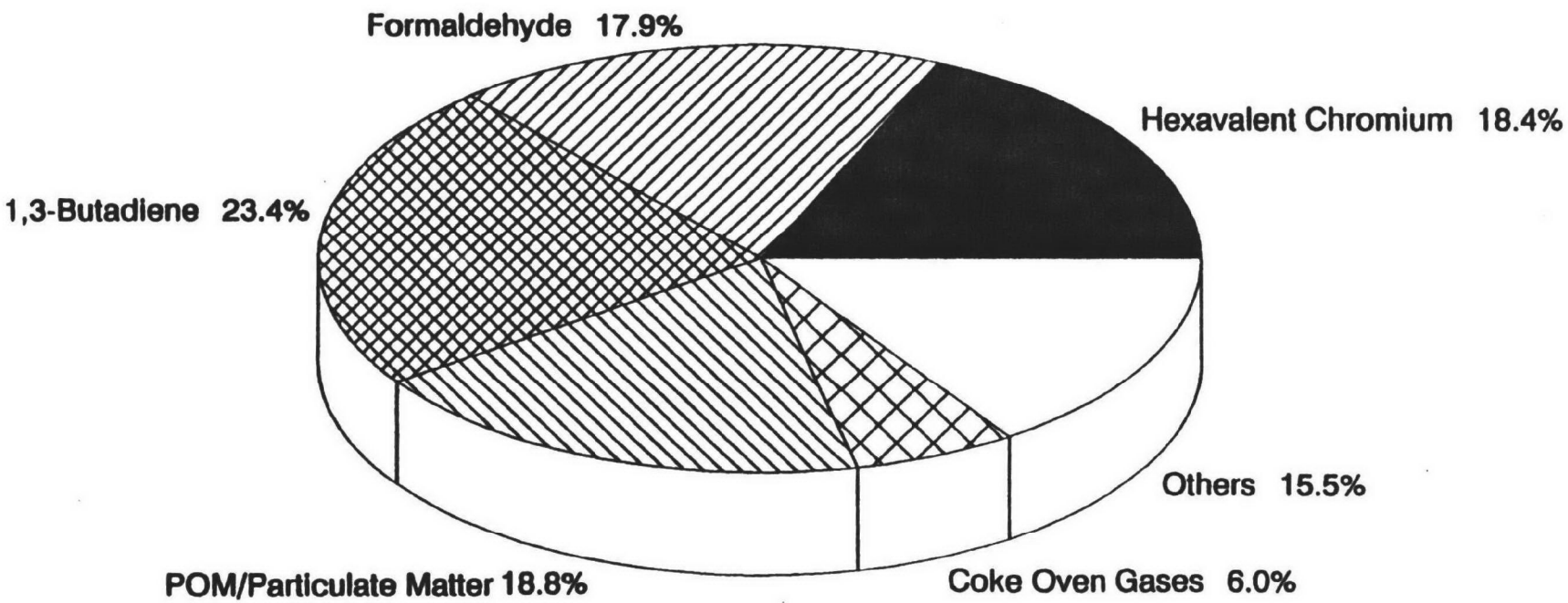
[a] Aggregated over all source categories among all receptor grids
[b] Aggregated over all inventoried POM emission sources
[c] "-" indicates less than 0.1%

TABLE 11
AGGREGATED HAZARD INDICES BY POLLUTANTS BY POM EMISSION ORIGIN[a]

Pollutant	Individual Concentrations (ug/m³)	Lifetime Individual Risks	Lifetime Cancer Cases	Percent Cancer Cases
1,3-Butadiene	1.09E+01	3.06E-03	4.69	23.36
Hexavalent Chromium	1.79E-01	2.15E-03	3.69	18.38
Formaldehyde	1.87E+02	2.44E-03	3.60	17.94
POM (Diesel Particulate)[b]	9.36E+01	1.59E-03	2.42	12.05
Coke Oven Emissions	1.30E+00	8.05E-04	1.20	5.96
Carbon Tetrachloride	4.87E+01	7.30E-04	1.07	5.33
Benzene	6.29E+01	5.22E-04	0.80	3.96
POM (Gasoline Particulate)[b]	9.29E+00	3.57E-04	0.54	2.72
POM (Turbine Particulate)	1.63E+01	2.76E-04	0.39	1.94
POM (B(a)P Surrogate)	1.37E-01	2.32E-04	0.35	1.76
Arsenic	4.37E-02	1.88E-04	0.27	1.35
Gasoline Vapors	2.35E+02	1.55E-04	0.24	1.19
Ethylene Oxide	1.29E+00	1.29E-04	0.19	0.94
Hexachlorobenzene	3.68E-01	1.69E-04	0.13	0.66
Trichloroethylene	3.07E+01	5.22E-05	0.077	0.38
Perchloroethylene	8.12E+01	4.71E-05	0.074	0.37
Cadmium	2.36E-02	4.25E-05	0.062	0.31
POM (Distillate Particulate[c])	4.24E+00	3.82E-05	0.059	0.30
Methylene Chloride	8.25E+01	3.88E-05	0.058	0.29
Chloroform	1.68E+00	3.86E-05	0.057	0.28
Asbestos	3.03E-03	2.30E-05	0.035	0.17
Dioxins	4.34E-07	1.43E-05	0.021	0.11
Vinyl Chloride	8.61E-02	7.23E-06	0.010	-[e]
Ethylene Dichloride	3.21E-01	8.34E-06	0.0087	-
POM (Piston Particulate)	4.61E-01	7.37E-06	0.0082	-
Ethylene Dibromide	2.28E-02	5.02E-06	0.0067	-
POM (Woodstoves)[d]	1.02E-01	2.96E-06	0.0044	-
Vinylidene Chloride	4.98E-02	2.49E-06	0.0038	-
Acrylonitrile	3.90E-02	2.65E-06	0.0037	-
Methyl Chloride	5.31E-01	9.56E-07	0.0015	-
Styrene	6.58E-01	3.75E-07	0.00041	-
Acrylamide	4.34E-05	5.64E-08	0.000083	-
Epichlorohydrin	3.51E-02	4.21E-08	0.000071	-
Propylene Oxide	8.46E-03	3.13E-08	0.000045	-
PCBs	8.76E-06	1.93E-08	0.000027	-
Beryllium	1.59E-06	3.82E-09	0.0000057	-

[a] Aggregated over all source categories among all receptor grids
[b] Includes particulate emissions from both road vehicles and nonroad mobile sources
[c] Particulate emissions from residential heating using distillate oil
[d] POM emissions from residential wood combustion including both woodstoves and fireplaces
[e] "-" indicates less than 0.1%

SOUTHWEST CHICAGO STUDY
CONTRIBUTIONS TO CANCER RISK
BY POLLUTANT



TOTAL NUMBER OF CASES = 20.1

FIGURE 17

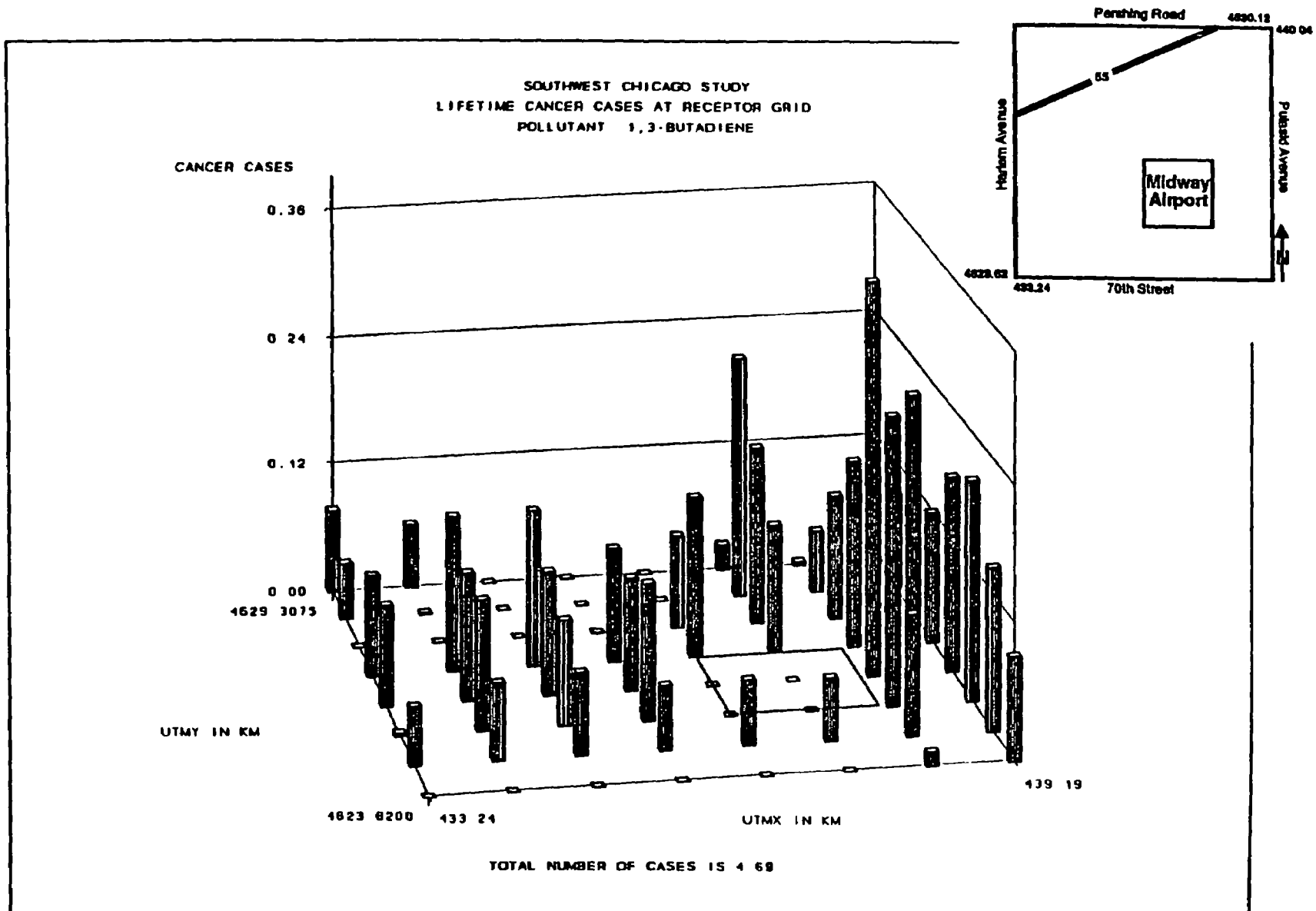

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
POLLUTANT 1,3-BUTADIENE
CANCER CASES
0.36
0 24
0.12
0 00
4629 3073
UTMY IN KM
4623 8200
433 24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 4 69
Pershing Road
Harlem Avenue
Pulaski Avenue
70th Street
Midway Airport
N

FIGURE 18

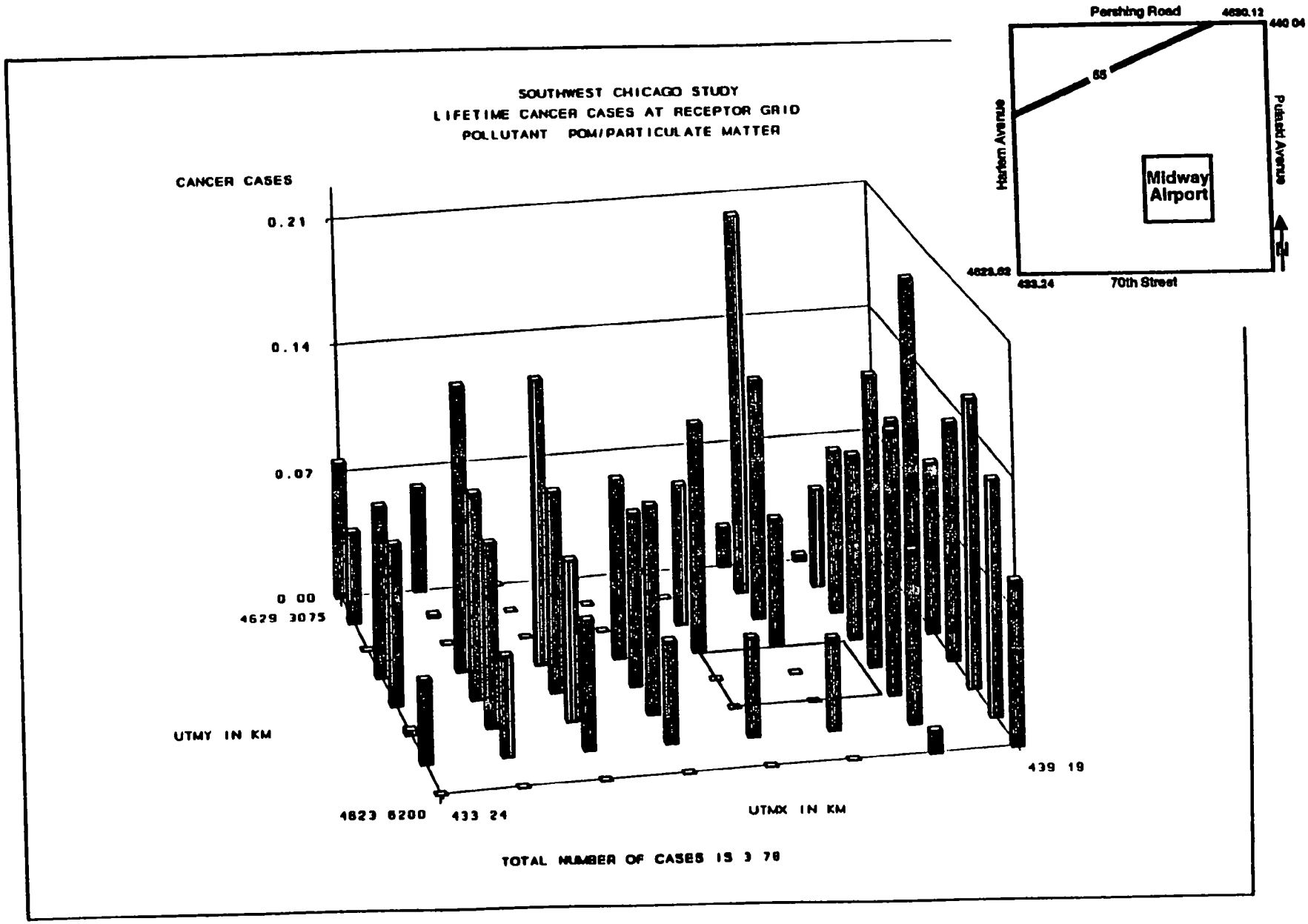

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
POLLUTANT POM/PARTICULATE MATTER
CANCER CASES
0.21
0.14
0.07
0 00
4629 3075
UTMY IN KM
4623 6200
433 24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 3 78
Pershing Road
4630.12
440 04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4623.62
433.24
70th Street
N

FIGURE 19

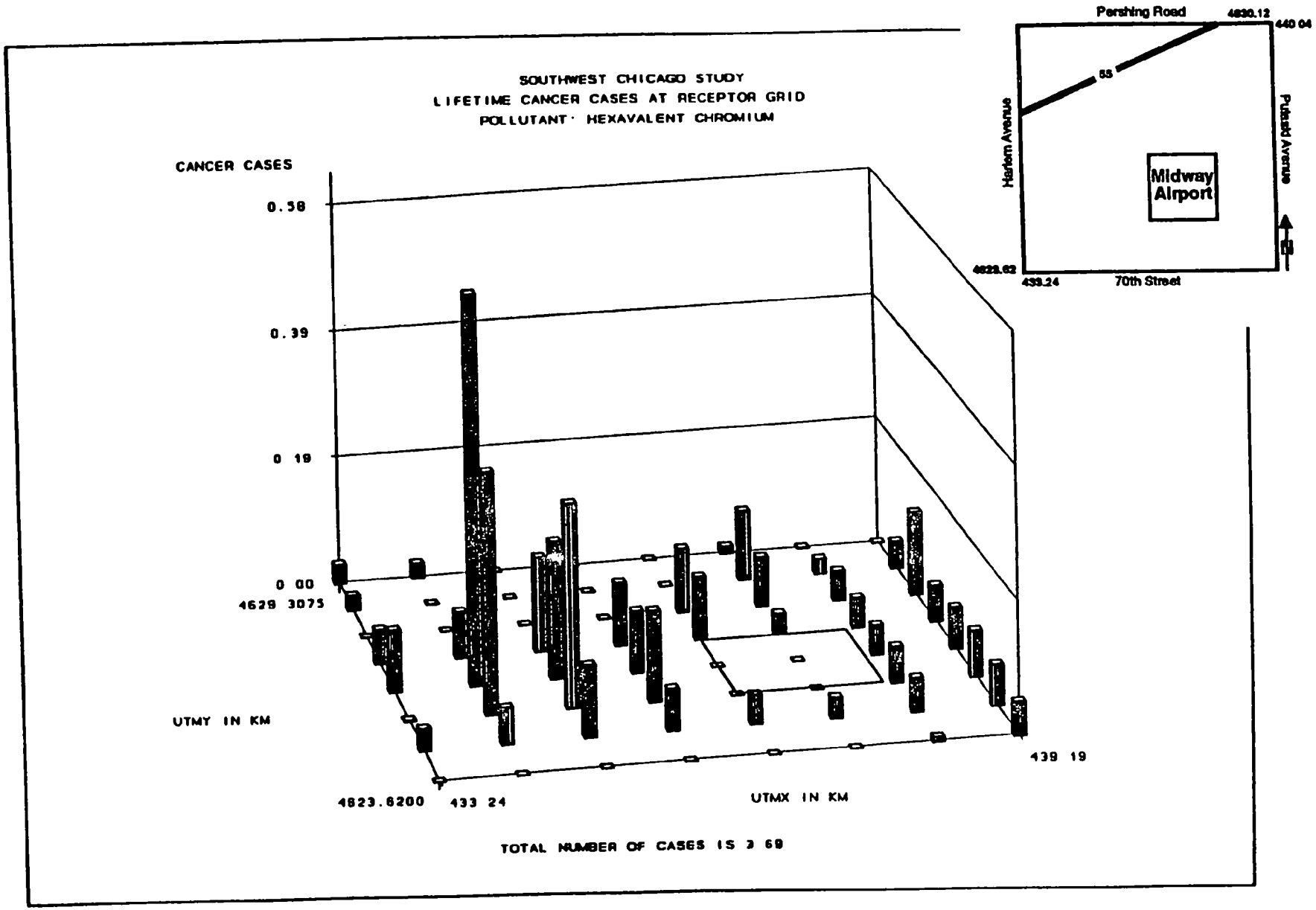

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
POLLUTANT: HEXAVALENT CHROMIUM
CANCER CASES
0.58
0.39
0 19
0 00
4629 3075
UTMY IN KM
4823.6200
433 24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 3 69
Pershing Road
4830.12
440 04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4823.62
439.24
70th Street

FIGURE 20

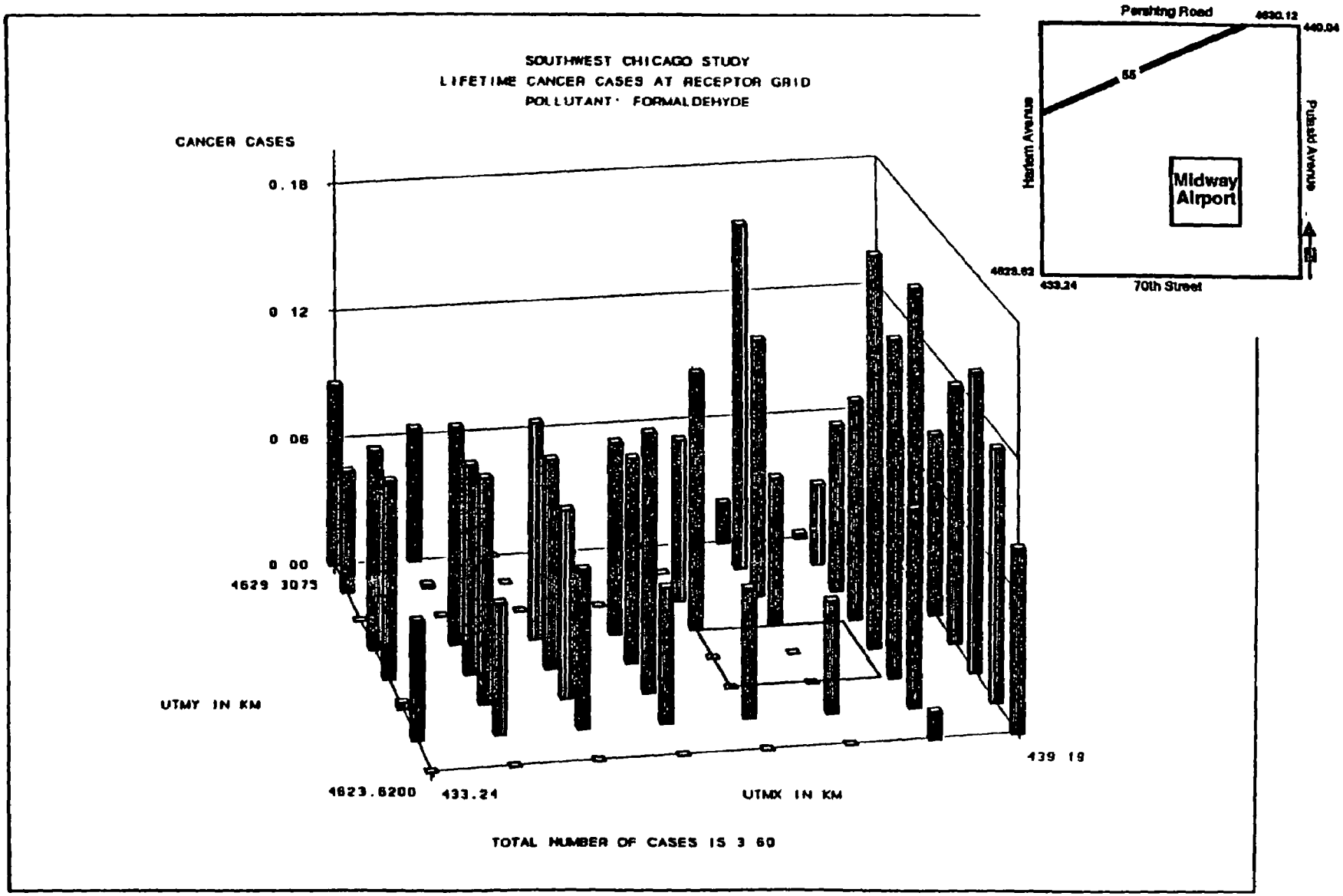

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
POLLUTANT · FORMALDEHYDE
CANCER CASES
0.18
0 12
0 06
0 00
4629 3075
UTMY IN KM
4623.6200
433.24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 3 60
Pershing Road
4630.12
440.04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4623.62
433.24
70th Street

FIGURE 21

IV.3 PEAK LIFETIME CANCER CASES

Peak cancer cases occur at receptor grid #26, (UTMY,UTMX) = (4626.06,434.09). This particular grid is approximately bounded by 59th Street to the south, Ridgeland Avenue to the east, 55th Street to the north, and Oak Park Avenue to the west. The number of lifetime cancer cases estimated at this receptor grid alone contributes 5% (about 1 case) of the cumulative total number of 18 lifetime cancer cases in the area. As expected, the hazard contributions to this particular receptor grid attributed to source categories and pollutants (Figures 22 and 23) are also dominated by contributors identified in the overall risk scenarios.

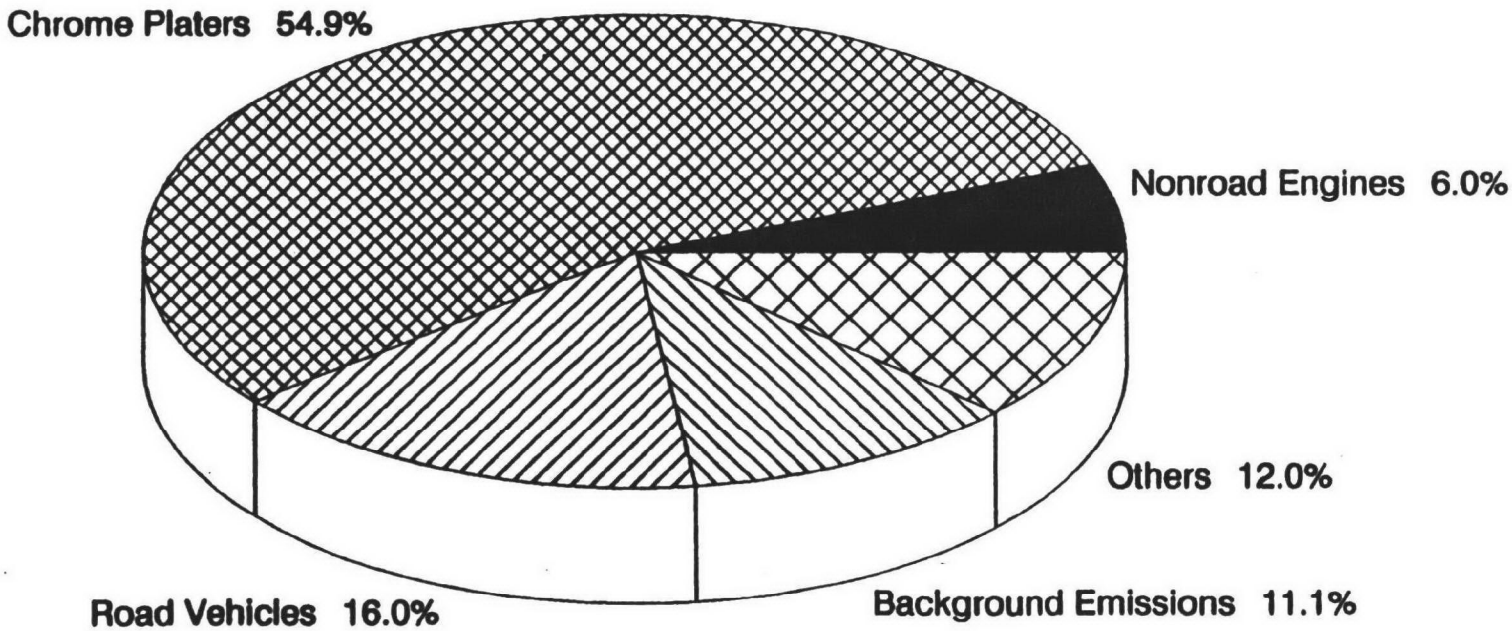
The lifetime individual risk at receptor #26 is 3.64×10^{-4} (see Table 8). The lifetime individual risk at receptor #30 is 4.16×10^{-4}, but there is no population at this grid because it is in the middle of Midway Airport Grid #31 also has a higher estimated lifetime individual risk (3.96×10^{-4}) but has a lower total population and thus less lifetime cancer cases. All these risks are within the range of expected cancer risks found in urban areas.

IV.4 RISK ASSESSMENT OF PROPOSED FACILITIES

Robbins Incinerator is a proposed facility. The public has been paying a great deal of attention to air toxic releases from this facility. Based on our assessment, it would pose a risk of approximately 0.0052 lifetime cancer cases to the study area. These potential risks associated with the Robbins Incinerator are for the receptor area only. This study has not attempted to characterize the overall risks of Robbins Incinerator to people throughout its airshed or to people living in its immediate vicinity.

Sun Chemical Incinerator, a formerly proposed RCRA facility, is estimated to pose a risk of 0.00033 cancer cases over 70 years in the Southwest Chicago study area. Sun Chemical Incinerator is included in the study solely to respond to public questions about the potential risk if it were to be built. The proposed project has been withdrawn by the company. U.S. EPA is not aware of any intent by the company to repropose this incinerator. Information on distribution of risks at individual receptor grids by Robbins Incinerator and Sun Chemical Incinerator is contained in Appendix I. It must be noted that the overall risk assessment results of the study would not have been significantly affected with inclusion of either facility.

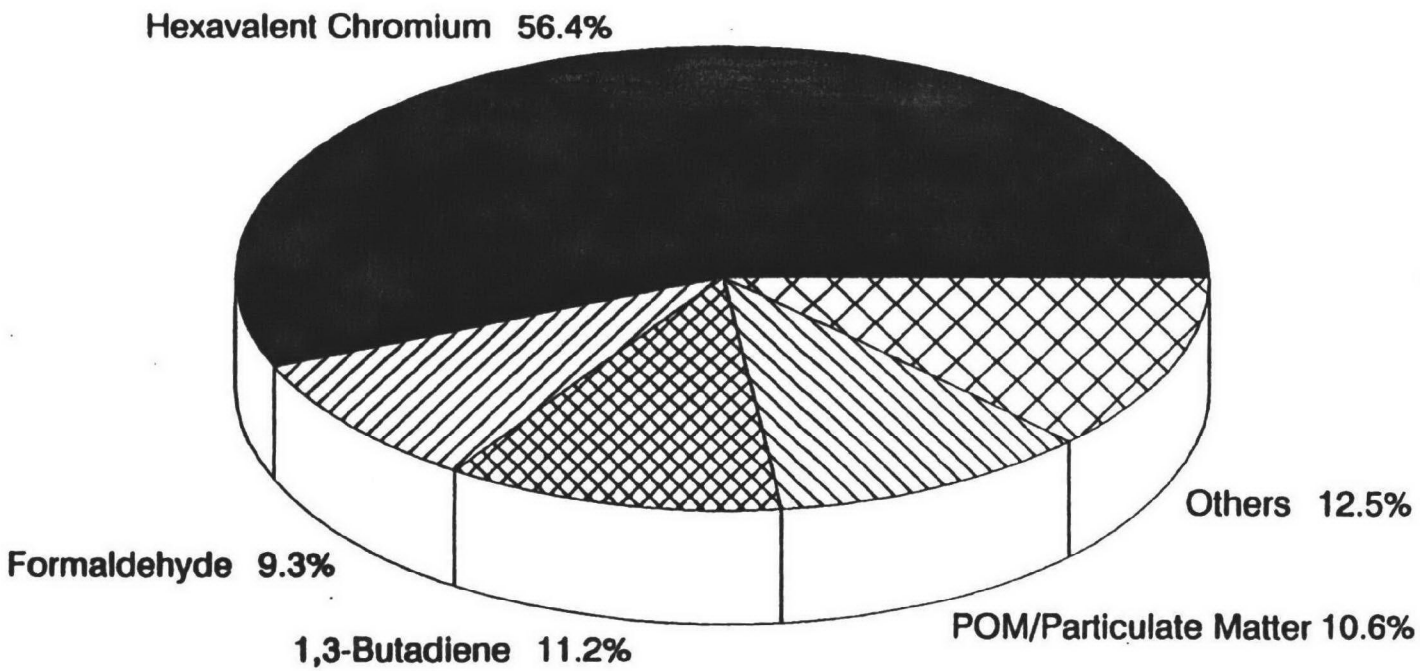
SOUTHWEST CHICAGO STUDY
CONTRIBUTIONS TO CANCER RISK AT PEAK RECEPTOR
BY SOURCE CATEGORY



TOTAL NUMBER OF CASES = 1.03

FIGURE 22

SOUTHWEST CHICAGO STUDY
CONTRIBUTIONS TO CANCER RISK AT PEAK RECEPTOR
BY POLLUTANT



TOTAL NUMBER OF CASES = 1.03

FIGURE 23

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CHAPTER V
UNCERTAINTIES

Since scientific uncertainty is a unavoidable concern for any risk assessment, several types of uncertainties must be noted while interpreting the risk assessment results concluded in this study. They are described as follows:

a. Some of the toxicants investigated in this study are characterized as either probable or possible human carcinogens. The quantified cancer potency factors of these toxicants may overstate or understate the true cancer potency. Thus, the cancer risk estimates are not meant to be representative of actual risk. Instead, they are meant to be used in a relative sense, to compare risks among pollutants. It should also be noted that U.S. EPA is currently reevaluating the health data for formaldehyde, 1,3-butadiene, and benzene. An U.S. EPA risk assessment for diesel particulate matter is also in progress.

b. Dispersion modeling itself is probabilistic, not deterministic. Concurrence of a wind direction and a stability class is stochastic, not predictable. Estimated concentrations at a receptor can only be computed based on averages and most-likely cases. The exposure methodology assumes that the population is continuously exposed to the outdoor modeled concentration. This assumption may not reflect the actual scenario.

c. Uncertain information on stack parameters and location of emission points may result in skewed dispersion factors. In addition, the AIRS/AFS emissions information for Illinois contains emissions data prior to 1988.

d. Most of the speciation factors used to speciate organics from VOCs and metals from particulate matter were derived based on nationwide statistics. Speciated emissions may not mirror the highly localized air toxics scenario. Also, the factor of 0.1% used to speciate hexavalent chromium emissions from total chromium emissions emitted by sources such as steel mills is not process-specific and may consequently result in over- or underestimation of risks.

e. Apportioning all area source emissions in the area north to the receptor network by population may not be precise. Land use patterns and dwelling units, for example, may be more representative of certain area emission types.

f The use of one compound of known toxicity as a surrogate for other similar compounds in a mixture may lead to over- or underestimates of risk. In this study, for example, POM is assumed to have the same cancer unit risk factor as B(a)P for some emission sources. Since B(a)P is among the most potent of the carcinogenic PAHs, and since not all PAHs are carcinogenic, the use of this value is likely to overestimate risk from the POM mixture. A similar overestimate may result from the use of the cancer potency factor for the most potent dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin) as a surrogate for all dioxins. Data on synergistic or antagonistic effects is almost never available, so cancer risks from various chemicals in a mixture are assumed to be additive.

g. Because of limitations, such as insufficient information available for military and air taxiing aircraft types at Midway Airport and corresponding toxics emission factors, many assumptions and approximations were made while preparing the Midway airport emissions inventory. These aspects of our methodology may have affected the accuracy of the emission estimates.

h. Emissions used to assess risks attributed to the aircraft taxi/idle phase were estimated based on the default time-in-mode (TIM) value. This may result in overestimation of cancer risks because the TIM value for taxi/idle at Midway had been decreased significantly following the Midway Airlines' bankruptcy in 1990.

i. With the exposure methodology used in this study, the lifetime cancer risk for each grid is calculated based on the population residing within the grid. This approach does not account for personal activity to and from other grids.

j. Some source contributors to cancer cases are likely to be underestimated, since the background concentrations of formaldehyde and carbon tetrachloride have not been attributed to sources.

k. The motor vehicle emission factors for benzene, formaldehyde, and 1,3-butadiene are derived based in part on the MOBILE4.1 emissions model. A revised version, MOBILE5a, has recently been released. Toxic emission factors derived using MOBILE5a would be larger than those given in this report.

l. Since no health data exist for exposure to aircraft particulate matter, and there is a paucity of particulate matter emissions data for aircraft (particularly for turboprop and piston engines), risk estimates associated with aircraft particulate matter are highly uncertain.

m. Emissions attributed to vehicle refueling loss are assumed to be zero in the study. This usually results in an underestimate of emissions, particularly of benzene. Therefore, a small amount of benzene would be missed by this assumption.

The above uncertainties underlying the risk estimates dictate that the risk assessment results in this study should be used cautiously. This study may either overestimate or underestimate the risks, and in either case may provide risk estimates which differ substantially from true risks. Any risk assessment study such as this represents a "snapshot in time" of one's collective understanding of the urban air toxics issue. In fact, emission estimates and risk characterization techniques are subject to frequent revisions as newer data become available. Hence, care should be taken when interpreting any results from this study or comparing these results to those from other studies where different data have been used.

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APPENDIX A
EMISSION ESTIMATES FOR ADDITIONAL POINT SOURCES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

DATE: APR 09 1991

SUBJECT: Emissions Estimate for Facilities in Southwest Chicago

FROM: John Summerhays
Regulation Development Section
Air Enforcement Branch

Xuan-Mai Tran
Regulation Development Section
Air Toxics and Radiation Branch

TO: Carl Nash, Chief
Regulation Development Section
Air Toxics and Radiation Branch

Based on a review of available literature, we have developed emissions estimates for three facilities in Southwest Chicago. These facilities are the Robbins Incinerator, the potential Sun Oil hazardous waste incinerator, General Electric, and Midway Airport.

Emissions estimates for the Robbins incinerator are based on design capacity of 1200 tons per day and 365 days per year of refuse derived fuel burned. Emission factors for this type of facility are taken from page 4-20 of the reference Locating and Estimating Air Toxics Emissions from Municipal Waste Combustors, published in April 1989 as EPA report number EPA-450/2-89-006. Table 1 shows the emissions factors and estimated emissions for each pollutant in the Southwest Chicago study.

Emissions estimates for the once-proposed Sun Oil hazardous waste incinerator are based largely on information in their permit application. For benzene, supplemental information on waste volumes was also used. The total volume of RCRA waste generated by Sun Oil in the first 10 months of 1987 was 4,189,200 lbs. Extrapolation to a full year yields an annual estimate of 5,027,040 lbs of RCRA waste per year. Table 4-1 of their RCRA Part B permit application provides information on the composition of Sun Oil's waste. This table indicates that distillate oil fraction of their waste represents 22% of their primary waste. Applying this fraction to the full waste stream, and conservatively assuming that 2% of this 22% is benzene, we estimate that the annual waste volume includes 22,119 lbs of benzene. Assuming that incineration will destroy or remove 99.99% of this substance yields an emission estimate of 2.212 lbs per year of benzene.

Similarly, Table 4-1 of the Part B permit application indicates that the primary waste includes 7.05 ppm of arsenic, 1.5 ppm of beryllium, 2.41 ppm of cadmium, and 350.5 ppm of chromium (conservatively assumed to be emitted 100% as hexavalent chromium). As noted on page 2-33, control equipment including a

baghouse is expected to reduce particulate emissions by 99.6%. Assuming on this basis that 0.4% of the above metals in the waste would be emitted to the atmosphere yields annual emissions estimates of 0.142 lbs of arsenic, 0.030 lbs of beryllium, 0.048 lbs of cadmium, and 7.048 lbs of (hexavalent) chromium.

Emissions estimates for General Electric facility are based on Midwest Research Institute (MRI). MRI recommends use of a spillage factor of 0.01% of material being spilled. This spillage factor was then cited in Section 4.7 of AP-42, Waste Solvent Reclamation. The total tetrachloroethylene generated was 20 lbs/yr. Assuming all of this would spilled, then the emission estimate for tetrachloroethylene is 0.002 lbs/yr.

The emissions estimates for Midway Airport rely on an emissions estimate of 462 tons per year of volatile organic compounds (VOC) developed for the ozone Federal Implementation Plan. The emissions estimate also relies on species emissions factor information provided in a September 1987 reference entitled Literature Review Concerning Air Carcinogens Near Airports. A summary of the relevant information is attached. Tests of exhaust composition for a CFM-56 engine were considered most representative of jets using Midway Airport. Measurements of benzene and styrene were based on gas chromatography with cryogenic preconcentration; measurements of formaldehyde were based on dinitrophenylhydrazine impinger collection; and measurements of polycyclic aromatic hydrocarbon were based on X-ray diffraction. Measurements were conducted at idle, 30% thrust, and 80% thrust.

Species fractions were calculated by dividing the species exhaust concentration by the total VOC exhaust concentration. The relationship between species emissions and total VOC emissions was relatively constant among the three thrust rates. Nevertheless, for completeness, an initial set of calculations was performed to establish the relative significance of the three thrust rates. Fuel use rates for each cycle component were multiplied times typical durations of these cycle components to estimate fuel usage for each cycle component. For each cycle component and for each of three military engines, this fuel usage component was multiplied times a VOC emissions rate per 1000 lbs of fuel to obtain an estimate of emissions for the cycle component. These estimates were used to estimate each engine's fraction of emissions in each landing/takeoff (LTO) cycle arising from idle, approach, climb, and takeoff operations. Fractions for each engine were averaged to yield overall fractions for each LTO cycle component. These overall fractions were used to calculate a weighted average of species fractions measured at different thrust rates. Specifically, the species fractions for idle were weighted 94.87%, species fractions for 30% thrust were weighted 4.94%, and species fractions for 80% thrust were weighted 0.19 % (representing both "climb" and "takeoff"). Note that the species fractions for idle represent the average of the species fractions from multiple tests. The weighted average species fractions were then multiplied times the estimate 462 tons per year of VOC emissions to yield the following species emissions estimates: 9.226 tons per year of benzene; 1.736 tons per year of styrene; 29.677 tons per year of formaldehyde; and 4.876 tons per year of polynuclear aromatic hydrocarbons.

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TABLE 1

EMISSIONS ESTIMATES FOR ROBBINS INCINERATOR

Pollutants	Emissions Factors	Estimated Emissions
Arsenic	46 lbs/10^6 tons	20.148 lbs/yr
Cadmium	38 lbs/10^6 tons	16.644 lbs/yr
Chromium	660 lbs/10^6 tons	289.080 lbs/yr

APPENDIX B
MIDWAY EMISSIONS INVENTORY AND DISPERSION MODELING RESULTS

B.1 INTRODUCTION

An emissions inventory was developed for Midway Airport. The inventory includes emission estimates from two major mobile sources at the airport: aircraft and automobiles. These two mobile sources required diverse approaches to estimating the emissions, including computer database calculations and manual calculations. Source research was conducted in many areas, and several agencies were contacted regarding emissions and operations data.

Source data were collected on the number and type of aircraft that have used Midway Airport in the past ten years as well as the number of flights which were attributed to Midway Airlines before bankruptcy. This information is presented in Exhibit B-1. Additionally, source data were collected so that emissions amounts for total hydrocarbons (THC) and particulate matter could be calculated. When necessary, assumptions and default values were utilized due to the lack of actual data. These assumptions are identified in the report. Following calculation of the THC and particulate matter emission amounts, the THC data were then used to estimate emission amounts of three carcinogens: benzene, formaldehyde, and 1,3-butadiene. Particulate matter emissions were also estimated. Please note that it is particularly difficult to estimate emissions of particulate matter, since direct measurement of particulate matter emissions from aircraft engines are typically not available. Also, particulate matter emission rates that are available are likely to be overestimates.

Based on the prepared inventory, air dispersion modeling was conducted to estimate concentrations at targeted receptor grids. This provided the necessary information to assess carcinogenic risks to the area population attributed to air pollution from mobile sources at Midway Airport.

B.2 EMISSIONS INVENTORY PREPARATION

During the development of the Midway Airport emissions inventory, efforts were focused on four possible emission source types: aircraft, automobiles, service vehicles, and other non-aircraft sources. In this section, we present the sources of data as well as the assumptions and approaches taken to estimate the emissions from these sources.

Emission estimates from the various types of sources were calculated using several methods and procedures, including two computer programs, the Emissions and Dispersion Modeling System (EDMS) and the FAA Aircraft Engine Emissions Database (FAEED), and spread sheet calculations. Both EDMS and FAEED were released by the Federal Aviation Authority (FAA).

B.2.1 EMISSIONS FROM AIRCRAFT SOURCES

Aircraft are the largest source of pollutant emissions at Midway. However, there is limited emissions data on the various aspects of aircraft operations. Emissions for this source type were often calculated using default values and assumptions derived through research and discussions with various representatives in several agencies at the Federal, State, and local levels.

Four aircraft categories providing services at Midway in 1990 were identified: commercial air carriers, air taxi, general aviation, and military. For each category, the following steps were used to estimate particulate emissions and toxics emissions:

(1) Determine the *mixing height* to be applied to the landing and takeoff (LTO) cycle. A LTO cycle consists of 4 operational phases: approach, landing, taxi/idle, and climbout.

- The mixing height is important mainly for nitrogen oxide (NO_x) emissions. Since this inventory only calculated THC and particulate matter emissions, a default value of 3,000 feet in FAEED was used.

(2) Define the fleet make-up for each aircraft category using the airport. The make-up of an aircraft fleet contains all aircraft types in each category that either landed or took off from the airport during a given year. The 1990 Midway Airport fleet was used for this inventory.

(a) Commercial Air Carriers

- The fleet make-up was taken from data supplied in Airport Activity Statistics of Certified Route Carriers, 1990, published by the FAA.

(b) Air Taxis

- No data regarding the fleet make-up were available. After discussions with the U.S. EPA Office of Mobile Sources (OMS), it was decided to assume that 73% of air taxi operations were conducted by piston engine aircraft. The remaining 27% were assumed to be turbine engine operations.

(c) General Aviation

- As with the air taxi fleet, no data regarding the make-up were available. OMS recommended an aircraft engine mix of 94% piston and 6% turbine.

(d) Military

- This category contained the least amount of available data. Several agencies were contacted to determine the fleet make-up.

  (i) The U.S. Air Force Reserves stated no operations were conducted at Midway Airport, only at O'Hare. They recommended contacting the National Guard.

  (ii) The National Guard does conduct operations at Midway, but does not maintain statistics. They did make some observations:

  - There are almost no piston engines in operation; practically all of the air force aircraft use turboprop or turbojet engines.

  - They estimated that approximately 95% of the operations are conducted by BELL UH-1 helicopters, with BEECH C-12 small cargo jets comprising most of the remaining operations.

  - The National Guard approximations were discussed with the Midway Airport Control Tower. They generally concurred with the National Guard, but estimated that 95%-98% of operations were conducted by UH-1 helicopters.

(3) Determine airport activity as the number of LTO cycles for each aircraft category.

- Airport operations data for commercial air carriers were taken from Airport Activity Statistics of Certified Route Carriers, 1990.

- Airport operations data for all other aircraft categories were contained in FAA Air Traffic Activity. It supplied the number of operations (an operation being either a landing or takeoff), that was divided by two to determine the number of LTOs.

(4) Select emission indices for each category.

- Indices were based on the type and number of engines on the aircraft, and on type of pollutant being emitted.

THC Emission Estimation

(a) Commercial Air Carriers

- Aircraft types were identified in Airport Activity Statistics of Certified Route Carriers, 1990.

- Engine types and number of engines were identified in FAEED, with the following exceptions:

  (i) Emission rates for the BEECH 18 aircraft engine (R-985-AN PW) were not listed in FAEED and could not be found elsewhere. Therefore, we used the emission rates from engine PT6A-41 (Piper PA-42 Cheyenne). This engine was used for general Air Taxi turboprop engines in the Illinois Environmental Protection Agency (IEPA) 1990 Base Year Emissions Inventory for Cook County.

  (ii) Boeing B 737-100 and B 737-200 were grouped as B 737-100/200 in Airport Activity Statistics of Certified Route Carriers, 1990. When the data were input to FAEED, the emission rates from Boeing B 737-100 aircraft were used.

  - Emission rates were not available in FAEED for the JT8D-7D engine (one of the engine types of the B-737-100), so its market share (4%) was reassigned to engine JT8D-7B.

  (iii) FAEED identified three engines for Boeing B 737-500, each with a different emission rate and a 0% market share. To compute the inventory, each engine type was given a one third (33 1/3%) market share.

(b) Air Taxis

- No specific engine data were available. To estimate an emission rate, piston engine emissions were manually calculated using an emission rate that was the average of seven piston engine emission rates identified in AP-42. Emissions from turbine engines were calculated in FAEED using two turbojet engines: the PT6A-27 (32% of turbine operations) from the De Havilland DHC-6/300 aircraft and the PT6A-41 (68% of turbine operations) from the Piper PA-42 Cheyenne aircraft. The operation percents were based on percents relative to the number of U.S. registered aircraft as of December 31, 1989. Turbine data were obtained from Chapter 5 of the U.S. EPA report number EPA-450/4-81-026d, Procedures for Emission Inventory Preparation -- Volume IV: Mobile Sources (Volume IV guidance).

(c) General Aviation

- The inventory for both piston and turbine engine aircraft was calculated using the same assumptions, data, and methods as Air Taxis for the appropriate engine type.

(d) Military

- Emissions from the Beech C-12 were calculated in FAEED.
- Emissions from the Bell UH-1 (engine T53-L-11D) were calculated using data from the Volume IV guidance document.

Particulate Emission Estimation

Data were only available from AP-42. If the particulate emission rate for a corresponding engine type was available, the data were used. For all others, particulate emissions were calculated using an average emission rate.

(a) Commercial Air Carriers

- Specific particulate matter emissions data were available for only one engine type: the JT8D-17. This engine type comprised 81% of the DC-50 fleet in 1990; it was assumed to constitute 100% for the inventory.

- The average emission rate was determined from seven turbofan engine emission rates identified in AP-42. Five of the emission rates were specifically identified, the other two were assumed (in AP-42).

(b) Air Taxis

- Piston engine emissions were estimated by multiplying by 5% the total organic gases (TOG) emission factors for appropriate piston engines representative of the mix at Midway, as recommended by OMS. This percentage is approximately the percentage of particulate matter relative to TOG for non-catalyst light-duty gasoline vehicles (LDGVs).

- Turbine engine emissions were determined using the one available turboprop engine emission rate (from a Garrett AiResearch TPE 331-3 engine) identified in AP-42.

(c) General Aviation

- The inventory for both piston and turbine engine aircraft was calculated using the same assumptions, data, and methods as Air Taxis for the appropriate engine type.

(d) Military

- Emissions from Beech C-12 aircraft were determined using the emission rate from the same turboprop engine (TPE 331-3) used for determining Air Taxi turbine engine emissions.

- No data could be found regarding particulate emissions from Bell UH-1 helicopters; since they are a relatively small part of the entire emissions inventory, they were considered negligible.

(5) Estimate a "Time-In-Mode" (TIM) for each aircraft category at the airport.

- TIM values are necessary for each phase-of-operation; each phase contains its own characteristics, including fuel flow and emission rates. Therefore, modeling is different for each phase and source. The four phases-of-operation are: taxi/idle (TI), takeoff (TO), climbout (CO), and approach (AP). The TIM and phase-of-operation are important because they determine the position of a moving emission source.

- Table B.1 identifies all TIM values used in the emissions inventory. Unless otherwise noted, all numbers are default values given in FAEED and/or Volume IV guidance.

TABLE B.1 TIM VALUES

Type of Operation	Type of Aircraft	Time-In Mode (min.) TI	TO	CO	AP
Commercial	BEECH 18[1]	26	0.5	2.5	4.5
	All Other commercial	26	0.7	2.2	4.0
	All aircraft	10[2]			
Air Taxi and Gen. Aviation	All non-piston engines	26	0.5	2.5	4.5
	All piston engines	16	0.3	5.0	6.0
	All aircraft	10[2]			
Military	C-12/A/B/C	13	0.4	0.5	1.6
	UH-1	15[3]	-[4]	6.8	6.8
	All aircraft	10[2]			

Note:

1 = The engine for a PA-42 Cheyenne aircraft (PA6A-41) was used instead of the engine for the BEECH 18 aircraft.
2 = *De minimis value*. See explanation in the report.
3 = The taxi/idle time for UH-1 helicopters was given for two phases: Fl. and Gr.; an average TIM was calculated and used in the inventory
4 = No takeoff TIM was identified. See explanation in the report.

- The taxi/idle TIMs listed in Table B.1 and used in the inventory are the sums of the taxi/idle-in TIM and taxi/idle-out TIM identified in Volume IV guidance for each respective type of operation or aircraft category. The two TIMs were combined since FAEED computes emissions for only one taxi/idle mode; also, the emission rates for the respective phases are equal.

- Two inventories were prepared, each with a different taxi/idle TIM. One utilized default TIMs found in FAEED or in Volume IV guidance document. The other utilized a 10 minute taxi/idle TIM. The 10 minute TIM is a *de minimis* value recommended by the Deputy Commissioner of Midway Airport, and confirmed by the Midway Control Tower. *De minimis* was defined as the minimum amount of

time required for an aircraft to complete a phase-of-operation if it is the only aircraft in the queue. The *de minimis* assumption is valid for future emissions since Midway Airport operations were significantly reduced with the bankruptcy of Midway Airlines in 1991.

- No takeoff TIM was identified for UH-1 helicopters. We assumed the takeoff time negligible for the following reasons:

  - The takeoff phase of a helicopter operation would take a short amount of time, less than one minute (based on the assumption that takeoff is defined as the time from the start of upward motion until the helicopter lifts off the ground)

  - The identified emission rates are extremely low (less than 1 lb/hr).

  - The small emission rate and short TIM would combine with the other factors to produce a calculated emission amount that was very small in comparison with the other phases of operation. Therefore, it can be considered negligible.

(6) Calculate an inventory based on airport activity, TIM, and aircraft emission factors.

- The inventory was calculated for THC and particulate matter emissions. FAEED was utilized for all THC emission calculations except for air taxi and general aviation turbine engines, and the UH-1 helicopter engine. All particulate matter emissions were hand-calculated (or determined on a spread-sheet).

(7) Convert the THC data to determine the respective emission amounts of benzene, formaldehyde, and 1,3-butadiene using correction factors for the steps noted below:

  (a) Convert the THC data to volatile organic compounds (VOC) data.

  (b) Convert the VOC data to TOG data.

  (c) Use aircraft toxic fractions of TOG to determine required toxic pollutant emissions.

All correction factors, conversion formulae, and toxic fractions are contained in Volume IV guidance document or were supplied in a memo by OMS (Exhibit B-2).

B.2.2 EMISSIONS FROM AUTOMOBILE SOURCES

To evaluate the cancer risk attributed to Midway Airport, emissions caused by vehicles which travelled within the three parking lots located around Midway Airport for access by airline passengers and airport employees should be assessed wherever possible. Park Lot B shown on Figure B.1 was no longer in service prior to 1990 and therefore was not considered in the study. In addition, vehicular emissions generated by vehicles on the portion of Helen Mikols Drive (west of South Cicero Avenue) which is on Midway Airport property should also be taken into account.

The capacity of each parking lot was provided by the Chicago Department of Aviation (Chicago DOA) and is listed below.

- Main Parking Lot - 1,366 stalls (444 hourly spaces, 700 daily space, and 222 rental car spaces). We assumed that hourly spaces were occupied by different vehicles every hour during the 20-hour daily operating period from 5:00 am (exactly one hour earlier than the scheduled first departure) to 1:00 am (approximately one hour later than the scheduled last arrival). Any daily or rental car space was assumed to be accessed by only one vehicle per day.

- Employee Lot (East side of Cicero Avenue) - 300 stalls. We assumed that each space was used by one employee vehicle once a day.

- Economy Parking Lot (North side of 55th Street) - 2,200 stalls. We also assumed that each space was used only once as a daily parking space.

The Chicago DOA also provided the number of vehicles that travelled on Helen Mikols Drive in one summer week (ending June 17, 1990). During that week, 65,821 vehicles travelled on Helen Mikols Drive as counted by the Chicago DOA. All vehicles were counted travelling to the terminal, as the count was conducted past the main parking lot entrance. Therefore, it was assumed that no vehicles from the parking lots were included in the count. Based on this weekly number, annual traffic volume was estimated at 3,422,692 vehicles in 1990.

Distances travelled by vehicles in the parking lots or on Helen Mikols Drive were then estimated to compute the vehicle miles travelled (VMT). Table B.2 lists the estimated annual VMT. Please note that each parking lot was considered fully occupied year around.

TABLE B.2
ESTIMATED VMT AT IDENTIFIED LOCATIONS

Location	Distance Travelled per Vehicle (ft)	Annual Traffic Volume	Annual VMT
Main Parking Lot	1,500	3,577,730	1,016,401
Employee Parking Lot	750	109,500	15,554
Economy Parking Lot	1,500	803,000	228,125
Helen Mikols Drive	1,300	3,422,692	842,708

The last step prior to estimating emissions was to determine the vehicle fleet in these four sources. We used the representative vehicle fleet mix averaged over all the 1990 fleet mixes of the 343 selected traffic zones in the Cook County motor vehicle emissions inventory. The representative fleet mix is as follows in Table B.3:

TABLE B.3
REPRESENTATIVE FLEET MIX

Vehicle Type	Fleet Mix
LDGV	81%
LDGT1	6%
LDGT2	3%
HDGV	1%
LDDV	1%
LDDT	1%
HDDV	6%
MC	1%

Based on the representative fleet mix and estimated annual VMT, toxic air pollution was estimated for each of the four sources. Emission factors selected were directly extracted from the 1990 IEPA Baseline Emissions data base and were used in conjunction with the OMS-suggested toxic fractions. The speed was assumed to be 10 mph in these four sources and Inspection/Maintenance (I/M) credits were in effect as well.

B.2.3 EMISSIONS FROM SERVICE VEHICLES

Service vehicles are those used in land-based airport operations (*i.e.* luggage transfer vehicles, aircraft refueling vehicles, emergency and support vehicles). Required data includes type of vehicle, hours of operation, and fuel use.

B.2.4 EMISSIONS FROM OTHER NON-AIRCRAFT SOURCES

Covered under this source type are power plants/heating plants, incinerators, fuel storage tanks, and training fires; however, the Deputy Commissioner of Midway Airport identified fuel storage tanks as the only source of this type at Midway. Required information includes:

- Number and size of tanks;
- Type and amount of fuel stored in each tank; and
- The percent vapor recovery - both when filling the tank and emptying the tank into vehicles.

B.3. EMISSIONS INVENTORY RESULTS

B.3.1 EMISSIONS FROM AIRCRAFT

Tables B.4 - B.8 list the annual THC, particulate matter, VOC, TOG, benzene, formaldehyde, and 1,3-butadiene emissions breakdown by phase-of-operation. Please note that VOC and TOG are listed for references only. They were not used to conduct the required air dispersion modeling.

TABLE B 4 ANNUAL EMISSIONS (TPY) FOR TAXI/IDLE MODE (DEFAULT TIM)

Pollutant	Aircraft Category Comm	AT	GA	Mil	Total
Particulate	21.61	2.17	0.38	0.01	24.18
THC	235.02	78.01	17.20	1 48	331.71
VOC	257.28	81 97	18.12	1 64	359.01
TOG	287.30	88.45	19.70	1.83	397.28
Benzene	5.57	1.77	0 45	0 04	7.83
Formaldehyde	43 12	11.57	2.28	0.28	57.25
1,3-Butadiene	5.17	1.34	0.28	0 03	6.82

Notes:

Comm. = Commercial air carriers
AT = Air Taxis
GA = General aviation
Mil. = Military

TABLE B.5 ANNUAL EMISSIONS (TPY) FOR TAXI/IDLE MODE (DE MINIMIS TIM)

Pollutant	Aircraft Category Comm	AT	GA	Mil	Total
Particulate	8.31	1.80	0.43	*	10.54
THC	90.39	31.79	7.58	1.02	130.78
VOC	98.95	33.34	7.82	1.13	141.24
TOG	110.50	36.08	8.54	1.26	156.38
Benzene	2.14	0.76	0.21	0.02	3.13
Formaldehyde	16.59	4.52	0.89	0.19	22.19
1,3-Butadiene	1.99	0.54	0.12	0.02	2.67

Notes:

Comm. = Commercial air carriers
AT = Air Taxis
GA = General aviation
Mil. = Military
* = Annual amount less than 0.01 tpy

TABLE B.6 ANNUAL EMISSIONS (TPY) FOR TAKEOFF MODE

Pollutant	Aircraft Category Comm.	AT	GA	Mil	Total
Particulate	3.99	0.11	0.01	*	4.11
THC	2.25	0.34	0.15	*	2.74
VOC	2.46	0.33	0.15	*	2.94
TOG	2.75	0.38	0.17	*	3.30
Benzene	0.05	0.01	0.00	*	0.06
Formaldehyde	0.41	0.01	*	*	0.42
1,3-Butadiene	0.05	*	*	*	0.05

Notes:

Comm. = Commercial air carriers GA = General aviation
AT = Air Taxis Mil. = Military
* = Annual amount less than 0.01 tpy

TABLE B.7 ANNUAL EMISSIONS (TPY) FOR CLIMBOUT MODE

Pollutant	Aircraft Category Comm	AT	GA	Mil	Total
Particulate	10.48	0.55	0.14	*	11.17
THC	6.81	4.16	2.11	0.02	13.10
VOC	7.46	4.05	2.04	0.02	13.37
TOG	8.33	4.57	2.32	0.02	15.24
Benzene	0.16	0.18	0.09	*	0.43
Formaldehyde	1.25	0.17	0.07	*	1.49
1,3-Butadiene	0.15	0.05	0.02	*	0.22

Notes:

Comm. = Commercial air carriers GA = General aviation
AT = Air Taxis Mil. = Military
* = Annual amount less than 0.01 tpy

TABLE B 8 ANNUAL EMISSIONS (TPY) FOR APPROACH MODE

Pollutant	Aircraft Category Comm	AT	GA	Mil	Total
Particulate	10.48	0.78	0.15	*	11.41
THC	14.62	7.54	2.41	0.05	24.62
VOC	16 00	7 71	2.39	0.05	26.15
TOG	17.87	8 45	2.67	0.06	29.05
Benzene	0.35	0.23	0.08	*	0.66
Formaldehyde	2.68	0 78	0.17	0.01	3.64
1,3-Butadiene	0.32	0 11	0.03	*	0.46

Notes:

Comm. = Commercial air carriers GA = General aviation
AT = Air Taxis Mil. = Military
* = Annual amount less than 0 01 tpy

Table B.9 lists the total emission amounts for each phase-of-operation as well as a combined total of all aircraft emissions at Midway Airport. Detailed emissions data may be found in Exhibit B-3, which identifies annual THC and particulate matter emissions by aircraft and engine type. The exhibit also identifies annual VOC, TOG, benzene, formaldehyde, and 1,3-butadiene emissions by aircraft category.

B.3.2 EMISSIONS FROM AUTOMOBILE SOURCES

The calculated emissions for automobile sources at Midway Airport are listed in Tables B.10 - B.13.

TABLE B.9 ANNUAL AIRCRAFT EMISSIONS (TPY)

Pollutant	Phase-of-Operation TI	TO	CO	AP	Total
Particulate	24.18 (10.54)[2]	4.11	11.17	11.41	50.87 (37.23)
THC	331 71 (130.78)	2.74	13.10	24.62	372.17 (171.24)
VOC	359.01 (141.24)	2.94	13.37	26.15	401.47 (183.70)
TOG	397 28 (156.38)	3.30	15.24	29.05	444.87 (203.97)
Benzene	7 83 (3.13)	0.06	0.43	0.66	8.98 (4.28)
Formaldehyde	57 25 (22.19)	0.42	1.49	3.64	62.80 (27.74)
1,3-Butadiene	6 82 (2.67)	0.05	0.22	0.46	7.55 (3.40)

Notes:

1) TI = Taxi/idle mode CO = Climbout mode
TO = Takeoff mode AP = Approach mode

2) Numbers in parenthesis are for emissions calculated using the *de minimis* taxi/idle time.

TABLE B.10
EMISSIONS IN MAIN PARKING LOT

Pollutant	Annual Emissions (ton/yr)
TOG	5.711
Gasoline Particulate	0.033
Diesel Particulate	0.092
Benzene	0.150
1,3-Butadiene	0.027
Formaldehyde	0.057

TABLE B.11
EMISSIONS IN EMPLOYEE PARKING LOT

Pollutant	Annual Emissions (ton/yr)
TOG	0.087
Gasoline Particulate	0.0005
Diesel Particulate	0.0014
Benzene	0.023
1,3-Butadiene	0.0004
Formaldehyde	0.0008

TABLE B.12
EMISSIONS IN ECONOMY PARKING LOT

Pollutant	Annual Emissions (ton/yr)
TOG	1.282
Gasoline Particulate	0.007
Diesel Particulate	0.021
Benzene	0.034
1,3-Butadiene	0.006
Formaldehyde	0.013

TABLE B.13
EMISSIONS ON HELEN MIKOLS DRIVE

Pollutant	Annual Emissions (ton/yr)
TOG	4.735
Gasoline Particulate	0.027
Diesel Particulate	0.076
Benzene	0.125
1,3-Butadiene	0.022
Formaldehyde	0.047

Please note that no emissions generated by refueling loss were considered. This may underestimate the overall emissions. On the other hand, the assumed maximum usage of each parking lot may cause the over-estimation of emissions. Also, cadmium and asbestos emissions from automobile sources at Midway were not inventoried since the estimated emissions are negligible.

B.3.3 EMISSIONS FROM SERVICE VEHICLES

Limited information was received from Midway Airport regarding the service vehicles that the airport operates. The vehicles were identified by name and type, but no operation parameters were supplied. Generally, Midway Airport operates a rolling vehicle fleet of approximately 70 vehicles. This number is split relatively equally between heavy vehicles used predominantly for snow removal efforts during the winter and light vehicles utilized throughout the year. Comparing this number to the frequency of daily vehicle assess to Midway due to travellers' activities (comprising a fleet of approximately 9,000 vehicles), emissions from the Midway service vehicles are negligible. In addition, emissions from utility vehicles (such as snowblowers, de-icers, and lawn mowers) at Midway were accounted for in the nonroad mobile source emissions inventory prepared for the entire study area and could not be easily singled out as a separate emission category. For these reasons, we excluded the service vehicle emissions from the Midway Airport inventory.

B.3.4 EMISSIONS FROM OTHER NON-AIRCRAFT SOURCES

Midway Airport informed us that our request for information regarding fuel storage tanks at the Airport was forwarded to the Chicago DOA for review and authorization. At the time of this report, we had not yet received this information. Due to time constraints, fugitive and other emissions from the feul storage tanks at Midway are not included in this risk assessment.

B.4 AIR DISPERSION MODELING AND RISK ASSESSMENT

B.4.1 EMISSION GRIDS FOR AIRCRAFT EMISSIONS DISPERSION MODELING

Dispersion modeling was conducted based on the results of the Midway Airport emissions inventory. The entire airport area (including runways and terminals) was included in the emission modeling domain (Figure B.1). The emission quantities were identified and distributed by the location on an emission grid of a specific operational phase. The airport area, encompassing approximately a 1.7-kilometer by 1.7-kilometer square with a southwest corner of (UTM northing, UTM easting) = (4625.2, 436.64) in kilometers, was divided into 25 340-meter by 340-meter equal squares as displayed in Figure B.2. The emission rate for each toxic and particulate per phase was determined using the following formula:

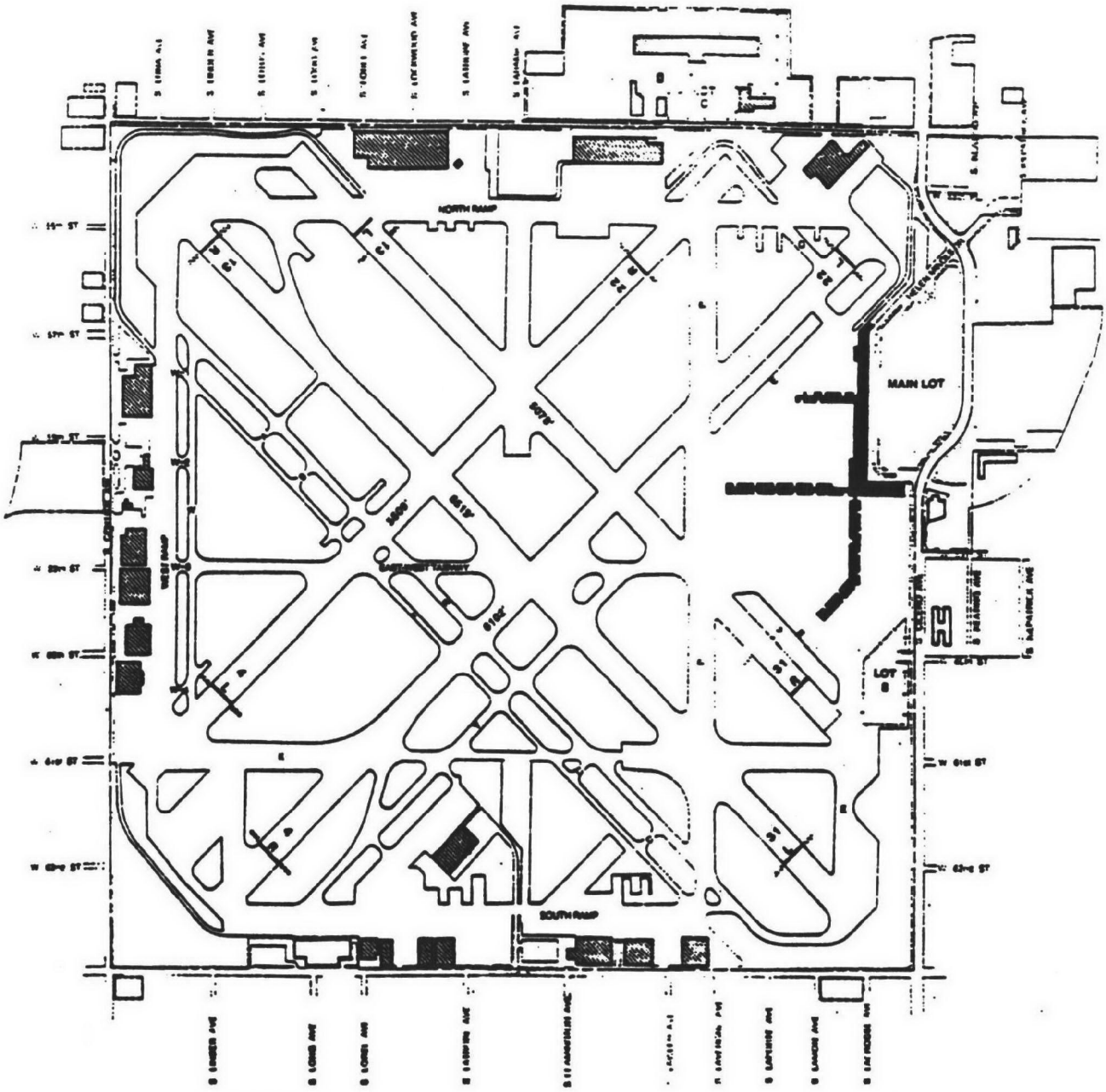
$$\textbf{Emission Rate}_{\text{(per aircraft per foot travelled)}} = \textbf{Annual Emissions/Total Aircraft Travelling Feet}$$

Next, the annual emissions (by phase) from each emission grid were determined using the following formula:

$$\textbf{Annual Emissions in Grid} = (\textbf{No. Aircraft x Distance Covered in Grid}) \textbf{ x Emission Rate}_{\text{(per aircraft per foot travelled)}}$$

Based upon discussions with the personnel at Midway Airport's Control Tower, the following assumptions were used in preparation for emission rates assigned among all emission grids:

- The control tower stated that most takeoffs are to the northwest, and most approaches from the southeast. Therefore, the No. 31 runways are used most often, approximately 75% of the time. A majority of the remaining operations occur on the No. 4 runways (taking off to the northeast, and approaching from the southwest). Therefore, the modeling will be conducted assuming 75% of operations occur on the No. 31 runways, and the remaining 25% of operations occur on the No. 4 runways. In addition, runways No. 31C and No. 31R are for commercial carriers and turbine-engine aircraft only. Piston aircraft will land on runway No. 31L.



RUNWAY LENGTH DATA

R/W	Takeoff Length	Landing Length Day	Landing Length Night	Landing Threshold Day	Landing Threshold Night
13L	5075	4420	4280	658	818
31R		4770	4416	305	662
13R	6519	6061	6055	458	464
31L		5909		610	
4R	6102	5680	5680	512	522
22L		5852	5852	250	250
4L	5509	4751	-	758	-
22R		4629		880	

GRAPHIC SCALE IN FEET

JANUARY 1989

FIGURE B.1

Southwest Chicago Study

Midway Area Source Emission Grids

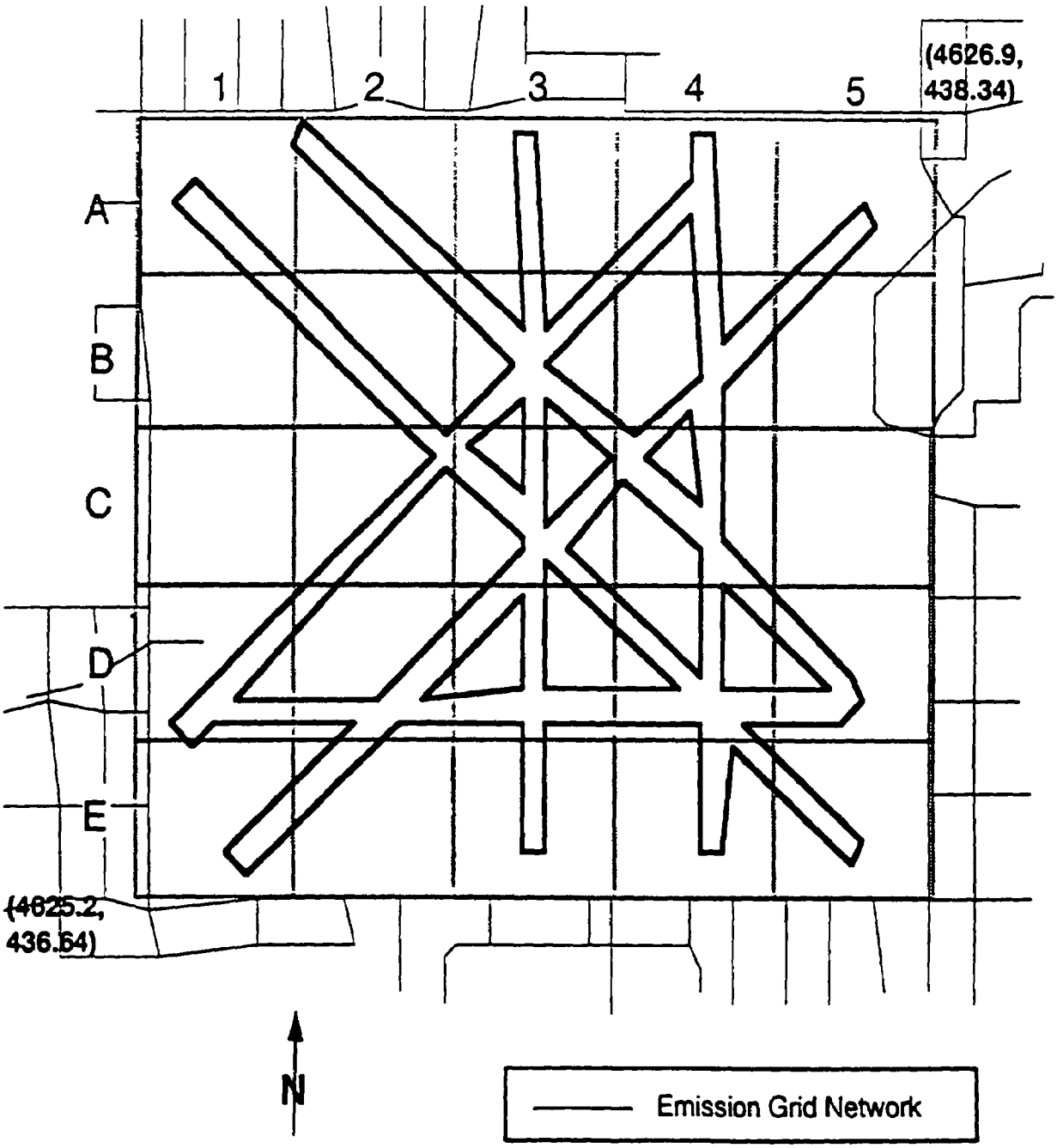


FIGURE B.2

- All turbine-engine air taxis and general aviation aircraft will utilize the main terminals. These are the same terminals as those used by commercial air carriers.

- All piston-engine air taxis and general aviation aircraft will use the west facilities and the southwest corner of Midway's property.

- The military aircraft are located in the southwest corner of the airport. The emissions for dispersion modeling would only include helicopter emissions, since helicopters account for 95% of military aircraft emissions.

- Takeoffs and landings will each utilize approximately 2/3 of their respective runways.

Additional assumptions were also made to facilitate the estimation of emissions among all emission grids. These assumptions are as follows:

- Emissions from the taxi/idle phase for both before takeoff (out) and after landing (in) segments must be accounted for. In the emissions inventory, both segments were combined into one taxi/idle phase. For dispersion modeling, all pollutant emission quantities will be proportioned between the two segments according to the ratio of segment time over taxi/idle phase time. Therefore, the taxi/idle in segment will contain 19 minutes/26 minutes, or 19/26 of total pollutant emissions in the taxi/idle phase; the taxi/idle out segment will contain 7/26 of the pollutant emissions.

- The climbout phase to be considered for the dispersion modeling will include only the distance from point of takeoff to the edge of the airport boundary. This will include 1/3 of the relevant runway plus any ground or other area to the airport border. Although aircraft are typically only at 300 feet when leaving the airport, we will assume that all climbout phase emissions occur within the airport boundary only.

- The approach phase to be considered for dispersion modeling will include only the distance from the edge of the airport to a respective runway, plus 2/3 of that runway. Although aircraft begin their approach some distance from the airport, we will assume that all approach phase emissions occur within the airport boundary only.

A sample calculation of emissions at an individual emission grid is included in Exhibit B-4.

B.4.2 AIR DISPERSION MODELING TECHNIQUES

Emissions from each phase of a LTO cycle distributed to each of the 25 emission grids were modeled *via* the Complex Dispersion Model (CDM). For approach and climbout phases, the emission height was assumed to be 50 meters for certain emission grids located at the boundary of Midway Airport, specifically grids A1, A2, A4, A5, D1, D5, E1, or E5 (see Figure B-2). This simulates the emissions originated in the air. Emissions generated from taxi/idle and landing at each emission grid were assumed to be released at the ground level (5 meters). Emissions due to automobiles travelled in the parking lots and passenger pick-up and drop-off lanes (Helen Mikols Drive) were assigned to one of the four 340-meter by 340-meter emission grids corresponding to the locations of the sources. These emissions were then modeled *via* CDM using the same approach The emission height selected to model vehicular emissions was also set to be 5 meters.

Thirty-three modeling runs were conducted to generate the necessary concentration estimates from aircraft engines at Midway. One run was conducted for each emission grid (32 total) with the assumption of ground-level release height. One additional run was conducted to model the emissions released in the air for each of the identified eight emission grids. One-thousand metric tons per year was used as the input to CDM for each modeling run. We then stored the CDM-modeled concentrations computed at the 8 x 8 receptor grids in the matrix format as unit concentration profiles. For each pollutant, combining the CDM concentration profile, based on the phase of LTO cycle, with its actual emission rate divided by a thousand, one can come up with the estimated annual concentration profile at the 8 x 8 receptor grids.

B.4.3 RISK CALCULATION

Once we have the annual concentration estimates at the receptor grids, determining the individual risk estimates is a straightforward procedure. Two assumptions were made. First, we assume a linear relationship between annual concentration and cancer risk. Second, we assume a zero threshold value for computing cancer risk. Based on these two assumptions, we can compute the individual lifetime cancer risk by multiplying the annual concentration value at a receptor grid by the unit risk factors of those pollutants emitted from the Midway mobile sources.

$$R_{i,j,k} = C_{i,j,k} \times F_j$$

$R_{i,j,k}$ = individual lifetime cancer risk at receptor "k" due to the emission of pollutant "j" from emission source "i",

$C_{i,j,k}$ = annual concentration at receptor "k" due to the emission of pollutant "j" from emission source "i",

F_j = lifetime unit risk factor of pollutant "j".

Figure B.3 shows the population profile for the targeted 8 x 8 receptor network. With the population data available for each receptor grid, cancer cases over a 70-year period can be computed using the following equation.

$$I_{i,j,k} = R_{i,j,k} \times P_k$$

$I_{i,j,k}$ = cancer incidence at receptor "k" due to the emission of pollutant "j" from emission source "i",

$R_{i,j,k}$ = individual lifetime cancer risk at receptor "k" due to the emission of pollutant "j" from emission source "i",

P_k = population residing within the receptor grid "k".

B.4.4 UNIT RISK FACTOR

Table B.14 lists the unit risk factors used in the study to estimate cancer risks attributed to emissions from the Midway mobile sources. The unit risk factor is defined as an estimate of the probability that an individual would contract cancer when exposed to a pollutant at an ambient concentration of one microgram per cubic meter (ug/m^3) for 70 years (the average lifetime).

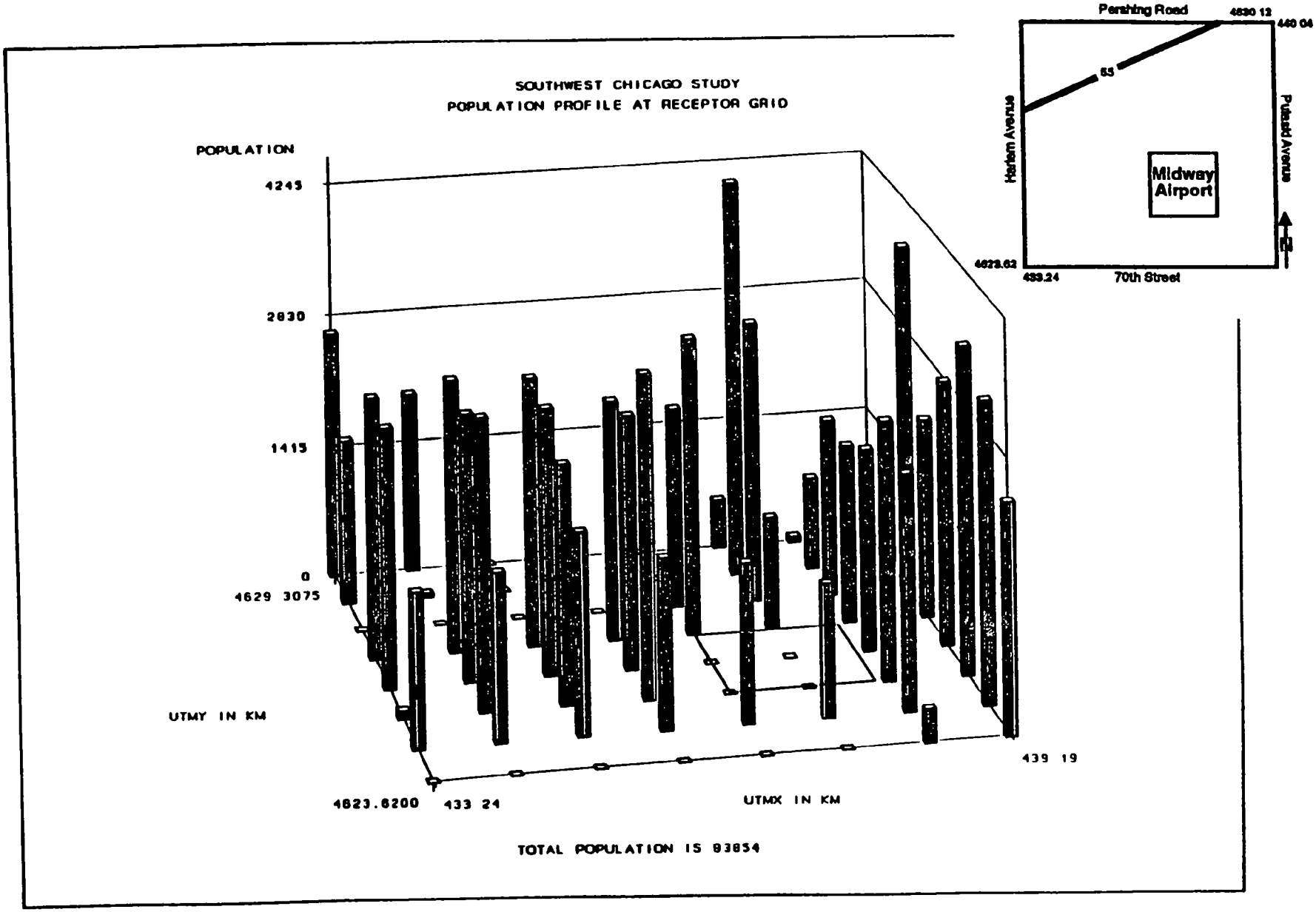

SOUTHWEST CHICAGO STUDY
POPULATION PROFILE AT RECEPTOR GRID
POPULATION
4245
2830
1415
0
4629 3075
UTMY IN KM
4623.6200
433 24
UTMX IN KM
439 19
TOTAL POPULATION IS 93854
Pershing Road
4630 12
440 04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4623.62
433.24
70th Street

FIGURE B.3

TABLE B.14
CARCINOGENICITY OF POLLUTANT
LIFETIME EXPOSURE TO A UNIT POLLUTANT CONCENTRATION
(For Pollutants Inventoried in Midway Mobile Sources Only)

Pollutant	Unit Risk Factor $(ug/m^3)^{-1}$ [a]	Weight of Evidence Rating	Source of Data
Benzene	0.0000083	nd	IRIS
1,3-Butadiene	0.00028	B2	IRIS
Formaldehyde	0.000013	B1	IRIS
Diesel Particulate	0.000017	B2	AWMA
Gasoline Particulate	0.000051	nd	HERL
Piston Particulate	0.000016	nd	HERL
Turbine Particulate	0.000017	B2	AWMA

A - Known human carcinogen
B - Probable human Carcinogen
B1 - Based on "limited" human data
B2 - Based on "sufficient" animal data
nd - Not determined

HERL: Health Effects Research Laboratory
IRIS: Integrated Risk Information System
AWMA: Published by Air and Waste Management Association

[a] The unit risk factor is defined as an estimate of the probability that an individual will develop cancer when exposed to a pollutant at an ambient concentration of one microgram per cubic meter (ug/m^3) for 70 years. These unit risk factors are either upper-bound values or maximum likelihood values

B.5 RISK ASSESSMENT RESULTS

In this section, we present the cancer risk estimates computed using the modeled concentrations at receptor grids. The total number of cancer cases attributed to estimated air pollution emitted from the Midway mobile sources is approximately 2 cases over a 70-year period, or one case every 30 years. This includes cancer risks attributed to emissions from both aircraft and vehicles travelled at Midway in 1990. The population residing at receptor grids were estimated at 93,854 people. This suggests that the average risk across the area due to the emissions from Midway is approximately 2.3×10^{-5}. By comparing to the average cancer risk of 1.9×10^{-4} assessed for all identified sources in the Southwest Chicago area, this average risk is less by roughly 10-fold. Figure B.4 displays the lifetime cancer cases caused by mobile sources' air pollution at Midway at the receptor grid network. Not surprisingly, receptors located around Midway Airport have higher cancer cases than others. Table B.15 lists the hazard indices at each grid with the percentage of cancer contribution over the estimated total cancer cases of 2, which are attributable solely to air pollution at Midway.

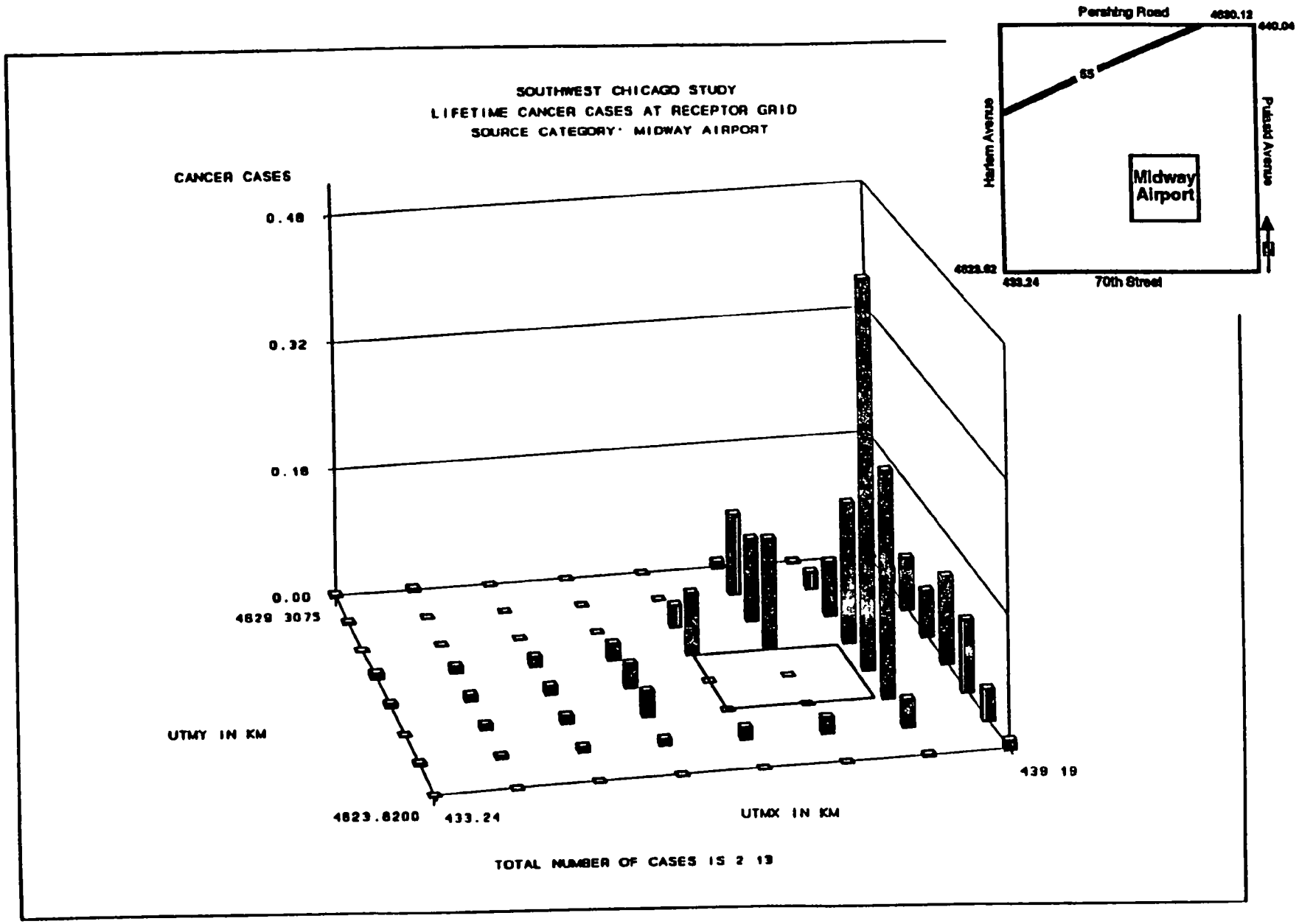

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
SOURCE CATEGORY: MIDWAY AIRPORT
CANCER CASES
0.48
0.32
0.16
0.00
4829 3075
UTMY IN KM
4823.8200
433.24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 2 13
Pershing Road
4830.12
440.04
65
Harlem Avenue
Pulaski Avenue
Midway Airport
4823.82
433.24
70th Street

FIGURE B.4

TABLE B.15. AGGREGATE HAZARD INDICES AT RECEPTOR
(For Inventoried Midway Mobile Sources Only)

Grid ID	Receptor (S.W. Corner)	Individual Lifetime Cancer Risks	Lifetime Cancer Cases	Percent Cancer Cases
1	4623.6200 433.24	1.29E-06	0	0
2	4623.6200 434.09	1.73E-06	0	0
3	4623.6200 434.94	1.89E-06	0	0
4	4623.6200 435.79	2.80E-06	0	0
5	4623.6200 436.64	3.94E-06	0	0
6	4623.6200 437.49	6.21E-06	0	0
7	4623.6200 438.34	7.34E-06	0.0026	0.12
8	4623.6200 439.19	5.14E-06	0.012	0.58
9	4624.4325 433.24	1.55E-06	0.0025	0.12
10	4624.4325 434.09	2.18E-06	0.0038	0.18
11	4624.4325 434.94	3.08E-06	0.0065	0.30
12	4624.4325 435.79	4.89E-06	0.0087	0.41
13	4624.4325 436.64	9.56E-06	0.016	0.75
14	4624.4325 437.49	1.46E-05	0.020	0.95
15	4624.4325 438.34	1.42E-05	0.035	1.64
16	4624.4325 439.19	1.26E-05	0.040	1.87
17	4625.2450 433.24	1.89E-06	0.00017	0.008
18	4625.2450 434.09	2.37E-06	0.0073	0.34
19	4625.2450 434.94	3.96E-06	0.010	0.47
20	4625.2450 435.79	9.42E-06	0.032	1.50
21	4625.2450 436.64	4.35E-05	0	0
22	4625.2450 437.49	5.65E-05	0	0
23	4625.2450 438.34	1.02E-04	0.28	13.04
24	4625.2450 439.19	2.60E-05	0.090	4.22
25	4626.0575 433.24	1.79E-06	0.0049	0.23
26	4626.0575 434.09	2.87E-06	0.0081	0.38
27	4626.0575 434.94	4.09E-06	0.012	0.54
28	4626.0575 435.79	1.15E-05	0.031	1.45
29	4626.0575 436.64	4.23E-05	0	0
30	4626.0575 437.49	2.49E-04	0	0
31	4626.0575 438.34	2.23E-04	0.48	22.58
32	4626.0575 439.19	3.88E-05	0.11	5.12

TABLE B.15 (CONT'D). AGGREGATE HAZARD INDICES AT RECEPTOR
(For Inventoried Midway Mobile Sources Only)

Grid ID	Receptor (S.W. Corner)	Individual Lifetime Cancer Risks	Lifetime Cancer Cases	Percent Cancer Cases
33	4626.8700 433.24	2.73E-06	0.0076	0.36
34	4626.8700 434.09	3.01E-06	0.0087	0.41
35	4626.8700 434.94	4.54E-06	0.013	0.61
36	4626.8700 435.79	8.37E-06	0.021	1.01
37	4626.8700 436 64	2.42E-05	0.076	3.58
38	4626.8700 437 49	1.14E-04	0.14	6.40
39	4626.8700 438.34	9.08E-05	0.17	8.16
40	4626.8700 439.19	2.71E-05	0.058	2.71
41	4627.6825 433.24	1.62E-06	0	0
42	4627.6825 434.09	2.26E-06	0	0
43	4627.6825 434.94	3.55E-06	0	0
44	4627.6825 435.79	6.18E-06	0	0
45	4627.6825 436.64	1.28E-05	0.027	1.29
46	4627.6825 437.49	3.45E-05	0.10	4.86
47	4627.6825 438.34	3.55E-05	0.067	3.17
47	4627.6825 439.19	1.77E-05	0.065	3.07
49	4628.4950 433.24	1.27E-06	0.0022	0.11
50	4628.4950 434.09	2.27E-06	0.00011	0.005
51	4628.4950 434.94	3.34E-06	0	0
52	4628.4950 435.79	5.16E-06	0	0
53	4628.4950 436.64	7.07E-06	0	0
54	4628.4950 437.49	2.39E-05	0.10	4.76
55	4628.4950 438.34	2.20E-05	0.022	1.02
56	4628.4950 439.19	1.28E-05	0.020	0.94
57	4629.3075 433.24	1.09E-06	0.0029	0.14
58	4629.3075 434.09	2.04E-06	0.0039	0.18
59	4629.3075 434.94	2.88E-06	0	0
60	4629.3075 435.79	3.28E-06	0	0
61	4629.3075 436.64	5.41E-06	0	0
62	4629.3075 437.49	1.60E-05	0.0084	0.39
63	4629.3075 438.34	1.47E-05	0.00099	0.05
64	4629.3075 439.19	9.76E-06	0.000029	0.001

Cancer cases attributed to the Midway mobile sources were also studied by refined source types and by pollutant. Table B.16 provides a cross reference list of cancer contribution by mobile source origin and by pollutant.

TABLE B.16
CANCER CASES BY POLLUTANT BY SOURCE CATEGORY

Pollutant	Emission Source	Annual Concentrations (ug/m^3)	Individual Cancer Risks	Lifetime Cancer Cases
1,3-Butadiene	All Aircraft	2.87E+00	8 03E-04	1.21
	All Vehicles	1.97E-02	5.51E-06	0 01
Formaldehyde	All Aircraft	2.38E+01	3.09E-04	0.47
	All Vehicles	4 15E-02	5 39E-07	0.001
POM/Particulate Matter	Turbine Aircraft	1.63E+01	2.76E-04	0.39
	Piston Aircraft	4.61E-01	7.37E-06	0.008
	Gasoline Vehicles	2.43E-02	1.24E-06	0.0023
	Diesel Vehicles	6.73E-02	1.14E-06	0.0021
Benzene	All Aircraft	3.40E+00	2.82E-05	0.041
	All Vehicles	1.10E-01	9.15E-07	0.0017

From Table B.16, we found that 1,3-butadiene is the most significant contributor to cancer risk in the area. Approximately one case, or 57% of the total cancer cases attributed to the identified Midway air pollution is caused by 1,3-butadiene. Formaldehyde and particulate emissions each contributes roughly 20% of the total cancer cases (about a half case respectively). Cancer cases due to benzene emissions from Midway, on the other hand, are negligible in comparison to the total cancer cases of 2.

Overall, emissions from aircraft operated at Midway in 1990 contribute up to 99% of the total cancer cases. This was expected since the vehicular emissions estimated at Midway are insignificant compared to the aircraft emissions at Midway. Figures B.5 - B.10 portray the cancer cases at the receptor grid network by pollutant and by emission source.

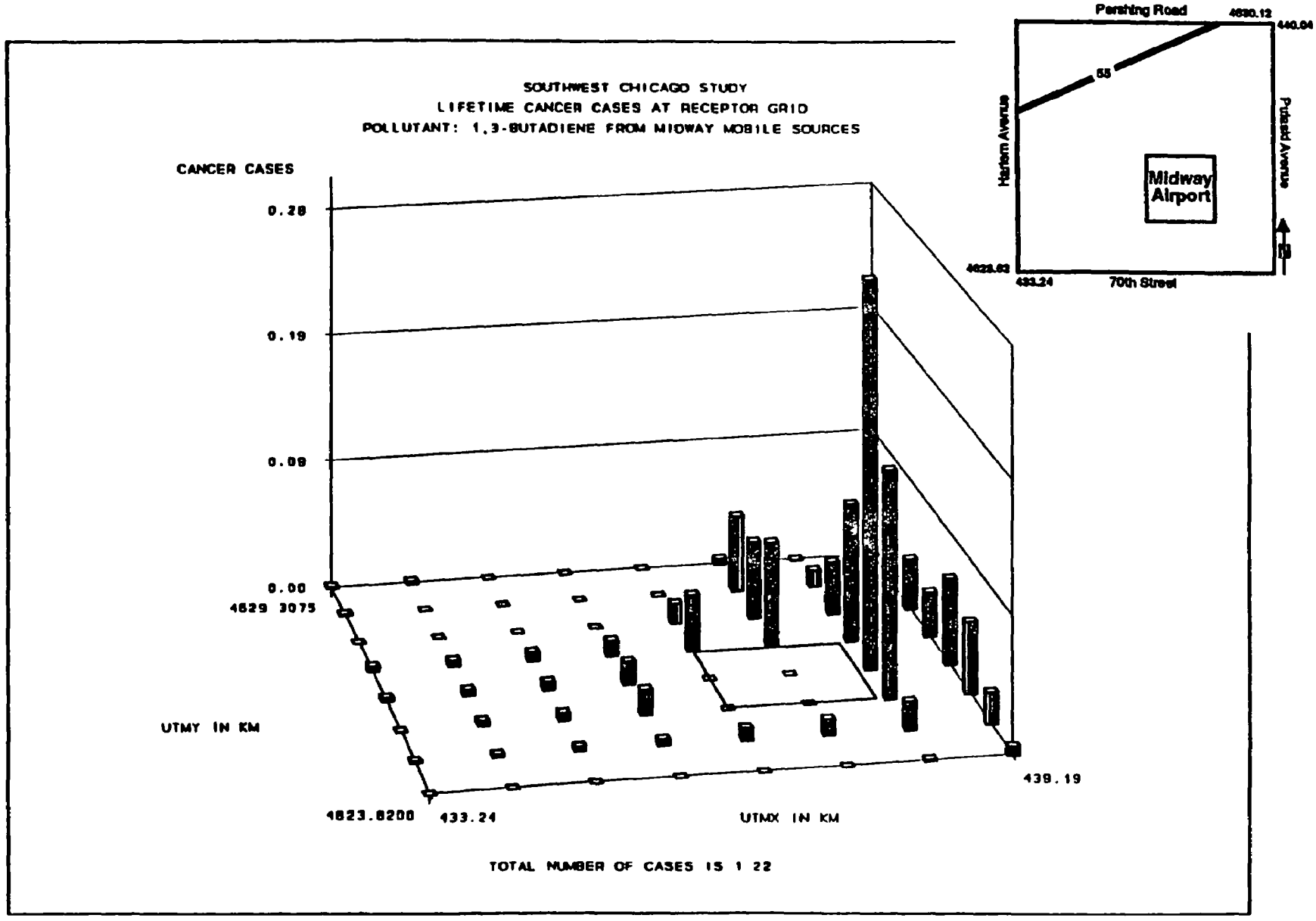

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
POLLUTANT: 1,3-BUTADIENE FROM MIDWAY MOBILE SOURCES
CANCER CASES
0.28
0.19
0.09
0.00
4829 3075
UTMY IN KM
4823.8200
433.24
UTMX IN KM
439.19
TOTAL NUMBER OF CASES IS 1 22
Pershing Road
4830.12
440.04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4823.82
433.24
70th Street

FIGURE B.5

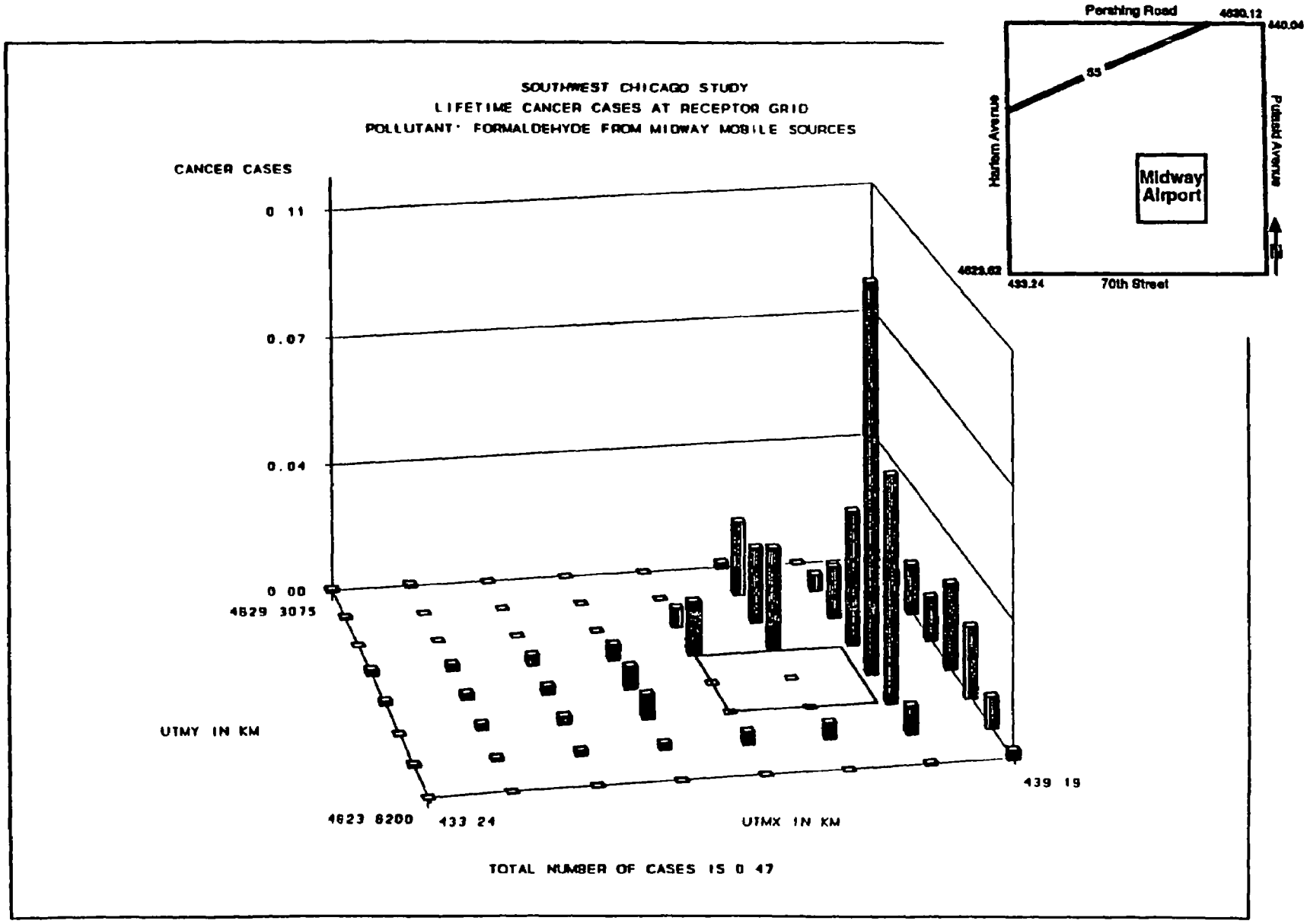

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
POLLUTANT: FORMALDEHYDE FROM MIDWAY MOBILE SOURCES
CANCER CASES
0 11
0.07
0.04
0 00
4629 3075
UTMY IN KM
4623 8200
433 24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 0 47
Pershing Road
4630.12
440.04
35
Harlem Avenue
Pulaski Avenue
Midway Airport
4623.62
433.24
70th Street

FIGURE B.6

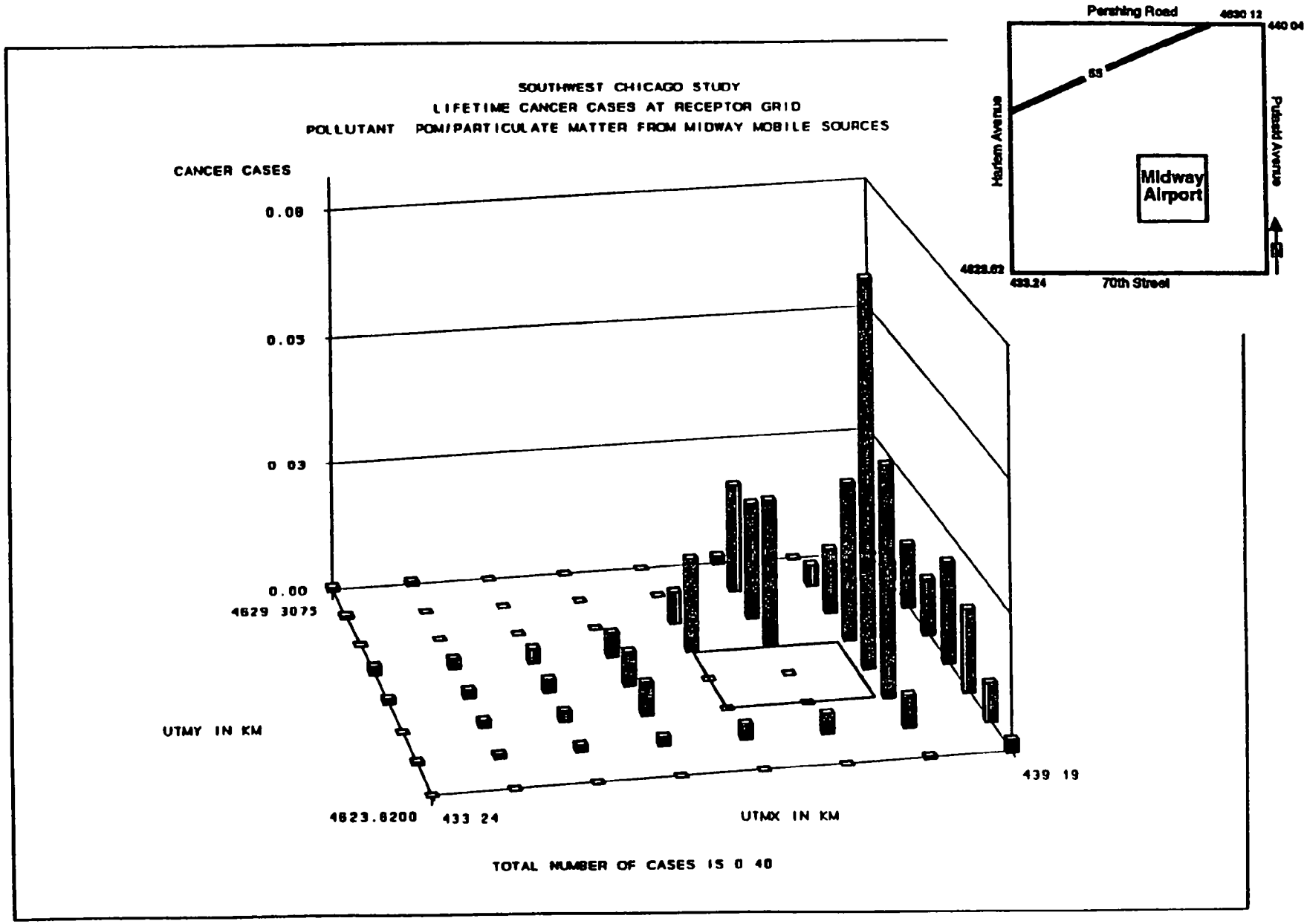

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
POLLUTANT POM/PARTICULATE MATTER FROM MIDWAY MOBILE SOURCES
CANCER CASES
0.08
0.05
0.03
0.00
4629 3075
UTMY IN KM
4623.6200
433 24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 0 40
Pershing Road
4630 12
440 04
Harlem Avenue
Pulaski Avenue
Midway Airport
4622.62
433.24
70th Street

FIGURE B.7

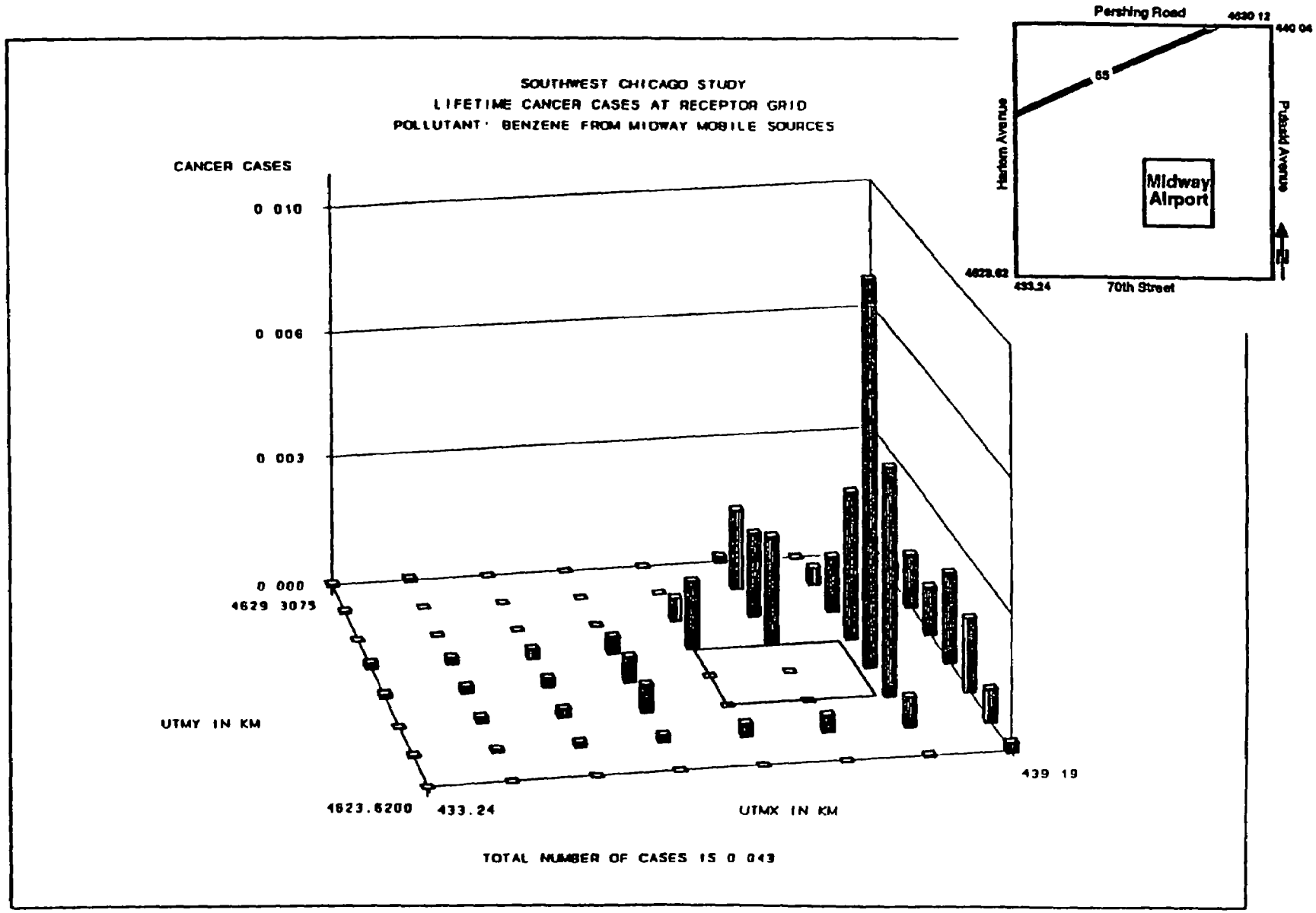

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
POLLUTANT: BENZENE FROM MIDWAY MOBILE SOURCES
CANCER CASES
0 010
0 006
0 003
0 000
4629 3075
UTMY IN KM
4623.6200
433.24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 0 043
Pershing Road
4630 12
440 04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4623.62
433.24
70th Street

FIGURE B.8

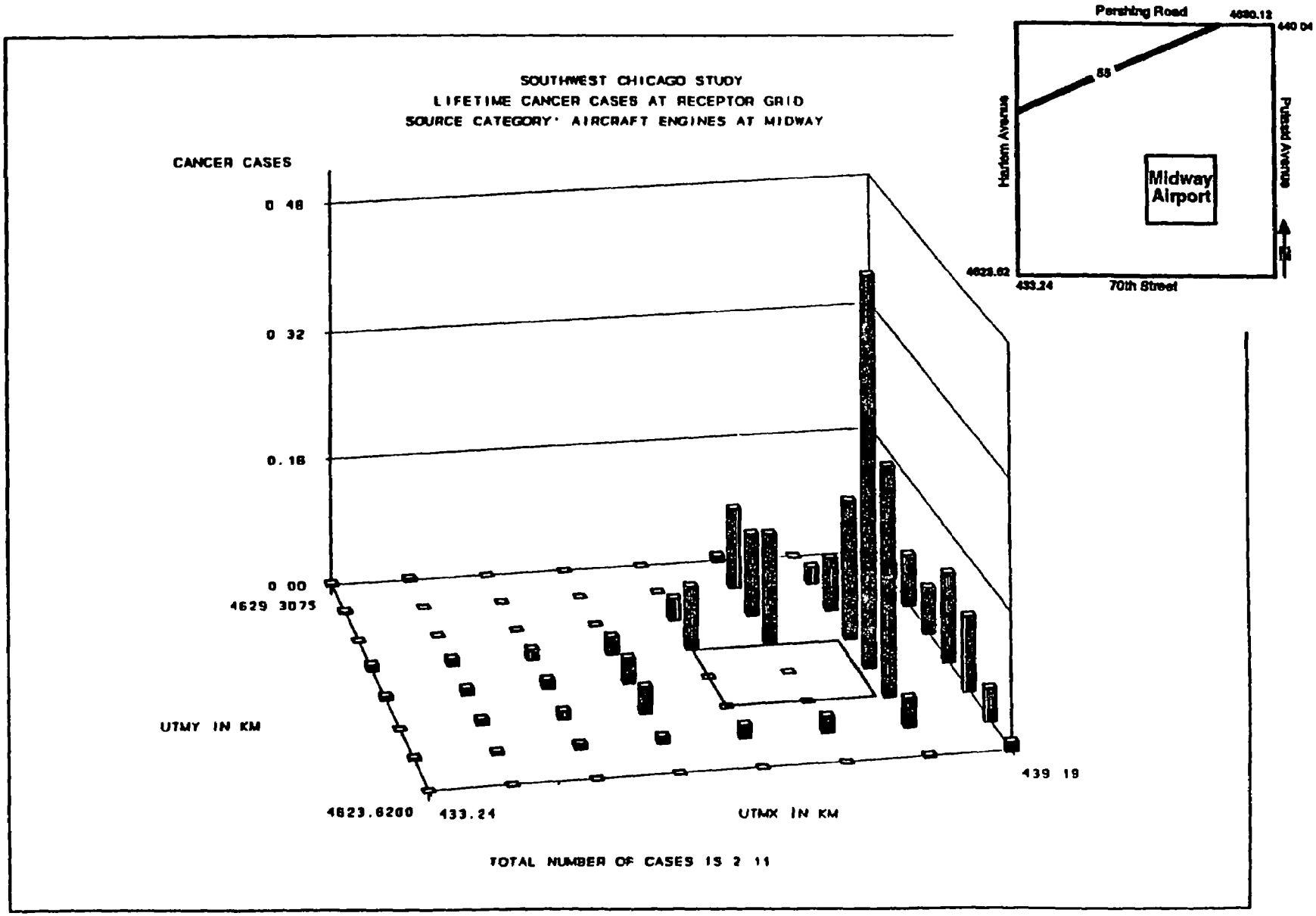

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
SOURCE CATEGORY: AIRCRAFT ENGINES AT MIDWAY
CANCER CASES
0 48
0 32
0.16
0 00
4629 3075
UTMY IN KM
4623.6200
433.24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 2 11
Pershing Road
4630.12
440 04
85
Harlem Avenue
Pulaski Avenue
Midway Airport
4623.62
433.24
70th Street

FIGURE B.9

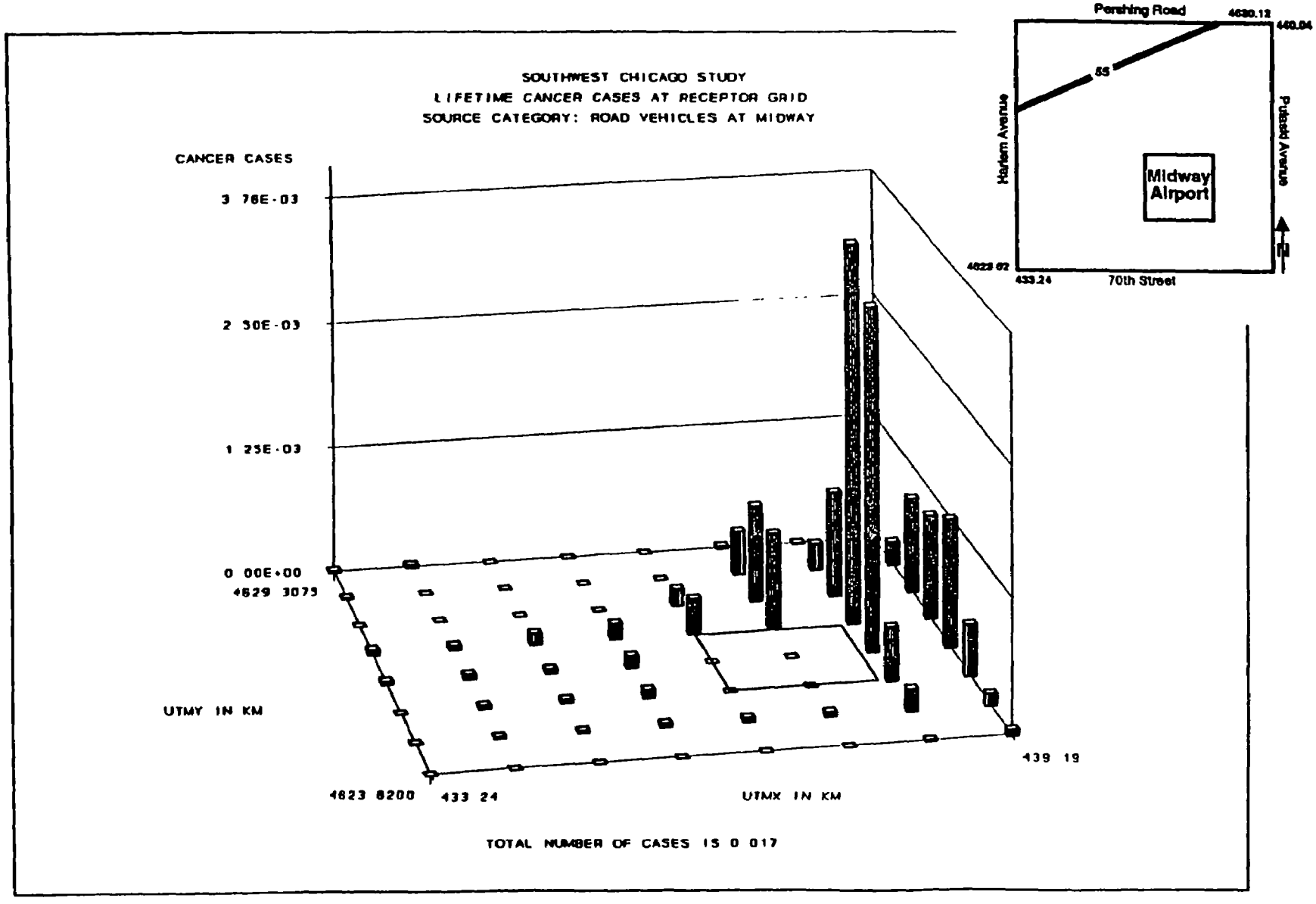

SOUTHWEST CHICAGO STUDY
LIFETIME CANCER CASES AT RECEPTOR GRID
SOURCE CATEGORY: ROAD VEHICLES AT MIDWAY
CANCER CASES
3 78E-03
2 50E-03
1 25E-03
0 00E+00
4629 3075
UTMY IN KM
4623 8200
433 24
UTMX IN KM
439 19
TOTAL NUMBER OF CASES IS 0 017
Pershing Road
4630.12
440.04
55
Harlem Avenue
Pulaski Avenue
Midway Airport
4623.02
433.24
70th Street
N

FIGURE B.10

EXHIBIT B-1
NUMBER AND TYPE OF AIRCRAFT AT MIDWAY AIRPORT

The data used in this exhibit were obtained at the FAA Library from the FAA Airport Activity Statistics of Certified Route Carriers reports for the years 1981 through 1991. Specifically the data was contained in *Table 7 - Aircraft Departures Scheduled and Aircraft Departures Performed By Type of Operation, By Aircraft Type, By Community, and By Carrier.* This source contained a listing of the air carriers and types of aircraft that used Midway Airport between 1981 and 1991. In addition, it was possible to quantify the number of flights (departures) attributed to Midway Airlines. This data contains only information for departures.

Two other sources of airport operations data for Chicago's Midway Airport were obtained. The first set of data includes excerpts from *Table 4 - Airport Operations at Airports With FAA-Operated Traffic Control Towers By Region and By State and Aviation Category* of the FAA Air Traffic Activity report for fiscal years 1982 through 1991. The final source of data is the Illinois Depart of Transportation (IDOT) Illinois Airport Inventory Report, 1992. This data contains counts of all operations, not just departures.

Based on the data received, and telephone calls to IDOT and Mr. David Soumi, Deputy Commissioner at Midway Airport, the following information on the Chicago Midway Airport was obtained:

Following deregulation in 1978, Midway Airlines was formed. Midway Airlines was based out of Midway Airport. As Midway Airlines grew, the air traffic at Midway Airport increased. Once other airlines recognized the market that Midway Airlines had discovered, they also began to fly out of Midway Airport, increasing air traffic accordingly. This growth in air traffic at Midway Airport went through a dip in the early 1980's as a result of the air traffic controller strike of August 3, 1981 and the recession that affected the entire airline industry in the early 1980's. Air traffic at Midway Airport was also significantly affected by the cancellation of all Midway Airlines flights when they filed for Chapter 7 (bankruptcy) at midnight on Wednesday, November 13th, 1991. At the time of Midway Airlines collapse they represented 70% of the airports traffic. Following the Midway Airlines collapse, some but not all of their gates and corresponding air traffic have been assumed by other airlines. Southwest Airlines alone acquired 17 gates from Midway Airlines.

The types of aircraft that used Midway Airport between 1981 and 1991 are:

B-727-100	BAC-111-400	C-208	DC-9-50
B-727-200	BAE-146-1	CESSNA 404	DC-9-80
B-737-100/200	BAE-146-100	CV-580	F-28-4000/600
B-737-200C	BAE-146-2	DC-9-10	FH-227
B-737-300	BAE-146-300	DC-9-15F	FOKKER 100
B-737-500	BEECH 18	DC-9-30	MISCELLANEOUS
BAC-111-200	BH-99	DC-9-40	SWEAR-METRO
			SWEAR-METRO I

There were several Air Carriers who used Midway Airport during the 1981 to 1991 time period. The Air Carriers and their associated FAA codes are listed below:

2M	-	Midway Express Airlines	NW	-	Northwest Airlines
9N	-	Trans States	QH	-	Air Florida
AA	-	American Airlines	QS	-	Northeastern International
AP	-	Aspen Airways	RC	-	Republic Airlines
BN	-	Braniff Airways	RU	-	Britt Airways
CO	-	Continental	TW	-	Trans World Air
DL	-	Delta Air Lines	UA	-	United Air Lines
FM	-	Federal Express	US	-	U.S. Air
FW	-	Skybus Inc.	WN	-	Southwest Airlines
HP	-	America West	XV	-	Presidential Airways
JI	-	Jet Fleet	ZV	-	Air Midwest
ML	-	Midway Airlines	ZW	-	Air Wisconsin
NI	-	American International Airways			

The total number of flights at Midway Airport and the number associated with Midway Airlines by year (obtained from Table 7 of FAA Airport Activity Statistics of Certified Route Carriers) are depicted in the Table 1 and Figure 1, Midway Airlines and Airport Total Departures.

FIGURE 1

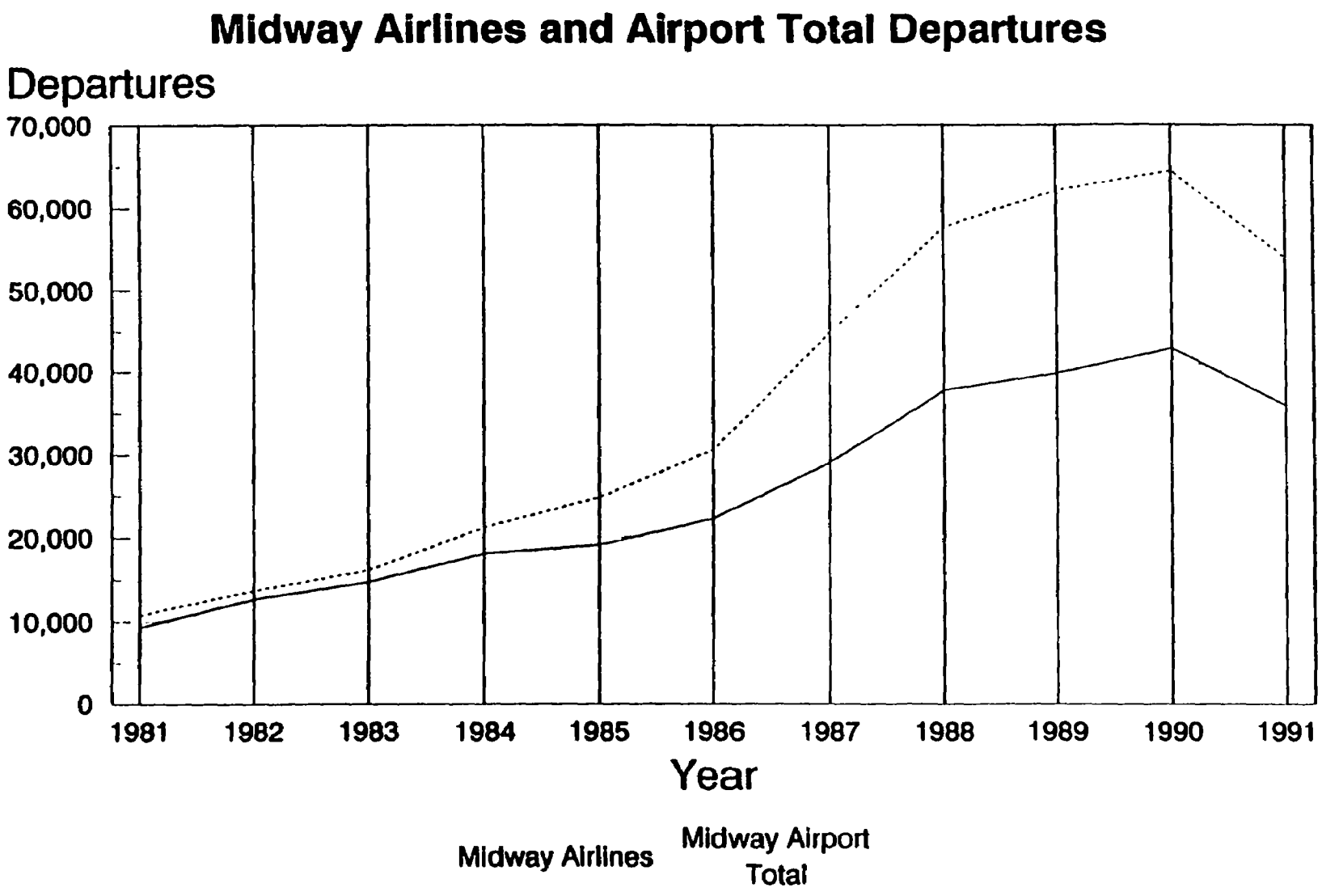

Midway Airlines and Airport Total Departures
Departures
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
Year
Midway Airlines
Midway Airport Total

Table 1

Year	Midway Airlines	All Airlines
1981	9352	10771
1982	12627	13713
1983	14710	16103
1984	18087	21229
1985	19067	24760
1986	22217	30565
1987	28994	44801
1988	37677	57631
1989	39777	62238
1990	42848	64465
1991	35781	53933
Total	281137	400209

The number of flights by aircraft type and year are depicted in the Table 2 and Figure 2, Departures By Aircraft Type. Please note that several types of aircraft are grouped together under miscellaneous because the number of departures for those aircraft types were too small to appear on the chart.

Table 2

Year	B-727s	B-737-100/200	B-737-300	Other B-737	Misc
1981	961	0	0	0	0
1982	1086	0	0	0	0
1983	1299	94	0	0	0
1984	1755	1009	0	0	283
1985	1469	5081	43	0	0
1986	1936	8746	982	0	13
1987	2375	14768	4115	0	43
1988	1524	17669	4340	400	21
1989	1152	16829	6669	444	54
1990	331	15659	6405	487	1777
1991	97	9159	4809	1393	1094

Year	DC-9-10	DC-9-30	DC-9-80	Other DC-9s	Totals
1981	8760	1050	0	0	10771
1982	6180	4145	0	2302	13713
1983	8324	5916	470	0	16103
1984	8103	8292	1787	0	21229
1985	7602	10202	363	0	24760
1986	8247	10350	162	129	30565
1987	9006	13798	460	236	44801
1988	10401	23066	89	111	57631
1989	10071	24793	1771	455	62238
1990	1607	24271	7269	6669	64465
1991	1758	25224	8498	1801	53933

The events described above regarding the fluctuations in air traffic at Midway Airport are depicted in Figure 3, FAA and IDOT Annual Totals. This chart represents the data received from FAA Airport Traffic Activity and Illinois Airport Inventory Report. The next figure (Figure 4), Total Operations By Category, represents the FAA data broken out by aviation category. Following the figures are two tables containing the data which were used to create Figures 3 and 4.

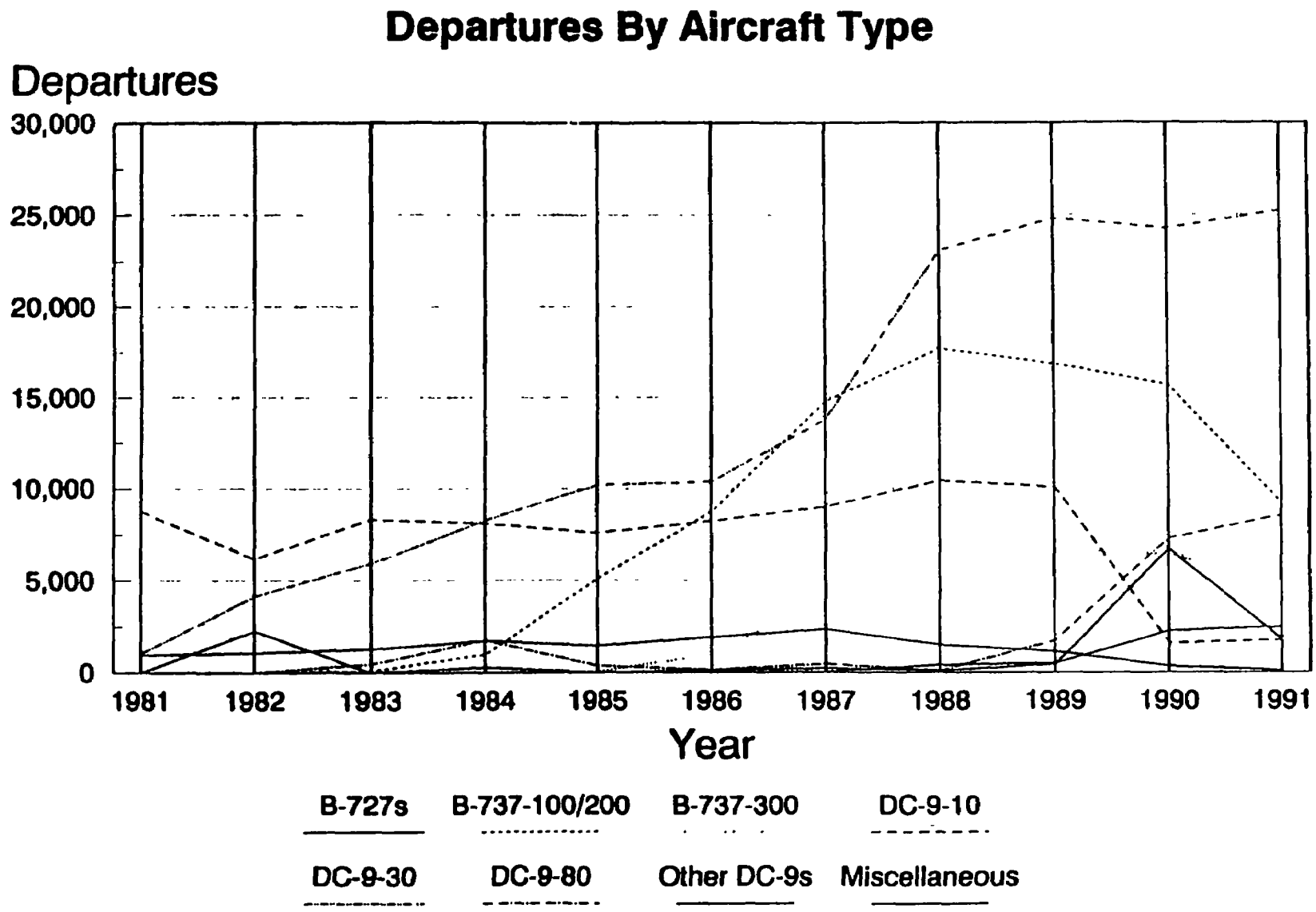

Departures By Aircraft Type
Departures
30,000
25,000
20,000
15,000
10,000
5,000
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
Year
B-727s
B-737-100/200
B-737-300
DC-9-10
DC-9-30
DC-9-80
Other DC-9s
Miscellaneous

FIGURE 2

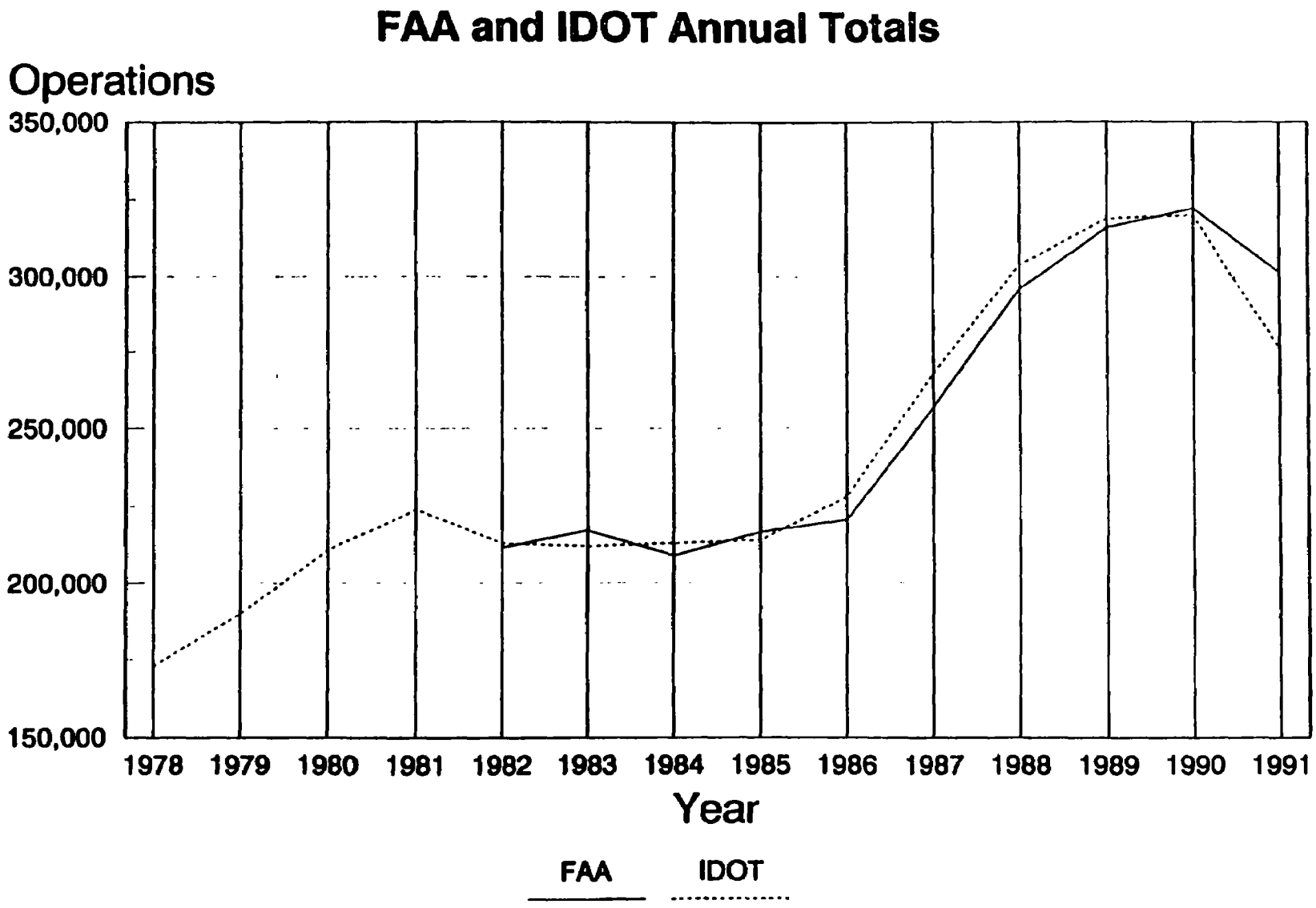
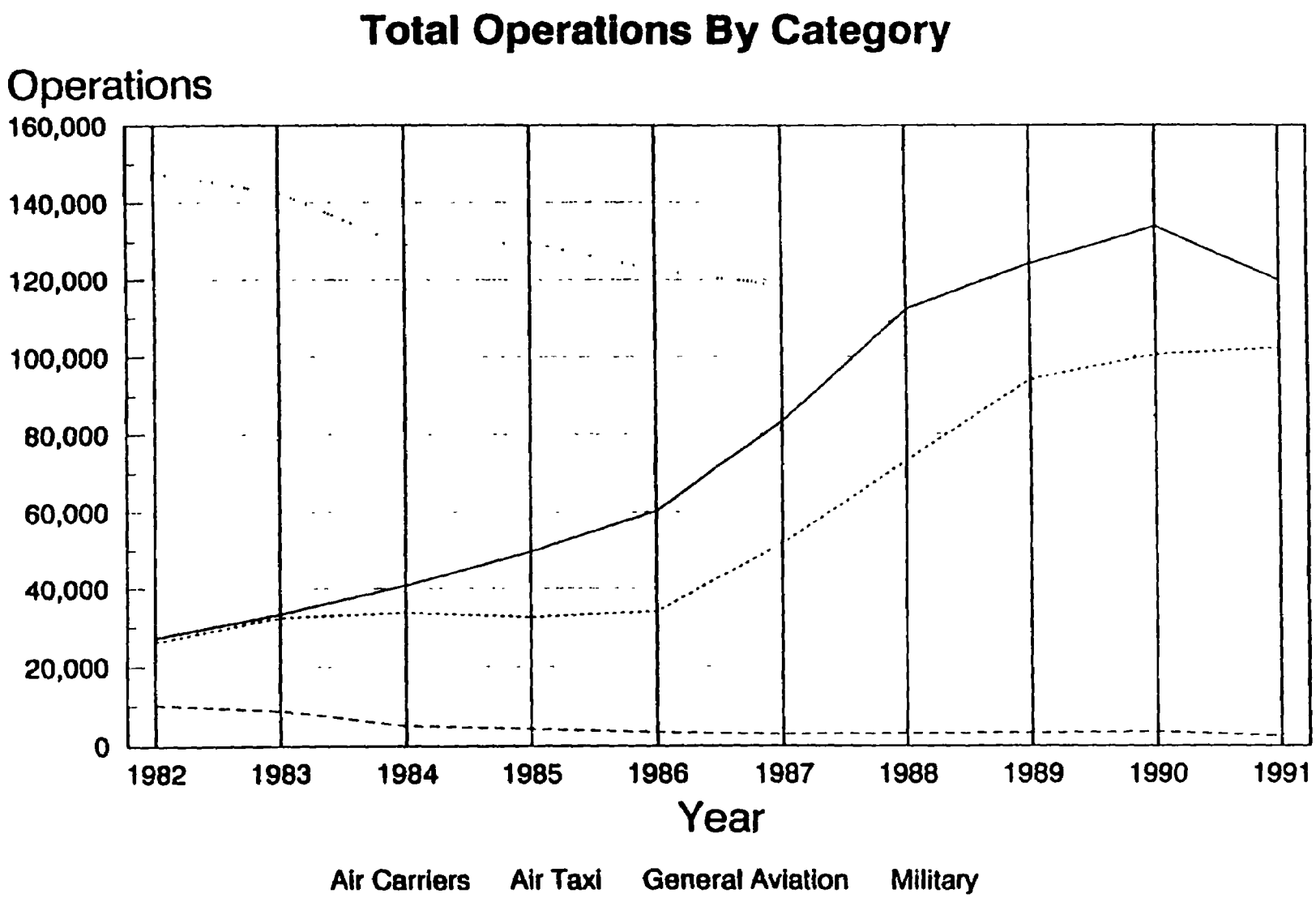

FAA and IDOT Annual Totals
Operations
350,000
300,000
250,000
200,000
150,000
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
Year
FAA
IDOT

FIGURE 3

FIGURE 4


Total Operations By Category
Operations
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
Year
Air Carriers
Air Taxi
General Aviation
Military

Chicaco Midway Air Traffic Data

Year	Itin Total	Itin Carrier	Itin Taxi	Itin Gen Av	Itin Military	Local Total	Local Gen Av	Local Military
1978								
1979								
1980								
1981								
1982	191898	27417	26259	134843	3379	19735	12732	7003
1983	191116	33318	32439	122302	3057	26084	20283	5801
1984	184968	40908	33712	107319	3029	24041	21988	2053
1985	189158	49809	32474	104032	2843	27350	25872	1478
1986	201338	60286	34071	104335	2646	19115	18399	716
1987	248863	83621	51981	110564	2697	8013	7742	271
1988	292140	112213	73339	103565	3023	4032	3888	144
1989	315583	124258	94210	93939	3176	458	352	106
1990	320951	133855	100445	83264	3387	1246	1102	144
1991	301186	119931	102154	76856	2245	504	389	115

Year	FAA Total	Total Carrier	Total Taxi	Total Gen Av	Total Military	Enplanement	IDOT Total	IDOT Itin	IDOT Local
1978						60000	173000	149000	24000
1979						60098	190000		
1980						191581	211000	185000	26000
1981						527896	224000	201000	23000
1982	211633	27417	26259	147575	10332	664955	213000	191000	22000
1983	217200	33318	32439	142585	8858	760367	212000	188000	24000
1984	209009	40908	33712	129307	5082	989854	213000	188000	25000
1985	216508	49809	32474	129904	4321	1244799	214000	187000	27000
1986	220453	60286	34071	122734	3362	1719872	228000	213000	15000
1987	256876	83621	51981	118306	2968	2637784	268000	260000	8000
1988	296172	112213	73339	107453	3167	3265850	304000	301000	3000
1989	316041	124258	94210	94291	3282	3598045	319000	318000	1000
1990	322197	133855	100445	84366	3531	3935966	320000	319000	1000
1991	301690	119931	102154	77245	2360	3399087	276000	275000	1000

EXHIBIT B-2
OMS SUGGESTED EMISSION FACTORS, TOXIC EMISSION FRACTIONS, AND VOC/TOG CORRECTION FACTOR FOR AIRCRAFT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR AND RADIATION

FEB 17 1993

MEMORANDUM

SUBJECT: Piston Engine Particulate Matter Emission Factors, Toxic Emission Fractions, and VOC to TOG Correction Factor for Aircraft

FROM: Richard Cook
Technical Support Branch

TO: Patricia Morris, Environmental Scientist
EPA Region 5

The purpose of this memo is to provide piston engine TOG and particulate matter emission factors, toxic emission fractions, and VOC to TOG correction factors for aircraft. You requested this information in our phone conversation on February 4 with ViGYAN, Inc., concerning work assignment number 6, contract number 68-D0-0018, "Evaluation of Cancer Risks in Southwest Chicago Using Polycyclic Organic Matter (POM) Potency Factors."

To estimate particulate matter emission factors for aircraft piston engines, we recommend taking the TOG emission factors for appropriate piston engines representative of the mix at Midway, and multiply by 5%, which is approximately the percent of particulate matter relative to TOG for non-catalyst LDGVs.

The only speciation profiles for aircraft available are from the EPA VOC/PM Speciation Data System, which provide one composite profile for commercial aircraft, one profile for military aircraft, and one profile for general aviation aircraft. All these profiles were based on the same data for one engine, a CFM-56 turbojet engine, but weighted differently according to the LTO cycles described in AP-42. These profiles were used to estimate toxic emission fractions to be applied to TOG emission factors.

Since commercial and military aircraft fleets are dominated by turbine engines, one set of toxic emission fractions is used for each of these categories (Table 1). However, since the air taxi fleet has a piston and turbine engine component (73% piston versus 27% turbine), separate toxic fractions should be used for each engine type within that category. To calculate toxics for air taxi piston engine aircraft in Table 1, we used the non-catalyst LDGV toxic fractions for baseline gasoline given in the Motor Vehicle-Related Air Toxics Report.

Table 1. Aircraft Toxic Fractions of TOG

	Commercial	Military	AT Piston	AT Turbine
Benzene	0.0194	0.0202	0.0405	0.0179
Formaldehyde	0.1501	0.1548	0.0269	0.1414
1,3-Butadiene	0.0180	0.0189	0.0098	0.0157

Table 2 presents correction factors to be used in converting VOC to TOG for commercial, military, AT piston, and AT turbine aircraft. These correction factors were derived in the following manner. First, using the TOG mass fractions (MFs) and mass per carbon (MPC) numbers given in Attachment 1, carbon fractions (CFs) for methane, ethane, and VOC were calculated. The formula is given below using methane as an example:

$$CF_{methane} = \frac{\dfrac{MF_{methane}}{MPC_{methane}}}{\dfrac{MF_{methane}}{MPC_{methane}} + \dfrac{MF_{ethane}}{MPC_{ethane}} + \dfrac{MF_{VOC}}{MPC_{VOC}}}$$

We had to make the assumption that the MPC number for VOC would apply to aircraft emissions, even though it is derived for motor vehicles. The following equation was then used to determine TOG from VOC:

$$CCF_{TOG} = \frac{TOG}{VOC}$$

$$= \frac{(CF_{methane} \times MPC_{methane}) + (CF_{ethane} \times MPC_{ethane}) + (CF_{VOC} \times MPC_{VOC})}{CF_{VOC} \times MPC_{VOC}}$$

The CFs and MPC numbers used to calculate the correction factors are given in Attachment 1.

Table 2. VOC to TOG Correction Factors for Aircraft Categories.

	Commercial	Military	AT Piston	AT Turbine
Correction Factor	1.1167	1.1147	1.1347	1.0738

I would also like to briefly address two issues that were discussed in the February 4 conference call. First, ViGYAN mentioned in the meeting that they had been unable to obtain an engine type mix for military aircraft at Midway from either Midway or Illinois Airport authorities. I suggested that, in this case, ViGYAN use an emission factor averaged from all available military aircraft emission factors. I discussed this matter with Rich Wilcox, and he suggested that before doing this, ViGYAN should contact Illinois EPA, who should have this information to complete their SIP, or alternatively, contact the Air Force Reserve to determine what types of military aircraft typically fly in and out of Midway Airport. Rich Wilcox also agreed that it would be acceptable to use the one available turboprop particulate matter emission factor for the turbine component of the air taxi category.

Please let me know if you need any additional information to provide to the contractor.

Attachment

cc: Rich Wilcox
Phil Lorang
Glenn Passavant
Vasu Kilaru (MD-13)
Charles Masser (MD-62)

Attachment 1

TOG Correction Factors for Aircraft Categories and Non-Cat LDGV

6/22/92

Compound	Mass Fraction (TOG)	Mass/Carbon	Carbon Fraction
Commercial Aircraft			
Methane	0.0957	16.0400	0.0839
Ethane	0.0088	15.0350	0.0082
Gasoline VOC	0.8955	13.8758	0.9078
TOG COMPOSITE CORRECTION FACTOR =		1.1167	
Military Aircraft			
Methane	0.0938	16.0400	0.0822
Ethane	0.0091	15.0350	0.0085
Gasoline VOC	0.8971	13.8758	0.9092
TOG COMPOSITE CORRECTION FACTOR =		1.1147	
General Aviation (Non-Piston Engine)			
Methane	0.1095	16.0400	0.0962
Ethane	0.0092	15.0350	0.0086
Gasoline VOC	0.8813	13.8758	0.8952
TOG COMPOSITE CORRECTION FACTOR =		1.1347	
Non-Cat LDGV (Aircraft Piston Engine Surrogate)			
Methane	0.0596	16.0400	0.0520
Ethane	0.0091	15.0350	0.0085
Gasoline VOC	0.9313	13.8758	0.9395
TOG COMPOSITE CORRECTION FACTOR =		1.0738	

EXHIBIT B-3
ESTIMATED ANNUAL EMISSIONS

ANNUAL EMISSIONS OF THC FROM AIRCRAFT AT MIDWAY AIRPORT (1990)

(Assumes De Minimus Value for Taxi/Idle Time)

Type of Operation	Aircraft Name	Aircraft Manufacturer	Engine Name	Engine Manufac	# Eng	LTO Cycles	Total Hydrocarbons (lb)			
							Taxi/Idle	Takeoff	Climbout	Approach
COMMERCIAL	BAE 146-100	BAE	Weighted Average	Not App	4	26	30 25	0.21	0 45	1 25
	B-737-200(CARG)	BOEING	Weighted Average	Not App	2	95	267 83	7 88	26 41	47 43
	DC9-15F	MCDONNELL DOUGLAS	Weighted Average	Not App	2	6553	23723 98	480 17	1547 14	3174 34
	DC9-30	MCDONNELL DOUGLAS	Weighted Average	Not App	2	24271	87730 95	1881 92	5686 38	12239 00
	DC9-80	MCDONNELL DOUGLAS	Weighted Average	Not App	2	7269	8897 40	499 52	1959 70	4704 28
	DC9-10	MCDONNELL DOUGLAS	Weighted Average	Not App	2	1607	5817 86	117 75	379 41	778 45
	DC9-40	MCDONNELL DOUGLAS	Weighted Average	Not App	2	86	347.21	4 68	11 92	48 71
	DC9-50	MCDONNELL DOUGLAS	Weighted Average	Not App	2	30	100 19	4 17	12 06	19 07
	B-727-200	BOEING	Weighted Average	Not App	3	38	170 08	4 03	11 40	26 38
	B-737-300	BOEING	Weighted Average	Not App	2	6405	3752 06	48 39	157 13	229 09
	F100-100	FOKKER	Weighted Average	Not App	2	1750	1753 15	176 10	217 20	393 34
	B-737-100	BOEING	Weighted Average	Not App	2	15659	46417.38	1233 10	3505 47	7349 74
	B-727-100	BOEING	JT8D-7	P&WA	3	47	255.23	5 17	16 64	34 15
	B-727-100	BOEING	JT8D-9	P&WA	3	3	4.91	0 13	0 40	0 85
	B-727-100	BOEING	JT8D-9A	P&WA	3	6	9.83	0.26	0 80	1 70
	B-727-100	BOEING	JT8D-7B	P&W	3	225	1221 86	24 73	79 68	163 49
	B-727-100	BOEING	JT8D-7A	P&WA	3	12	65.17	1.32	4.25	8 72
	B-737-500	BOEING	CFM56-3	GE	2	128	74.98	0.97	3 14	4 58
	B-737-500	BOEING	CFM56-3B	GE	2	127	54.60	1.07	3 44	3 87
	B-737-500	BOEING	CFM56-3C	GE	2	127	86.28	1.11	2.87	4 11
	PA-42 CHEYENNE	PIPER	PT6A-41	P&WA	2	1	4.98	0 01	0 08	0 93
TOTAL						64465	180786 18	4492 69	13625 97	29233 48
AIR TAXI	PA-42 CHEYENNE	PIPER	PT6A-41	P&WA	2	9221	45919.38	137.16	737 83	8575.29
	DHC-6/300	DE HAVILLAND	PT6A-27	P&WA	2	4339	8350 50	0.00	0 00	306 57
	PISTON ENGINE	Not Applicable	Average	Not App	2	36663	9319.73	538.29	7574 58	6203 38
TOTAL						50223	63589 61	675 45	8312 41	15085.24
GEN AVIATION	PA-42 CHEYENNE	PIPER	PT6A-41	P&WA	2	1721	8570.36	25.60	137.71	1600 49
	DHC-6/300	DE HAVILLAND	PT6A-27	P&WA	2	810	1558.86	0.00	0 00	57.23
	PISTON ENGINE	Not Applicable	Average	Not App	1	39652	5039 77	291 08	4096 05	3354 56
TOTAL						42183	15168 99	316 68	4233 76	5012.28
MILITARY	C-12A/B/C	BEECH	PT6A-41	P&WA	2	88	438.23	1.05	1 41	29 10
	UH-1	BELL	T53-L-11D	Lyc	1	1677	1599 75	0	33 86	69 88
TOTAL						1765	2037 98	1 05	35.27	98 98

NOTE: Weighted Average for each aircraft calculated by FAEED based on the approximate percentage of all engine types used for each respective U S -operated aircraft.

ANNUAL EMISSIONS OF THC FROM AIRCRAFT AT MIDWAY AIRPORT (1990)

(Assumes Default Value for Taxi/Idle Time)

Type of Operation	Aircraft Name	Aircraft Manufacturer	Engine Name	Engine Manufac	# Eng	LTO Cycles	Total Hydrocarbons (lb)			
							Taxi/Idle	Takeoff	Climbout	Approach
COMMERCIAL	BAE 146-100	BAE	Weighted Average	Not App	4	26	78 66	0.21	0 45	1.25
	B-737-200(CARG)	BOEING	Weighted Average	Not App	2	95	696.35	7 88	26 41	47 43
	DC9-15F	MCDONNELL DOUGLAS	Weighted Average	Not App	2	6553	61682.36	480 17	1547 14	3174 34
	DC9-30	MCDONNELL DOUGLAS	Weighted Average	Not App	2	24271	228100 48	1881 92	5686 38	12239 00
	DC9-80	MCDONNELL DOUGLAS	Weighted Average	Not App	2	7269	23133.25	499 52	1959 70	4704 28
	DC9-10	MCDONNELL DOUGLAS	Weighted Average	Not App	2	1607	15126 44	117 75	379 41	778 45
	DC9-40	MCDONNELL DOUGLAS	Weighted Average	Not App	2	86	902 73	4 68	11 92	48 71
	DC9-50	MCDONNELL DOUGLAS	Weighted Average	Not App	2	30	260 49	4 17	12 06	19 07
	B-727-200	BOEING	Weighted Average	Not App	3	38	442.21	4 03	11 40	26 38
	B-737-300	BOEING	Weighted Average	Not App	2	6405	9755 35	48 39	157 13	229 09
	F100-100	FOKKER	Weighted Average	Not App	2	1750	4558.20	176 10	217.20	393 34
	B-737-100	BOEING	Weighted Average	Not App	2	15659	120685.20	1233 10	3505 47	7349 74
	B-727-100	BOEING	JT8D-7	P&WA	3	47	663 61	5 17	16 64	34 15
	B-727-100	BOEING	JT8D-9	P&WA	3	3	12 78	0.13	0 40	0 85
	B-727-100	BOEING	JT8D-9A	P&WA	3	6	25 55	0.26	0 80	1 70
	B-727-100	BOEING	JT8D-7B	P&W	3	225	3176 83	24 73	79 68	163 49
	B-727-100	BOEING	JT8D-7A	P&WA	3	12	169 43	1.32	4.25	8 72
	B-737-500	BOEING	CFM56-3	GE	2	128	194 95	0.97	3 14	4.58
	B-737-500	BOEING	CFM56-3B	GE	2	127	141 95	1.07	3 44	3.
	B-737-500	BOEING	CFM56-3C	GE	2	127	224.33	1 11	2.87	4.11
	PA-42 CHEYENNE	PIPER	PT6A-41	P&WA	2	1	12.95	0 01	0 08	0 93
TOTAL						64465	470044 10	4492.69	13625 97	29233 48
AIR TAXI	PA-42 CHEYENNE	PIPER	PT6A-41	P&WA	2	9221	119390.39	137.16	737.83	8575.29
	DHC-6/300	DE HAVILLAND	PT6A-27	P&WA	2	4339	21711.29	0 00	0 00	306.57
	PISTON ENGINE	Not Applicable	Average	Not App	2	36663	14911.57	538.29	7574.58	6203.38
TOTAL						50223	156013.25	675.45	8312.41	15085.24
GEN AVIATION	PA-42 CHEYENNE	PIPER	PT6A-41	P&WA	2	1721	22282.93	25.60	137.71	1600 49
	DHC-6/300	DE HAVILLAND	PT6A-27	P&WA	2	810	4053.04	0.00	0.00	57.23
	PISTON ENGINE	Not Applicable	Average	Not App	1	39652	8063.63	291 08	4096 05	3354.56
TOTAL						42183	34399 60	316.68	4233 76	5012.28
MILITARY	C-12A/B/C	BEECH	PT6A-41	P&WA	2	88	569 70	1 05	1 41	29 10
	UH-1	BELL	T53-L-11D	Lyc	1	1677	2400	0	33.86	69 88
TOTAL						1765	2969 70	1 05	35.27	98 98

NOTE: Weighted Average for each aircraft calculated by FAEED based on the approximate percentage of all engine types used for each respective U S -operated aircraft.

ESTIMATION OF TOXIC EMISSIONS FROM COMMERCIAL AIRCRAFT AT MIDWAY AIRPORT
BY PHASE OF OPERATION: 1990
(LB)

POLLUTANT	Taxi/Idle	Takeoff	Climbout	Approach
Total Hydrocarbons	470044	4492	13626	29233
Volatile Organic Comp	514557	4917	14916	32001
Total Organic Gases	574606	5491	16657	35736
Benzene	11147	107	323	693
Formaldehyde	86248	824	2500	5364
1,3-Butadiene	10343	99	300	643

NOTE: VOC, TOG, and toxics data are derived from the THC data.

ESTIMATION OF TOXIC EMISSIONS FROM TURBINE-ENGINE AIRCRAFT AT MIDWAY AIRPORT
BY PHASE OF OPERATION: 1990
(LB)

POLLUTANT	Taxi/Idle	Takeoff	Climbout	Approach
Total Hydrocarbons	167438	163	876	10539
Volatile Organic Comp	178003	173	931	11204
Total Organic Gases	191140	186	1000	12031
Benzene	3421	3	18	215
Formaldehyde	27027	26	141	1701
1,3-Butadiene	3001	3	16	189

NOTE:
1. Turbine-engine aircraft in this table consist of Air Taxi as well as General Aviation operations
2. VOC, TOG, and toxics data are derived from the THC data.

ESTIMATION OF TOXIC EMISSIONS FROM PISTON-ENGINE AIRCRAFT AT MIDWAY AIRPORT
BY PHASE OF OPERATION: 1990
(LB)

POLLUTANT	Taxi/Idle	Takeoff	Climbout	Approach
Total Hydrocarbons	22976	829	11671	9558
Volatile Organic Comp	22170	800	11261	9223
Total Organic Gases	25156	908	12778	10465
Benzene	1019	37	518	424
Formaldehyde	677	24	344	282
1,3-Butadiene	247	9	125	103

NOTE:

1 Piston-engine aircraft in this table consist of Air Taxi as well as General Aviation operations
2 VOC, TOG, and toxics data are derived from THC data.

ESTIMATION OF TOXIC EMISSIONS FROM MILITARY AIRCRAFT AT MIDWAY AIRPORT
BY PHASE OF OPERATION: 1990
(LB)

POLLUTANT	Taxi/Idle	Takeoff	Climbout	Approach
Total Hydrocarbons	2970	1	35	99
Volatile Organic Comp	3281	1	39	109
Total Organic Gases	3657	1	43	122
Benzene	74	0	1	2
Formaldehyde	566	0	7	19
1,3-Butadiene	69	0	1	2

NOTE: VOC, TOG, and toxics data are derived from the THC data.

ANNUAL EMISSIONS OF PARTICULATE MATTER FROM AIRCRAFT AT MIDWAY AIRPORT (1990)

(Assumes Default Time in Mode Values)

Type of Operation	Aircraft Name	Aircraft Manufacturer	Engine Name	Engine Manufac	# Eng	LTO Cycles	Total Particulate Matter (lb)			
							Taxi/Idle	Takeoff	Climbout	Approach
COMMERCIAL	DC9-50	MCDONNELL DOUGLAS	JT8D-17	P&WA	2	30	7 8	2 59	5 72	6
	Other Air Carriers	Not Applicable	Average	Not App	1	1	0 68	0 09	0 36	0.34
	Other Air Carriers	Not Applicable	Average	Not App	2	64077	43316 05	7802 48	20259 18	19504 18
	Other Air Carriers	Not Applicable	Average	Not App	3	331	335 63	60 46	156 98	151 13
	Other Air Carriers	Not Applicable	Average	Not App	4	26	35 15	6 33	16 44	15 83
TOTAL						64465	43695 31	7871 95	20438 68	19677 48
AIR TAXI	All Turbine Aircraft	Not Applicable	TPE 331-3	GA	2	13560	3525 6	180 8	678	1220 4
GEN AVIATION	All Turbine Aircraft	Not Applicable	TPE 331-3	GA	1	2531	329 03	16 87	63.28	113 9
GA/AT	All Piston Aircraft	Not Applicable	Not App	Not App	-	76315	1257 8	45 4	638 9	523.25
TOTAL						92406	5112 43	243 07	1380 18	1857 55
MILITARY	C-12A/B/C	BEECH	TPE 331-3	GA	2	88	22 88	0.94	0 88	2.82

ANNUAL EMISSIONS OF PARTICULATE MATTER FROM AIRCRAFT AT MIDWAY AIRPORT (1990)

(Assumes De Minimis Time in Mode Values)

Type of Operation	Aircraft Name	Aircraft Manufacturer	Engine Name	Engine Manufac	# Eng	LTO Cycles	Total Particulate Matter (lb)			
							Taxi/Idle	Takeoff	Climbout	Approach
COMMERCIAL	DC9-50	MCDONNELL DOUGLAS	JT8D-17	P&WA	2	30	3	2 59	5.72	6
	Other Air Carriers	Not Applicable	Average	Not App	1	1	0.26	0 09	0.36	0 34
	Other Air Carriers	Not Applicable	Average	Not App	2	64077	16660 02	7802 48	20259 18	19504 18
	Other Air Carriers	Not Applicable	Average	Not App	3	331	129 09	60 46	156 98	151 13
	Other Air Carriers	Not Applicable	Average	Not App	4	26	13 52	6.33	16 44	15 83
TOTAL						64465	16805 89	7871 95	20438 68	19677 48
AIR TAXI	All Turbine Aircraft	Not Applicable	TPE 331-3	GA	2	13560	3097 61	180 8	678	1220 4
GEN AVIATION	All Turbine Aircraft	Not Applicable	TPE 331-3	GA	1	2531	126 55	16 87	63.28	113 9
GA/AT	All Piston Aircraft	Not Applicable	Not App	Not App	-	76315	786 09	45.4	638 9	523.25
TOTAL						92406	4010.25	243 07	1380.18	1857 55
MILITARY	C-12A/B/C	BEECH	TPE 331-3	GA	2	88	8.8	0 94	0 88	2 82

Note: DeMinimis values are applicable only in taxi/idle mode

EXHIBIT B-4
SAMPLE CALCULATION OF EMISSIONS AT EMISSION GRIDS

CALCULATED BENZENE EMISSIONS AT EMISSION GRIDS
COMMERCIAL AIRCRAFT (Taxi/Idle Out)

	Runway 31		Runway 4			TOTAL	BENZENE		
	Path 1	Path 2	Path 1	Path 2		A/C-FT	(LB)	LB/MFT	
# Aircraft	24175	24174	8058	8058					
Distance	4400	3800	6350	5350					
A/c-ft	1 06E+08	9 19E+07	5 12E+07	4 31E+07		2 93E+08	8145 88	27 85	
		Runway 31					Runway 4		
	Path 1		Path 2			Path 1		Path 2	
GRID	Distance	Benzene	Distance	Benzene	GRID	Distance	Benzene	Distance	Benzene
B5	600	403 94			B5	500	112.20		
B4	400	269 29			B4	400	89 76		
C5			600	403 92	C5			500	112 20
C4	1100	740 55	900	605 88	C4	1550	347 82	1350	302 94
D5	800	538 59	1200	807 84	C3	250	56 10	250	56 10
D4	600	403 94	600	403 92	D3	1200	269 28	1250	280 50
E5	900	605 91	500	336 60	D2	1100	246 84	250	56 10
					D1	750	168 30		
					E2			1200	269 28
					E1	600	134 64	550	123 42

CALCULATED BENZENE EMISSIONS AT EMISSION GRIDS
COMMERCIAL AIRCRAFT (Taxi/Idle In)

	Runway 31		Runway 4			TOTAL	BENZENE		
	Path 1	Path 2	Path 1	Path 2		A/C-FT	(LB)	LB/MFT	
# Aircraft	24175	24174	8058	8058					
Distance	6125	4375	4100	2525					
A/c-ft	1 48E+08	1 06E+08	3 30E+07	2.03E+07		3 07E+08	3001 12	9 77	
	Runway 31						Runway 4		
	Path 1		Path 2			Path 1		Path 2	
GRID	Distance	Benzene	Distance	Benzene	GRID	Distance	Benzene	Distance	Benzene
A2	1200	283 39			A4	1350	106 27		
A3	1075	253 87			B3	700	55 10		
A4	1200	283 39			B4	1450	114 14	750	59 04
B2	50	11 81			B5	600	47 23		
B3	700	165 31			C4			1175	92 49
B4	1350	318 81			C5			600	47.23
B5	550	129 89							
C2			1450	342 42					
C3			1075	253 86					
C4			1300	306 99					
C5			550	129 88					

CALCULATED BENZENE EMISSIONS AT EMISSION GRIDS
COMMERCIAL AIRCRAFT (Takeoff)

	Runway 31		Runway 4			TOTAL	BENZENE		
	Path 1	Path 2	Path 1	Path 2		A/C-FT	(LB)	LB/MFT	
# Aircraft	24175	24174	8058	8058					
Distance	4346	3429	3673	4298					
A/c-ft	1 05E+08	8 29E+07	2 96E+07	3 46E+07		2 52E+08	107 00	0 42	
		Runway 31					Runway 4		
	Path 1		Path 2			Path 1		Path 2	
GRID	Distance	Benzene	Distance	Benzene	GRID	Distance	Benzene	Distance	Benzene
B2	800	8 21			B3	1400	4 79		
B3			1379	14 14	B4	100	0 34	800	2 74
C2	46				C2	1500	5 13	1100	3 76
C3	1400	14 36			C3	36	0 12		
C4			1500	15 39	C4			450	1 54
D3	100	1 03			D1	600	2 05		
D4	1400	14 36			D2	37	0 13	1100	3 76
D5			550	5 64	D3			400	1 37
E4	100	1 03			E1			48	0 16
E5	500	5 13			E2			400	1 37

CALCULATED BENZENE EMISSIONS AT EMISSION GRIDS
COMMERCIAL AIRCRAFT (Climbout)

	Runway 31		Runway 4			TOTAL	BENZENE		
	Path 1	Path 2	Path 1	Path 2		A/C-FT	(LB)	LB/MFT	
# Aircraft	24175	24174	8058	8058					
Distance	2200	1700	1550	1850					
A/c-ft	5 32E+07	4 11E+07	1 25E+07	1 49E+07		1 22E+08	323 00	2 65	
		Runway 31					Runway 4		
	Path 1		Path 2			Path 1		Path 2	
GRID	Distance	Benzene	Distance	Benzene	GRID	Distance	Benzene	Distance	Benzene
A1	1500	96 26			A4	1400	29 95		
A2			1550	99 47	A5	100	2 14	1100	23 53
B1	25	1 60			B4			300	6 42
B2	675	43 32			B5			450	9 63
B3			150	9 63					

CALCULATED BENZENE EMISSIONS AT EMISSION GRIDS
COMMERCIAL AIRCRAFT (Approach)

	Runway 31		Runway 4			TOTAL	BENZENE		
	Path 1	Path 2	Path 1	Path 2		A/C-FT	(LB)	LB/MFT	
# Aircraft	24175	24174	8058	8058					
Distance	3829	4746	3873	4848					
A/c-ft	9 26E+07	1 15E+08	3 12E+07	3 91E+07		2 78E+08	693 00	2 50	
		Runway 31					Runway 4		
	Path 1		Path 2			Path 1		Path 2	
GRID	Distance	Benzene	Distance	Benzene	GRID	Distance	Benzene	Distance	Benzene
B2			200	12 07	B3	800	16 09		
B3	625	37 72			B4			300	6 04
C2			100	6 04	C2	1500	30 18		
C3	140	8 45	1400	84 50	C3			1100	22 13
C4	1475	89 03			C4			400	8 05
D3			146	8 81	D1	1450	29 17		
D4	139	8 39	1400	84 50	D2	73	1 47	1100	22 13
D5	1450	87 52			D3			498	10 02
E4			100	6 04	E1	50	1 01	1100	22 13
E5			1400	84 50	E2			350	7 04

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APPENDIX C
REVISED ROAD VEHICLE EMISSIONS INVENTORY

C.1 INTRODUCTION

This appendix describes the data sources and technical approaches used to revise the motor vehicle emissions inventory for the Southwest Chicago Cancer Risk Assessment Study. The revised inventory was used as the input to Climatological Dispersion Model (CDM) air dispersion modeling runs to predict the consequent annual concentrations at the designated receptors. Based on the number of people exposed to the concentrations at each receptor, annual cancer cases caused by motor vehicle emissions in the study area could be estimated and evaluated.

C.2 PRIMARY DATA SOURCE

The required vehicular emissions related data, such as volatile organic compound (VOC) emission factors by speed, vehicle miles travelled (VMT), and VMT mix by vehicle, were provided by the Division of Air Pollution of IEPA for individual traffic links in each traffic zone. The IEPA data base, developed by IEPA using MOBILE4.1 to support its 1990 Illinois Baseline Emissions Inventory preparation initiative, covers all of Cook County and accounts for both free speed and congested speed daily travel scenarios. Emission factors contained in the IEPA data also consider the Inspection/Maintenance (I/M) credit program and are specific for summer 1990. Exhibit C-1 contains an IEPA memorandum describing the emissions data and recommended approach to calculate motor vehicle emissions in Cook County.

The vehicle fleet in the IEPA data base consists of the following vehicle types which are in agreement with the MOBILE4.1 definition:

- Light Duty Gasoline Vehicle (LDGV) - primarily gasoline-fueled passenger cars
- Light Duty Gasoline Truck (LDGT1) - small light gasoline-fueled trucks less than 6,500 lbs
- Light Duty Gasoline Truck (LDGT2) - light gasoline-fueled trucks between 6,500 and 8,500 lbs
- Heavy Duty Gasoline Truck (HDGV) - gasoline-fueled trucks greater than 8,500 lbs
- Light Duty Diesel Vehicle (LDDV) - diesel-fueled cars

- Light Duty Diesel Truck (LDDV) - light diesel-fueled trucks less than 8,500 lbs
- Heavy Duty Diesel Truck (HDDV) - diesel-fueled trucks greater than 8,500 lbs
- Motorcycle (MC)

In the IEPA data base, VOC emission factors were broken down by emission phase, namely exhaust, evaporative, running loss, and resting loss. Emission factors for refueling loss and hot stabilized idling are not included in the IEPA data base and hence not considered in the study. In addition, VOC emission factors in the IEPA data base have been corrected for gasohol usage by gasoline-fueled vehicles.

The average daily VMT in the IEPA data base was chosen to estimate the annual Cook County motor vehicle emissions even though the daily VMT based on typical summer weekdays were also provided by IEPA. The reason for this selection is to avoid further over-estimation of vehicular emissions in Cook County using the IEPA data. The IEPA emission factors are specific for summer 1990 and usually have higher numbers (approximately 9% to 10%) than emission factors generated based on travelling scenarios in non-summer seasons.

Information on road type in the IEPA data base also served an important role in preparation for the emissions inventory. Based on the road type information associated with each link, arterial emissions and freeway emissions could be separated for appropriate estimates. A traffic link that is not classified as a rural interstate (Road Type=01), an urban interstate (Road Type=11), or an urban expressway/freeway (Road Type=12) is grouped under the arterial category to differentiate from the freeway category.

VOC emissions under both the congested speed scenario and the free speed scenario were computed. As recommended by IEPA, the weighted VOC emissions (25% of emissions under the free speed scenario and 75% under the congested speed scenario) were used to present the 1990 VOC vehicular emissions from the selected area coverage in Cook County.

C.3 ADJUSTED GEOGRAPHIC COVERAGE IN COOK COUNTY

The Cook County motor vehicle inventory previously used in the Southwest Chicago Study covers only the southern half of the county (Figure C-1). To be consistent with this geographic consideration, a subset of IEPA data was used to extract the data in traffic zones which approximately encompass the same geographic coverage (Figure C-2). By so doing, the following traffic zones (343 zones in total) were chosen to represent the geographic domain of the Cook County motor vehicle emission sources:

- Zones 1 to 30
- Zones 86 to 456
- Zones 515, 520 and 521
- Zones 586 to 625
- Zones 628 and 629
- Zones 634 to 645
- Zones 901 to 903

While most of the traffic zones encompass a 1.6 km by 1.6 km square each, 31 of the selected zones cover a 3.2 km by 3.2 km square each. These emission squares representing individual traffic zones consist of the Cook County motor vehicle emission grid network, replacing the previous network shown in Figure C-1, to be used in air dispersion modeling.

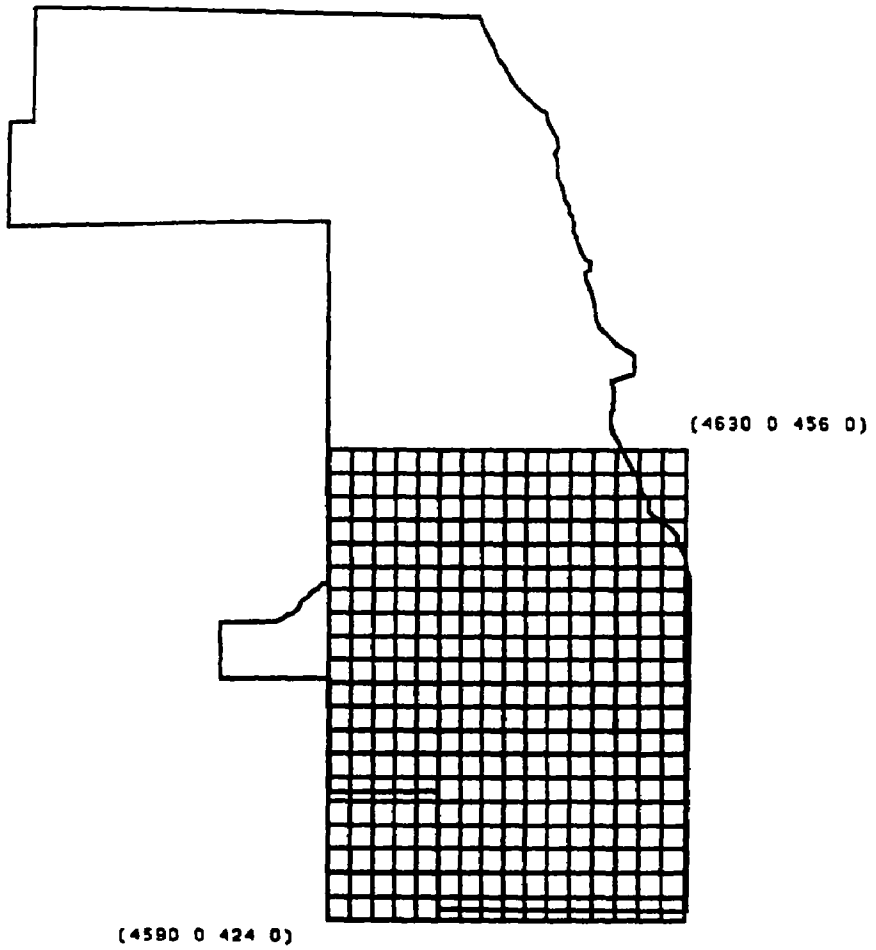
C.4 EMISSIONS INVENTORY PREPARATION

C.4.1 VOC CONVERSION TO TOG

The IEPA data base contains only the VOC emission rates and therefore requires conversion to total organic gases (TOG) emission rates to meet the study requirement. Since methane and ethane are negligible in evaporative emissions, VOC evaporative emissions are equivalent to TOG evaporative emissions. However, methane and ethane must be accounted for in development of TOG exhaust emissions using VOC exhaust emissions. The correction factors used to convert VOC exhaust emissions into TOG exhaust emissions are as follows:

Vehicle Type	Correction Factor
Light Duty Gasoline-Fueled Vehicle (LDGV, MC)	1.1
Light Duty Gasoline-Fueled Truck (LDGT1, LDGT2)	1.085
Heavy Duty Gasoline-Fueled Vehicle (HDGV)	1.09
Light Duty Diesel-Fueled Vehicle (LDDV, LDDT)	1.02
Heavy Duty Diesel-Fueled Vehicle (HDDV)	1.04

SOUTHWEST CHICAGO STUDY
PREVIOUS COOK COUNTY MOTOR VEHICLE EMISSION GRID DOMAIN

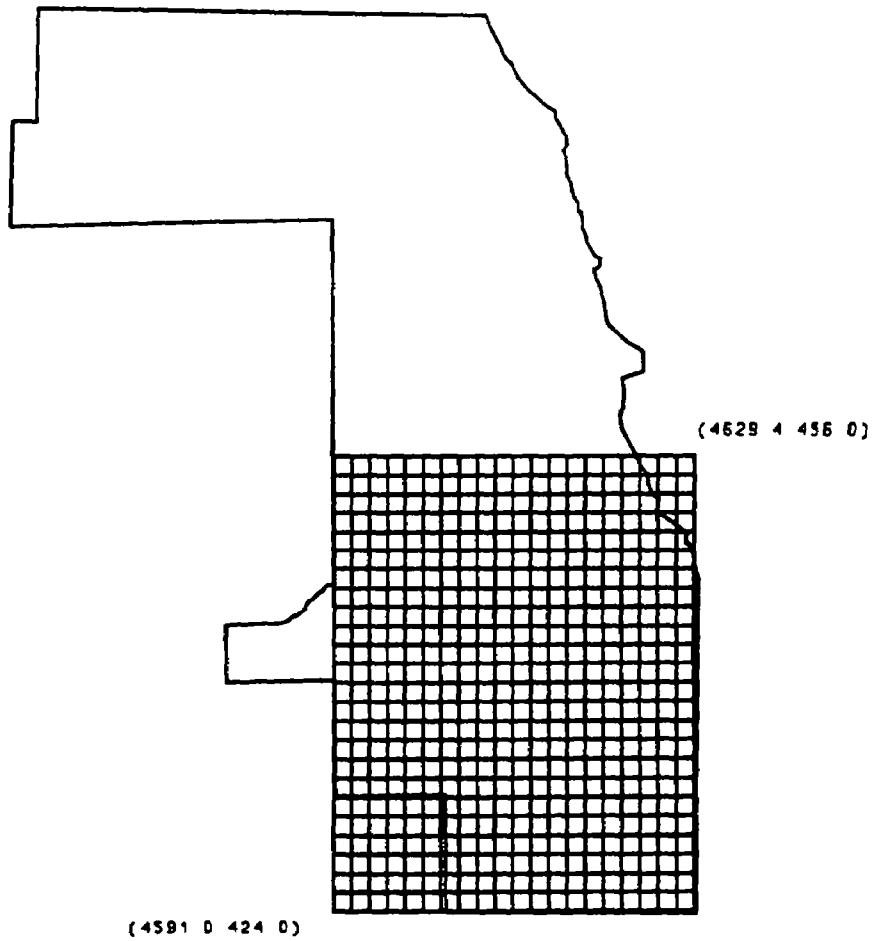


A EACH UNIT SQUARE REPRESENTS A 2 KM X 2 KM AREA
B 11 EMISSION ZONES COMPRISE 4 ADJACENT UNIT SQUARES EACH
C COORDINATES IN (UTM NORTHING, UTM EASTING)

FIGURE C.1

SOUTHWEST CHICAGO STUDY

ADJUSTED COOK COUNTY MOTOR VEHICLE EMISSION GRID DOMAIN



A EACH UNIT SQUARE REPRESENTS A 1 6 KM X 1 6 KM AREA

B 31 EMISSION ZONES COMPRISE 4 ADJACENT UNIT SQUARES EACH

C COORDINATES IN (UTM NORTHING, UTM EASTING)

FIGURE C.2

These correction factors were developed by averaging the ratios of TOG and VOC exhaust emission factors generated by a number of independent MOBILE4.1 runs with different average speeds as input.

C.4.2 DIESEL PARTICULATE EMISSIONS

OMS recommends the use of the following emission factors to derive the diesel particulate emissions.

Vehicle Type	Emission Factor (g/mile)
Light Duty Diesel-Fueled Vehicle (LDDV)	0.321
Light Duty Diesel-Fueled Truck (LDDT)	0 338
Heavy Duty Diesel-Fueled Vehicle (HDDV)	1 301

The product of the diesel emission factor and its correspondent diesel VMT (total VMT x VMT mix of a given diesel vehicle type) is the diesel particulate emission amount of the given diesel vehicle type.

C.4.3 GASOLINE PARTICULATE EMISSIONS

Multiplying TOG exhaust emission amounts by 0.011 for all gasoline vehicle types enables us to calculate gasoline particulate emissions. This is also an OMS recommended approach.

C.4.4 TOXIC EMISSIONS

Also of great interest in the study are three toxic air pollutants: benzene, 1,3-butadiene, and formaldehyde. OMS suggested multiplying the TOG emission factor of each emission phase of each vehicle type by the following toxic fractions for 1990 to calculate toxic emission factors.

1990 Toxic/TOG Emission Fractions Table

Benzene

	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
Exhaust	0 037	0 040	0.041	0.042	0 023	0 023	0 010	0.042
Evaporative	0.023	0 020	0 009	0.011				0 012
Refueling Loss	0.01	0 01	0.01	0 01				
Running Loss	0.01	0 01	0 01	0.01				
Resting Loss	0.01	0 01	0 01	0 01				0.01

1,3-Butadiene

	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
Exhaust	0 007	0 008	0.009	0.010	0 010	0 010	0.016	0 011

Formaldehyde

	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
Exhaust	0.015	0.016	0.021	0.029	0.039	0.039	0.028	0.026

Emissions attributed to vehicle refueling loss are set to be zero in the 1990 Illinois Baseline Emissions Inventory. Benzene/TOG emission fractions for the refueling loss phase are listed here for reference and are not applied to the study. Exhibit C-2 contains the memorandum from OMS describing the recommended approaches in estimating required emission factors and sources of information.

C.5 REVISED MOTOR VEHICLE EMISSIONS INVENTORY

The annual emission amounts by pollutant were first computed at the traffic link level. We then summed up the emission amounts by pollutant from all links in the traffic zone to calculate the emissions inventory of each zone, which will be used as the emission grid for air dispersion modeling. However, only the overall emission estimates summarizing emissions from the selected 343 traffic zones are presented in the report. Following the convention established in the EPA Region 5 Southeast Chicago Emissions Inventory project (last updated in 1989), a breakdown table presenting emissions by freeway exhaust, arterial exhaust, and evaporative

(including running loss and resting loss) emission is first used to describe the results. It should be noted that these estimates are highly uncertain.

1990 Cook County Motor Vehicle Emissions Inventory
(in ton/yr)

Pollutant	Freeway Exhaust	Arterial Exhaust	Evaporative
TOG	3,672.66	8,729.21	14,316 32
Gasoline Particulate	30.02	86.33	n/a
Diesel Particulate	809.51	528.19	n/a
Benzene	112 76	304 80	241.02
1,3-Butadiene	35.22	71.25	n/a
Formaldehyde	71.06	149 55	n/a

Cook County Motor Vehicle Emissions Inventory
(in ton/yr)

Pollutant	1990 Annual Emission	Previous Annual Emission
TOG	26,718.19	n/a
Gasoline Particulate	116.35	n/a
Diesel Particulate	1,337.70	n/a
Benzene	658.58	777.58
1,3-Butadiene	106.47	69.89
Formaldehyde	220.61	337.17

C.6 OTHER TOXIC AIR EMISSIONS

Two other carcinogens were listed in the previous Cook County motor vehicle emissions inventory. Annual vehicular emissions of these two pollutants were also revisited to reflect the 1990 emission scenario.

Cook County Motor Vehicle Emissions Inventory
(in ton/yr)

Pollutant	1990 Annual Emission	Previous Annual Emission
Asbestos	0.045	0.039
Cadmium	0.019	0.019

Asbestos emissions and cadmium emissions were derived based on the technical report entitled Air Toxic Emissions from Motor Vehicles by Penny Carey (September 1987). Emission factors used are 4 ug/mile and 1.9 ug/mile for asbestos and cadmium respectively. The VMT of the entire vehicle fleet was considered for asbestos emissions while only the VMT of the light duty vehicle class (including both gasoline- and diesel-fueled vehicles, as well as MC) was used to estimate cadmium emissions.

C.7 MOTOR VEHICLE EMISSIONS FROM OTHER COUNTIES

No major revisions to annual vehicular emissions from parts of Du Page County, IL, Will County, IL, and Lake County, IN were undertaken since no current data are readily accessible. Gasoline particulate emissions and diesel particulate emissions, which were absent in the previous emissions inventory for these three counties, were estimated to replace POM emissions. The estimated particulate emissions attributed to motor vehicles in these three counties were derived by multiplying existing POM estimates in each county by the respective ratio of diesel or gasoline particulate emissions and revised POM emissions in Cook County. The following three tables list the estimated emissions for the pollutants of interest by county:

1990 Du Page County Motor Vehicle Emissions Inventory
(in ton/yr)

Pollutant	Freeway Exhaust	Arterial Exhaust[a]
Gasoline Particulate	0.55	6.42
Diesel Particulate	14.70	39.28
Benzene[b]	1.91	23.78
1,3-Butadiene[b]	0.21	2.08
Formaldehyde[b]	1.38	9.58
Asbestos[b]	0.0003	0.001
Cadmium[b]	0.0001	0.0005

[a] Includes emissions from evaporative emissions
[b] No changes in emission amounts

1990 Will County Motor Vehicle Emissions Inventory
(in ton/yr)

Pollutant	Freeway Exhaust	Arterial Exhaust[a]
Gasoline Particulate	1.52	8.70
Diesel Particulate	41 06	53.20
Benzene[b]	5.35	32.20
1,3-Butadiene[b]	0.60	2.82
Formaldehyde[b]	3.86	12.98
Asbestos[b]	0.0007	0 0013
Cadmium[b]	0.0003	0.0006

a Includes emissions from evaporative emissions
b No changes in emission amounts

1990 Lake County Motor Vehicle Emissions Inventory
(in ton/yr)

Pollutant	Freeway Exhaust	Arterial Exhaust[a]
Gasoline Particulate	2.18	12.82
Diesel Particulate	58.73	78.41
Benzene[b]	7.66	47.47
1,3-Butadiene[b]	0.85	4.16
Formaldehyde[b]	5.53	19.14
Asbestos[b]	0.001	0.0019
Cadmium[b]	0.0005	0.0009

a Includes emissions from evaporative emissions
b No changes in emission amounts

C.8 ASSOCIATED UNIT RISK FACTORS

Cancer risks caused by toxic air pollution of asbestos and cadmium in the Cook County motor vehicle inventory will be revisited using the revised annual emissions in the report. Furthermore, POM emissions from motor vehicles in the study area would not be inventoried in the study. Instead, diesel particulate emissions and gasoline particulate emissions, which are considered to include POM, were assessed based on the available unit risk factors. The 70-year lifetime unit cancer risk factors (in $(ug/m^3)^{-1}$) used in the study were extracted from the report Carcinogenic Risks of Polycyclic Organic Matter (POM) from Selected Emission Sources by Dr. Lewtas, and the paper Update On U.S. Environmental Protection Agency Activities in the Assessment of Mobile Source Air Toxics by W. Pepelko and C. Ris (1992), and are listed as follows:

Pollutant	Unit Risk Factor	Comment
Gasoline Particulate	5.1×10^{-5}	Using the risk factor for catalyst-equipped vehicles since the majority of the gasoline-fueled vehicles in the 1990 fleet were catalyst-equipped
Diesel Particulate	1.7×10^{-5}	For the entire diesel-fueled fleet

C.9 MISCELLANEOUS

There are several issues related to this emissions inventory preparation task. We briefly describe them as follows:

a. VOC emission factors data for 1990 generated using the newly released MOBILE5a were provided by IEPA in February 1993. However, these emission factors were not yet corrected for gasohol usage and therefore are not utilized in the study. MOBILE5a VOC emission factors would be greater than those generated using MOBILE4.1.

b. Two revised splits, one by arterial VMT distribution and another by freeway VMT distribution, were implemented for the required air dispersion modeling using Climatological Dispersion Model (CDM). One CDM modeling run for each split was required for estimating concentrations, attributed to vehicular air pollution from Cook County, at individual receptor grids. Both splits have the same emission grid network which uses each selected traffic zone as an emission source square. The unit emission amount (*i.e.*, 1,000 metric ton/yr) was portioned among all the emission source squares based on either arterial VMT or freeway VMT in each square (or traffic zone). Once the concentration profiles at the receptor grid network (referred to as unit concentration) had been estimated for both VMT splits using the unit emission amount, multiplying the unit concentration by actual annual emission estimates would yield the estimated annual concentrations of individual pollutants.

c. To follow the same approach utilized in the Southeast Chicago Study, both the arterial exhaust emissions and the evaporative emissions were multiplied by the unit concentration profile generated using the arterial VMT split to estimate the annual concentrations. The unit concentration profile modeled by CDM for the freeway VMT split was used to predict annual concentrations generated by the freeway exhaust emissions only.

EXHIBIT C-1

IEPA DATA BASE DESCRIPTION AND RECOMMENDED APPROACH

State of Illinois
ENVIRONMENTAL PROTECTION AGENCY

Mary A. Gade, Director
217/524-4343

2200 Churchill Road, Springfield, IL 62794-9276

December 17, 1992

RECEIVED
DEC 2 1 1992
REGULATION DEVELOPMENT BRANCH
U.S. EPA, REGION V

Ms. Patricia Morris
U.S. Environmental Protection Agency
Region V
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Dear Ms. Morris:

You asked for emissions information from motor vehicles in certain traffic zones in central Cook County. I am sending you extracts from our computer files, from which you can determine the various hydrocarbon component emissions in the zones you wish.

Enclosed is a 3.5 inch floppy disk containing three databases (* .DBF) files and two databases index (*.CDX) files which I used in my emissions calculations with the Foxpro 2 database program:

(1) COOKNET.DBF, containing link-based information for all links in Cook County; zone data dare available for each link.

(2) & (3) CHIJLXIM.DBF and its index file CHIJLXIM.CDX, containing MOBILE4.1 emission rates in grams/mile for various speeds for the case where no vehicle inspection and maintenance (I/M) effects are to be calculated.

(4) & (5) CHIJLIMC.DBF and its index file CHIJLXIM.CDX, containing MOBILE4.1 I/M emission credits in grams/mile for various speeds for the case where the effects of IEPA's I/M program are to be taken into account.

I will be recalculating the emission rate files CHIJLXIM and CHIJLIMC in the near future using the recently-released MOBILE5. I'll send you updates of those files some time in January. The *.DBF files may be used as they are, since they are compatible in Foxpro 2.0 and in DBase. The *.CDX files are peculiar to Foxpro; similar index files are used in DBase.

The attached sheet will give the structure of the files listed above, as well as some advice about how to calculate emissions with them. I trust this information will meet your needs. If you need further information or help, call me at (217)524-4619.

Yours sincerely,

Samuel S. Long
Air Quality Planning Section
Division of Air Pollution Control
SSL:bj/62-58
Enclosures

cc: Dick Forbes

Printed on Recycled Paper

1990 ON-HIGHWAY MOBILE SOURCE INFORMATION FOR PAT MORRIS

1) COOKNET.DBF contains CATS transportation model output for 1990 for Cook County only. These same data used in the calculation of the 1990 Chicago area on-highway mobile-source emissions inventory.

COOKNET.DBF contains 7793 records in 21 fields, as follows:

Field	Field Name	Type	Width	Decimals	Notes
1.	LINKID	C	10		Unique identifier of each link
2.	COUNTY	C	3		"031" = Cook County
3.	ZONE	N	5		Your traffic Zone number
4.	ROADTYPE	C	2		See table below for decode
5.	FREESPEED	N	4	1	"Free" speed in mph
6.	CONGSPEED	N	4	1	"Congested" speed in mph
7.	POLLUTANT	C	4		Blank; see table below.
8.	ADVMT	N	8		Average Daily VMT on the link
9.	SUMMERVMT	N	8		Avg. Summer Weekday VMT on link
10.	CARIMFRAC	N	5	3	Fraction of I/M cars on link
11.	LDTIMFRAC	N	5	3	Fraction of I/M lgt trucks
12.	HDVIMFRAC	N	5	3	Fraction of I/M hvy trucks
13.	IMPCT	N	4	1	Percent I/M vehicles on link
14.	LDGVMIX	N	5	3	VMT mix of LDGVs on link
15.	LDGT1MIX	N	5	3	VMT mix of LDGT1s on link
16.	LDGT2MIX	N	5	3	VMT mix of LDGT2s on link
17.	HDGVMIX	N	5	3	VMT mix of HDGVs on link
18	LDDVMIX	N	5	3	VMT mix of LDDVs on link
19.	LDDTMIX	N	5	3	VMT mix of LDDTs on link
20.	HDDVMIX	N	5	3	VMT mix of HDDVs on link
21.	MCMIX	N	5	3	VMT mix of motorcycles on link.

(2) CHIJLXIM.DBF and CHIJLIMC.DBF are files of Chicago-area emission rates in grams per mile and I/M credits with the same units as emission rates, respectively, for speeds from 1 to 65 mph for July 1991, in accordance with USEPA inventory guidance.

CHIJLXIM.DBF and CHIJLIMC.DBF both have 520 data records in 16 fields, as follows:

Field	Field Name	Type	Width	Decimals	Notes
1.	SPEED	N	4	1	Between 1 and 65 mph
2.	POLLUTANT	C	4		See table below for decode
3.	LDGV x	N	8	3	No-g'hol emission rate for LDGV
4.	LDGT1 x	N	8	3	No-g'hol emission rate for LDGT1
5.	LDGT2 x	N	8	3	No-g'hol emission rate for LDGT2
6.	LDGT x	N	8	3	No-g'hol emission rate for LDGT
7.	HDGV x	N	8	3	No-g'hol emission rate for HDGV
8.	LDGV_G	N	8	3	LDGV E.R. corrected for gasohol
9.	LDGT1_G	N	8	3	LDGT1 E.R. corrected for gasohol
10.	LDGT2_G	N	8	3	LDGT2 E.R. corrected for gasohol
11.	HDGV_G	N	8	3	HDGV E.R. corrected for gasohol
12.	LDDV	N	8	3	LDDV emission rate
13.	LDDT	N	8	3	LDDT emission rate
14.	HDDV	N	8	3	HDDV emission rate
15.	MC	N	8	3	Motorcycle emission rate
16.	AVER x	N	8	3	All-Vehicle E.R.. default VMT mix

Fields marked with an x are not used to calculate emissions.

(3) VEHICLE TYPES

LDGV = light-duty gasoline vehicles, "cars"
LDGT1 = light-duty gasoline trucks < 6500 lb, "small light trucks"
LDGT2 = light-duty gasoline trucks, 6500-8500 lb. "light trucks"
LDGT = LDGT1 + LDGT2; LDGT E.R is weighted average of the E.R.s
HDGV = heavy-duty gasoline trucks > 8500 lb
LDDV = light-duty diesel vehicles, "diesel cars"
LDDT = light-duty diesel trucks < 8500 lb. "light diesel trucks"
HDDV = heavy-duty diesel vehicles > 8500 lb. "heavy diesels", including trucks and buses
MC = motorcycles

(4) GASOHOL USAGE in Chicago area is estimated at 30% in 1990. Emission rates in fields with "_G" in their field names have been corrected for gasohol use by USEPA-approved methods. Naturally diesel emission rates are not affected by gasohol; nor is any correction made in the rates for motorcycles. Do NOT use the no-gasohol emission rates to compute emissions for any pollutant or component..

(5) <u>POLLUTANTS</u> in the CHIJLXIM and CHIJLIMC files are as follows:

VOC	Volatile organic compounds without methane/ethane
X	Exhaust VOC emissions
V	Evaporative VOC emissions
R	Refueling Loss VOC emissions (set to zero)
T	Running Loss VOC emissions
S	Resting Loss VOC emissions
CO	Carbon monoxide emissions
NOx	Oxides of nitrogen emissions.

VOC = X + V + R + T + S

X, V, R, T, and S are often referred to as "components" of the hydrocarbon emissions. X, V, T, and S could be changed to EXH, EVAP, RNNG, and RSTG if desired.

The POLLUTANT field in the COOKNET file would have one of these seven pollutant codes in it (not R), depending on which type of emissions you are trying to calculate. The network and emission rate files are "linked" through this variable.

(6) <u>ROADTYPES</u> are as follows:

01	Rural Interstate	11	Urban Interstate
04	Rural Other Principal Arterials (OPA)	12	Urban Other Expwys/Freewys
06	Rural Minor Arterials	14	Urban OPA
07	Rural Major Collectors	16	Urban Minor Arterials
08	Rural Minor Collectors	15	Urban Minor Collectors
09	Rural Local Roads	19	Urban Local streets

7) VEHICLE MILES TRAVELED or VMT is calculated from CATS transportation model output. Two VMTs are available: Average Daily VMT (ADVMT), and Average Summer Weekday VMT (ASWVMT), which is about 9%-10% higher than ADVMT, and calculated from factors supplied by IDOT. IEPA can supply correction factors for other months or seasons of the year as well if required, but note that emission rates are specific for summer 1990..

(8) FREE SPEED and CONGESTED SPEED by link are outputs from the transportation model. The free speed represents more or less the speed limit on the link, i.e., the speed under free-flow conditions, such as occur typically at night. The congested speed represents the speed under congested conditions, such as occur during rush hours during the day. Free speed and congested speed may be the same, as on some roads with little traffic, but usually the congested speed is lower than the free speed, sometimes dramatically so. IEPA estimates that approximately 75% of the VMT and hence of the emissions occur under "congested" conditions, and only 25% under "free speed" conditions. Therefore to get accurate results you calculate emissions under free and congested conditions and take a weighted average, thus: Suppose "congested" emissions are 200 tons/day and "free-speed" emissions are 160 tons/day. Average emissions are thus (75%*200 - 25%*160)= (150 + 40) = 190 tons/day.

(9) VMT MIX by link is found in the COOKNET file and is the percent of VMT on the link generated by each of the eight vehicle types. These VMT mixes were calculated by IEPA from transportation model data that CATS sent, and are the same as those used in the '90 inventory. They are not the same as the default VMT mix that the MOBILE model generates.

(10) I/M PERCENTAGES by link are found in the COOKNET file. They represent the percent of cars (LDGVs), light gasoline trucks (LDGT1 and LDGT2), and heavy gasoline trucks (HDGV) that are subject to I/M out of the total of each vehicle type.

(11) CALCULATION OF EMISSIONS: For a given link, emissions from LDGVs are calculated as follows:

No-I/M Car emissions = VMT * VMT Mix for cars * Emission Rate for cars at the link speed

The reduction in emissions on a link due to I/M is similarly calculated:

I/M reductions = VMT * VMT Mix * Emission Credits for cars at link speed * percent of I/M cars on link

Total car emissions = No-I/M car emissions minus I/M reductions.

Similar calculations are done for each vehicle type and for each link: a database is probably more convenient for this than a spreadsheet. The resulting emissions in grams (emission rates are in grams/mile) are written to a third, "results", file, two for each POLLUTANT: one for "free speed" conditions (IEPA's name for it was FREEEMIS.DBF) and one for "congested speed" conditions (CONGEMIS.DBF). The file structure for the "emissions" results file would be as follows:

Field	Field Name	Type	Width	Decimals	Notes
1.	LINKID	C	10		Same as LINKID elsewhere
2.	COUNTY	C	3		"031" = Cook
3.	ROADTYPE	C	2		Optional
4.	ZONE	N	4		Optional but you'll want it
5.	LDGV_VOC	N	8		link VOC emissions from LDGVs
6.	LDGT1_VOC	N	8		link VOC emissions from LDGT1
7.	LDGT2_VOC	N	8		link VOC emissions from LDGT2
8.	HDGV_VOC	N	8		link VOC emissions from HDGV
9.	LDDV_VOC	N	8		link VOC emissions from LDDV
10.	LDDT_VOC	N	8		link VOC emissions from LDDT
11.	HDDV_VOC	N	8		link VOC emissions from HDDV
12.	MC_VOC	N	8		link VOC emissions from MC

The field names for the emission fields are the vehicle type + the pollutant. IEPA's original CONGEMIS and FREEEMIS files had 16 further fields for LDGV_CO through MC_CO and LDGV_NOX through MC_NOX. You might want to use filenames like CONGEMEX (field 5 = LDGV_EXH) and CONGEMRU (field 5 = LDGV_RUN) or CONGEMNX (field 5 = LDGV_NOX) to keep the component and pollutant results straight.

There were of course two I/M results files, named FREECRED.DBF and CONGCRED.DBF; their structure was similar to the above but abbreviated:

Field	Field Name	Type	Width	Decimals	Notes
1.	LINKID	C	10		Same as LINKID elsewhere
2.	COUNTY	C	3		"031" = Cook
3.	ROADTYPE	C	2		Optional
4.	ZONE	N	4		Optional but you'll want it
5.	LDGV_VOC	N	8		link VOC credits from LDGVs
6.	LDGT1_VOC	N	8		link VOC credits from LDGT1
7.	LDGT2_VOC	N	8		link VOC credits from LDGT2
8.	HDGV_VOC	N	8		link VOC credits from HDGV

Again, the field names for the credit fields are the vehicle type + the pollutant. IEPA's original CONGCRED and FREECRED files had 8 further fields for LDGV_CO through HDGV_CO and LDGV_NOX through HDGV_NOX. The same file-naming remarks apply here as to the emissions files above.

IEPA computed emissions by link in grams, and converted to tons (using the factor 1.102/1,000,000 or 1.102E-06) when the emissions files were "queried" in Foxpro to sum the emissions up and arrange them by vehicle type and county.

EXHIBIT C-2

OMS RECOMMENDED EMISSION FACTORS AND TOXIC FRACTIONS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

ANN ARBOR MICHIGAN 48105

JUL 23 1992

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OFFICE OF AIR AND RADIATION

1992

REGULATION DEVELOPMENT BRANCH
U.S. EPA, REGION V

MEMORANDUM

SUBJECT: Inputs and Methodology for Calculating Motor Vehicle Emission Factors for the Southwest Chicago Study Work Assignment

FROM: Rich Cook, Environmental Scientist
Technical Support Branch

TO: Patricia Morris, Environmental Scientist
EPA Region 5

The purpose of this memo is to provide diesel particulate emission factors, gasoline particulate TOG emission fractions, and toxic (benzene, 1,3-butadiene, formaldehyde) TOG emission fractions to be used in calculating emission estimates for the motor vehicle portion of the Southwest Chicago 1990 calendar year emission inventory. From our recent phone conversation, I understand 1990 MOBILE4.1 runs with TOG output are available for the study area. This information will be provided to ViGYAN, Inc. for work assignment number 6, contract number 68-D0-0018, "Evaluation of Cancer Risks in Southwest Chicago Using Polycyclic Organic Matter (POM) Potency Factors."

Diesel Particulate Emission Factors

In order to calculate emission estimates for diesel particulate in the study area, you requested 1990 calendar year gram/mile emission factors for diesel vehicle categories. Attachment 1 summarizes urban gram/mile emission factors for light-duty diesel vehicles, light-duty diesel trucks, and heavy-duty diesel vehicles. These numbers represent the ratio of urban diesel particulate mass to urban diesel VMT. In order to calculate total mass emissions of diesel particulate, these emission factors should be multiplied by diesel VMT estimates for the study area. These estimates were obtained from the following reference:

Sienicki, E. J. 1992. Letter from E. J. Sienicki, Navistar International Transportation Corporation, to Phil Lorang, Environmental Protection Agency, April 23, 1992.

These estimates have also been used in the draft Motor Vehicle-Related Air Toxics Report, which we plan to release shortly for public comment. However, these estimates should be used with the

caveat that such use should not be construed to imply an endorsement by EPA of assumptions or inputs used by Navistar to obtain these estimates.

Gasoline Particulate Emission Factors

To calculate gasoline particulate emission factors, we recommend multiplying MOBILE4.1 TOG exhaust estimates for all gasoline vehicle categories from the 1990 Illinois Baseline Emissions Inventory by 0.011. In the draft Motor Vehicle-Related Air Toxics Report, we assumed that gasoline particulate represented approximately 1.1% of exhaust HC. This estimate was obtained from the following reference:

Hammerle, R. H., T. J. Korniski, J. E. Weir, E. Chladek, C. A. Gierczak, R. E. Chase, and R. G. Hurley. 1992. Effect of Mileage Accumulation on Particulate Emissions from Vehicles Using Gasoline with Methylcyclopentadienyl Manganese Tricarbonyl. SAE Paper 920131.

The gasoline particulate estimate from this reference was obtained from 1991 model year Ford Escorts and Explorers with three-way and dual three-way catalysts respectively. Also, data were collected at various mileage intervals up to 105,000 miles. Due to the paucity of data, fractions for other gasoline vehicle categories are also assumed to be 0.011.

Toxic Emission Factors

To calculate toxic emission factors, we recommend multiplying MOBILE4.1 TOG exhaust, evaporative, refueling loss, running loss, and resting loss gram/mile estimates from the 1990 Illinois Baseline Emissions Inventory by the toxic fractions in Attachment 2. For 1,3-butadiene and formaldehyde, evaporative, refueling loss, running loss, and resting loss emissions are assumed to be zero.

The toxic fractions for exhaust emissions (of benzene, 1,3-butadiene, and formaldehyde) and evaporative emissions (of benzene) were calculated using data from an updated version of MOBILE4.1, denoted MOBTOX, developed specifically to calculate in-use toxic gram/mile emission factors for the draft Motor Vehicle-Related Air Toxics Report. In MOBTOX, toxic emission fractions for various vehicle categories and technology types are applied to in-use TOG estimates to calculate in-use g/mile toxic emission factors. By dividing g/mile toxic emission factors from MOBTOX by TOG emission factors from MOBTOX, in-use emission fractions for the vehicle categories can be obtained. Toxic emission fractions obtained directly from available speciation studies would likely result in

an underestimation of true emissions, since virtually all of the available emission data are from well-maintained, low mileage vehicles.

Toxic fractions for benzene refueling loss, running loss, and resting loss are assumed to be 0.01. This assumption is supported by data contained in the draft Motor Vehicle-Related Air Toxics Report.

The MOBTOX runs used to derive the toxic fractions in Attachment 2 were 1990 calendar year runs, and assumed basic I/M with no anti-tampering program, an average ambient temperature of 80.5°F, and an altitude of 500 feet.

I hope the data contained in this memo are sufficient to develop a 1990 mobile source emission inventory for this study. Please contact me at (313)741-7827 if you require any additional information.

Attachments

cc: Rich Wilcox
Vasu Kilaru (MD-13)
Phil Lorang

Attachment 1

Urban Diesel Particulate Emission Factors for 1990

Year	LDV	I	IIA	IIB	III	IV	V	VI	VII	VIIIA	VIIIB	Buses
Diesel particulate Mass-- Gigs grams (in urban areas)*												
1990	2 637	0.452	0.399	4 474	0 105	0.289	0 076	2.651	10 669	6 715	26 572	4 011
Urban diesel VMT (billions)*												
1990	8.222	1 316	1.203	8.237	0 128	0 381	0 093	2 535	6 951	4 099	16 097	2 193
Urban Gram/Mile Emission Factors												
1990	0.321	0.344	0.332	0.543	0 822	0 758	0 809	1 046	1 192	1 638	1 651	1 829

LDDV= **0.321**

LDDT(I,IIA)=** **0.338**

HDDV (IIB-VIIIB, urban buses)=** **1.301**

*Urban diesel particulate mass and VMT estimates for 1990 represent the sum of estimates for model years 1971 through 1990 These estimates were obtained from the following reference:

Sienicki, E. J 1992. Letter from E J Sienicki, Navistar International Transportation Corporation, to Phil Lorang, Environmental Protection Agency, April 23, 1992

**Gram/mile emission factors for LDDTs and HDDVs are calculated as the ratios of the sum of diesel particulate mass and the sum of diesel VMT for the vehicle categories in parentheses

7/22/92

Attachment 2

Toxic/TOG Emission Fractions for 1990

	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC
Benzene									
Exhaust	0.037	0.040	0.041	0.039	0.042	0.023	0.023	0.010	0.042
Evaporative	0.023	0.020	0.009	0.015	0.011				0.012
Refueling L.	0.01	0.01	0.01	0.01	0.01				
Running L.	0.01	0.01	0.01	0.01	0.01				
Resting L.	0.01	0.01	0.01	0.01	0.01				0.01
1,3-Butadiene[1]									
Exhaust	0.007	0.008	0.009	0.008	0.010	0.010	0.010	0.016	0.011
Formaldehyde[1]									
Exhaust	0.015	0.016	0.021	0.018	0.029	0.039	0.039	0.028	0.026

[1]Evaporative, refueling loss, running loss, and resting loss emissions for 1,3-butadiene and formaldehyde are assumed to be zero.

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APPENDIX D
REVISITED POM EMISSION SOURCES

D.1 INTRODUCTION

The term polycyclic organic matter (POM) describes a complex mixture of polycyclic aromatic hydrocarbons, substituted aromatic hydrocarbons, and aromatic hydrocarbons. POM is generally associated with the carcinogenic particle or soot component of air pollution created by incomplete combustion of fossil fuels, vegetative matter, or synthetic chemicals. Previously it was assumed that the cancer risk of complex mixtures of POM could be represented by a surrogate compound, benzo(a)pyrene or B(a)P. This approach is often referred to as the B(a)P surrogate approach. However, as quantitative methods improved, it was discovered that B(a)P doesn't always correlate well with total carcinogenic compounds present in a complex mixture of POM. The B(a)P surrogate approach remains useful for simple mixtures. The unit risk factor for polycyclic organic matter (POM) previously used in the Southwest Chicago Study for residential oil heating and woodstoves (1.7×10^{-3}) was developed based on the B(a)P surrogate approach.

Recent U.S. EPA publications recommend the use of the comparative potency approach which applies a cancer unit risk factor to the entire mixture of POM emitted by each source category rather than to a particular surrogate compound. This approach uses epidemiological data from human exposure to complex mixtures of POM and tumor initiation potency resulting from treatment of mouse skin with the extractable organic matter from a complex mixture of POM. The comparative potency approach is based on the concept of constant relative potency and is used to estimate human cancer risk where there is no data for a specific mixture, but there is data for a similar mixture. The constant relative potency assumption is implicit in comparisons which utilize the relative toxicity of two substances in animals to estimate their relative toxicity in humans. The constant relative potency hypothesis exhibits a constant relationship (k) between the relative potencies of two bioassays being compared.

$$\frac{\textit{relative human potency}}{\textit{relative bioassay potency}} = (k)$$

Since there is a constant relative potency relationship between rodent bioassay systems and human bioassay systems, rodent relative potency data can be used to extrapolate risk in humans. Potency constants for known POM mixtures can be used to estimate the cancer risk in a complex POM mixture that has no human cancer data.

$$risk\ factor_{unknown} = risk\ factor_{known}\ [\frac{bioassay\ potency_{unknown}}{bioassay\ potency_{known}}]$$

The basis for the comparative potency approach is similar to those approaches used in studying cancer risks of single compounds. The primary limitation for this approach is the lack of a large data base for quantitative human cancer risks. The comparative potency approach is more comprehensive than the B(a)P surrogate approach with regard to complex POM mixtures such as those encountered with residential oil heating and woodstoves. Therefore, the Southwest Chicago emissions inventory was revisited to adapt the POM comparative potency approach for gasoline vehicles, woodstoves, aluminum smelters, and residential heating. In contrast, the unit risk factor for diesel vehicles was developed based on rat inhalation studies of diesel exhaust.

D.2 EMISSIONS INVENTORY PREPARATION

The following summary table lists the emission sources and associated unit risk factors derived based on the comparative potency approach. This information was extracted from the report Carcinogenic Risks of Polycyclic Organic Matter (POM) from Selected Emission Sources by Dr. Lewtas.

Emission Source	POM Unit Risk[a] Factor	Particle Unit Risk Factor
Woodstoves	2.9×10^{-5}	1.0×10^{-5}
Aluminum Smelter[b]	9.1×10^{-4}	1.1×10^{-5}
Residential Heating (Distillate Oil)		0.9×10^{-5}

a Unit risk factor (over a lifetime) is presented in $(ug/m^3)^{-1}$

b No aluminum smelters are identified in the Southwest Chicago emissions inventory

The Southwest Chicago emissions inventory contains the POM emissions for two area sources to which the comparative potency approach can be applied for cancer assessment: Wood Stoves and Residential Heating Using Oil.

D.2.1 POM EMISSIONS FROM WOODSTOVES

No revisions in POM emission amounts from woodstoves (including fireplaces) are required since the annual POM emissions and the unit risk factor derived by the comparative potency approach are both available.

D.2.2 POM EMISSIONS FROM RESIDENTIAL HEATING

The unit risk factor recommended in the comparative potency approach has only the particle unit risk factor for Residential Heating Using Oil. Instead of estimating the annual POM emissions, the U.S. EPA Office of Air Quality Planning and Standards (OAQPS) suggested that particulate emissions should be developed to accommodate the available unit risk factor. Furthermore, both distillate oil use and natural gas use are included in the category according to the established definition of Residential Heating area source category. The revised POM emissions from Residential Heating should recognize this difference in fuel type wherever possible.

Steps to revise POM emissions from Residential Heating are as follows:

1. Separate the existing POM emissions by fuel usage type.

2. Compute particulate emissions using the existing POM emissions from Residential Heating with available particulate emission factors.

Step 1.

The number of housing units using natural gas and distillate oil were provided by U.S. EPA Region 5. Based on the POM emission factors and monthly fuel consumptions by fuel type (10,346 x 10^6 cubic feet for natural gas and 8,717,660 gallons for distillate oil), county-wide monthly POM estimates were first estimated. The emission factors used here are extracted from Air Toxic Emission Inventory for The Southeast Chicago Area and listed as follows:

Residential Heating Fuel Type	POM Emission Factor
Distillate Oil	1.4 mg/gal
Natural Gas	12 g/mmcf

Annual POM emissions currently in the inventory were then portioned based on the monthly county estimates to develop the annual POM emissions by fuel type for Residential Heating for each county (only a portion of each county is considered in the study). Residential Heating POM emissions by fuel type for Lake County in Indiana were portioned based on the averaged ratios of POM emissions by natural gas use and distillate oil use in the Illinois counties since no residential fuel consumption information is available.

Step 2A.

In this step, residential heating particulate emissions by distillate oil were estimated by first dividing POM emissions from distillate oil use by the POM emission factor (1.4 mg/gal, or 0.0030864 lb/1000 gals), then multiplied by the particulate emission factor of (2.5 lb/1000 gals). The particulate emission factor is listed in U.S. EPA's AP-42 series.

Step 2B.

Applied the same procedures used in Step 2A to estimate the particulate emissions from the residential natural gas use. The particulate emission factor ranging from 1 to 5 lb/mmcf can be found in U.S. EPA's AP-42 as well. The POM emission factor of 12 g/mmcf is approximately equal to 0.02646 lb/mmcf.

D.3 REVISED EMISSIONS INVENTORY

In this section, we present both POM and particulate emissions used for woodstoves and residential heating in the study.

D.3.1 POM EMISSIONS FROM WOODSTOVES

These annual POM emission amounts remain the same as the previous estimates.

County	POM Emission from Woodstoves (ton/yr)
Cook County, IL	2.0525
Du Page County, IL	0.0758
Will County, IL	0.0895
Lake County, IN	0.5463

D.3 2 POM EMISSIONS FROM RESIDENTIAL HEATING

The following table lists the annual POM emission breakdown by fuel type for Residential Heating, as well as the estimated particulate emissions emitted by Residential Heating Using Oil.

County	Particulate Emission from Dist Oil Use[a]	POM Emissions from Dist Oil Use	Particulate Emission from Nat Gas Use[b]	POM Emission from Nat. Gas Use[c]
Cook	82.6700	0.1021	235 8516	1 2479
Du Page	0.5800	0.0007	3 6477	0 0193
Will	1 2712	0 0016	5.3676	0 0284
Lake, IN	9 7212	0 0120	29 8619	0 1580

[a] Used with the unit risk factor of $0\ 9 \times 10^{-5}$ derived by comparative potency approach
[b] Emissions presented are based on the particulate emission factor of 5 lb/mmcf
[c] Used with the unit risk factor of $1\ 7 \times 10^{-3}$ derived by B(a)P surrogate approach

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APPENDIX E
ANNUAL EMISSIONS BY POLLUTANT/SOURCE CATEGORY

ANNUAL EMISSIONS BY POLLUTANT/SOURCE CATEGORY

Pollutant	Source Category	Emissions (tons/yr)
Acrylamide	Other Industrial Points	0.025000
Acrylonitrile	Other Hazardous Waste TSDFs	0.001981
	Other Industrial Points	2.842000
Arsenic	Other Industrial Points	3.985086
	RCRA Hazardous Waste Sites	0.000461
	Steel Mills	4.298343
Asbestos	Demolition	0.032886
	RCRA Hazardous Waste Sites	0.000120
	Road Vehicles	0.091600
Benzene	Aircraft Engines	8.998666
	Barge Loading	2.905000
	Gasoline Marketing	60.260238
	Municipal Waste Landfills	0.831000
	Nonroad Engines	195.267708
	Other Hazardous Waste TSDFs	13.277737
	Other Industrial Points	126.764602
	RCRA Hazardous Waste Sites	0.000008
	Road Vehicles	1376.911354
	Steel Mills	3355.569452
	Surface Coating	8.477311
	Wastewater Treatment	0.800000
Beryllium	Other Industrial Points	0.000856
	RCRA Hazardous Waste Sites	0.000009
Cadmium	Other Industrial Points	1.435750
	RCRA Hazardous Waste Sites	0.000287
	Road Vehicles	0.039582
	Steel Mills	4.766730
Carbon Tetrachloride	Background Concentrations	n/a
	Other Hazardous Waste TSDFs	2.972864
	Other Industrial Points	0.110385

ANNUAL EMISSIONS BY POLLUTANT/SOURCE CATEGORY (CONT'D)

Pollutant	Source Category	Emissions (tons/yr)
Chloroform	Other Hazardous Waste TSDFs	0.220948
	Other Industrial Points	0.016885
	Per Capita Area Sources	60.753454
	RCRA Hazardous Waste Sites	0.000012
	Wastewater Treatment	0.800000
Hexavalent Chromium	Chrome Platers	2.806720
	Cooling Towers	0.815103
	Commercial Heating	0.125526
	Industrial Heating	0.019105
	Residential Heating	0.067316
	Other Industrial Points	0.044503
	RCRA Hazardous Waste Sites	0.000001
	Steel Mills	0.076470
Coke Oven Emissions	Steel Mills	427.676000
Distillate Particulate	Residential Heating	169.515106
Diesel Particulate	Nonroad Engines	785.871604
	Road Vehicles	2841.265595
Dioxins	Other Hazardous Waste TSDFs	0.000001
	Other Industrial Points	0.000233
Epichlorohydrin	Other Hazardous Waste TSDFs	0.000025
	Other Industrial Points	0.100000
Ethylene Oxide	Hospitals	21.833589
	Other Industrial Points	68.044600
Formaldehyde	Aircraft Engines	62.865350
	Background Concentrations	n/a
	Commercial Heating	8.851186
	Industrial Heating	6.797304
	Nonroad Engines	69.459432
	Residential Heating	99.470073
	Other Hazardous Waste TSDFs	0.040689

ANNUAL EMISSIONS BY POLLUTANT/SOURCE CATEGORY (CONT'D)

Pollutant	Source Category	Emissions (tons/yr)
Formaldehyde (continued)	Other Industrial Points	114.809030
	Per Capita Area Sources	100.585285
	Road Vehicles	474.062711
	Steel Mills	16.041845
Gasoline Vapors	Gasoline Marketing	9566.400046
	Other Industrial Points	238.300000
Gasoline Particulate	Nonroad Engines	104.035569
	Road Vehicles	254.528222
Methyl Chloride	Other Hazardous Waste TSDFs	0.000300
	Other Industrial Points	0.323460
	Surface Coating	21.253065
	Wastewater Treatment	0.080000
Methylene Chloride	Degreasing	546.925726
	Municipal Waste Landfills	14.471000
	Other Hazardous Waste TSDFs	68.190442
	Other Industrial Points	46.072285
	Paint Strippers	786.506722
	Per Capita Area Sources	1047.561462
	Surface Coating	263.986398
	Wastewater Treatment	9.440000
PCBs	Municipal Waste Landfills	0.000019
	Other Hazardous Waste TSDFs	0.001152
	Other Industrial Points	0.000175
	RCRA Hazardous Waste Sites	0.000589
Piston Particulate	Aircraft Engines	1.232505
POM (B(a)P)	Commercial Heating	0.786892
	Industrial Heating	1.845260
	Residential Heating	2.589838
	Other Industrial Points	0.022388
	RCRA Hazardous Waste Sites	0.100711
POM (Woodstoves)	Residential Wood Combustion	4.632943
Propylene Oxide	Other Industrial Points	0.944500

ANNUAL EMISSIONS BY POLLUTANT/SOURCE CATEGORY (CONT'D)

Pollutant	Source Category	Emissions (tons/yr)
Styrene	Other Hazardous Waste TSDFs	1.634881
	Other Industrial Points	20.384700
	Wastewater Treatment	2.640000
Turbine Particulate	Aircraft Engines	48.874590
Vinyl Chloride	Municipal Waste Landfills	2.294000
	Other Hazardous Waste TSDFs	4.405844
	Other Industrial Points	3.198500
Vinylidene Chloride	Municipal Waste Landfills	0.413000
	Other Hazardous Waste TSDFs	0.933013
	Wastewater Treatment	0.012000
Ethylene Dibromide	Other Industrial Points	0.903000
Ethylene Dichloride	Other Hazardous Waste TSDFs	0.200143
	Other Industrial Points	61.100500
	Wastewater Treatment	0.800000
1,3-Butadiene	Aircraft Engines	7.604370
	Nonroad Engines	82.088420
	Other Hazardous Waste TSDFs	0.183425
	Other Industrial Points	1.324000
	Road Vehicles	214.194182
	Steel Mills	0.195000
Trichloroethylene	Degreasing	620.698104
	Municipal Waste Landfills	2.167000
	Other Hazardous Waste TSDFs	30.632783
	Other Industrial Points	94.232385
	RCRA Hazardous Waste Sites	0.000001
	Wastewater Treatment	2.080000
Perchloroethylene	Degreasing	386.444815
	Dry Cleaners	1534.721482
	Municipal Waste Landfills	9.705500
	Other Hazardous Waste TSDFs	0.729222
	Other Industrial Points	204.529051
	Wastewater Treatment	6.560000

ANNUAL EMISSIONS BY POLLUTANT/SOURCE CATEGORY (CONT'D)

Pollutant	Source Category	Emissions (tons/yr)
Hexachlorobenzene	Other Hazardous Waste TSDFs	0.506905
	Other Industrial Points	0.048000
	RCRA Hazardous Waste Sites	0.000501
	Wastewater Treatment	1.480000
Total		*26831.85 tons/yr*

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APPENDIX F
AIR DISPERSION MODELING AND RISK CALCULATION TECHNIQUES

F.1 AIR DISPERSION MODELING TECHNIQUE

F.1.1 POINT SOURCE

With the Southwest Chicago Point Source Emissions Inventory, three air dispersion modeling runs *via* the Industrial Source Complex -- Long Term (ISCLT) were submitted to estimate the annual concentrations at the receptors. One run was for the regular industrial point sources, one was for TSDF facilities, and the last one was for point sources listed in the northern boundary emissions inventory. The Stability Array (STAR) station at Midway Airport was used to simulate the meteorological data and the annual concentration estimates for 64 receptors were computed using the emission rate of 1 metric ton/yr from each emission point. Multiplying the actual emission in metric tons by the unit concentration at a receptor grid provided the actual annual concentration at that receptor grid.

F.1.2 AREA SOURCE

Seventy-two air modeling runs were conducted to generate the necessary concentration estimates from all area source emissions in this study. For the area source emissions data, thirty-four Climatological Dispersion Model (CDM) runs were required based on the different county and split combination. Please note that splits based on population or dwelling units in a county were updated according to the 1990 Census total population and housing unit counts data (Public Law 94-171, or PL 94-171) in this study. One CDM run in response to the northern boundary area emissions inventory and 37 CDM runs for mobile sources at Midway airport also were submitted. Again, the meteorological condition around the Midway airport was utilized as the representative climate in the target area while modeling. For each area source run, the CDM-modeled concentrations computed were stored at the 8 x 8 receptor grids. For each pollutant, combining the CDM concentration matrix, based on the appropriate source category, with its actual emission rate, one can come up with the estimated annual concentration profile at the 8 x 8 receptor grids.

While modeling *via* CDM, the height above the ground for a emission grid is required. In general, the value of 5 meters was assigned as the Southeast Chicago study if the height is missing.

F.2 RISK CALCULATION

Once the annual concentration estimates at the receptor grids have been estimated, determining the individual risk estimates is a very straightforward procedure. Two assumptions

were made. A linear relationship between annual concentration and cancer risk is first assumed. The second assumption is that there is a zero threshold value for computing cancer risk. These two assumptions were used in the Southeast Chicago Study. Based on these two assumptions, one can compute the individual cancer risk by multiplying the annual concentration value at a receptor grid by the unit risk factors of those pollutants emitted from an emission source (stack or emission area).

$$R_{i,j,k} = C_{i,j,k} \times F_j$$

$R_{i,j,k}$ = individual lifetime cancer risk at receptor "k" due to the emission of pollutant "j" from emission source "i",

$C_{i,j,k}$ = annual concentration at receptor "k" due to the emission of pollutant "j" from emission source "i",

F_j = lifetime unit risk factor of pollutant "j".

Background concentrations are computed using the above equation as well, based on uniform annual concentrations (formaldehyde: 2.23 ug/m^3, carbon tetrachloride: 0.76 ug/m^3) assumed at each receptor grid. Tables 1 and 2 in Chapter II detail the lifetime unit risk factor values associated with the identified carcinogenic air toxics in this study.

Figure 9 in Chapter IV shows the population profile for the Southwest Chicago area of 8 x 8 receptor matrix. This population profile was obtained by summing up populations at BGED centroids within a receptor of the 8 x 8 grid matrix. The following equation outlines the calculation of lifetime incidences.

$$I_{i,j,k} = R_{i,j,k} \times P_k$$

$I_{i,j,k}$ = lifetime incidence at receptor "k" due to the emission of pollutant "j" from emission source "i",

$R_{i,j,k}$ = individual lifetime cancer risk at receptor "k" due to the emission of pollutant "j" from emission source "i",

P_k = population residing within the receptor grid "k".

APPENDIX G
TOP FIVE SOURCE CONTRIBUTORS TO CANCER CASES

TOP FIVE SOURCE CONTRIBUTORS TO CANCER CASES

Pollutant	Concentrations (ug/m^3)	Lifetime Individual Risks	Lifetime Cancer Cases
SOURCE CATEGORY - ROAD VEHICLES			
1,3-Butadiene	5.23E+00	1.46E-03	2.22
Diesel Particulate	6.68E+01	1.13E-03	1.69
Gasoline Particulate	5.93E+00	3.03E-04	0.46
Benzene	3.29E+01	2.73E-04	0.42
Formaldehyde	1.11E+01	1.45E-04	0.22
Asbestos	2.20E-03	1.67E-05	0.025
Cadmium	9.49E-04	1.71E-06	0.0026
SOURCE CATEGORY - BACKGROUND CONCENTRATIONS			
Formaldehyde	1.43E+02	1.86E-03	2.72
Carbon Tetrachloride	4.86E+01	7.30E-04	1.07
SOURCE CATEGORY - CHROME PLATERS			
Hexavalent Chromium	1.48E-01	1.78E-03	3.13
SOURCE CATEGORY - NONROAD MOBILE SOURCES			
1,3-Butadiene	2.68E+00	7.52E-04	1.19
Diesel Particulate	2.69E+01	4.57E-04	0.73
Gasoline Particulate	3.36E+00	5.38E-05	0.085
Benzene	6.39E+01	5.31E-05	0.084
Formaldehyde	2.27E+01	2.95E-05	0.047
SOURCE CATEGORY - AIRCRAFT ENGINES			
1,3-Butadiene	2.87E+00	8.03E-04	1.21
Formaldehyde	2.38E+01	3.09E-04	0.47
Turbine Particulate	1.63E+01	2.76E-04	0.39
Benzene	3.40E+00	2.82E-05	0.041
Piston Particulate	4.61E-01	7.37E-06	0.0082

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APPENDIX H
TOP FOUR POLLUTANT CONTRIBUTORS TO CANCER CASES

TOP FOUR POLLUTANT CONTRIBUTORS TO CANCER CASES

Source Category	Concentrations (ug/m³)	Lifetime Individual Risks	Lifetime Cancer Cases
POLLUTANT - 1,3-BUTADIENE			
Road Vehicles	5.23E+00	1 46E-03	2.22
Aircraft Engines	2.87E+00	8 03E-04	1.21
Nonroad Engines	2.68E+00	7 52E-04	1.19
Other Industrial Points	1.54E-01	4.30E-05	0 071
Other Hazardous Waste TSDFs	3.88E-03	1.09E-06	0 0018
Steel Mills	3.29E-04	9.20E-08	0 00014
POLLUTANT - POM/Particulate Matter			
Road Vehicles	7.27E+01	1 43E-03	2.15
Diesel Particulate	*6.68E+01*	*1.13E-03*	*1.69*
Gasoline Particulate	*5.93E+00*	*3.03E-04*	*0.46*
Nonroad Engines	3.03E+01	5.11E-04	0.82
Diesel Particulate	*2.69E+01*	*4.57E-04*	*0.73*
Gasoline Particulate	*3.36E+00*	*5.38E-05*	*0.085*
Aircraft Engines	1.68E+01	2.83E-04	0.40
Piston Particulate	*1.63E+01*	*2.76E-04*	*0.39*
Turbine Particulate	*4.61E-01*	*7.37E-06*	*0.0082*
Others POM Sources (B(a)P Surrogate)	1.37E-01	2.32E-04	0.35
Residential Heating (Distillate Oil Use)	4.24E+00	3.82E-05	0.059
Woodstoves	1.02E-01	2.96E-06	0.0044

TOP FOUR POLLUTANT CONTRIBUTORS TO CANCER CASES (CONT'D)

Source Category	Concentrations (ug/m³)	Lifetime Individual Risks	Lifetime Cancer Cases
POLLUTANT - HEXAVALENT CHROMIUM			
Chrome Platers	1.48E-01	1.78E-03	3.13
Cooling Towers	2.50E-02	3.00E-04	0.45
Commercial Heating	3.14E-03	3.77E-05	0.058
Residential Heating	1.57E-03	1.88E-05	0.029
Industrial Heating	8.79E-04	1.06E-05	0.016
Steel Mills	1.69E-04	2.03E-06	0.0030
Other Industrial Points	1.72E-04	2.06E-06	0.0030
RCRA Hazardous Sites	1.34E-09	1.60E-11	0.00000002
POLLUTANT - FORMALDEHYDE			
Background Concentrations	1.43E+02	1.86E-03	2.72
Aircraft Engines	2.38E+01	3.09E-04	0.47
Road Vehicles	1.11E+01	1.45E-04	0.22
Per Capita Area Sources	2.50E+00	3.25E-05	0.051
Residential Heating	2.49E+00	3.24E-05	0.050
Nonroad Engines	2.27E+00	2.95E-05	0.047
Other Industrial Points	2.03E+00	2.64E-05	0.037
Commercial Heating	2.47E-01	3.21E-06	0.0049
Industrial Heating	1.84E-01	2.39E-06	0.0036
Steel Mills	5.00E-02	6.51E-07	0.00098
Other Hazardous Waste TSDFs	1.77E-04	2.31E-09	0.0000034

APPENDIX I
POTENTIAL IMPACTS OF ROBBINS INCINERATOR AND SUN CHEMICAL

POTENTIAL RISKS POSED BY ROBBINS INCINERATOR

Grid ID	Receptor Location (S.W. Corner)	Lifetime Individual Risks	Lifetime Cancer Cases
1	4623.62 433.24	5.99E-09	0
2	4623.62 434.09	6.43E-09	0
3	4623.62 434.94	6.86E-09	0
4	4623.62 435.79	7.35E-09	0
5	4623.62 436.64	7.41E-09	0
6	4623.62 437.49	7.35E-09	0
7	4623.62 438.34	7.24E-09	0.0000025
8	4623.62 439.19	7.03E-09	0.000017
9	4624.43 433.24	5.72E-09	0.0000092
10	4624.43 434.09	6.10E-09	0.000011
11	4624.43 434.94	6.54E-09	0.000014
12	4624.43 435.79	6.81E-09	0.000012
13	4624.43 436.64	6.81E-09	0.000011
14	4624.43 437.49	6.70E-09	0.0000093
15	4624.43 438.34	6.59E-09	0.000016
16	4624.43 439.19	6.43E-09	0.000020
17	4625.25 433.24	5.45E-09	0.00000050
18	4625.25 434.09	5.83E-09	0.000018
19	4625.25 434.94	6.15E-09	0.000015
20	4625.25 435.79	6.26E-09	0.000021
21	4625.25 436.64	6.26E-09	0
22	4625.25 437.49	6.15E-09	0
23	4625.25 438.34	6.05E-09	0.000016
24	4625.25 439.19	5.94E-09	0.000020
25	4626.06 433.24	5.23E-09	0.000014
26	4626.06 434.09	5.56E-09	0.000016
27	4626.06 434.94	5.83E-09	0.000016
28	4626.06 435.79	5.83E-09	0.000016
29	4626.06 436.64	5.77E-09	0
30	4626.06 437.49	5.72E-09	0
31	4626.06 438.34	5.61E-09	0.000012
32	4626.06 439.19	5.45E-09	0.000015

POTENTIAL RISKS POSED BY ROBBINS INCINERATOR (CONT'D)

Grid ID	Receptor Location (S.W. Corner)	Lifetime Individual Risks	LifetimeGrid Cancer Cases
33	4626.87 433.24	5.01E-09	0.000014
34	4626.87 434.09	5.28E-09	0.000015
35	4626.87 434.94	5.45E-09	0.000016
36	4626.87 435.79	5.39E-09	0.000014
37	4626.87 436.64	5.34E-09	0.000017
38	4626.87 437.49	5.28E-09	0.0000063
39	4626.87 438.34	5.17E-09	0.0000099
40	4626.87 439.19	5.06E-09	0.000011
41	4627.68 433.24	4.79E-09	0
42	4627.68 434.09	5.06E-09	0
43	4627.68 434.94	5.06E-09	0
44	4627.68 435.79	5.06E-09	0
45	4627.68 436.64	5.01E-09	0.000011
46	4627.68 437.49	4.90E-09	0.000015
47	4627.68 438.34	4.85E-09	0.0000092
48	4627.68 439.19	4.74E-09	0.000018
49	4628.50 433.24	4.57E-09	0.0000081
50	4628.50 434.09	4.74E-09	0.00000023
51	4628.50 434.94	4.74E-09	0
52	4628.50 435.79	4.74E-09	0
53	4628.50 436.64	4.68E-09	0
54	4628.50 437.49	4.57E-09	0.000019
55	4628.50 438.34	4.52E-09	0.0000045
56	4628.50 439.19	4.41E-09	0.0000068
57	4629.31 433.24	4.41E-09	0.000012
58	4629.31 434.09	4.47E-09	0.0000086
59	4629.31 434.94	4.47E-09	0
60	4629.31 435.79	4.41E-09	0
61	4629.31 436.64	4.36E-09	0
62	4629.31 437.49	4.30E-09	0.0000023
63	4629.31 438.34	4.25E-09	0.00000028
64	4629.31 439.19	4.14E-09	0.000000012
TOTAL			*0.00052*

POTENTIAL RISKS POSED BY SUN CHEMICAL INCINERATOR

Grid ID	Receptor Location (S.W. Corner)	Lifetime Individual Risks	Lifetime Cancer Cases
1	4623.62 433.24	8.12E-10	0
2	4623.62 434.09	1.36E-09	0
3	4623.62 434.94	4.04E-09	0
4	4623.62 435.79	5.00E-09	0
5	4623.62 436.64	3.45E-09	0
6	4623.62 437.49	2.52E-09	0
7	4623.62 438.34	1.54E-09	0.00000054
8	4623.62 439.19	9.93E-10	0.0000024
9	4624.43 433.24	1.10E-09	0.0000018
10	4624.43 434.09	2.54E-09	0.0000044
11	4624.43 434.94	1.40E-08	0.000029
12	4624.43 435.79	4.99E-08	0.000089
13	4624.43 436.64	5.87E-09	0.0000098
14	4624.43 437.49	2.28E-09	0.0000032
15	4624.43 438.34	1.26E-09	0.0000031
16	4624.43 439.19	8.21E-10	0.0000026
17	4625.25 433.24	1.23E-09	0.00000011
18	4625.25 434.09	2.51E-09	0.0000077
19	4625.25 434.94	5.32E-09	0.000013
20	4625.25 435.79	2.30E-08	0.000078
21	4625.25 436.64	4.53E-09	0
22	4625.25 437.49	1.97E-09	0
23	4625.25 438.34	1.16E-09	0.0000031
24	4625.25 439.19	7.73E-10	0.0000027
25	4626.06 433.24	8.04E-10	0.0000022
26	4626.06 434.09	1.00E-09	0.0000028
27	4626.06 434.94	1.89E-09	0.0000053
28	4626.06 435.79	5.92E-09	0.000016
29	4626.06 436.64	3.69E-09	0
30	4626.06 437.49	1.80E-09	0
31	4626.06 438.34	1.07E-09	0.0000023
32	4626.06 439.19	7.15E-10	0.0000020

POTENTIAL RISKS POSED BY SUN CHEMICAL INCINERATOR (CONT'D)

Grid ID	Receptor Location (S.W. Corner)	Lifetime Individual Risks	Lifetime Cancer Cases
33	4626.87 433.24	4.50E-10	0.0000012
34	4626.87 434.09	7.35E-10	0.0000021
35	4626.87 434.94	8.71E-10	0.0000025
36	4626.87 435.79	2.17E-09	0.0000055
37	4626.87 436.64	2.92E-09	0.0000092
38	4626.87 437.49	1.57E-09	0.0000019
39	4626.87 438.34	1.00E-09	0.0000019
40	4626.87 439.19	7.04E-10	0.0000015
41	4627.68 433.24	3.82E-10	0
42	4627.68 434.09	5.30E-10	0
43	4627.68 434.94	5.13E-10	0
44	4627.68 435.79	1.10E-09	0
45	4627.68 436.64	2.12E-09	0.0000045
46	4627.68 437.49	1.44E-09	0.0000043
47	4627.68 438.34	9.01E-10	0.0000017
48	4627.68 439.19	6.57E-10	0.0000024
49	4628.50 433.24	3.14E-10	0.00000055
50	4628.50 434.09	3.69E-10	0.000000018
51	4628.50 434.94	3.44E-10	0
52	4628.50 435.79	6.67E-10	0
53	4628.50 436.64	1.28E-09	0
54	4628.50 437.49	1.23E-09	0.0000052
55	4628.50 438.34	8.72E-10	0.00000086
56	4628.50 439.19	6.02E-10	0.00000093
57	4629.31 433.24	2.59E-10	0.00000068
58	4629.31 434.09	2.71E-10	0.00000052
59	4629.31 434.94	2.51E-10	0
60	4629.31 435.79	4.50E-10	0
61	4629.31 436.64	8.51E-10	0
62	4629.31 437.49	1.04E-09	0.00000055
63	4629.31 438.34	7.98E-10	0.000000053
64	4629.31 439.19	5.95E-10	0.0000000018
TOTAL			*0.00033*