No.

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DOTC*MMDA*DPWH*NEDA*PNP-NCR*HUDCC*UP-NCTS*EMB
Japan International Cooperation Agency (JICA)

METRO MANILA URBAN TRANSPORTATION INTEGRATION STUDY

TECHNICAL REPORT NO. 10

TRAFFIC ENVIRONMENTAL STUDY, AIR AND NOISE POLLUTION IN METRO MANILA

March 1999

mmutis

MMUTIS STUDY TEAM

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LIST OF ACRONYMS/ABBREVIATIONS

ADB	Asian Development Bank
AQG	National Air Quality Guideline
CMDC	Construction Manpower Development Center
CO	Carbon Monoxide
COx	Carbon Oxides
DENR	Department of Environment and Natural Resources
DOTC	Department of Transportation and Communications
DPWH	Department of Public Works and Highways
EMB	Environmental Management Bureau
EDSA	Epifanio de los Santos Avenue
EIA	Environmental Impact Assessment
IEE	Initial Environmental Examination
JICA	Japan International Cooperation Agency
LRT	Light Rail Transit
LTO	Land Transportation Office
mg	Milligram
u g	Microgram
u g/m^3	Particulate Concentration per Microgram per Cubic Meter
MC/TC	Motorcycle/Tricycle
MMDA	Metro Manila Development Authority
MMUTIS	Metro Manila Urban Transportation Integration Study
MMUTSTRAP	Metro Manila Urban Transportation Strategic Planning Project
MRT	Mass Rail Transit
NCR	National Capital Region
NCTS	National Center for Transportation Studies
NOx	Nitrogen Oxides
Pb	Lead
PD	Presidential Decree
PM10	Particulate Matter Less Than 10 Microns
ppm	Parts Per Million
SEATAC	Southeast Asian Agency for Regional Transport and Communications Development
SOx	Sulfur Oxides
SPM	Suspended Particulate Matter
TOG	Total Organic Gases
TDM	Transport Demand Management
TSM	Transport System Management
TSP	Total Suspended Particulate
URBAIR	Urban Air Quality Management Strategy in Asia
UV	Utility Vehicle
WB	World Bank
WHO	World Health Organization

1. INTRODUCTION

1.1 Objectives

The Metro Manila Urban Transportation Integration Study (MMUTIS) had a three-fold task of formulating medium- to long-term sustainable transportation development strategies at the metropolitan level (structure plan) and a five-year implementation plan; conducting feasibility studies for identified priority projects; and recommending policies and strategies for strengthening the metropolitan transportation planning administration, education and research activities. The development challenge was to formulate a comprehensive strategic transportation plan that will ensure the satisfaction of the community's demand for mobility at a level that is sustainable from the economic, social, financial and environmental perspectives. Thus, it was necessary to include an environmental impact study as an integral component of the planning process.

The environmental study was divided into the following three phases:

Phase 1 Collection and review of existing institutions, regulatory framework and guidelines on the environment;

Phase 2 Conduct of an air pollution survey and a noise survey for six selected roads;

Phase 3 Evaluation of the existing environmental issues in the study area, such as relocation of residents affected by transportation project activities and split of communications; and

Phase 4 Study of noise/air pollution forecast models.

The second phase of this study particularly aimed to do the following:

1) Formulate an Initial Environmental Examination (IEE) for the programs which are proposed by the MMUTIS members; and

2) Present this technical report on environment study in support of the final report on MMUTIS investigations.

The recommendations in this technical report are a result of the findings from the environmental study and the discussions of the study team with the various agencies concerned with transportation in Metro Manila.

This report summarizes the review of air and noise pollution issues caused by traffic operation in Metro Manila. It outlines existing legislation and administrative and technical procedures for the control of air and noise pollution, and describes currently available data on concentration of air pollution. A comparison of the current situation of air pollution with other mega-cities in Southeast Asia (e.g., Bangkok, Thailand and Jakarta) is likewise presented

The issue of air pollution is discussed in greater detail. It is clearly a major issue and has serious health implications. Noise pollution is a more subjective problem and is generally more difficult to control. Some examples of successful enforcement, and proposals for further action are also outlined in the report.

1.2 General Description of Metro Manila

Metro Manila, also called the National Capital Region (NCR), is situated on the plain located on the southwestern coast of Luzon Island, around the mouth of the Pasig River in Manila Bay. It is bounded by Manila Bay in the west, the agricultural plains of Central Luzon in the north, the Sierra Madre mountains in the east, and Laguna Bay in the south. Metro Manila covers a total land area of 636 square kilometers, covering ten cities and seven municipalities.

Meteorological characteristics, especially wind direction and wind velocity, are one of the important factors of air pollution. The study area's climate is characterized by a dominant rainy season from May to October and a dominant dry season during the rest of the year. The annual rainfall is 2,000 mm to 3,000 mm in the study area and around 2,000 mm in the Metro Manila area. The temperature varies from 25°C in January to about 30°C in May. The average annual temperature is 27°C. No severe temperature change can be observed throughout the year in the study area. The prevailing wind direction in the Metro Manila area is southwestward during the rainy months, changing its direction to eastward during the dry months. The wind velocity is observed to be stable throughout the year, with an average velocity of about three meters per second, except during tropical cyclone season.

Metro Manila is expected to become one of the world's megacities by the turn of the century. Its total population has been rapidly increasing, from 1.6 million in 1948 to 2.5 million in 1960, 5.6 million in 1980, 7.9 million in 1990, and 9.5 million as of 1995 (refer to Table 1.1 and Figure 1.1). In addition, continuous urban migration has expanded the metropolitan area beyond the municipal boundaries and has caused rapid population growth in adjoining areas such as Cavite, Laguna, Rizal and Bulacan. The MMUTIS study area now has a total population of 14.4 million and has been growing at a rate of 4.2% per year. The Metro Manila area shares more than 20% of the country's population.

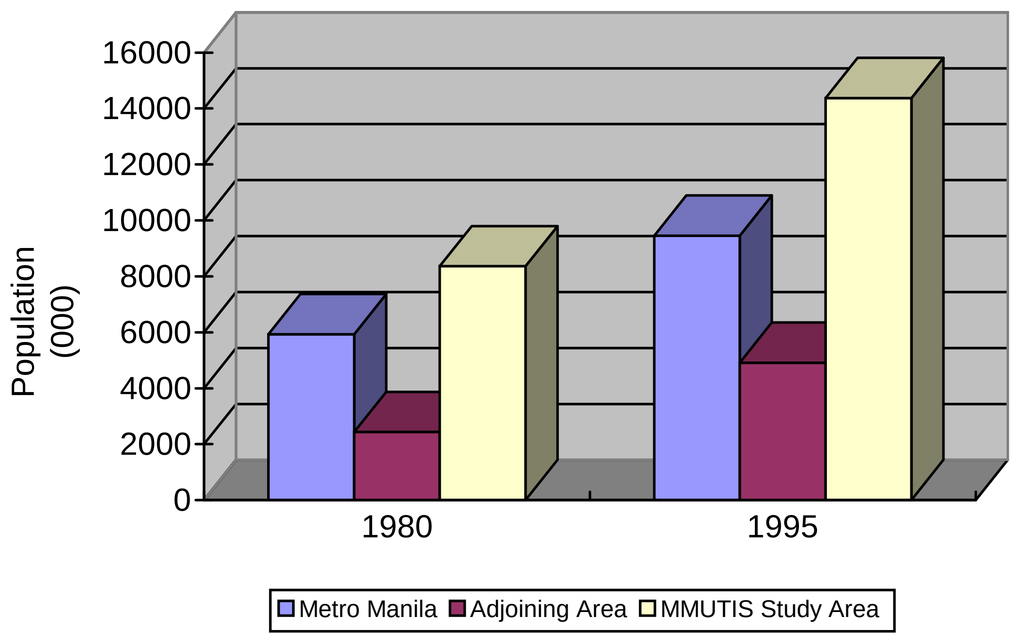
The expansion of urban areas is starting to severely strain the existing urban infrastructure and ecology. In particular, the supply and operation of various transport infrastructure can no longer cope with the increasing demand for efficient movement of goods and people. The problem is further compounded by the increasing levels of pollution brought about by man and machine. The number of motor vehicles, the primary source of pollutants in Metro Manila, has been rapidly increasing by an annual average rate of 8.66%, outpacing the 2.3% increase in roads through construction and improvement. This has resulted in a continuous increase in road traffic and, consequently, in the degradation of the air quality by exhaust gases.

TABLE 1.1
POPULATION OF THE STUDY AREA

Area	Population: '000 (% Share)			Growth Rate: % / yr.		
	1980	1990	1995	1980-90	1990-95	1980-95
Metro Manila	5,962 (70.9)	7,929 (67.7)	9,454 (65.8)	2.9	3.6	3.1
Adjoining Areas	2,434 (29.1)	3,774 (32.3)	4,912 (34.2)	4.5	5.4	4.8
Study Area	8,360 (100.0)	11,702 (100.0)	14,368 (100.0)	3.4	4.2	3.7
Philippines	48,098	60,703	68,614	2.4	2.5	2.4
% of Study Area to RP	17.4	19.3	20.9	-	-	-

Source: MMUTIS Report

FIGURE 1.1
TREND OF POPULATION IN MMUTIS STUDY AREA



1.3 Data Sources

1.3.1 Previous Studies

Several institutions and agencies have already researched and reported on the air pollution status in Metro Manila. The most important among these reports are the following:

- "Urban Air Quality Management Strategy in Asia" by World Bank, 1997;
- "Urban Environmental Pollution Study" by Japan International Cooperation Agency, 1996;
- "Vehicular Emission Control Planning in Metro Manila" by ADB/EMB, 1992;
- "Survey on the Environmental Impacts of Urban Expressways in SEATEC Countries" by Southern Asian Agency for Regional Transport and Communication Development, 1989;
- "Metro Manila Urban Transportation Strategy Planning Project" by Ministry of Transportation and Communications, 1984; and
- "Philippine Environmental Sector Study Toward Improved Environmental Policies and Management" by World Bank, 1993.

1.3.2 MMUTIS Primary Data Collection

The Environmental Impact Analysis Study conducted by the National Center for Transportation Studies of the University of the Philippines (NCTS)/MMUTIS in 1997 analyzed primary data which had been measured at six measurement points on the six main roads in Metro Manila (refer to Table 1.2). A follow-up survey was conducted by MMUTIS in 1998, covering eight survey sites at the north and south areas of Metro Manila and adjoining areas, in order to examine the air pollution level of the entire MMUTIS study area (see Table 1.3).

TABLE 1.2
ENVIRONMENTAL SURVEY SITES IN 1997

Survey Area	Category	Survey Site	Location
Center of M.M.	Roadside	1) Taft Avenue	Manila City
		2) Epifanio de los Santos Avenue	Quezon City
		3) Roxas Boulevard	Pasay City
		4) Quezon Ave.	Quezon City
		5) Quirino Highway	Quezon City
		6) South Superhighway	Paranaque

TABLE 1.3
ENVIRONMENTAL SURVEY SITES IN 1998

Survey Area	Category	Survey Site	Location
North Side of M.M.	Roadside	1) Regalado Avenue	Quezon City
		2) Commonwealth Avenue	Quezon City
		3) MacArthur Highway	Valenzuela
	Background	4) Far Eastern University	Quezon City
Center of M.M	Background	5) EDSA	Quezon City
South Side of M.M.	Roadside	6) Aguinaldo Highway	Las Pinas City
		7) National Highway	Muntinlupa City
	Background	8) C.M.D.C.	Cavite

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1.4 Motor Vehicles in Metro Manila

The vehicle fleet in Metro Manila is divided into four categories, as follows:

a) **Cars** : passenger, taxi, light duty vehicles;
b) **Utility Vehicles (UV)**: light duty truck, jeepney (a mid-size passenger vehicle);
c) **Trucks and Buses**; and
d) **MC/TC**: Motorcycle and tricycle.

In 1994, the total vehicle fleet was reported at 9,590,000 vehicles, broken down as follows (refer to Table 1.4 and Figure 1.2):

Cars and Taxis:	3,970,000	(41.4%)
Utility Vehicles:	3,890,000	(40.1%)
Trucks and Buses:	706,000	(7.4%)
Two- and Three-Wheelers:	1,027,000	(10.7%)

The number of vehicles grew between 1986 and 1994, especially after 1992 when a 10.1% increase in the total fleet—primarily composed of utility vehicles, motorcycles and tricycles—was recorded (refer to Table 1.5).

In terms of vehicle density, the following figures are reported for Metro Manila:

Cars:	37 per 1,000 inhabitants
UV:	36 per 1,000 inhabitants
Truck/Buses:	7.6 per 1,000 inhabitants
MC/TC:	9.8 per 1,000 inhabitants

TABLE 1.4
VEHICLE FLEET IN METRO MANILA

Year	Vehicle (1000)				
	Cars	UV	Trucks/ Buses	MC/TC	Total
1980	267	105	27	42	441
1981	206	163	37	33.9	439.9
1982	223	164	38	38.6	463.6
1983	237	179	40	47.6	503.6
1984	227	169	34	40.4	470.4
1985	222	166	32	37.6	457.6
1986	229	170	33	43.3	475.3
1987	231	179	34	39.4	483.4
1988	241	189	37	43.7	510.7
1989	269	216	42	53.7	580.7
1990	307	252	50	66.6	675.6
1991	309	278	51.6	73.9	712.5
1992	343	313	62.4	80.4	798.8
1993	370	356	65.8	97	888.8
1994	397	389	70.6	102.7	959.3

Source: NCR

FIGURE 1.2
NUMBER OF VEHICLES IN METRO MANILA

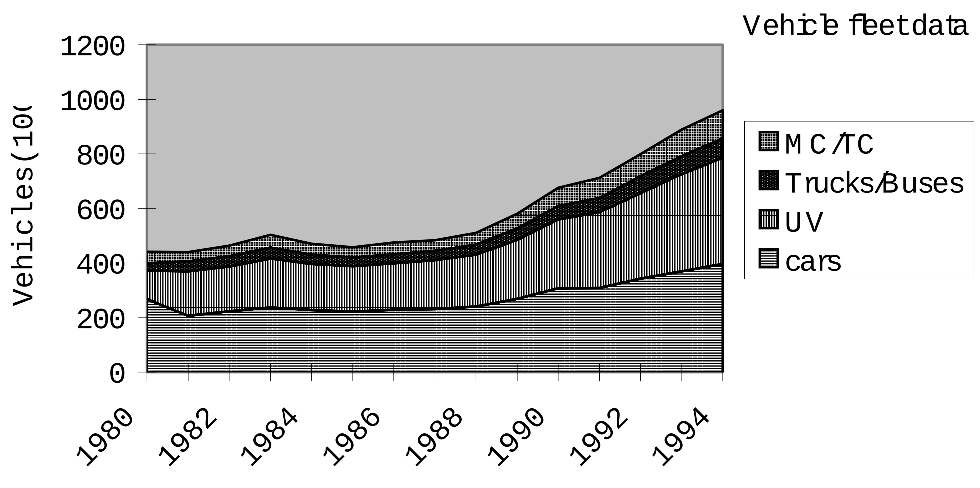


TABLE 1.5
VEHICLE AVERAGE ANNUAL GROWTH RATE (%)

Type	1981-1986	1986-1992
Passenger Cars	2.3	5.4
Utility Vehicles	0.8	14.1
Trucks	-1.7	13.8
Buses	-6.6	10.2
MC/TC	5.5	14.8
TOTAL	**1.6**	**10.1**

The percentage of diesel vehicles in the total fleet is indicated in Table 1.6. The number of buses and trucks has grown substantially since 1980. In 1990, about 90% of these vehicles were diesel-powered. Utility vehicles were split evenly between gasoline-operated and diesel-powered. The total number of diesel-powered cars have also grown.

TABLE 1.6
DIESEL VEHICLES IN THE FLEET (% SHARE)

Type	1980	1985	1990
Passenger Cars	2.3	4.2	4.7
Utility Cars	36.4	48.2	45.4
Buses	32.3	94.3	93.3
Trucks	30.4	85.3	86.7
Motorcycles/Tricycles	1.8	0.55	0

2. TYPE, SOURCE AND EFFECTS OF AIR AND NOISE POLLUTION

Despite the unquestionable benefits that appropriate transport provision can bring, there are inevitable opportunity costs and social costs involved. In particular, environmental concerns in transport are not restricted to local factors such as noise, severance and visual intrusion, but they also have regional, national and global implications such as global warming, acid rain and a range of pollution-induced diseases. Environmental degradation from the transport sector is mainly caused by road-based transport.

In Metro Manila, traffic congestion and environmental degradation in transport have been one of the most important social issues. The 1990 Emission Inventory conducted by the Environmental Management Bureau (EMB) showed that motor vehicles contribute to about 78% of the total air pollution load in the metropolis. Carbon Monoxide (CO) in particular, the most toxic among the air pollutants, is almost 100% attributed to mobile sources.

2.1 Types of Air Pollutants

Table 2.1 shows the 1990 data on the sources of air pollution in Metro Manila. Air pollution comes from mobile, stationary and area sources. Air pollutants are composed of these complexes. Mobile sources (motor vehicles) emit the largest amount of carbon monoxide (CO), nitrogen oxides (NOx), Lead (Pb) and suspended particulate matter (SPM). Primary sources of emissions in Metro Manila are the large number of motor vehicles serving transport needs and the industrial facilities. The level of emissions, principally particulate matter, consistently exceeds healthful standards. Motorized transport in Metro Manila accounts for the largest share in air pollutants, including 94% of total organic gas, 99% of CO, and 83% of NOx. The rest comes from industrial installations, utilities and windblown/resuspended dust.

TABLE 2.1
1990 DATA ON SOURCES OF AIR POLLUTION IN METRO MANILA

Pollutant (tons)	Source Category			Total
	Transport	Industry	Energy Generation	
CO	537,000 (99.4%)	2,502 (0.5%)	845 (0.2%)	540,347 (100%)
Nox	73,000 (86.7%)	1,867 (2.2%)	9,299 (11.0%)	84,166 (100%)
Pb	71.8 (100%)	0 (0.0%)	0 (0.0%)	71.8 (100%)
Particulates	12,100 (63.1%)	1,449 (7.6%)	5,636 (29.4%)	19,185 (100%)
Sox	15,900 (15.9%)	8,118 (7.8%)	79,805 (76.9%)	103,823 (100%)
HC	89,100 (99.7%)	195 (0.2%)	42 (0.1%)	89,337 (100%)

Source: ADB, 1992

2.1.1 Suspended Particulate Matter (SPM)

SPM, or Total Suspended Particulate (TSP), are highly visible products of poorly controlled combustion and are mainly dust and carbon. The larger particles settle out of the air; finer materials stay suspended and may form the basis of smog or fog. By themselves, they are not toxic, but they may act to convey toxic pollutants to the lungs. SPM is a major air pollution problem in Metro Manila. It is especially concentrated near streets and industrial areas particularly during the dry season. The sources of particulate in urban areas include motor vehicle exhaust emissions, combustion of fuels, fires and construction activities.

2.1.2 Particulate Matter 10 (PM_{10})

PM_{10}, which is defined as particles with diameters of less than 10 micrometer, is a better indicator of the possible health effects of airborne particles than SPM. Because PM_{10} particles are smaller, they are most likely to penetrate the lungs and cause respiratory illness. They include fine solids or liquid particles found in the air or in emission such as dust, smoke or smog. Sources include the fine asbestos and other particles stemming from wear and tear of tires and brakes as well as matter resulting from engine, especially diesel engine, combustion. Particulate matter may be toxic in itself or carry toxic trace substances absorbed into its surfaces.

2.1.3 Carbon Monoxide (CO)

CO is an odorless and almost colorless gas. It is primarily a product of the combustion of fuel in a motor vehicle when it is idling or operating below normal cruise speeds. It can have detrimental effects on health because it interferes with the absorption of oxygen by red blood cells. This may lead to increased morbidity and adversely affected fertility, and there is evidence that it affects worker productivity. CO is especially a problem in urban areas where synergistic effects with other pollutants mean it contributes to photochemical smog and surface ozone (O_3). Concentrations of O_3 at lower levels have implications for the respiratory system. In low concentrations, CO can produce sluggishness, nausea, headaches and dizziness. In large doses, it can kill by reacting with blood hemoglobin. High concentrations of this gas are found in areas of high traffic density. It usually resides in the atmosphere for one to two months.

2.1.4 Sulfur Dioxide (SOx)

Sulfur dioxide results from the combustion of fossil fuels and the decomposition and combustion of organic matter, and many remain in the atmosphere for periods ranging from hours to several weeks. “Acid rain” is associated with the combination of sulfur dioxide with water to form sulfurous and sulfuric acid. Exposure to high levels of sulfur dioxide results in chest irritation and persistent bronchitis. These health effects are aggravated if particulate matter is also present. Transport is directly responsible for about 5% of total SO_2 emissions with diesel fuel containing more SO_2 per liter than gasoline.

2.1.5 Nitrogen Oxides (NOx)

Nitric acids and nitrogen dioxide are produced by combustion processes, the former found in vehicle exhaust and the latter formed by subsequent oxidation of the nitric acids. These oxides, with nitrous oxide, may reside in the atmosphere for several days. The oxides can be oxidized to nitric acid and particulate matter. With strong sunlight, the oxides react with hydrocarbons and oxygen to form photochemical smog. This causes very severe breathing problems at high concentrations. It poses particular difficulties when combined with other air pollutants or in areas where residents already suffer from ill-health. In the latter case, they can lead to respiratory difficulties and extended exposure can result in oedema or emphysema. At the transboundary level, NO_x emissions converted to nitric acid and combined with SO_2, form a significant component of acid rain which has serious detrimental effects on ecosystems.

2.1.6 Lead (Pb)

Lead compounds are found in exhaust gas produced from anti-knock agents in fuel. It affects the central nervous system, lowers an individual's IQ, causes behavioral disturbance, decreases ability to concentrate, increases the incidence of high blood pressure, and has been found to be carcinogenic to animals and potentially to humans. When emitted after combustion, lead is in an inorganic form. Airborne lead particles can exist in many chemical forms which may influence their environmental properties and toxicity. The major sources of lead are evaporation losses incurred during transport and handling of leaded petrol and emission in motor vehicle exhaust.

Results of air quality measurement undertaken by the EMB-NCR in different monitoring stations from 1986 showed levels occasionally exceeding environmental standards. In the 1997 NCTS-MMUTIS environmental impact study covering 6 arterial roads in Metro Manila, CO, NO2, Pb and SPM were measured as main pollutants from mobile sources. Simultaneously with the air pollution level monitoring, wind speed and wind direction and 24-hour traffic volume counts were undertaken.

2.2 Noise Pollution

Noise due to motor vehicles is related to the number of vehicles using a road, particularly the number of heavy vehicles. The reaction of people to vehicle noise varies considerably depending upon individual irritation from noise, the background level of noise, and the characteristics of the noise (e.g., frequency, tone, intensity hertz, as well as absolute level). Cars are widespread contributors of unwanted noise, though larger trucks, buses and jeepneys are generally noisier than cars.

Sound is measured in terms of its intensity as this is associated with the human perception of loudness and is measured in units of power per unit area. Sound is rarely constant over time, and time is found to affect noise impacts in several ways, as follows:

- The length or duration of the sound;
- The number of times the sound is repeated; and
- The time of day at which the noise occurs.

A number of noise descriptions have been developed to characterize the nature of highway traffic noise. Ideally, any descriptor should be capable of reflecting frequency, sound pressure level, and the fluctuation of these two variables over time. Those that are currently used include:

- Percentile exceeded noise levels (Lx), which defines the sound level that is exceeded X percent of the time;
- Equivalent continuous (A-weighted) sound levels (Leq), which is the average sound level over a prescribed period of time. Common periods are 1 hour, 24 hours, daytime or night time; and
- Maximum sound pressure level (Lmax).

2.3 Methodology

2.3.1 Air Pollution

a) Equipment

For CO and SPM, the Air Pollution Monitoring System by Horiba Ltd., equipped with gas sampling mechanism and automatic recorder-analyzers, was used in the study. Air pollution analyzers and automatic data management hardware were fixed in a *Mitsubishi Rosa*. Data management hardware included a data logger which stored and integrated field data in a computer file format, and recorders which plotted real time site measurements.

For NO2, the simple NO2 detectors and Eco Analyzer produced by Tsukuba Science Laboratory Ltd. was used in the study.

For lead, the high volume air sampler by Shibata Ltd. was used to collect the atmospheric TSP in the study. It has an ability to inhale 500 liters of sample air per minute as standard capacity.

b) Methods of Measurement

Non-Dispersive Infrared Radiation Method (NDIR) for CO

The measurement of CO in ambient air is based on the absorption of infrared radiation by non-dispersive spectrometry. The infrared radiation emitted from an infrared source is split into parallel beams and directed through two cells. One beam passes a reference cell which contains a non-absorbing background gas; the other sample cell contains a continuous flowing sample of ambient air. Any CO introduced into the sample cell will absorb radiation. The detector converts the difference in energy between sample and reference cell to capacitance change. This capacitance change, equivalent to the CO concentration, is detected electronically and amplified to produce output signal. Ambient CO concentrations can be determined by reference to the analyzer response versus the CO concentration calibration curve (EMB, 1994). The duration of measurements for CO was 48 hours with one sample point for every hour.

Saltzman and Absorption Spectrophotometry Method for NO2

In the survey, NO2 in ambient was measured by the simple detector and analyzer. The specific filter of the NO2 detector has the ability to absorb NO2 in the air. After the detector was exposed for 24 hours in the survey site, the filter was taken out and put into the Saltzman Liquid. This liquid changes to a darker color the higher the NO2 level. The concentration of atmospheric NO2 was measured by the translucency value of the colored liquid by using the absorbance analyzer. The duration of measurements for NO2 was two days with one sample point.

Beta-Ray Absorption Method for SPM

In this method, a beta radiation source was located on one side of a high-grade filter tape and a detector on the other. The low-energy beta ray was absorbed in proportion to the particle volume. Beta rays were directed on the filter tape that gathered particles and the density was derived from the intensity of ray transmission (EMB, 1994). The duration of measurements for SPM was 48 hours with one sample point for every hour.

Atomic Absorption Spectro-Photometer Method for Lead (Pb)

The pre-weighted filters used in the collection of TSP were submitted to the laboratory for lead (Pb) analysis. Before doing so, the TSP concentration was calculated from the resulting weight of the filters after sampling the volume of air that passed through the high volume sampler. Filter papers used in the high volume sampler were digested using 10ml ashing acid (4:1 mitric-perchloric acid) into dryness. The digested filter was left to stand for 30 minutes at room temperature. Then, 2ml of ashing acid was again added and the solution heated in a hot plate at 120^{o}C until 0.5ml remained. The same procedure was repeated until the solution became clear. The sample was rinsed by 10ml distilled water in a watch glass and then heated to a temperature of 150^{o}C until it was dry. The remaining residue was dissolved in 2-3ml of dilution acid (4% nitric; 1% perchloric acid) for analysis of lead (Pb) using atomic absorption spectro-photometer (AAS). A lead standard curve was prepared to determine the level of lead in the sample. Concentration was computed using the resulting weight of lead in the filter over the volume of air that passed through the high volume sampler. The duration of measurements for lead (Pb) was 24 hours with one sample point.

2.3.2 Meteorological Monitoring

a) Equipment

The equipment used for wind speed and wind direction were the ananemometer and anemoscope mounted on top of the mobiles, the Air Pollution Monitoring System by Horiba Ltd.

b) Method of Measurement

The ananemometer and anemoscope were elevated to 9.0 meters to clear any windward obstacle. Hourly measurements of wind speed were expressed in m/s with wind speed of 0.40 m/s or less considered as calm. Most prevalent hourly wind directions were established using the 16 compass points. These data were recorded automatically by the data management hardware, including a data logger, with other air pollution data. For each location, the monitoring was done with air pollution level measurement for a period of 48 hours.

2.3.3 Traffic Volume Count

a) Equipment

Traffic manual counters connecting five individual counters were used to measure the traffic volume classified into five classes. The traffic volume surveyor recorded every 15 minutes the traffic volume into the recording sheets prepared previously.

b) Method of Measurement

The main variable in roadside environment is traffic volume. Defined as the number of vehicles passing a given point during a specified period of time, traffic volume gives an accurate information on the total traffic from each direction contributing to the pollution level in the areas (TTC, 1983). Since air pollution level is source-dependent, the number of vehicles is expected to be directly proportional to pollution concentration.

Five general classes of vehicles were used in the survey, namely: cars (including fiera, taxi, Hi-Ace, L300, FX, pick-up), passenger jeepney, bus, trucks (including rigid and articulated types), and others (including motorcycles and tricycles). For each location, the counting was done simultaneously with air pollution level measurements for a period of 24 hours.

3. PRESENT SITUATION OF AIR QUALITY IN METRO MANILA

3.1 General

Among the cities in the Philippines, Metro Manila is the most affected by the problems of air quality and unwanted noise due to transportation systems. This chapter describes the air pollution situation in Metro Manila, based on secondary data measured by EMB/NCR through its air quality measurement monitoring network consisting of seven (7) stations that regularly report TSP and SO2 (see Figure 3.1) and the primary data measured at six (6) stations by NCTS/MMUTIS (see Figure 3.2).

Air quality is measured against accepted environmental standards. These standards are based on the National Air Quality Guideline (AQG) which adopts the World Health Organization (WHO) international air quality guideline summarized in Table 3.1.

TABLE 3.1
NATIONAL AMBIENT QUALITY GUIDELINE FOR CRITERIA POLLUTANTS

Pollutant	Short Term (a)		Averaging Time	Long Term (b)		Averaging Time
	ug/m^3	Ppm		ug/m^3	ppm	
Suspended Particulate Matters (c)						
TSP	230(f)	-	24 hrs.	90	-	1 yr. (c)
PM_{10}	150(g)		24 hrs.	60	-	1 yr. (c)
Sulfur Dioxide (e)	180	0.07	24 hrs.	80	0.03	1 yr.
Nitrogen Dioxide	-	0.1	1 hr.			
	150	0.8	24 hr.	-	-	-
Photochemical	140	0.07	1 hr.	-	-	-
Oxidants as Ozone	60	0.03	8hrs.	-	-	-
Carbon Monoxide	35 mg/Ncm	30	1 hr.	-	-	-
	10 mg/Ncm	9	8hrs.	-	-	-
Lead (d)	1.5	-	3 months	1.0	-	I yr.

Notes:

a. Maximum limits represented by 98% values not to be exceeded more than once a year.
b. Arithmetic Mean.
c. Annual Geometric Mean.
d. Evaluation of this guideline is carried out for 24-hour averaging time and averaged over three moving calendar months. The monitored average value for three months shall not exceed the guideline value.
e. S02 and Suspended Particulate are sampled once every six days when using the manual method. A minimum of 12 sampling days per quarter or 48 sampling days each year is required for this method. Daily sampling may be done in the future once continuous analyzers are procured and available.
f. Limits for Total Suspended Particulate with mass median diameter less than 10 microns until sufficient monitoring data are gathered to the proper guideline.

Source: "Urban Air Quality Management Strategy in Asia (1993)"

3.2 Monitoring of Pollutants

3.2.1 TSP

The Philippines has accepted the upper permit value of the environmental standards of the WHO Air Quality Guideline. The WHO guideline for PM10 and total suspended particulate (TSP) is 60-90 μ g/m^3 for long-term (annual) average, and 150-230 μ g/m^3 for short-term (24 hours) average.

Table 3.2 and Figure 3.3 show TSP data measured by the DENR/NCR from 1992 to 1996. Allowable values are clearly exceeded at all DENR/NCR measurement stations. During the four-year period, the maximum values and average values of TSP at the Valenzuela monitoring station extremely exceeded environmental standards. The highest annual average concentration was measured at the Valenzuela station, situated in an industrial area dominated by lumberyards and light steel industries. High concentrations have also been measured in Manila (Ermita monitoring station). Annual TSP averages at the Valenzuela and Ermita monitoring station sites were 2.5-3.0 times the Guideline. Values are relatively higher in the late winter (dry season) than during the wet season (starting July/August). Dry season TSP may be higher than wet season TSP by as much as twice. This is probably because of increased wind speed and turbulence, causing dispersion, decreased resuspension from the ground, and/or increased washout of particles in the rain.

FIGURE 3.1
TSP AND SO2 MONITORING STATION MAP OF DENR / NCR IN METRO MANILA

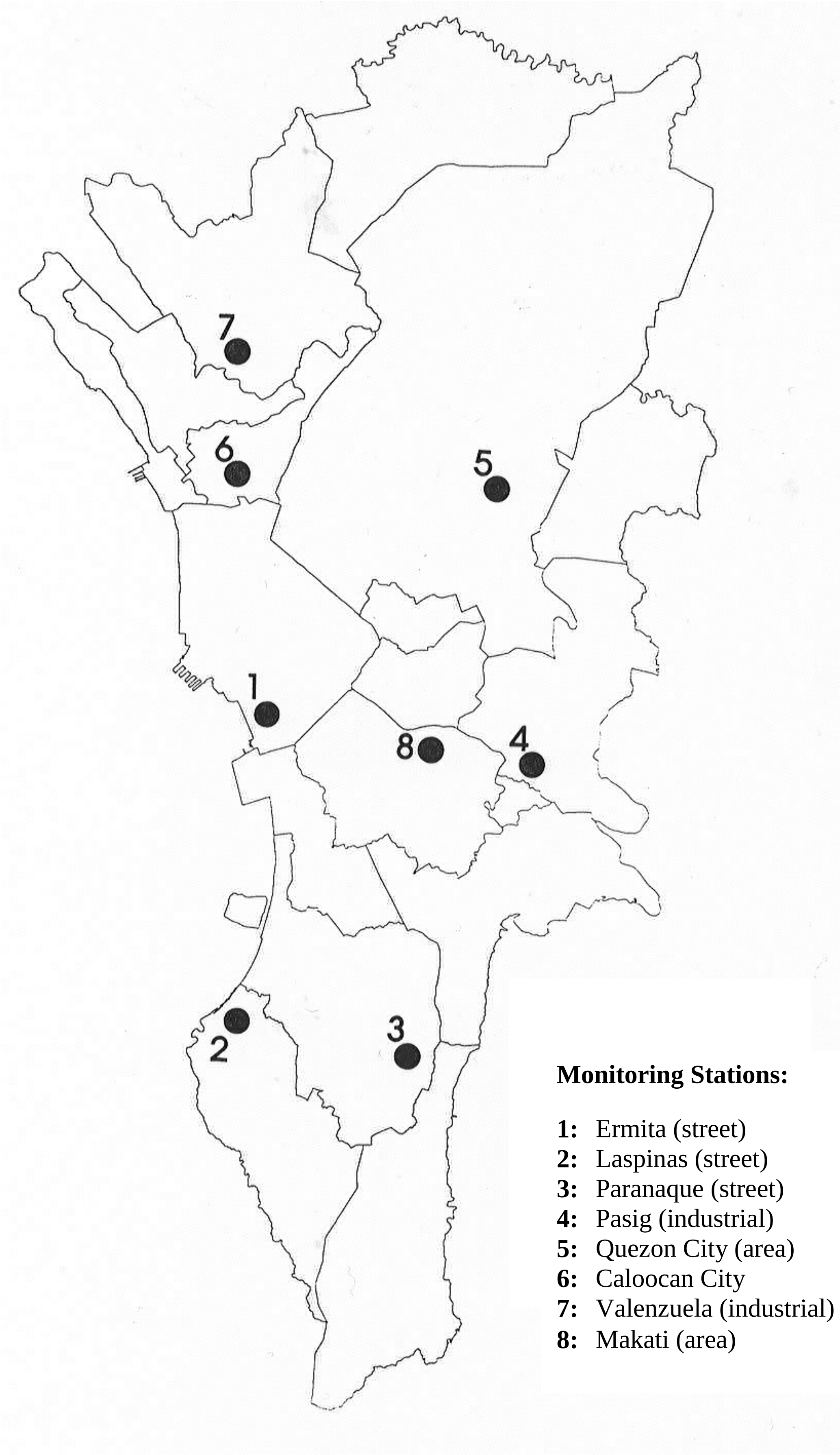
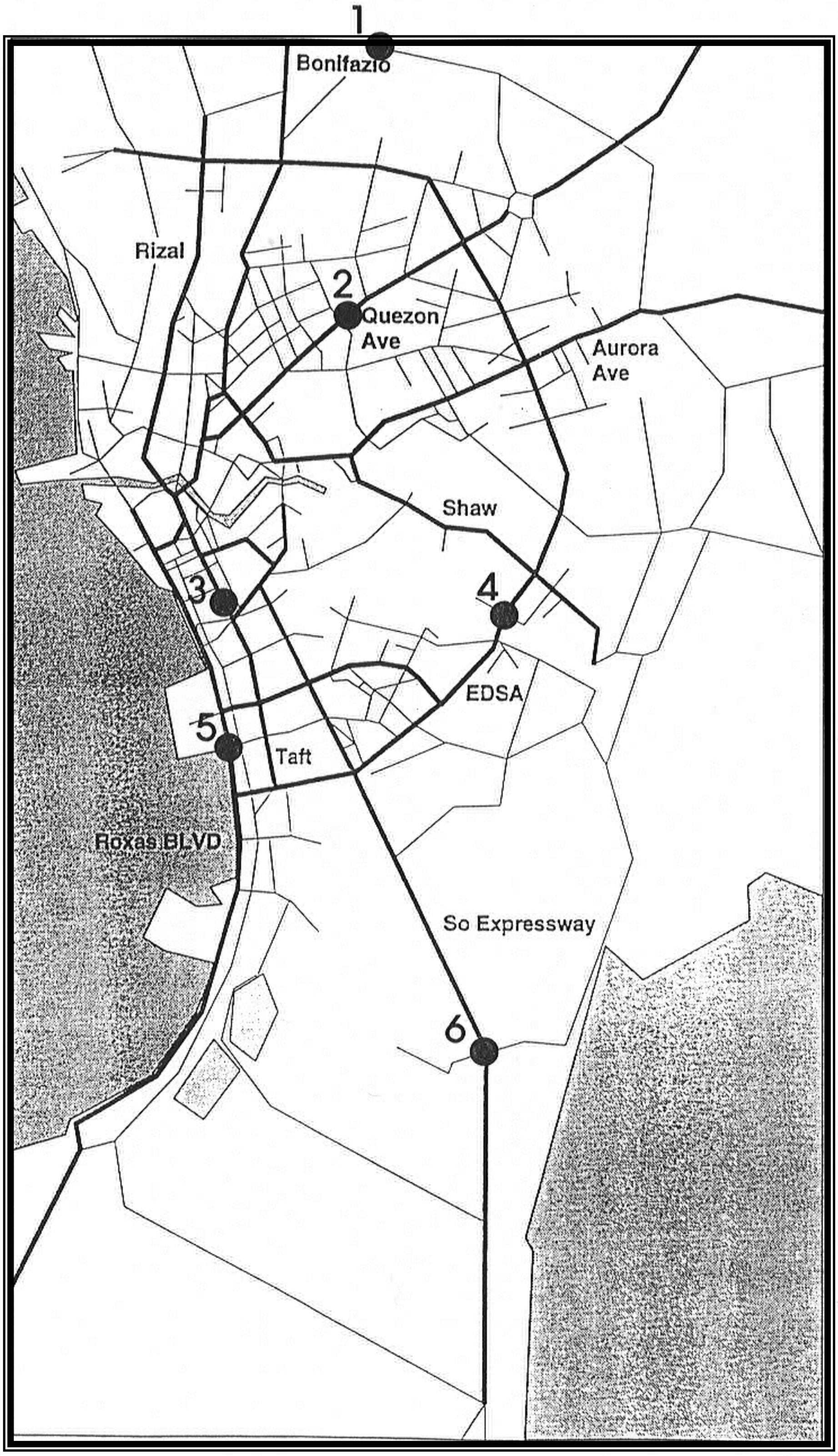


FIGURE 3.2
AIR QUALITY MEASUREMENT POINTS ON NCTS/MMUTIS SURVEY



1: Quirino Highway
2: Quezon Avenue
3: Taft Avenue
4: EDSA
5: Roxas Boulevard
6: South Superhighway

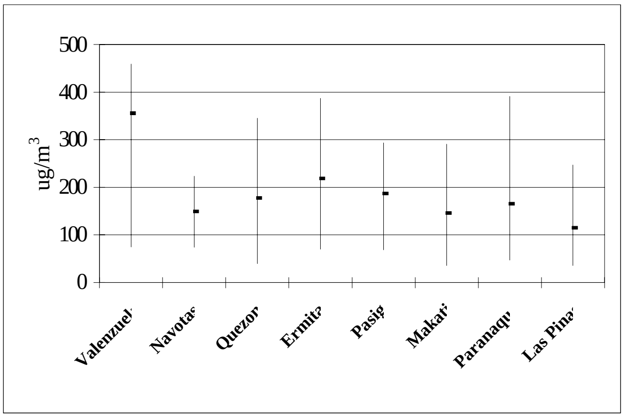
TABLE 3.2
TSP MINIMUM, MAXIMUM AND AVERAGE CONCENTRATIONS, 1992-1996
(UNIT: u g/m³)

Year	Monitoring Station	Minimum	Maximum	Average
1992	Valenzuela	75	459	356
	Navotas	74	224	150
	Quezon	40	345	178
	Ermita	70	387	219
	Pasig	69	294	187
	Makati	36	291	146
	Paranaque	47	391	166
	Las Pinas	36	247	115
1993	Valenzuela	50	295	173
	Navotas	-	-	-
	Quezon	47	254	121
	Ermita	59	300	164
	Pasig	27	314	154
	Makati	63	261	179
	Paranaque	47	261	169
	Las Pinas	30	141	72
1994	Valenzuela	77	559	322
	Navotas	-	-	-
	Quezon	27	218	113
	Ermita	45	312	164
	Pasig	-	-	-
	Makati	47	324	188
	Paranaque	35	192	112
	Las Pinas	-	-	-
1995	Valenzuela	131	454	296
	EDSA – QC	64	401	193
	Pagasa – QC	43	310	133
	Ermita	77	302	174
	Makati	77	485	210
	Las Pinas	74	198	118
1996	Valenzuela	157	463	276
	East Ave. – QC	111	369	201
	Pagasa – QC	57	355	123
	Quezon Ave. – QC	205	384	269
	Ermita	45	217	146
	Makati	132	351	246
	Las Pinas	73	295	136
	Pasig	139	219	188

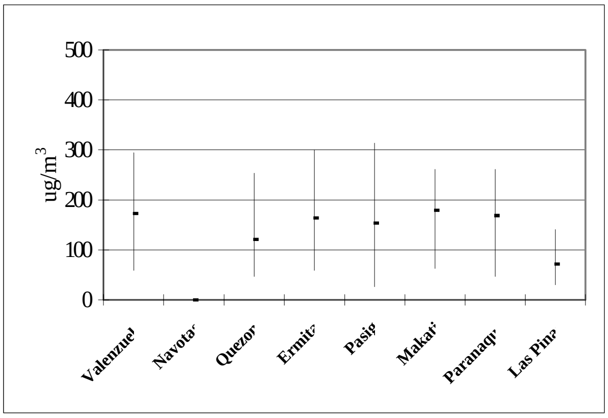
Source: DENR/NCR

FIGURE 3.3
TSP MINIMUM, MAXIMUM AND AVERAGE CONCENTRATIONS, 1992-1996

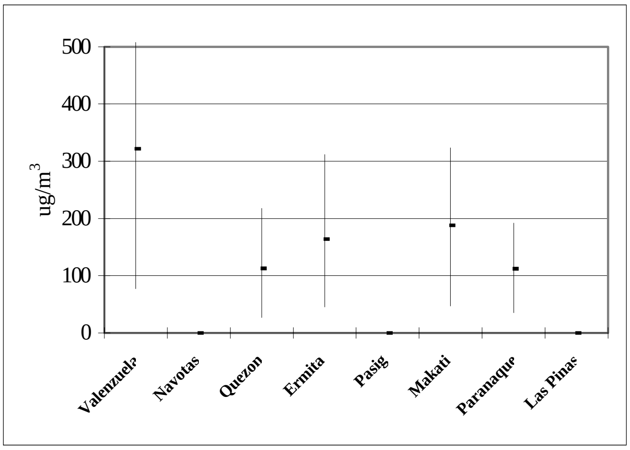
1992



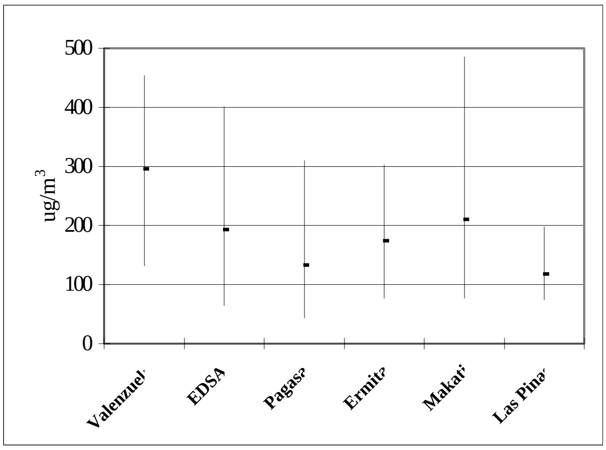
1993



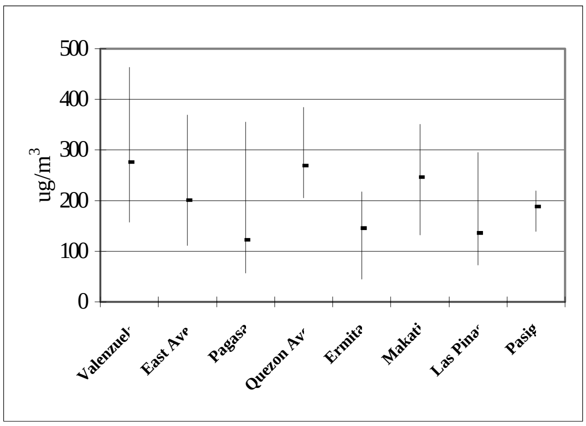
1994



1995



1996



Source: DENR/NCR

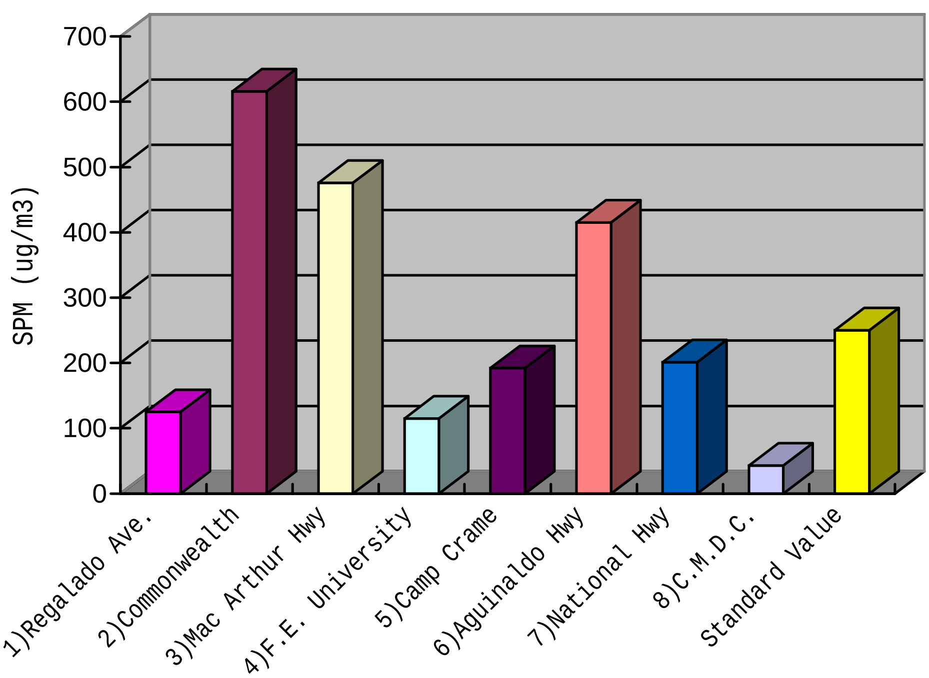
The results of the suspended particulate matter (SPM) monitoring during the MMUTIS survey tend to confirm the high concentration of this air pollutant in the study area. Table 3.3 and Figure 3.4 show the survey results and the standard values adopted by the DENR for SPM.

TABLE 3.3
MMUTIS SURVEY RESULTS OF SPM LEVEL AND STANDARD VALUES BY DENR

Survey Station	Collected Data (ug/m^3)			National. Air Pollution Quality Std. (ug/m^3)	
	Daily Ave.	Max	Min	Daily Ave.	Hourly Ave.
1) Regalado Ave.	69	125	21	180	250
2) Commonwealth Ave.	167	616	68	180	250
3) MacArthur Highway	245	476	60	180	250
4) Far Eastern University	52	115	21	180	250
5) Camp Crame	83	192	33	180	250
6) Aguinaldo Highway	106	415	31	180	250
7) National Highway	85	201	30	180	250
8) C.M.D.C.	27	43	15	180	250

The level of SPM in MacArthur Highway (245 ug/m^3) exceeded the tolerable limit of 180 ug/m^3 for daily average as prescribed by the National Ambient Air Pollution Quality Standard imposed by DENR. The maximum hourly averages in Commonwealth Avenue (616 ug/m^3), MacArthur Highway (476 ug/m^3) and Aguinaldo Highway (415 ug/m^3) far exceeded the tolerable limit of 250 ug/m^3 for hourly average SPM level.

FIGURE 3.4
SURVEY AND STANDARD VALUES OF SPM, MAX. HOURLY AVERAGE



3.2.2 PM10

The effects on health caused by air pollution are correlated more to the presence of PM10 than TSP. Because PM10 particles are smaller, they are more likely to penetrate the lungs and cause respiratory illness. The national AQG for PM10 are 60 u g/m^3 for long term (annual) average, and 150 u g/m^3 for the short time (24 hours) average. Table 3.4 presents ADB/EMB data measured in August 1991 to February 1992. PM10 was measured only at the traffic-exposed stations of the ADB/EMB project along EDSA, Quezon City.

TABLE 3.4
PM10 CONCENTRATION (μ G/M^3) MEASURED ON SITE LOCATED ON OR NEAR STREETS

Station	Street	PM10 Concentration		Period 1991/1992	Number of Observations
		Average	Maximum 24 Hrs.		
Ermita,Manila	Taft	144	258	Aug-Feb	62
ADB, EDSA	EDSA	219	321	Aug-Feb	47
DENR-NCR	Quezon Ave.	227	321	Oct-Feb	26
San Lorenzo		174	206	Jan.-Feb	10
Monumento	EDSA	198	241	Feb.92	5

Source: ADB/EMB Project

The NCTS/MMUTIS project team made measurements at six main roads in Metro Manila. The level of TSP in Taft Avenue and Quirino Avenue far exceeds the tolerable limit of 150 μ g/m^3 for daily average as prescribed by the National Ambient Air Pollution Quality Standard.

3.2.3 Lead (Pb)

Lead concentration measurement surveys in Metro Manila have been very few. The ADB/EMB data gathered in monitoring stations in Ermita, ADB and Monumento are shown in Table 3.5.

TABLE 3.5
LEAD CONTENTS (μ G/M^3)

Station	Mean	No. of Observations
Ermita	1.07	36
ADB	2.30	34
Monumento	3.00	4

Source: ADB/EMB Project

Measured long-term lead levels exceeded the national AQG (1.0 μ g/m^3). Some 24-hour averages of up to 5.5 μ g/m^3 were recorded at the ADB site in 1991/1992. Low lead gasoline (0.15g/l) started being used in July 1993. After February 1994, unleaded gasoline became available in key cities. Subsequent lead monitoring measurements showed that the lead concentration in the air have declined substantially. Tables 3.6 and 3.7 and Figure 3.5 show the summary of the survey results measured by the NCTS/MMUTIS team in 1997 and 1998, respectively.

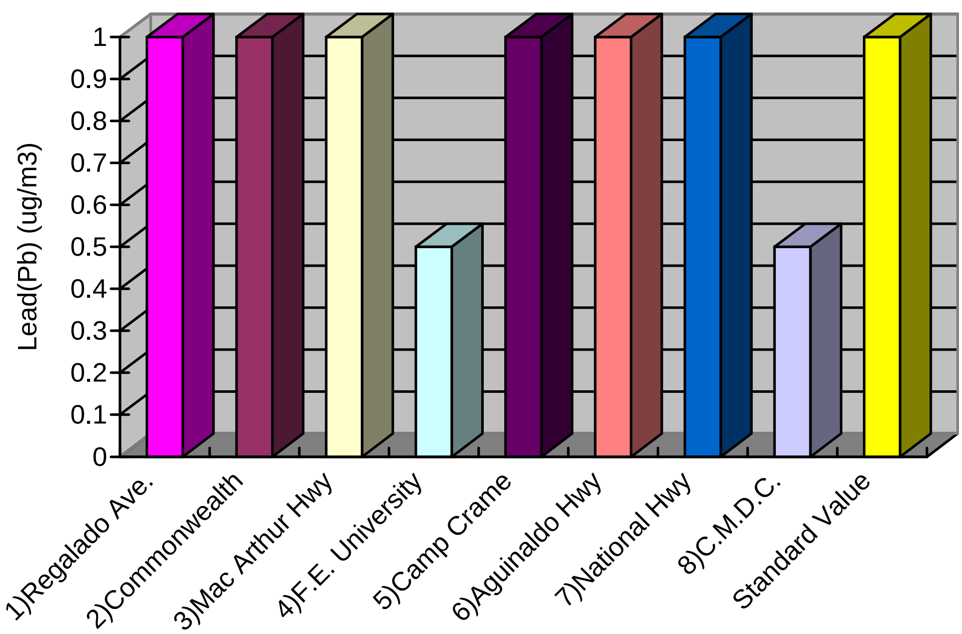
TABLE 3.6
SUMMARY OF NCTS/MMUTIS LEAD LEVEL SURVEY RESULTS

Sampling Station	Date	Pb (u g/m3) Short Time	AQG (u g/m3)
1) Quirino Highway	Feb. 5-6, 1997	0.073	1.0
2) Quezon Avenue	Feb. 19-20, 1997	0.223	1.0
3) Taft Avenue	Feb. 12-13, 1997	0.110	1.0
4) EDSA	April 16-17, 1997	0.063	1.0
5) Roxas Blvd.	May 14-15, 1997	0.063	1.0
6) South Expressway	April. 2-3, 1997	0.140	1.0

TABLE 3.7
1998 MMUTIS SURVEY RESULTS OF LEAD LEVEL AND DENR STANDARD VALUES

Survey Station	Collected Data (ug/m3)	National Ambient Air Pollution Quality Standards (ug/m3)	
	Daily Average	3 Month Ave.	1 Year Ave.
1) Regalado Ave.	1.0	1.5	1.0
2) Commonwealth Ave.	1.0	1.5	1.0
3) MacArthur Highway	1.0	1.5	1.0
4) Far Eastern University	0.5	1.5	1.0
5) Camp Crame	0.5	1.5	1.0
6) Aguinaldo Highway	1.0	1.5	1.0
7) National Highway	1.0	1.5	1.0
8) C.M.D.C.	0.5	1.5	1.0

FIGURE 3.5
MMUTIS SURVEY AND STANDARD VALUE OF LEAD (1 YR. AVERAGE)



3.2.4 Sulfur Dioxide (SO2)

Data on SO2 concentration in 1993 were also obtained from DENR/NCR (see Table 3.8 and Figure 3.6). As indicated, SO2 concentration was not yet a serious problem in 1993 and its average value did not exceed the national AQG of 0.03 ppm. Ermita, Pasig and Valenzuela had comparatively higher values than other areas.

However, SO2 concentration has been growing yearly (see Table 3.9 and Figure 3.7). Particularly in Paranaque, SO2 concentration has increased rapidly and dramatically from 1994 to 1996. This rapid increase is due to the significant growth in road-based traffic in these areas.

TABLE 3.8
ANNUAL SO2 CONCENTRATION, 1993
(Unit: ppm)

Monitoring Station	Minimum	Maximum	Average
Valenzuela	0.001	0.052	0.010
Quezon	0.003	0.011	0.007
Ermita	0.001	0.079	0.021
Pasig	0.001	0.100	0.018
Makati	0.001	0.035	0.006
Parañaque	0.0004	0.018	0.008

Source: DENR/NCR
Note: Annual mean AQG is 0.03 ppm

TABLE 3.9
CHANGE IN SO2 CONCENTRATION IN PARANAQUE, 1994-1996
(UNIT: PPM)

	1994	1995	1996
Maximum Hourly Value	0.160	0.204	0.824
Daily Mean	0.041	0.042	0.072
Annual Mean	0.010	0.015	0.029

Source: DENR/NCR
Note: Annual mean AQG, daily mean AQG and 1-hr AQG are 0.03 ppm, 0.07ppm and 0.13 ppm, respectively.

FIGURE 3.6
ANNUAL SO2 CONCENTRATION, 1993

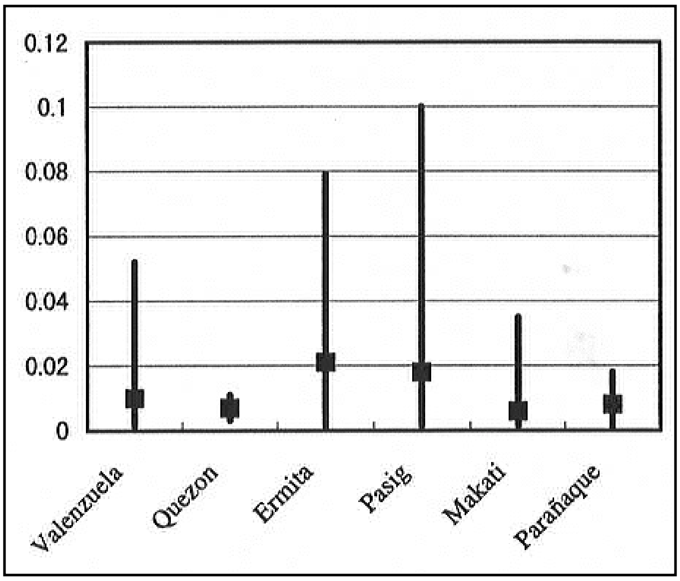
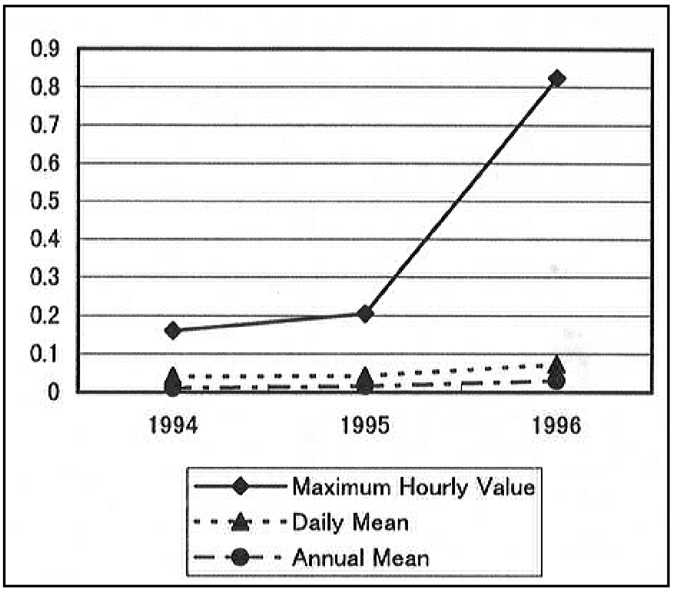


FIGURE 3.7
CHANGE IN SO2 CONCENTRATION, 1994-1996



3.2.5 Carbon Monoxide (CO)

CO concentration was measured by NCTS/MMUTIS and the results are shown in Table 3.10 and Figure 3.8. Nowhere in the sample sites did the CO level exceed the national AQG average CO concentration of 9 ppm, but it existing levels are approximating the national guideline value. Compared with other roads, EDSA and Roxas Blvd. had slightly higher values. Table 3.11 and Figure 3.9 show the monthly change in CO concentration, with the highest registered in August.

TABLE 3.10
8-HRS. CO CONCENTRATION, 1997
(UNIT: PPM)

Monitoring Station	Minimum	Maximum	Average
Taft Ave.	0.1	10.9	4.34
EDSA	0.6	16.0	8.05
Roxas Blvd.	1.1	14.8	8.96
Quezon Ave.	0.6	12.4	3.75
Quirino Highway	0.2	9.9	4.10
South Super Highway	0.4	6.3	4.28

Source: NCTS/MMUTIS
Note: 8-hrs. AQG is 9 ppm.

TABLE 3.11
MONTHLY CHANGE IN CO CONCENTRATION, 1991
(UNIT: PPM)

Month	1-Hour	8-Hours
August	20.6	11.3
September	13.7	9.0
October	9.0	6.7
November	6.9	5.1
December	7.3	4.0

Source: ADB
Note: 1-hr. and 8-hrs. AQG are 30 ppm and 8 ppm, respectively.

FIGURE 3.8
8-HOURS CO CONCENTRATION

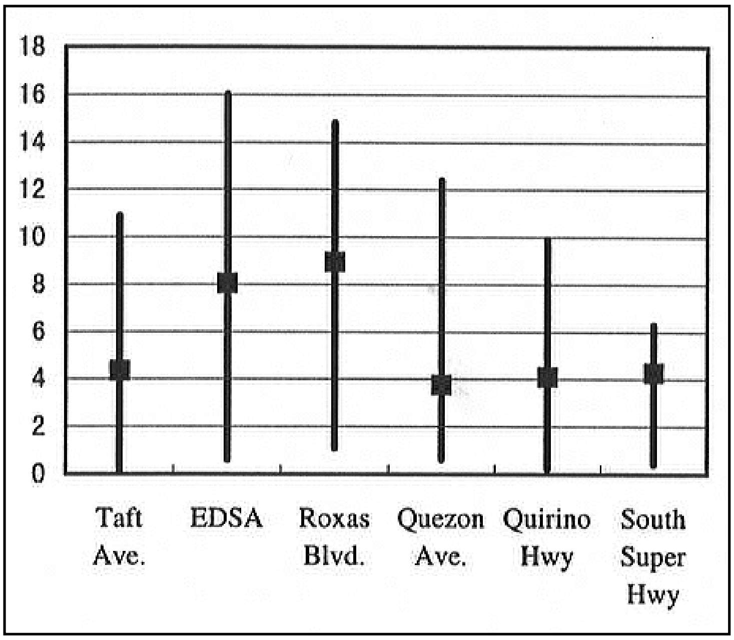


FIGURE 3.9
MONTHLY CHANGE IN CO CONCENTRATION

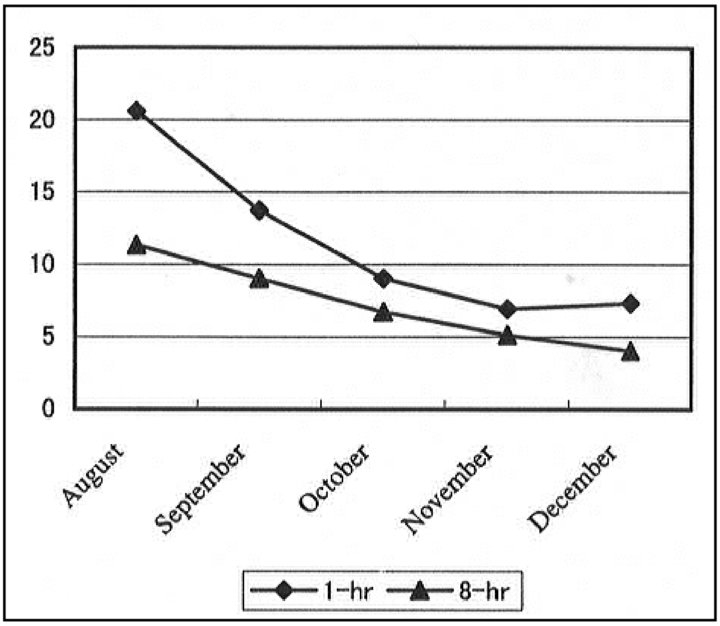


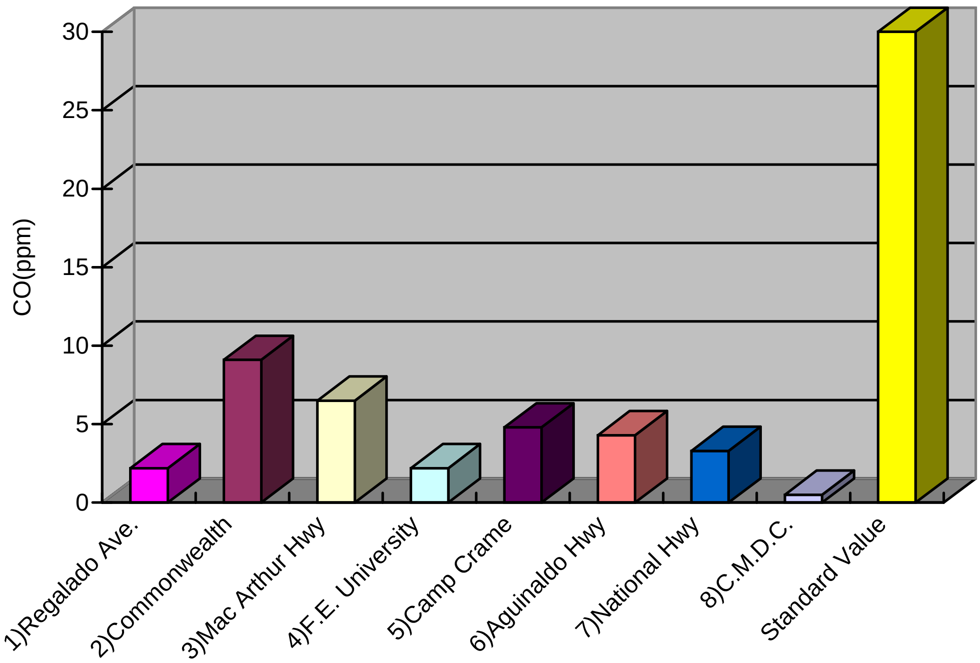
Table 3.12 and Figure 3.10 present the results of the 1998 MMUTIS supplementary survey in regard to CO monitoring and the standard values adopted by the DENR.

CO concentration levels were still below the DENR AQG. The maximum hourly average observed in Commonwealth Avenue was 9.1 ppm. The minimum hourly reading was 0.2 ppm, recorded in Far Eastern University. The highest 8-hour average of 4.9 ppm was registered in MacArthur Highway while the lowest 8-hour average of 0.4 ppm was noted in the Construction Manpower Development Center (CMDC) site.

TABLE 3.12
MMUTIS SURVEY RESULTS OF CO LEVEL AND STANDARD VALUES BY DENR

Survey Station	Collected Data (ppm)			National Ambient Air Pollution Quality Std.(ppm)	
	8-hr Ave	Max	Min	8-hour Ave.	Hourly Ave.
1) Regalado Ave.	1.6	2.2	0.3	9	30
2) Commonwealth Ave.	4.5	9.1	1.2	9	30
3) MacArthur Highway	4.9	6.5	0.4	9	30
4) Far Eastern University	1.5	2.2	0.2	9	30
5) Camp Crame	2.6	4.8	1.1	9	30
6) Aguinaldo Highway	3.0	4.3	0.5	9	30
7) National Highway	2.4	3.3	0.9	9	30
8) C.M.D.C.	0.4	0.5	0.3	9	30

FIGURE 3.10
MMUTIS SURVEY AND STANDARD VALUES OF CO MAX. HOURLY AVERAGE



3.2.6 NO2

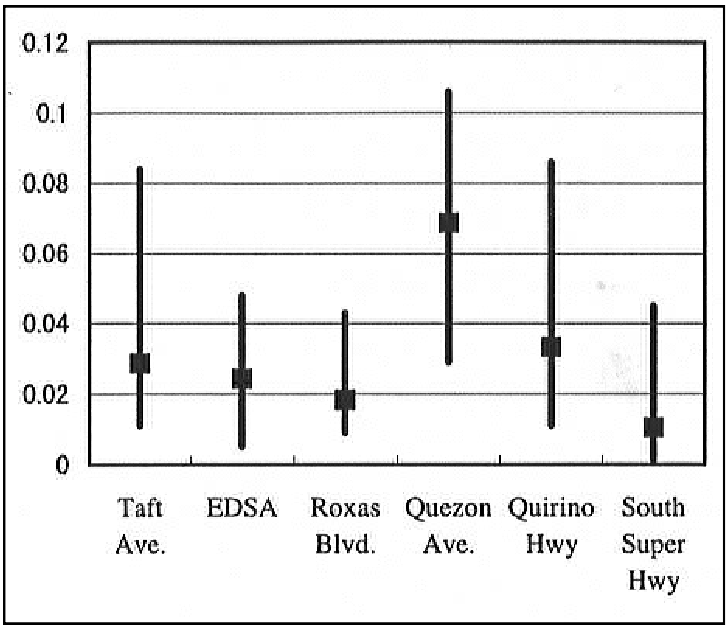
A NO_2 concentration survey was also conducted by NCTS/MMUTIS in 1997. As shown in Table 3.13 and Figure 3.11, none of the survey sites exceeded the national guideline of 0.07 ppm. However, it must be noted that such as NO_2 concentration is likewise approximating the national guideline and would exceed it in the near future. Quezen Avenue, in particular, had a relatively high value in spatial distribution.

TABLE 3.13
DAILY NO2 CONCENTRATION, 1997
(UNIT: PPM)

Monitoring Station	Minimum	Maximum	Average
Taft Ave.	0.011	0.084	0.0287
EDSA	0.005	0.048	0.0243
Roxas Blvd.	0.009	0.043	0.0183
Quezon Ave.	0.029	0.106	0.0688
Quirino Highway	0.011	0.086	0.0333
South Super Highway	0.001	0.045	0.0105

Source: NCTS/MMUTIS
Note: Daily mean AQG is 0.07 ppm.

FIGURE 3.11
DAILY NO2 CONCENTRATION, 1997

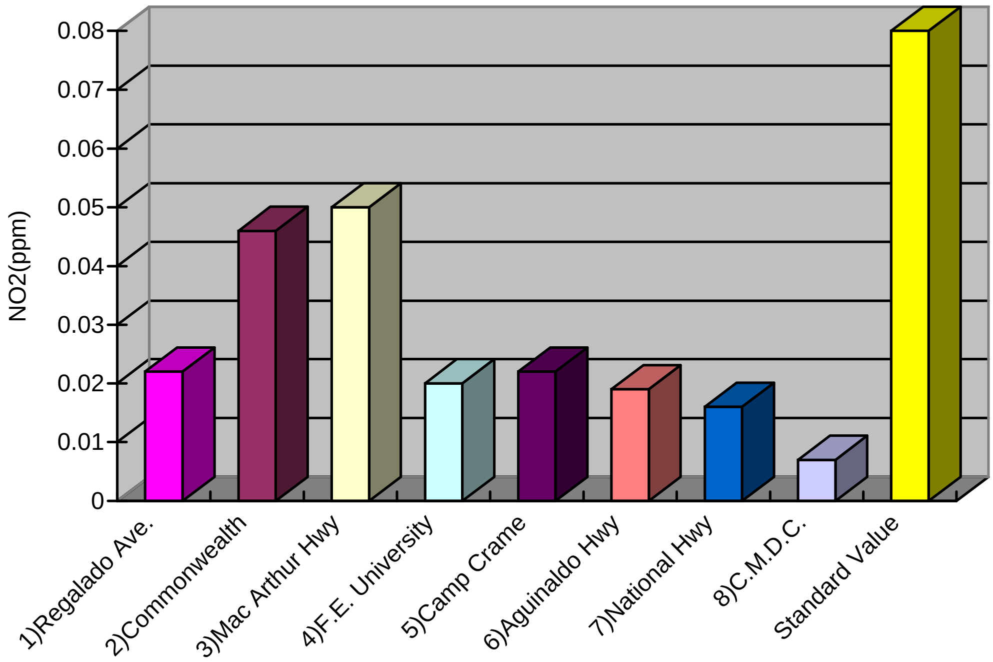


The results of NO2 monitoring under the 1998 MMUTIS survey and the standard values adopted by the DENR are shown in Table 3.14 and Figure 3.12.

TABLE 3.14
MMUTIS SURVEY RESULTS OF NO2 LEVEL AND STANDARD VALUES BY DENR

Survey Station	Collected Data (ppm)	National Ambient Air Pollution Quality Std. (ppm)	
	Daily Ave.	Daily Ave.	Hourly Ave.
1) Regalado Ave.	0.022	0.08	0.10
2) Commonwealth Ave.	0.046	0.08	0.10
3) MacArthur Highway	0.050	0.08	0.10
4) Far Eastern University	0.020	0.08	0.10
5) Camp Crame	0.022	0.08	0.10
6) Aguinaldo Highway	0.019	0.08	0.10
7) National Highway	0.016	0.08	0.10
8) C.M.D.C.	0.007	0.08	0.10

FIGURE 3.12
MMUTIS SURVEY AND STANDARD VALUES OF NO2 DAILY AVERAGE



Survey results showed that NO2 concentrations at the survey sites were low compared to the DENR standards. The maximum daily average NO2 was 0.050 ppm and the minimum daily average, 0.007 ppm. The maximum NO2 concentration was observed in MacArthur Highway. The next highest, at 0.046 ppm, was registered in Commonwealth Avenue. The minimum value of 0.007 ppm was observed in C.M.D.C.

3.3 Meteorological Monitoring

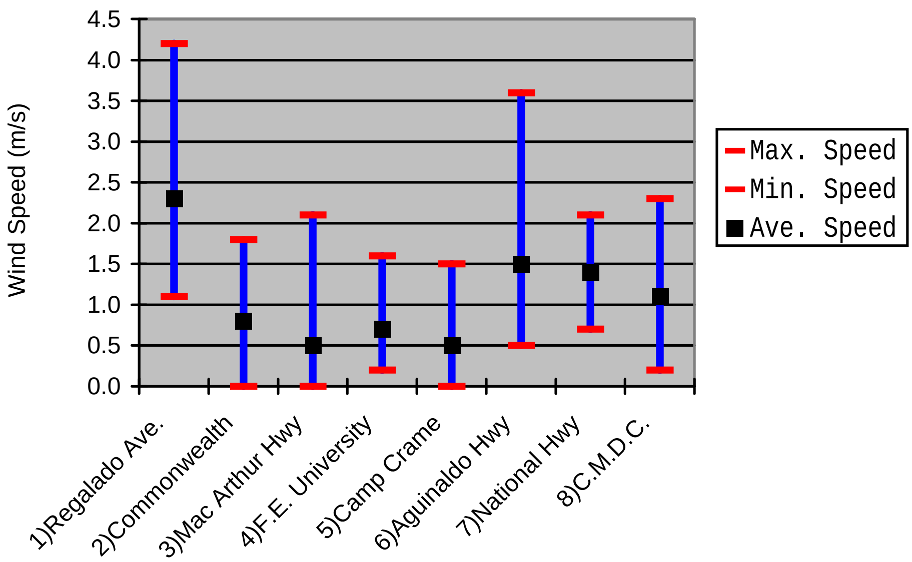
Table 3.15 presents the results of the 1998 MMUTIS meteorological monitoring. Using a 16-point directional system, the most prevalent wind direction was found to be southeast (SE) for the survey sites located along MacArthur Highway. This sector is influenced by the northeast monsoon which is prevalent in September and October.

Wind speed was highest in Regalado Avenue, with a magnitude of 4.2 m/s, followed by Aguinaldo Highway, at 3.6 m/s. The share of calm wind (<0.4m/s) was very high in MacArthur Highway and Camp Crame.

TABLE 3.15
MMUTIS SURVEY RESULTS OF METEOROLOGICAL MONITORING

Survey Station	Collected Data (m/s)			Prevalent Wind Direction	Share of Calm Wind (%)
	Daily Ave.	Max	Min		
1) Regalado Ave.	2.3	4.2	1.1	SSE	0.0
2) Commonwealth Ave.	0.8	1.8	0	NNE	4.2
3) MacArthur Highway	0.5	2.1	0	ES	47.9
4) Far Eastern University	0.7	1.6	0.2	ES	10.4
5) Camp Crame	0.5	1.5	0	E	37.5
6) Aguinaldo Highway	1.5	3.6	0.5	NNE	0.0
7) National Highway	1.4	2.0	0.7	S	0.0
8) C.M.D.C.	1.1	2.3	0.8	S	2.1

FIGURE 3.13
RESULTS OF MMUTIS WIND SPEED SURVEY



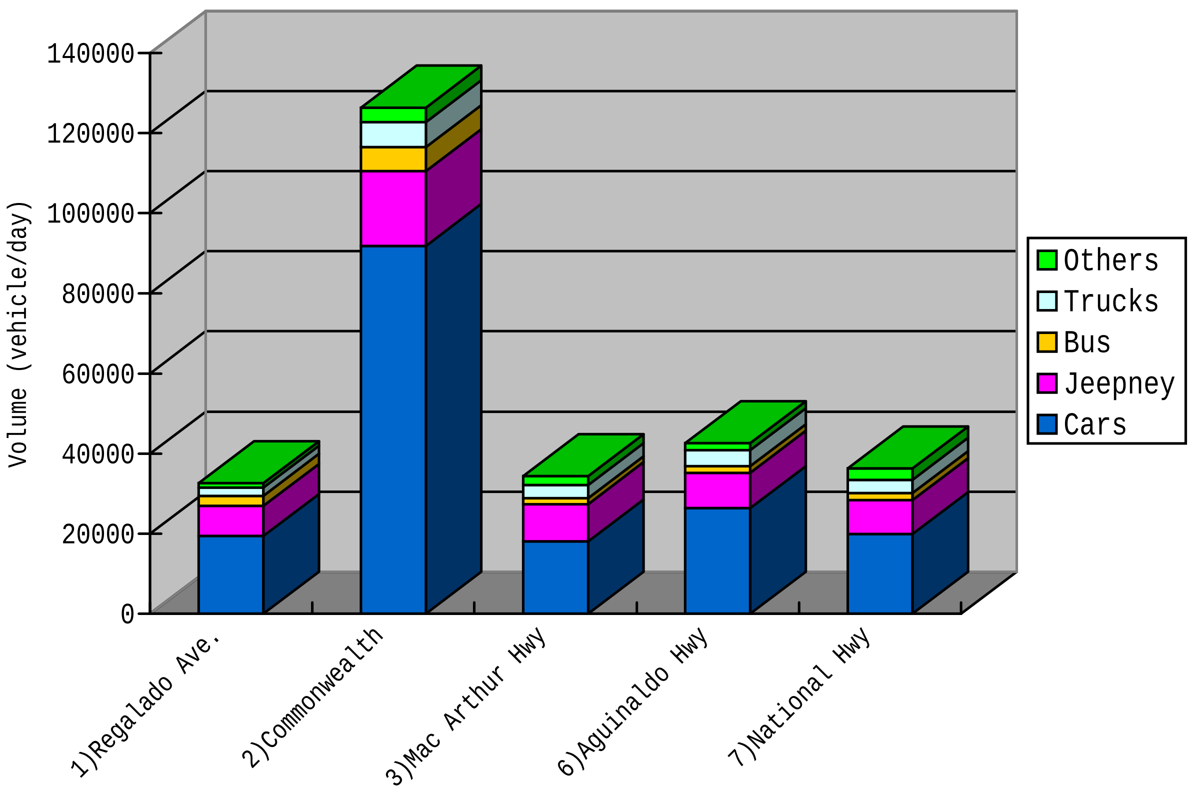
3.4 Traffic Volume Count

The results of the MMUTIS traffic volume count are shown in Table 3.16 and Figure 3.14. The total daily traffic volume of Commonwealth Avenue, which has 4 lanes/2 direction, was recorded at over 120,000 vehicles. The total daily traffic volume of other survey sites, which have 2 lanes/2 direction, ranged from 33,000 to 43,000 vehicles.

TABLE 3.16
RESULTS OF MMUTIS TRAFFIC VOLUME SURVEY

Survey Station	Collected Data					Total Volume
	Cars	Jeepneys	Buses	Trucks	Others	
1) Regalado Ave.	19,428 (0.60)	7,542 (0.23)	2,523 (0.08)	2,033 (0.06)	1,095 (0.03)	32,621 (1.00)
2) Commonwealth Ave.	91,807 (0.72)	18,687 (0.15)	5,997 (0.05)	6,230 (0.05)	3,645 (0.03)	126,366 (1.00)
3) MacArthur Highway	18,085 (0.53)	9,308 (0.27)	1,500 (0.04)	3,259 (0.09)	2,235 (0.07)	34,387 (1.00)
6) Aguinaldo Highway	26,384 (0.62)	8,834 (0.21)	1,636 (0.04)	4,028 (0.09)	1,725 (0.04)	42,607 (1.00)
7) National Highway	19,929 (0.55)	8,458 (0.23)	1,749 (0.05)	3,325 (0.09)	2,853 (0.08)	36,319 (1.00)

FIGURE 3.14
RESULTS OF MMUTIS TRAFFIC VOLUME SURVEY



3.5 Conclusion and Recommendations

The results of the air pollution survey should cause and move us to take the necessary steps in order to meet air pollution problems. While the amount of CO, NO2 and Lead in the surveyed areas has not exceeded allowable levels, it is precariously straddling the line between a healthy and a polluted environment. The SPM level is significantly above the national standards.

The air pollution level is related with traffic volume. Correlation of hourly CO and SPM values and traffic volume was done in Commonwealth Avenue, MacArthur Highway and Aguinaldo Highway (see Figures 3.15 and 3.16). These survey sites were selected in order to analyze why these survey sites had high portion of calm wind. The concentration of both CO and SPM tends to become higher when traffic volume is larger.

Figures 3.17 and 3.18 show the correlation of hourly CO and SPM values and traffic volume, with wind speed of lower than 1.0m/s. CO does not exceed 30 ppm as the hourly standard value in this survey. It is expected, however, that SPM will exceed 250ug/m^3 as the hourly standard value at roadside when the hourly traffic volume is more than 2,500 vehicles for 2 lanes/2 direction road or 6,000 vehicles for 4 lanes/2 direction road.

Based on the results of the surveys, it is concluded that Metro Manila is fast becoming highly polluted due to the rapid increase in motorized transit and population growth.

Given this scenario, pollution-abatement strategies must be considered imperative and several strategies are recommended. Recommended measures aimed at controlling motor vehicle emissions may be classified into four categories, namely: (a) use of cleaner fuels; (b) use of cleaner vehicles; (c) improvement of traffic flow; and (d) reduction of travel demand.

3.5.1 Use of Cleaner Fuels

In most developing countries, lead content in gasoline and sulfur content in diesel fuel are much higher compared with those in developed countries. Hence, dramatic reductions in particulate, lead, and sulfur emissions can be gained within the existing vehicle technology using conventional fuels (World Bank, 1996). The use of unleaded gasoline and low-sulfur diesel can be promoted through:

a) Differential taxation for leaded and unleaded gasoline in favor of the latter;
b) Fuel price surcharges based on lead content of gasoline and sulfur content of diesel fuel;
c) Lower taxes on cleaner fuels;
d) Tax deductions to retrofit vehicles with emission control devices;
e) Provision of infrastructure to distribute cleaner fuels; and
f) Imposition of stricter vehicle emission standards coupled with effective implementation of on-road inspection and maintainance (I/M) programs (Faiz, et al., 1990).

3.5.2 Use of Cleaner Vehicles

This strategy covers a range of measures, including:

a) Use of exhaust treatment devices such as catalysts and traps;
b) Retrofitting of on-the-road vehicles with emission control devices;
c) Promoting the use of less polluting conventional transport such as electric-powered rail systems and non-motorized travel modes;
d) Phasing out of aging and deteriorated vehicles which emit higher level of pollutants; and
e) Development and use of electric cars and buses.

In the context of developing countries, the most significant issues typically involve the continued operation of old and dilapidated vehicles, and the local production and importation of second-hand trucks and buses which are particularly polluting. Furthermore, there is an increasing trend towards using motorcycles powered by two-stroke engines which are up to ten times more polluting than modern four-stroke engines (World Bank, 1996). Therefore, measures aimed at modernizing the aging vehicle fleet, discouraging the importation and local production of substandard vehicles, and arresting the growth in motorcycle usage would significantly reduce motor vehicle emissions.

3.5.3 Improve Traffic Flow

Measures to improve traffic flow in terms of increased travel speed, less vehicle idling, and decreased accelerations and decelerations would serve to reduce carbon monoxide and hydrocarbon emissions. These measures include:

a) Widening of roadways and intersections;
b) On-street parking prohibitions;
c) Synchronization of traffic signal operations;
d) Implementation of one-way street systems;
e) Installation of reversible lanes;
f) Turning movement prohibitions;
g) Designation of exclusive lanes for buses and other high occupancy vehicle; and,
h) Designation of truck routes.

These measures are generally traffic engineering techniques geared towards maximizing the utilization of existing transport supply and typically known as Transportation System Management (TSM) measures.

3.5.4 Reduce Travel Demand

It is now widely believed that the worsening traffic congestion problem in cities cannot be solved by simply continuing to provide additional transport capacity. The demand for travel has to be reduced using Transportation Demand Management (TDM) measures. Examples of these include car pooling, staggered work hours, telecommuting, improvement of public transport service, high parking fees, and designation of high occupancy lanes.

FIGURE 3.15
CORRELATION OF HOURLY CO VALUE AND TRAFFIC VOLUME

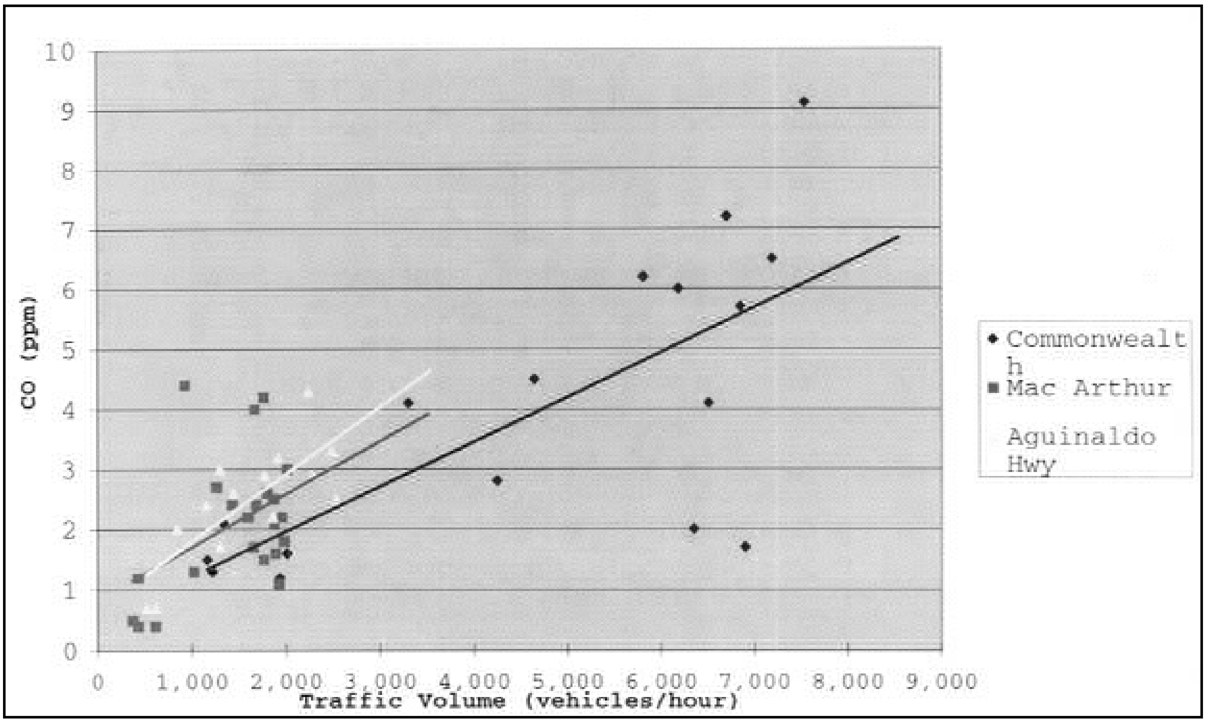


FIGURE 3.16
CORRELATION OF HOURLY SPM VALUE AND TRAFFIC VOLUME

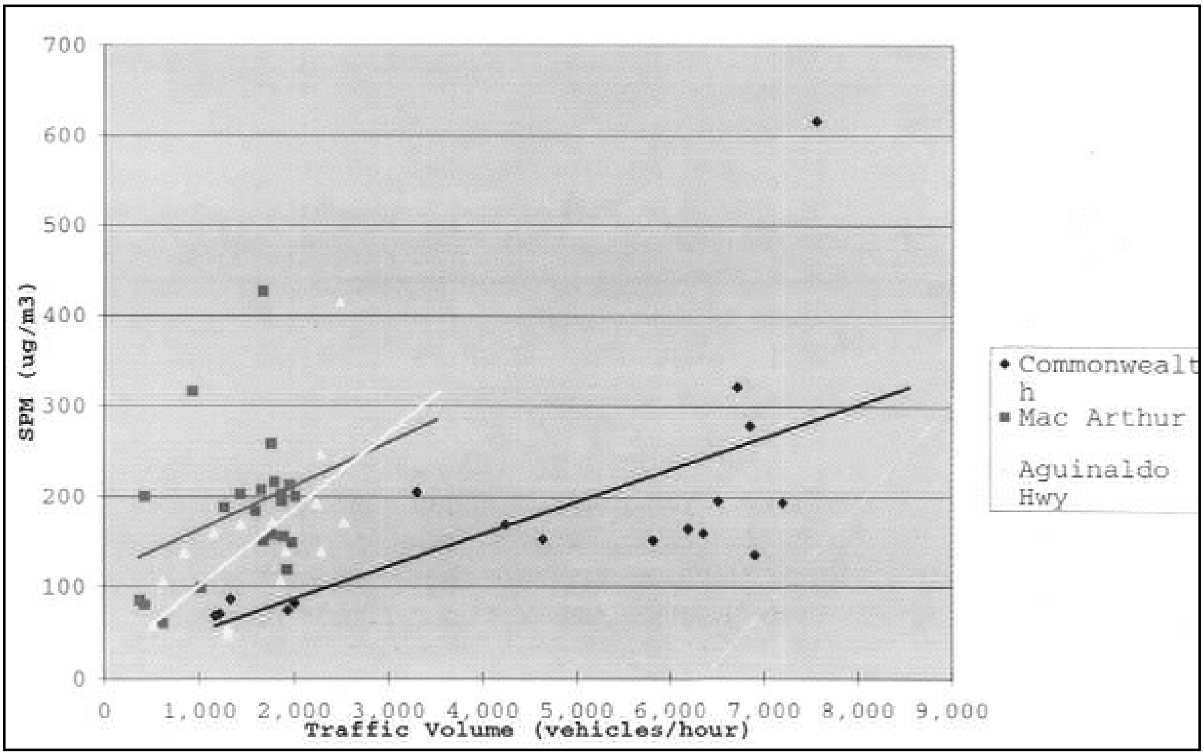


FIGURE 3.17
CORRELATION OF HOURLY CO VALUE AND TRAFFIC VOLUME
WITH WIND SPEED OF LOWER THAN 1.0M/S

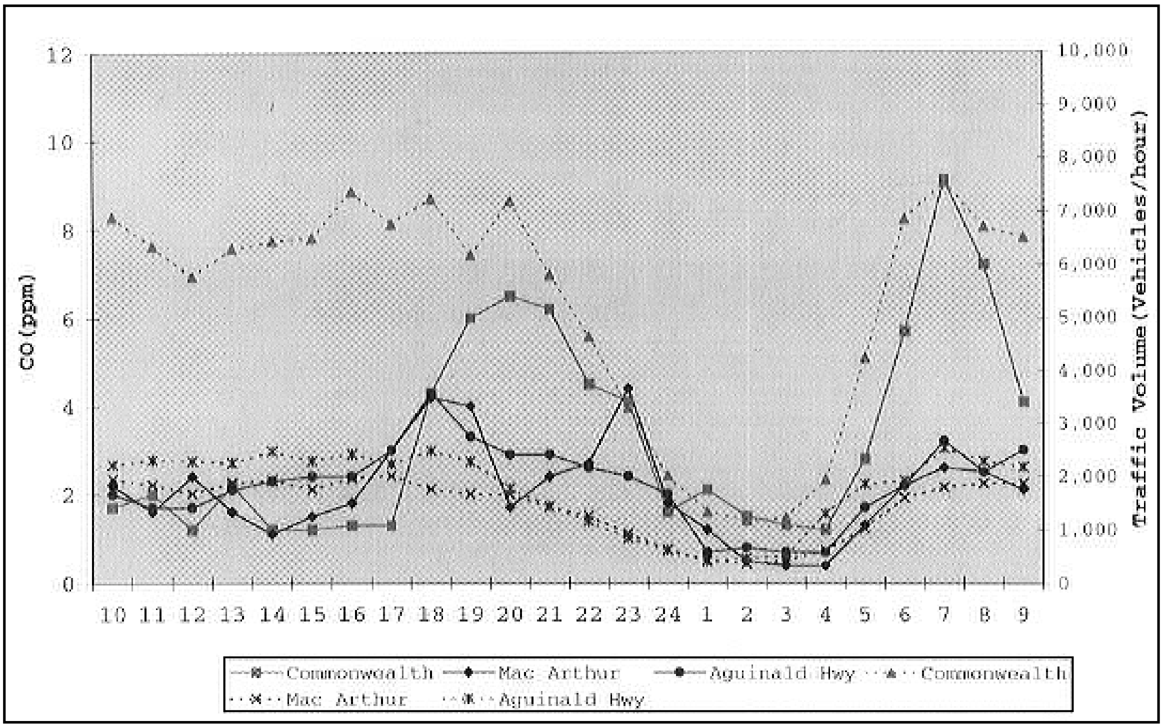
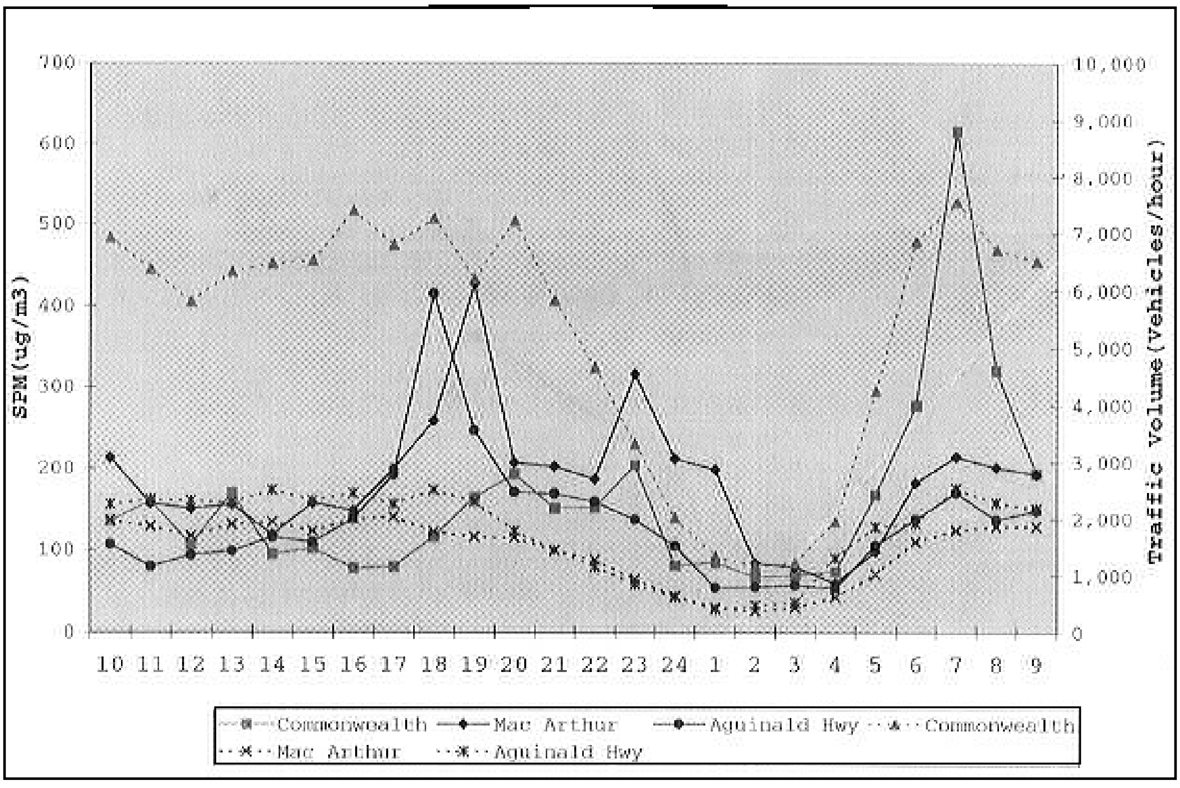


FIGURE 3.18
CORRELATION OF HOURLY SPM VALUE AND TRAFFIC VOLUME
WITH WIND SPEED OF LOWER THAN 1.0M/S



4. INITIAL ENVIRONMENTAL EXAMINATION

4.1 Objectives

Under the MMUTIS Project, subprojects proposed by the JICA study team members were identified for each project area. An Initial Environmental Examination (IEE) was undertaken for each subproject. The objective of the IEE in this phase was to determine the items for environmental analysis in preparation for a full-scale Environmental Impact Assessment (EIA) in the latter phase.

4.2 Methodology

The JICA study team has summarized and reviewed the 7 MMUTIS subprojects, namely: new road construction, existing road rehabilitation, LRT new line construction, public transport, transportation terminal development, traffic management, and traffic environmental improvement project. The current situation of the subproject areas has been determined by field research and relevant information has been collected (e.g., environmental standards, natural conservation areas, EIA procedure guidelines).

By using JICA's screening and scoping method, environmental guidelines for some environmental components such as socioeconomic, natural environment and pollution, were developed. Projected environmental impacts that may occur due to the project activities were evaluated (Yes/No/Unknown). The results of the overall evaluation and environmental analysis will be described in this chapter.

4.3 Screening of Subprojects in MMUTIS

Screening guidelines were based on the following definition: "a process of judgement on whether a development project requires an environmental impact study or not." However, evaluation of whether or not the IEE/EIA is required for a project should be based on appropriate ideas and views for environment by taking into consideration the project features and its environment.

The following concepts were established in the preliminary environmental survey:

- The development project should be planned in such a way as to provide society with sufficient benefits while securing the areas with sustainable development and growth without being detrimental to the lives and existence of the residents; and

- The development project should be planned in such a way as to maintain harmony with the natural environment, while avoiding significant damage to the existing environment, and preserving valuable natural environmental assets.

4.4 Conclusion

The analysis aimed to answer the question: which of the subprojects required full-scale EIA? As shown in Table 4.1, the new road construction, existing road rehabilitation, and LRT new line construction subprojects required full-scale EIA. The other subprojects did not but required the submission of project descriptions.

TABLE 4.1
SUBPROJECTS WHICH REQUIRE EIA

Subproject Title	EIA Required or Not		Remarks
	Yes	No	
1) New Road Construction			Resettlement of inhabitants, Split of community, Air pollution.
2) Existing Road Rehabilitation			Resettlement of inhabitants, Air pollution.
3) LRT New Line Construction			Resettlement of inhabitants, Split of community, Air pollution.
4) Public Transport			Project Description Submission
5) Transportation Terminal Development			Project Description Submission
6) Traffic Management			Project Description Submission
7) Traffic Environmental Improvement Project			Project Description Submission

Tables 4.2 to 4.18 present the results of the evaluation and screening of each subproject.

4.5 Scoping of Subprojects in MMUTIS

Scoping is defined as "a process of identification of the critical environmental impacts out of the possible environmental impacts of a development project. Through the scoping process, the priority fields or items of an environmental impact assessment are also identified."

To use the checklist for scoping, the following conditions should be taken into account:

a) Application Conditions

1) Periods Covered by Scoping: Scoping should cover both the construction and operation period.
2) Spatial Extent of Scoping: Scoping should cover the project site and surrounding area.
3) Type of Environmental Impacts: Environmental impacts subject to scoping are those having negative impacts on the existing environment.

b) Evaluation Method of Important Fields and Items

The evaluation of each item should be rated according to the following grades:

A - Serious impact is expected.
B - Some impact is expected.
C - Extent of impact is unknown but further examination is required because it might become clear as the study progresses.

D - No impact is foreseeable and EIA is not required.

Scoping checklists (see Tables 4.9 to 4.11) are applied to the following subprojects which, when examined during the IEE, were found to be the subprojects requiring EIA in the latter phase:

1) New Road Construction;
2) Existing Road Rehabilitation; and
3) LRT New Line Construction.

4.6 Possible Most Important Environmental Impacts in MMUTIS

a) Resettlement of Inhabitants

Resettlement of inhabitants due to land acquisition for construction of new roads/railway is the most important problem in the urban transportation development in Metro Manila, for the following reasons:

- Loss of living foundation of the residents to be relocated;
- Friction between permanent residents and relocated people (newcomers) due to social and economic burdens on the permanent residents;
- Deterioration of living standard after resettlement due to the poor compensation system.

b) Split of Communities

Community split due to interruption of area traffic results in the following:

- Inconvenience in the daily lives of the residents and negative effects on economic activities; and
- Split of communities would create territories or isolated areas.

c) Air Pollution

Pollution caused by exhaust gas or dust from vehicles may result in:

- An increase in traffic convenience that would cause a traffic flow increase which would then lead to traffic congestion and air pollution.;
- Air pollution caused by exhaust gas and dust that would affect the health of residents, and plants and animals;
- Sulfur oxides in the gas that may cause acid rain and carbon dioxide, which may then contribute to global warming if a large amount of exhaust gas is produced.

TABLE 4.2
SCREENING FOR NEW ROAD CONSTRUCTION SUBPROJECT

No.	Environmental Item	Description	Evaluation			Remarks
Social Environment						
1	Resettlement	Resettlement due to land occupancy, resettlement of Squatters in Metro Manila	**Yes**	No	?	
2	Economic Activities	Lost of bases of economic activities, such as land and change of economic structure	**Yes**	No	?	
3	Traffic and Public Facilities	Impacts on schools, hospitals and present traffic conditions such as the increase of traffic congestion and accidents	Yes	**No**	?	
4	Split of Communities	Community split due to interruption of area traffic	**Yes**	No	?	
5	Cultural Property	Damage to or loss of value of churches, archaeological remains or other cultural assets.	Yes	**No**	?	
6	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, right of common	**Yes**	No	?	
7	Public Health Condition	Deterioration of public health and sanitary conditions due to generation of garbage and the increase of vermin	Yes	**No**	?	
8	Waste	Generation of construction wastes, surplus soil and general wastes	**Yes**	No	?	
9	Hazards	Increase in danger of landslide, earthquake	Yes	No	**?**	
Natural Environment						
10	Topography and Geology	Change of valuable topography and geology due to excavation or filling work	Yes	**No**	?	
11	Soil Erosion	Topsoil erosion by rainfall	Yes	**No**	?	
12	Groundwater	Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft	Yes	No	**?**	
13	Hydrology and situation	Change of river of river discharge and riverbed condition due to land fill and drainage inflow	**Yes**	No	?	
14	Coastal Zone	Coastal erosion and change of vegetation due to coastal reclamation and coastal change	**Yes**	No	?	
15	Fauna and Flora	Obstruction of breeding and extinction of species due to changes of habitat condition.	Yes	No	**?**	
16	Meteorology	Change of temperature, precipitation, wind, etc. due to large-scale land reclamation and building constructions	**Yes**	No	?	
17	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures.	**Yes**	No	?	
Pollution						
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles	**Yes**	No	?	
19	Water Pollution	Pollution caused by inflow of silt, sand	**Yes**	No	?	
20	Soil Contamination	Contamination caused by dust and asphalt emulsion	**Yes**	No	?	
21	Noise and Vibration	Noise and Vibration generated by vehicles	**Yes**	No	?	
22	Land Subsidence	Deformation of land and land subsidence due to the lowering of ground water table	Yes	No	**?**	
23	Offensive Odor	Generation of exhaust gas and offensive odor by facility construction and operation	Yes	No	**?**	
Overall Evaluation: EIA is necessary for the project implementation.						

Yes : EIA is required, No : EIA is not required, ? : Impact is unknown, examination needed. Impact may become clear as study progresses.

TABLE 4.3
SCREENING FOR EXISTING ROAD REHABILITATION SUBPROJECT

No.	Environmental Item	Description	Evaluation			Remarks
Social Environment						
1	Resettlement	Resettlement due to land occupancy, resettlement of Squatters in Metro Manila	**yes**	No	?	
2	Economic Activities	Lost of bases of economic activities, such as land and change of economic structure	**yes**	No	?	
3	Traffic and Public Facilities	Impacts on schools, hospitals and present traffic conditions such as the increase of traffic congestion and accidents	**yes**	No	?	
4	Split of Communities	Community split due to interruption of area traffic	yes	**No**	?	
5	Cultural Property	Damage to or loss of value of churches, archaeological remains or other cultural assets.	yes	**No**	?	
6	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, right of common	yes	**No**	?	
7	Public Health Condition	Deterioration of public health and sanitary conditions due to generation of garbage and the increase of vermin	yes	No	**?**	
8	Waste	Generation of construction wastes, surplus soil and general wastes	**yes**	No	?	
9	Hazards	Increase in danger of landslide, earthquake	yes	No	**?**	
Natural Environment						
10	Topography and Geology	Change of valuable topography and geology due to excavation or filling work	yes	**No**	?	
11	Soil Erosion	Topsoil erosion by rainfall	yes	**No**	?	
12	Groundwater	Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft	yes	No	**?**	
13	Hydrology and situation	Change of river of river discharge and riverbed condition due to land fill and drainage inflow	**yes**	No	?	
14	Coastal Zone	Coastal erosion and change of vegetation due to coastal reclamation and coastal change	**yes**	No	?	
15	Fauna and Flora	Obstruction of breeding and extinction of species due to changes of habitat condition.	yes	No	**?**	
16	Meteorology	Change of temperature, precipitation, wind, etc. due to large-scale land reclamation and building constructions	**yes**	No	?	
17	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures.	yes	**No**	?	
Pollution						
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles	**yes**	No	?	
19	Water Pollution	Pollution caused by inflow of silt, sand	**yes**	No	?	
20	Soil Contamination	Contamination caused by dust and asphalt emulsion	**yes**	No	?	
21	Noise and Vibration	Noise and Vibration generated by vehicles	**yes**	No	?	
22	Land Subsidence	Deformation of land and land subsidence due to the lowering of ground water table	yes	**No**	?	
23	Offensive Odor	Generation of exhaust gas and offensive odor by facility construction and operation	yes	**No**	?	
Overall Evaluation: EIA is necessary for the project implementation.						

Yes : EIA is required, No : EIA is not required, ? : Impact is unknown, examination needed. Impact may become clear as study progresses.

TABLE 4.4
SCREENING FOR LRT NEW LINE CONSTRUCTION SUBPROJECT

No.	Environmental Item	Description	Evaluation			Remarks
Social Environment						
1	Resettlement	Resettlement due to land occupancy, resettlement of Squatters in Metro Manila	**yes**	No	?	
2	Economic Activities	Lost of bases of economic activities, such as land and change of economic structure	**yes**	No	?	
3	Traffic and Public Facilities	Impacts on schools, hospitals and present traffic conditions such as the increase of traffic congestion and accidents	**yes**	No	?	
4	Split of Communities	Community split due to interruption of area traffic	**yes**	No	?	
5	Cultural Property	Damage to or loss of value of churches, archaeological remains or other cultural assets.	yes	No	**?**	
6	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, right of common	**yes**	No	?	
7	Public Health Condition	Deterioration of public health and sanitary conditions due to generation of garbage and the increase of vermin	**yes**	No	?	
8	Waste	Generation of construction wastes, surplus soil and general wastes	**yes**	No	?	
9	Hazards	Increase in danger of landslide, earthquake	yes	No	**?**	
Natural Environment						
10	Topography and Geology	Change of valuable topography and geology due to excavation or filling work	yes	**No**	?	
11	Soil Erosion	Topsoil erosion by rainfall	yes	**No**	?	
12	Groundwater	Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft	yes	No	**?**	
13	Hydrology and situation	Change of river of river discharge and riverbed condition due to land fill and drainage inflow	**yes**	No	?	
14	Coastal Zone	Coastal erosion and change of vegetation due to coastal reclamation and coastal change	**yes**	No	?	
15	Fauna and Flora	Obstruction of breeding and extinction of species due to changes of habitat condition.	yes	**No**	?	
16	Meteorology	Change of temperature, precipitation, wind, etc. due to large-scale land reclamation and building constructions	**yes**	No	?	
17	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures.	**yes**	No	?	
Pollution						
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles	yes	**No**	?	
19	Water Pollution	Pollution caused by inflow of silt, sand	yes	**No**	?	
20	Soil Contamination	Contamination caused by dust and asphalt emulsion	yes	**No**	?	
21	Noise and Vibration	Noise and Vibration generated by vehicles	**yes**	No	?	
22	Land Subsidence	Deformation of land and land subsidence due to the lowering of ground water table	yes	No	**?**	
23	Offensive Odor	Generation of exhaust gas and offensive odor by facility construction and operation	yes	**No**	?	
Overall Evaluation: EIA is necessary for the project implementation.						

Yes : EIA is required, No : EIA is not required, ? : Impact is unknown, examination needed. Impact may become clear as study progresses.

TABLE 4.5
SCREENING FOR PUBLIC TRANSPORT SUBPROJECT

No.	Environmental Item	Description	Evaluation			Remarks
Social Environment						
1	Resettlement	Resettlement due to land occupancy, resettlement of Squatters in Metro Manila	**yes**	No	?	
2	Economic Activities	Lost of bases of economic activities, such as land and change of economic structure	**yes**	No	?	
3	Traffic and Public Facilities	Impacts on schools, hospitals and present traffic conditions such as the increase of traffic congestion and accidents	**yes**	No	?	
4	Split of Communities	Community split due to interruption of area traffic	yes	**No**	?	
5	Cultural Property	Damage to or loss of value of churches, archaeological remains or other cultural assets.	yes	**No**	?	
6	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, right of common	yes	**No**	?	
7	Public Health Condition	Deterioration of public health and sanitary conditions due to generation of garbage and the increase of vermin	yes	**No**	?	
8	Waste	Generation of construction wastes, surplus soil and general wastes	yes	**No**	?	
9	Hazards	Increase in danger of landslide, earthquake	yes	No	**?**	
Natural Environment						
10	Topography and Geology	Change of valuable topography and geology due to excavation or filling work	yes	**No**	?	
11	Soil Erosion	Topsoil erosion by rainfall	yes	**No**	?	
12	Groundwater	Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft	yes	**No**	?	
13	Hydrology and situation	Change of river of river discharge and riverbed condition due to land fill and drainage inflow	yes	**No**	?	
14	Coastal Zone	Coastal erosion and change of vegetation due to coastal reclamation and coastal change	yes	**No**	?	
15	Fauna and Flora	Obstruction of breeding and extinction of species due to changes of habitat condition.	yes	**No**	?	
16	Meteorology	Change of temperature, precipitation, wind, etc. due to large-scale land reclamation and building constructions	yes	**No**	?	
17	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures.	**yes**	No	?	
Pollution						
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles	**yes**	No	?	
19	Water Pollution	Pollution caused by inflow of silt, sand	**yes**	No	?	
20	Soil Contamination	Contamination caused by dust and asphalt emulsion	yes	**No**	?	
21	Noise and Vibration	Noise and Vibration generated by vehicles	yes	**No**	?	
22	Land Subsidence	Deformation of land and land subsidence due to the lowering of ground water table	yes	**No**	?	
23	Offensive Odor	Generation of exhaust gas and offensive odor by facility construction and operation	yes	**No**	?	
Overall Evaluation: EIA is not necessary for the project implementation, but project description should be submitted						

Yes : EIA is required, No : EIA is not required, ? : Impact is unknown, examination needed. Impact may become clear as study progresses.

TABLE 4.6
SCREENING FOR TRANSPORTATION TERMINAL DEVELOPMENT SUBPROJECT

No.	Environmental Item	Description	Evaluation			Remarks
Social Environment						
1	Resettlement	Resettlement due to land occupancy, resettlement of Squatters in Metro Manila	**yes**	No	?	
2	Economic Activities	Lost of bases of economic activities, such as land and change of economic structure	**yes**	No	?	
3	Traffic and Public Facilities	Impacts on schools, hospitals and present traffic conditions such as the increase of traffic congestion and accidents	yes	**No**	?	
4	Split of Communities	Community split due to interruption of area traffic	yes	**No**	?	
5	Cultural Property	Damage to or loss of value of churches, archaeological remains or other cultural assets.	yes	**No**	?	
6	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, right of common	yes	**No**	?	
7	Public Health Condition	Deterioration of public health and sanitary conditions due to generation of garbage and the increase of vermin	yes	**No**	?	
8	Waste	Generation of construction wastes, surplus soil and general wastes	**yes**	No	?	
9	Hazards	Increase in danger of landslide, earthquake	yes	No	**?**	
Natural Environment						
10	Topography and Geology	Change of valuable topography and geology due to excavation or filling work	yes	**No**	?	
11	Soil Erosion	Topsoil erosion by rainfall	yes	**No**	?	
12	Groundwater	Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft	yes	**No**	?	
13	Hydrology and situation	Change of river of river discharge and riverbed condition due to land fill and drainage inflow	yes	**No**	?	
14	Coastal Zone	Coastal erosion and change of vegetation due to coastal reclamation and coastal change	yes	**No**	?	
15	Fauna and Flora	Obstruction of breeding and extinction of species due to changes of habitat condition.	yes	**No**	?	
16	Meteorology	Change of temperature, precipitation, wind, etc. due to large-scale land reclamation and building constructions	yes	**No**	?	
17	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures.	**yes**	No	?	
Pollution						
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles	**yes**	No	?	
19	Water Pollution	Pollution caused by inflow of silt, sand	yes	**No**	?	
20	Soil Contamination	Contamination caused by dust and asphalt emulsion	yes	**No**	?	
21	Noise and Vibration	Noise and Vibration generated by vehicles	**yes**	No	?	
22	Land Subsidence	Deformation of land and land subsidence due to the lowering of ground water table	yes	**No**	?	
23	Offensive Odor	Generation of exhaust gas and offensive odor by facility construction and operation	yes	No	**?**	
Overall Evaluation: EIA is not necessary for the project implementation, but project description should be submitted						

Yes : EIA is required, No : EIA is not required, ? : Impact is unknown, examination needed. Impact may become clear as study progresses.

TABLE 4.7
SCREENING FOR TRAFFIC MANAGEMENT SUBPROJECT

No.	Environmental Item	Description	Evaluation			Remarks
Social Environment						
1	Resettlement	Resettlement due to land occupancy, resettlement of Squatters in Metro Manila	**yes**	No	?	
2	Economic Activities	Lost of bases of economic activities, such as land and change of economic structure	**yes**	No	?	
3	Traffic and Public Facilities	Impacts on schools, hospitals and present traffic conditions such as the increase of traffic congestion and accidents	yes	**No**	?	
4	Split of Communities	Community split due to interruption of area traffic	**yes**	No	?	
5	Cultural Property	Damage to or loss of value of churches, archaeological remains or other cultural assets.	yes	**No**	?	
6	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, right of common	yes	**No**	?	
7	Public Health Condition	Deterioration of public health and sanitary conditions due to generation of garbage and the increase of vermin	yes	**No**	?	
8	Waste	Generation of construction wastes, surplus soil and general wastes	yes	**No**	?	
9	Hazards	Increase in danger of landslide, earthquake	yes	**No**	?	
Natural Environment						
10	Topography and Geology	Change of valuable topography and geology due to excavation or filling work	yes	**No**	?	
11	Soil Erosion	Topsoil erosion by rainfall	yes	**No**	?	
12	Groundwater	Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft	yes	**No**	?	
13	Hydrology and situation	Change of river of river discharge and riverbed condition due to land fill and drainage inflow	yes	**No**	?	
14	Coastal Zone	Coastal erosion and change of vegetation due to coastal reclamation and coastal change	yes	**No**	?	
15	Fauna and Flora	Obstruction of breeding and extinction of species due to changes of habitat condition.	yes	**No**	?	
16	Meteorology	Change of temperature, precipitation, wind, etc. due to large-scale land reclamation and building constructions	yes	**No**	?	
17	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures.	**yes**	No	?	
Pollution						
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles	**yes**	No	?	
19	Water Pollution	Pollution caused by inflow of silt, sand	yes	**No**	?	
20	Soil Contamination	Contamination caused by dust and asphalt emulsion	yes	**No**	?	
21	Noise and Vibration	Noise and Vibration generated by vehicles	**yes**	No	?	
22	Land Subsidence	Deformation of land and land subsidence due to the lowering of ground water table	yes	**No**	?	
23	Offensive Odor	Generation of exhaust gas and offensive odor by facility construction and operation	yes	**No**	?	
Overall Evaluation: EIA is not necessary for the project implementation, but project description should be submitted						

Yes : EIA is required, No : EIA is not required, ? : Impact is unknown, examination needed. Impact may become clear as study progresses.

TABLE 4.8
SCREENING FOR TRAFFIC ENVIRONMENTAL IMPROVEMENT SUBPROJECT

No.	Environmental Item	Description	Evaluation			Remarks
Social Environment						
1	Resettlement	Resettlement due to land occupancy, resettlement of Squatters in Metro Manila	yes	No	?	
2	Economic Activities	Lost of bases of economic activities, such as land and change of economic structure	yes	No	?	
3	Traffic and Public Facilities	Impacts on schools, hospitals and present traffic conditions such as the increase of traffic congestion and accidents	yes	No	?	
4	Split of Communities	Community split due to interruption of area traffic	yes	No	?	
5	Cultural Property	Damage to or loss of value of churches, archaeological remains or other cultural assets.	yes	No	?	
6	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, right of common	yes	No	?	
7	Public Health Condition	Deterioration of public health and sanitary conditions due to generation of garbage and the increase of vermin	yes	No	?	
8	Waste	Generation of construction wastes, surplus soil and general wastes	yes	No	?	
9	Hazards	Increase in danger of landslide, earthquake	yes	No	?	
Natural Environment						
10	Topography and Geology	Change of valuable topography and geology due to excavation or filling work	yes	No	?	
11	Soil Erosion	Topsoil erosion by rainfall	yes	No	?	
12	Groundwater	Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft	yes	No	?	
13	Hydrology and situation	Change of river of river discharge and riverbed condition due to land fill and drainage inflow	yes	No	?	
14	Coastal Zone	Coastal erosion and change of vegetation due to coastal reclamation and coastal change	yes	No	?	
15	Fauna and Flora	Obstruction of breeding and extinction of species due to changes of habitat condition.	yes	No	?	
16	Meteorology	Change of temperature, precipitation, wind, etc. due to large-scale land reclamation and building constructions	yes	No	?	
17	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures.	yes	No	?	
Pollution						
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles	yes	No	?	
19	Water Pollution	Pollution caused by inflow of silt, sand	yes	No	?	
20	Soil Contamination	Contamination caused by dust and asphalt emulsion	yes	No	?	
21	Noise and Vibration	Noise and Vibration generated by vehicles	yes	No	?	
22	Land Subsidence	Deformation of land and land subsidence due to the lowering of ground water table	yes	No	?	
23	Offensive Odor	Generation of exhaust gas and offensive odor by facility construction and operation	yes	No	?	
Overall Evaluation: EIA is not necessary for the project implementation, but project description should be submitted						

Yes : EIA is required, No : EIA is not required, ? : Impact is unknown, examination needed. Impact may become clear as study progresses.

TABLE 4.9
SCOPING CHECKLIST FOR NEW ROAD CONSTRUCTION

No.	Environmental items	Evaluation	Basis
Socio Environment			
1.	Resettlement	A	Land acquisition for the construction of new road construction
2.	Economic Activities	B	Inflow and outflow of population and goods resulting from operation of traffic
3.	Traffic/Public Facilities	B	Change of transport means by the operation of new roads, traffic control.
4.	Split of Community	A	Interruption of existing regional transportation, pedestrian traffic, and distribution of goods due to construction of new roads.
5.	Cultural property	C	Vibration and air pollution caused by vehicles and heavy equipment.
6.	Water right/ Right of Common.	B	Obstruction of fishing right, and water right, right of common.
7.	Public health	A	Generation of construction wastes, surplus soil and general waste.
8.	Waste	B	Generation of debris and construction waste following the construction of new roads.
9.	Hazards(Risk)	C	Damage to roads and buildings due to construction work of transportation facilities.
Natural Environment			
10.	Topography/Geology	D	Change of valuable topography and geology due to excavation or filling work.
11.	Soil erosion	C	Topsoil erosion by rainfall
12.	Groundwater	C	Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft.
13.	Hydrology	C	Hydrology regime would be altered by structures, such as piers, when the route passes over lakes and rivers
14.	Coastal zone	B	Coastal erosion and change of vegetation due to coastal reclamation.
15.	Fauna / Flora	B	Removal of vegetation and extinction. Generation of exhaust gas from operating vehicles.
16.	Meteorology	D	Change of temperature, precipitation, wind etc. due to large scale elevated roads and
17.	Landscape	C	Change of topography by construction and appearance of transportation facilities
Pollution			
18	Air pollution	B	Exhaust gas and dust generated by heavy equipment and vehicles.
19	Water pollution	B	Pollution caused by inflow of silt, sand
20	Soil contamination	B	Dispersion of paving materials, such as asphalt emulsion, during construction
21	Noise and vibration	B	Operation of construction equipment and vehicles
22	Land subsidence	C	Deformation of land and land subsidence due to the lowering of ground water
23	Offensive odor	B	Generation of exhaust gas and offensive odor by facility construction and operation

Note : Evaluation grade
A : Serious impact is expected
B : Some impact is expected
C : Extent of impact is unknown (Examination is needed. Impacts may become clear as study progresses).
D : No impact is expected

TABLE 4.10
SCOPING CHECKLIST FOR EXISTING ROAD REHABILITATION

No.	Environmental items	Evaluation	Basis
Socio Environment			
1.	Resettlement	B	Land acquisition for the construction of new road construction
2.	Economic Activities	C	Inflow and outflow of population and goods resulting from operation of traffic
3.	Traffic/Public Facilities	C	Change of transport means by the operation of new roads, traffic control.
4.	Split of Community	D	Interruption of existing regional transportation, pedestrian traffic, and distribution of goods due to construction of new roads.
5.	Cultural property	D	Vibration and air pollution caused by vehicles and heavy equipment.
6.	Water right/ Right of Common.	D	Obstruction of fishing right, and water right, right of common.
7.	Public health	B	Generation of construction wastes, surplus soil and general waste.
8.	Waste	B	Generation of debris and construction waste following the construction of new roads.
9.	Hazards(Risk)	C	Damage to roads and buildings due to construction work of transportation facilities.
Natural Environment			
10.	Topography/Geology	D	Change of valuable topography and geology due to excavation or filling work.
11.	Soil erosion	D	Topsoil erosion by rainfall
12.	Groundwater		Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft.
13.	Hydrology	C	Hydrology regime would be altered by structures, such as piers, when the route passes over lakes and rivers
14.	Coastal zone	C	Coastal erosion and change of vegetation due to coastal reclamation.
15.	Fauna / Flora	D	Removal of vegetation and extinction. Generation of exhaust gas from operating vehicles.
16.	Meteorology	D	Change of temperature, precipitation, wind etc. due to large scale elevated roads and
17.	Landscape	D	Change of topography by construction and appearance of transportation facilities
Pollution			
18	Air pollution	B	Exhaust gas and dust generated by heavy equipment and vehicles.
19	Water pollution	B	Pollution caused by inflow of silt, sand
20	Soil contamination	B	Dispersion of paving materials, such as asphalt emulsion, during construction
21	Noise and vibration	C	Operation of construction equipment and vehicles
22	Land subsidence	C	Deformation of land and land subsidence due to the lowering of ground water
23	Offensive odor	C	Generation of exhaust gas and offensive odor by facility construction and operation

Note : Evaluation grade

A : Serious impact is expected

B : Some impact is expected

C : Extent of impact is unknown (Examination is needed. Impacts may be become clear as study progresses).

D : No impact is expected

TABLE 4.11
SCOPING CHECKLIST FOR LRT NEW LINE CONSTRUCTION

No.	Environmental items	Evaluation	Basis
Socio Environment			
1.	Resettlement	A	Land acquisition for the construction of new road construction
2.	Economic Activities	B	Inflow and outflow of population and goods resulting from operation of traffic
3.	Traffic/Public Facilities	B	Change of transport means by the operation of new roads, traffic control.
4.	Split of Community	A	Interruption of existing regional transportation, pedestrian traffic, and distribution of goods due to construction of new roads.
5.	Cultural property	C	Vibration and air pollution caused by vehicles and heavy equipment.
6.	Water right/ Right of Common.	B	Obstruction of fishing right, and water right, right of common.
7.	Public health	A	Generation of construction wastes, surplus soil and general waste.
8.	Waste	B	Generation of debris and construction waste following the construction of new roads.
9.	Hazards(Risk)	C	Damage to roads and buildings due to construction work of transportation facilities.
Natural Environment			
10.	Topography/Geology	D	Change of valuable topography and geology due to excavation or filling work.
11.	Soil erosion	C	Topsoil erosion by rainfall
12.	Groundwater	C	Contamination caused by drainage and filtrate water in excavation work and lowering of ground water table due to overdraft.
13.	Hydrology	C	Hydrology regime would be altered by structures, such as piers, when the route passes over lakes and rivers
14.	Coastal zone	B	Coastal erosion and change of vegetation due to coastal reclamation.
15.	Fauna / Flora	B	Removal of vegetation and extinction. Generation of exhaust gas from operating vehicles.
16.	Meteorology	D	Change of temperature, precipitation, wind etc. due to large scale elevated roads and
17.	Landscape	C	Change of topography by construction and appearance of transportation facilities
Pollution			
18	Air pollution	B	Exhaust gas and dust generated by heavy equipment and vehicles.
19	Water pollution	B	Pollution caused by inflow of silt, sand
20	Soil contamination	B	Dispersion of paving materials, such as asphalt emulsion, during construction
21	Noise and vibration	B	Operation of construction equipment and vehicles
22	Land subsidence	C	Deformation of land and land subsidence due to the lowering of ground water
23	Offensive odor	B	Generation of exhaust gas and offensive odor by facility construction and operation

Note : Evaluation grade
A : Serious impact is expected
B : Some impact is expected
C : Extent of impact is unknown (Examination is needed. Impacts may be become clear as study progresses).
D : No impact is expected.

5. ESTIMATION OF AIR POLLUTANT EMISSION IN METRO MANILA

Even while it brings unquestionable benefits, the transport sector may induce indispensable side effects, such as environmental degradation. This chapter examines the interaction between transport and the environment, contributing to unsustainability in urban travel.

Many transport policies in other countries have already taken into consideration the sector's effects on the environment. After a recent prototypical example of transport policy in other countries is introduced, proposed measures for air quality improvement in Metro Manila were reviewed. Based on this, an environmental analysis was carried out in Metro Manila, the findings of which are discussed in the following sections. Finally, appropriate transport policies for sustainable environmental development are tentatively recommended.

5.1 Relationship Between Transport and the Environment

It is very important to understand the interaction between transport and environment because transport policy starts from it. As shown in Figure 5.1, a lot of factors are considerably interrelated. In general, the transport sector's environmental impact is determined largely by the vehicles themselves and the way they are used. A critical issue is how to cope with rapidly increasing travel demand (i.e., more journeys, longer journeys and greater car use).

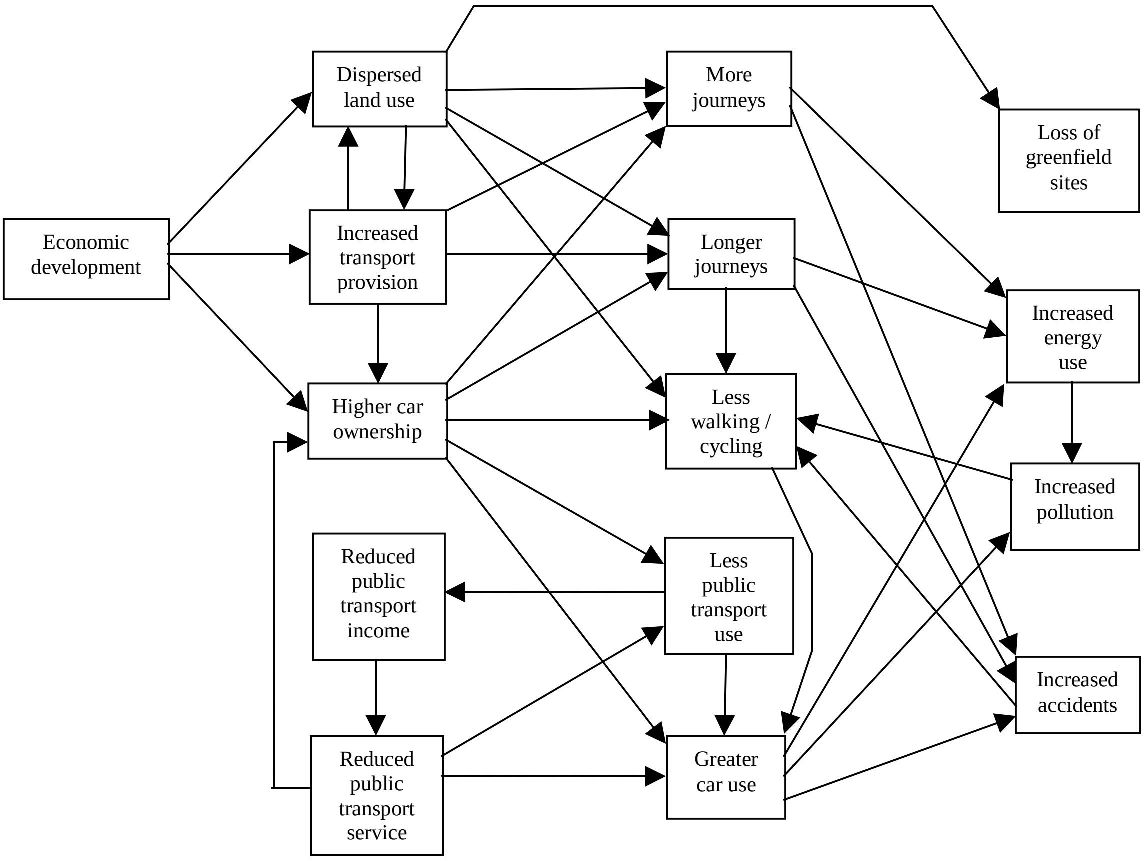
Travel demand has been increasing at a rapid rate annually. A comparison of the 1980 and 1996 person trip surveys in Metro Manila indicates that over that 16-year period, the number of trips increased by 63.6%. A rough estimation indicates that total vehicle travel by the year 2015, in vehicle-km, will increase by around 170% in the "Do-Nothing" case. This scenario is encouraged by a number of factors, including the trend to lower density development; the construction of larger, more remote, schools, shopping centers and hospitals; provision of transport at less than the marginal cost; and discouragement of shorter journeys. As a result, conditions for walking and cycling are worsened and the level of public service is reduced. More journeys, longer journeys and greater car use have worsened environmental quality and radical steps on how to deal with these factors are already being taken in many other countries. [Source: "Transport, the Environment and Sustainable Development" (1993)]

5.2 Policy Responses

As the environmental quality worsens day by day, a new approach or concept has been proposed. In the past, demand forecasts have been made for traffic and networks have been defined to meet that demand. It has now been recognized that it may not be socially efficient, or desirable or possible to meet unrestricted demand. Thus, TDM (Transport Demand Management) and institutionalized measures as well as supply-side measures have become the key concerns of transport planners. In particular, an integrated package approach, that includes not only supply-side measures but also demand-side or institutionalized measures, has been thought to be a more effective approach to reduce travel demand, improve the environmental quality and, as a result, attain policy goals.

An example of this integrated package approach is shown in Table 5.1, which includes financing factor, demand-side factor and fare level factor in addition to supply-side factor. It should be stressed that pricing-related measures and measures for improving non-motorized transport like walking/cycling are considered as important tools for air quality improvement.

FIGURE 5.1
INTERACTION BETWEEN TRANSPORT AND ENVIRONMENT IN SUSTAINABLE DEVELOPMENT



Source: "transport, the environment and sustainable development (1993)"

TABLE 5.1
AN EXAMPLE OF INTEGRATED PACKAGE APPROACH

Strategy	***Do Minimum***	***C1***	***C2***	***C3***	***C4***	***C5***	***C6***
Access by car	– – – – –	÷ ÷ ÷	–	÷ ÷	– –	– –	– –
Access by bus / rail	– – – –	÷ ÷ ÷	÷ ÷ ÷	÷ ÷ ÷	–	– – –	–
Environmental quality	– – – – –	–	– –	÷	– – –	–	– – –
Local economic activity	– – – –	– – – –	–	÷ ÷ ÷ ÷	– –	– – –	– – –
Fuel consumption	– 16%	– 2%	– 7%	0	– 10%	– 1%	– 16%
Casualties	– 7%	– 8%	– 1%	– 7%	– 2%	– 7%	– 2%
Benefits (£m NPV)	N/A	– 410	– 300	– 330	– 180	– 310	– 110
Finance (£m PVF)	N/A	– 260	– 270	– 100	– 160	– 10	0
Capital costs (£ 1990)	N/A	530	520	530	340	530	340

Key: < Worse Better >
– – – – –   – – – –   – – –   – –   –   ( )   –   – –   – – –   – – – –   – – – – –
NVP: Net Present Value (a measure of economic efficiency) relative to Do Minimum

The Six Combined Strategies

Strategy	***C1***	***C2***	***C3***	***C4***	***C5***	***C6***
Finance[1]	High	High	Medium	Medium	Low	Low
Infrastruture[2]	NS EW WR	NS EW WR	NS EW WR	NS WR	NS EW WR	NS WR
Capacity reduction (%)[3]	10%	10%	25%	10%	25%	10%
Fares level (%)[4]	– 50%	0	– 25%	0	– 10%	– 25%
Road Pricing[5]	Yes	No	Yes	No	Yes	No

Notes:
1. High: £200m - £300m PVF:
   Medium: £-100m - £200m PVF:
   Low: Zero Financial Outlay
2. NS: North-South Light Rapid Transit:
   EW: East-West Light Rapid Transit:
   WR: Western Radial
3. Percentage reduction in city center road capacity.
4. Percentage change from level anticipated in 2010.
5. Inclusion or otherwise of a charge of £ to enter or leave the city center throughout the day.
6. ***CI*** to ***C6*** relates to different strategies being evaluated in Edinburgh.

As a general guideline for improving air quality, measures such as those enumerated in Table 5.2 can be taken considered. In Metro Manila, policy measures that seems to be appropriate for reducing air pollution were proposed by a foreign research group. These measures are categorized as traffic, power plant, fuel combustion other than in power plants, non-combustion sources, construction, and refuse burning. Among them, specific measures pertaining to traffic are summarized as follows:

1) Enhancing effectiveness of the anti-smoke belching program;
2) Improving diesel fuel quality;
3) Implementation of a scheme for inspection and maintenance;
4) Fuel switches (diesel to gasoline) in the transportation sector induced by price-shifts;
5) Adoption of clean vehicle emission standards; and
6) Other measures. (Source: URBAIR, 1995)

TABLE 5.2
GENERAL GUIDELINES FOR ALLEVIATING THE AIR POLLUTION PROBLEM

1. Technical Fixes 1: Pollution Reduction and Energy Efficiency	
Pollution reduction technology	- oxidation catalysts Three-way catalysts Catalysts trap oxidizers
Improving energy efficiencies	- engine changes (e.g. lean burn) Weight reduction Aerodynamics Other technological modifications (e.g. transmission changes, rolling resistance)
2. Technical Fixes 2: Alternative Fuels and Power Sources	
Diesel	
Electricity	
Hydrogen	
Alternative power sources (e.g. nuclear power, gas from power stations, renewable sources)	
Gas (e.g. liquefied natural gas, liquefied petroleum gas)	
Methanol and ethanol	
3. The Role of the Driver	
Lower average engine size: the vehicle purchase decision	
The vehicle replacement decision	
Increasing car occupancies	
Better driving practices	
Better maintenance	
4. Transport Planning Policies	
Inter modal shift	
Road traffic management	- Improving traffic flow Reducing excessive speeds Discouraging car traffic
Land-use planning	
Other policies	- public information campaigns encouraging Telecommuting
5. Transport Pricing Policies	
Road pricing	
Fuel pricing and taxation policies	
Vehicle pricing and taxation	

Source: “Transport, the Environment and Sustainable Development,” (1993) These measures were evaluated from the viewpoint of benefit/cost analysis and evaluation results showed that such measures could, indeed, bring great benefits. However, the above mentioned measures are mainly related to technical factors and no transport demand-related measures were evaluated. From the transport perspective, therefore, their impact on air pollution is herein analyzed and discussed.

5.3 Estimation of Air Pollutant Emission in Metro Manila

An environmental analysis model was developed in order to examine the impact of transport on air pollution. In addition, some scenarios were evaluated based on this model.

5.3.1 Methodology

Air pollution is affected by many factors and consists of a very complex function. Its general form can be expressed as follows:

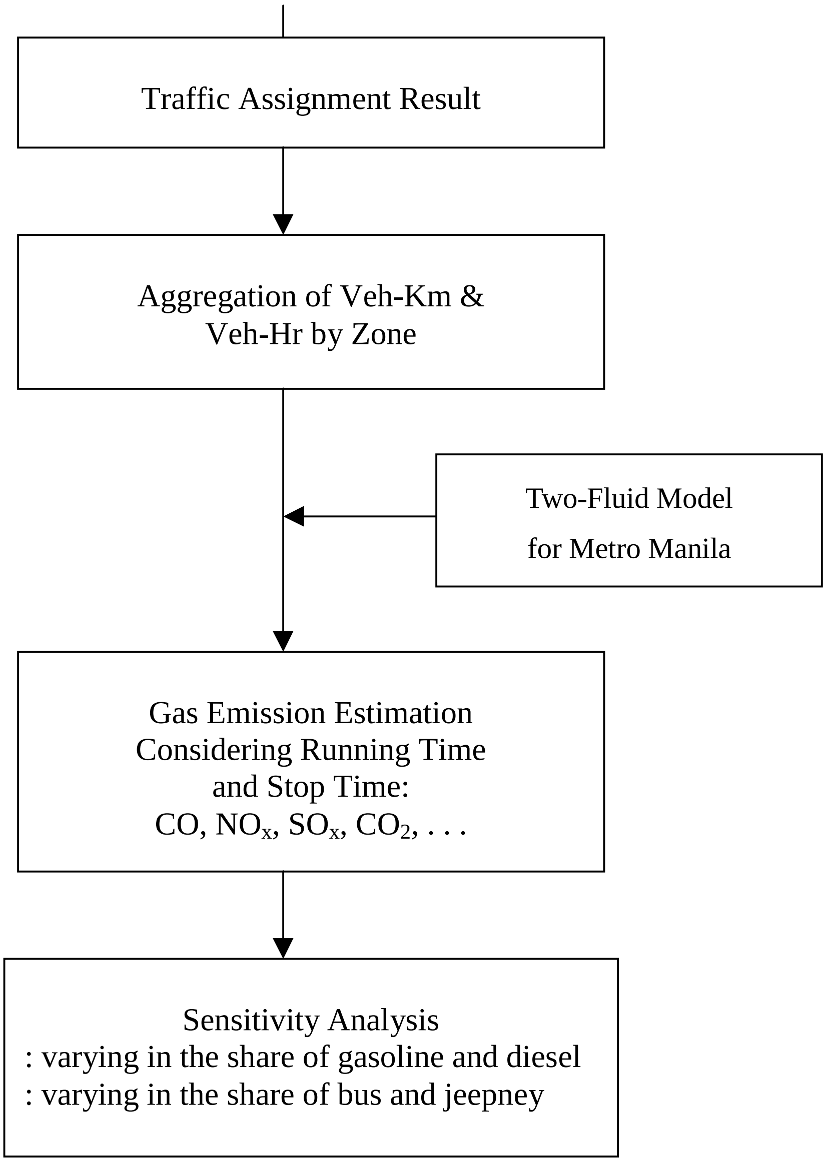
Air pollutant emissions = *f* (travel distance, travel speed, idling, emission factors, wind speed, wind direction)

However, it must be noted that it is very difficult to put so many factors into an air pollution model, especially a macroanalysis model. In general, the traditional traffic assignment model uses travel distance, travel speed and emission factor as exogenous factors to conduct emission estimation. Aside from these, the methodology presented in this report will include vehicle idling factor and estimated air pollutant emission.

The methodology for environment analysis is shown in Fig 5.2. Firstly, travel distances (veh-km) and average speed (km/h) are aggregated by each zone based on traffic assignment results for the “Do-Nothing,” the “Master Plan” and the “Do-Max” cases. Air pollutant emissions, as mentioned earlier, are estimated based on travel distances and average speed. However, we have to remember that air pollutant emissions are affected by traveling patterns not only while the vehicle is moving but also while it is stopped. Therefore, a reasonable emission estimation should consider air pollutant emissions in both moving and immobile vehicles.

The problem is that the traffic assignment result estimated from STRADA does not give any information on vehicle stop time. This is why we are incorporating the two-fluid model in order to divide travel time into running time and stop time. Only by using the two-fluid model can we estimate emission units while the vehicle is stopped (i.e., idling) as well as when it is moving. Afterwards, each air pollutant emission (CO, NO_x, SO_x and SPM) is estimated by zone. Finally, sensitivity analysis was carried out by varying the share of gasoline and diesel and the share of bus and jeepney.

FIGURE 5.2
METHODOLOGY FOR ENVIRONMENT ANALYSIS



5.3.2 Two-Fluid Model

The two-fluid model deals with a simple relation between two traffic variables, namely: the travel time per unit distance (reciprocal of speed), and the stop time per unit distance. Likewise, traffic in a non-highway urban street network may be considered as consisting of two traffic fluids. One is composed of moving vehicles and the other of vehicles that are stopped as a consequence of congestion, traffic control devices, obstructions resulting from construction, accidents, etc., but not cars stopped in the parked condition.

In the two-fluid model, the ideas are followed by assuming that the average speed of the moving cars, v_r, depends on the fraction of the cars that are moving, f_r, in the following form:

$$v_r = vf_r^{-1} = v_m f_r^n = v_m(1 - f_r)^n$$

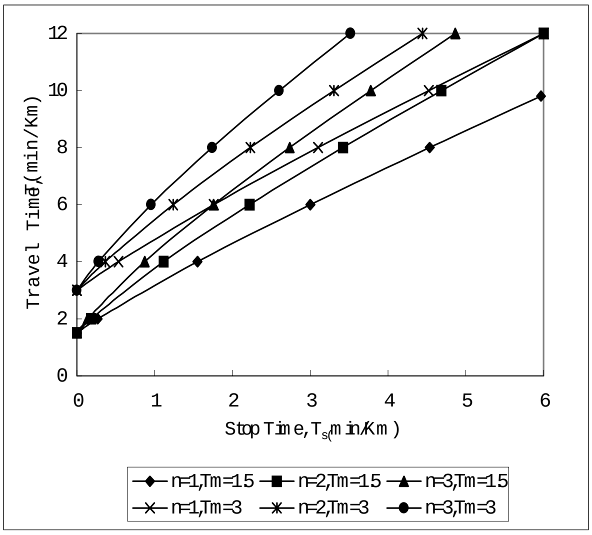
where v_m is the average maximum running speed in the network, v is the average speed of the traffic, and n is a parameter. Note that:

$$f_r + f_s = 1$$
$$v_m = 1/T_m$$
$$v_r = 1/T_r$$
$$v = 1/T$$

where f_s and f_r are the fraction of the vehicles stopped and moving, respectively; T_m is a parameter representing the average minimum trip time per unit distance; T_r is the running time per unit distance; and T is the trip time per unit distance. If, in addition, the stop time per unit distance is denoted by T_s, it follows that:

$$T = T_s + T_r$$

FIGURE 5.3
TRAVEL TIME VERSUS STOP TIME RELATION



In the two-fluid model, it is also assumed that the fraction of time stopped for the *i*th vehicle circulating in a network, $(T_s/T)_i$, is equal to the average fraction of the population of vehicles stopped in the system, $<f_s>_p$, over the same time period, namely:

$$< f_s >_p = (T_s / T)_i$$

These assumptions lead to the two-fluid model relation between the trip time, T, and the running time, T_r, namely:

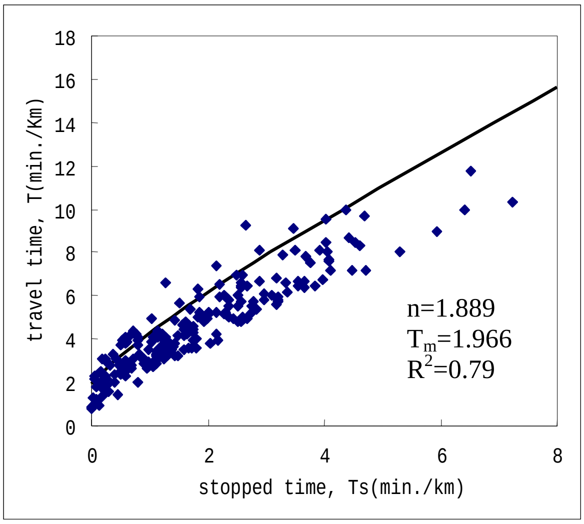
$$T_r = T_m^{\frac{1}{n+1}} T^{\frac{n}{n+1}}$$

yielding the final result:

$$T_s = T - T_m^{\frac{1}{n+1}} T^{\frac{n}{n+1}}$$

The two-fluid model represented by the equation yields a curvilinear relation between T and T_s (as shown in Figure 5.3) for T_m values of 1.5 and 3.0 minutes per km and for n values of 1, 2, and 3.

FIGURE 5.4
TWO-FLUID MODEL FOR METRO MANILA



A traffic system with smaller values of parameters T_m and n offers a better quality of traffic service. In particular, the parameter T_m indicates an estimate of the average minimum travel time per unit distance or the reciprocal of the average maximum speed that can be achieved in a network under the lightest traffic conditions. Therefore, the larger T_m implies a less efficient network geometry and control system.

A two-fluid model in Metro Manila, as shown in Figure 5.4, was estimated using speed survey data (refer to Appendix A) collected in the MMUTIS speed survey in 1997. As a result, the two-fluid model in Metro Manila has significantly high values of T_m=1.966 (min./km) and n =1.889. As mentioned earlier, it must be noted that a city which appears to have less traffic control and geometric features has higher values of T_m and n. Therefore, it seems that Metro Manila, with significantly high values of T_m and n, has less traffic control and geometric features. Actually, it is thought that Metro Manila has higher values of T_m and n because it has bad traffic control, long-cycled traffic signals, and so on.

Table 5.3 shows the comparison of two-fluid models with those for other cities. The two-fluid model in Metro Manila has significantly high values of T_m and n compared to other cities. From this comparison, it is manifest that Metro Manila has a less efficient network geometry and control system.

TABLE 5.3
COMPARISON OF TWO-FLUID MODELS WITH OTHER CITIES

Downtown Network	Two-Fluid Model Parameters		
	T_m(min./km)	n	R^2
London, 1984	1.26	1.66	0.86
Lubbock, 1984	1.33	0.82	0.70
San Antonio, 1984	1.24	1.33	0.81
Albuquerque	1.20	1.62	0.70
Roanoke	1.19	1.60	0.79
Tehran, Iran	1.57	1.45	0.74
Matamoros, Mexico	1.85	2.10	0.88
Brussels	0.78	2.67	0.92
Austin	1.11	1.65	0.78
Dallas	1.22	1.48	0.80
Houston	1.68	0.80	0.63
Milwaukee	0.98	1.41	0.81
Melbourne	1.08	1.41	0.95
Sydney	1.15	1.68	0.88
Metro Manila	1.97	1.89	0.79

Note: Data on two-fluid models, except Metro Manila, were source from “Traffic Engineering and Control” (1985)

5.3.3 Aggregation of Travel Distance and Average Speed

Travel distance (veh-km) and average speed (km/h) were aggregated by zone (refer to Appendix B). Table 5.4 shows the summary of changes in travel distance and average speed. It must be noted that, in the case of "Do-Nothing" without any projects, travel distance greatly increased, especially among private vehicles, and average speed greatly decreased. On the other hand, travel distance for public vehicles for both "Master Plan" and "Do-Max" cases decreased up to 40%. This may be due to the MRT system being incorporated into the "Master Plan" and "Do-Max" scenarios resulting in users of public transport converting to the MRT. This, as already known well, means that railways systems such as MRT, subway, etc. contribute to shorter travel journey and to environmental improvement. However, the increase of travel distance for private vehicles is still high even for both the "Master Plan" and "Do-Max."

TABLE 5.4
CHANGES IN TRAVEL DISTANCE AND AVERAGE SPEED

	Present (1996)		Do-Nothing (2015)		Master Plan (2015)		Do-Max (2015)	
	Public	Private	Public	Private	Public	Private	Public	Private
Veh-km ('000)	9,827	24,434	15,017 (+52.3)	76,319 (+212.3)	6,480 (-34.1)	43,290 (+77.2)	4,925 (-49.9)	39,764 (+62.7)
Ave. Speed	28.9	30.6	13.5 (-53.3)	13.1 (-57.2)	19.4 (-32.9)	19.2 (-37.3)	19.2 (-33.6)	20.1 (-34.3)

Note: Figures in parentheses refer to % changes with regard to the present situation.

One problem in the traffic assignment results estimated from STRADA is that average speeds in CBD areas, such as Manila and Makati City, were estimated highly (refer to Appendix B), even though actual speeds are significantly low. It seems that traffic assignment results estimated from STRADA did not consider factors such as delay time at signal intersections, and so on.

Based on travel distance and average speed, the next step is to estimate air pollutant emissions.

5.3.4 Emission Estimation

In emission estimation, a basic requirement is the air pollutant emission parameter varying travel by speed and mode type. As the emission parameter could not be obtained, it was developed from the MMUTIS environmental survey. The air pollutant emission parameters are presented in Tables 5.5 to 5.8. All the air pollutants discussed in this report are related to local or regional factors. It is noted that global factors such as CO_2 were not discussed because of data constraints.

The emission parameters vary by mode types, i.e. car, jeepney and bus. A problem was encountered in how to reflect the emission parameters of jeepney and bus in the emission estimation for public transport because jeepney and bus were not separated in the traffic assignment results. So, the share of the present travel distance for jeepney and bus (obtained from the MMUTIS person trip survey) was used to divide the travel distance by public transport into travel distances by jeepney and bus (see Table 5.9).

TABLE 5.5
CO EMISSION PARAMETERS

		Idling	~10km/h	10km/h~20km/h	20km/h~
Gasoline	Car	0.0858	27.57	23.50	18.70
	Jeepney	0.0781	47.58	52.20	41.14
Diesel	Car	0.0095	7.85	6.54	5.94
	Jeepney	0.0124	8.02	6.80	6.20
	Bus	0.0214	8.12	7.11	6.50
Unit		g/min.	g/km	g/km	g/km

Note: Air pollutant emission parameters were developed from the MMUTIS air pollution survey.

TABLE 5.6
NOX EMISSION PARAMETERS

		Idling	~10km/h	10km/h~20km/h	20km/h~
Gasoline	Car	1.51	2.75	2.76	2.78
	Jeepney	1.55	4.70	3.59	3.53
Diesel	Car	6.84	5.65	4.28	3.89
	Jeepney	9.35	8.95	7.66	7.01
	Bus	12.6	11.24	10.59	9.22
Unit		g/min.	g/km	g/km	g/km

Note: Air pollutant emission parameters were developed from the MMUTIS air pollution survey.

TABLE 5.7
SOX EMISSION PARAMETERS

		Idling	~10km/h	10km/h~20km/h	20km/h~
Gasoline	Car	0.018	0.013	0.011	0.011
	Jeepney	0.02	0.015	0.011	0.010
Diesel	Car	0.09	0.140	0.080	0.070
	Jeepney	0.18	0.180	0.121	0.110
	Bus	0.22	0.200	0.150	0.100
Unit		g/min.	G/km	g/km	g/km

Note: Air pollutant emission parameters were developed from the MMUTIS air pollution survey.

TABLE 5.8
SPM EMISSION PARAMETERS

		Idling	~10km/h	10km/h~20km/h	20km/h~
Gasoline	Car	0.10	0.07	0.05	0.05
	Jeepney	0.10	0.07	0.06	0.05
Diesel	Car	0.90	1.20	0.07	0.07
	Jeepney	1.50	1.80	0.90	0.81
	Bus	1.50	2.30	1.50	0.80
Unit		g/min.	G/km	g/km	g/km

Note: Air pollutant emission parameters were developed from the MMUTIS air pollution survey.

TABLE 5.9
SHARE OF THE PRESENT TRAVEL DISTANCE BY JEEPNEY AND BUS

	Vehicle trips ('000)	Ave. trip length (km)	Veh-km ('000)	Share of Veh-km (%)
Bus	57	13.0	741	31.5
Jeepney	460	3.5	1,610	68.5

Source: MMUTIS Person Trip Survey

In addition, it is necessary to consider the share of gasoline and diesel by mode type because emission parameters are different by engine type. Table 5.10 shows the share of gasoline and diesel by mode type. Emission estimation was conducted by assuming that their shares would not change even in the future, 2015.

TABLE 5.10
SHARE OF GASOLINE AND DIESEL BY MODE TYPE

	Car	Jeepney	Bus
Gasoline	95.3%	54.6%	6.7%
Diesel	4.7%	45.4%	93.3%

Source: MMUTIS Survey

Air pollutants can be estimated as follows:

Air pollutants = travel distance (veh-km) * emission factor at running speed (g/veh-km) + total stop time (min.) * emission factor at stop time (g/min.)

The air pollutants were estimated based on this equation (refer to Figures 5.4 to 5.7 and Appendix C). Table 5.11 shows the emission estimation results.

Some observations can be taken from the emission estimation results. Firstly, areas with MRT system have comparatively low increases in air pollutant emission. Secondly, there are significant increases in air pollutant emission even in the "Master Plan" and "Do-Max" cases and it seems that this is mainly caused by the travel distance increase of private transport. In order to preserve the present situation or improve the air pollution quality, the reduction of private transport volume is necessary. This will be later discussed in detail.

TABLE 5.11
EMISSION ESTIMATION RESULTS
(UNIT: TONS/DAY)

	Present (1996)	Do-Nothing (2015)	Master Plan (2015)	Do-Max (2015)
CO	841.5	2372.1 (+181.9)	1286.1 (+52.8)	1161.6 (+38.0)
NO_x	145.7	613.7 (+321.2)	232.2 (+59.4)	201.4 (+38.2)
SO_x	1.3	6.9 (+430.7)	2.2 (+69.2)	1.9 (+46.1)
PM	9.5	49.0 (+415.8)	15.5 (+63.1)	13.1 (+37.9)

Note: Figures in parentheses refer to % increases with regard to the present situation.

5.3.5 Sensitivity Analysis

Sensitivity analysis was done in order to investigate how changes in the mode and engine type will affect air pollutant emissions. Scenarios 1 and 2 indicate the change in the share of gasoline and diesel, and Scenarios 3 and 4 indicate the change in the share of bus and jeepney.

TABLE 5.12
CHANGES IN THE SHARE OF GASOLINE AND DIESEL

	Jeepney gasoline	Jeepney diesel
Present	54.6%	45.4%
Scenario 1	75.0%	25.0%
Scenario 2	100.0%	0.0%

TABLE 5.13
CHANGES IN THE SHARE OF BUS AND JEEPNEY

	Bus	Jeepney
Present	31.5%	68.5%
Scenario 3	50.0%	50.0%
Scenario 4	75.0%	25.0%

Sensitivity analysis was conducted based on these four scenarios. Results, as presented in Table 5.14, show that as the share of gasoline vehicle increases, CO emission increases and the remainder decreases; and as the bus share increases, CO emission decreases and the remainder increases. However, the increase of CO emission, generally speaking, is very small and it seems that more gasoline vehicle and less bus share have good impacts on air pollution.

TABLE 5.14
SENSITIVITY ANALYSIS RESULTS
(UNIT: TONS/DAY)

	Master Plan	Scenario 1	Scenario 2	Scenario 3	Scenario 4
CO	1,286.1	1,319.4 (+2.6)	1,360.3 (+5.7)	1,262.4 (-1.8)	1,230.4 (-4.3)
NO_x	232.2	225.4 (-2.9)	217.0 (-6.5)	242.1 (+4.3)	255.3 (+9.9)
SO_x	2.23	2.06 (-7.6)	1.86 (-16.6)	2.37 (+6.3)	2.54 (+13.9)
PM	15.5	14.1 (-9.0)	12.4 (-20.0)	16.6 (+7.1)	18.1 (+16.8)

Note: Figures in parentheses refer to % changes with regard to the Master Plan.

5.4 Recommendations for Sustainable Environment Development

Analysis results showed that, compared to “Do-Nothing,” the “Master Plan” and “Do-Max” cases brought significant reduction in air pollutant emission. However, it must be noted that the increase of air pollutant emission even in “Master Plan” and “Do-Max” is very significant and it will increase by around 30~50 % as compared to the present situation. This is easily attributable to the intractable private vehicle increase. This means that supply-side transport measures alone may not solve transport problems such as traffic congestion and the environmental concerns which Metro Manila is facing now. From now on, as explained earlier, an integrated package approach for Metro Manila should be considered and evaluated.

In MMUTIS, pricing-related measures such as heavier vehicle tax, heavier fuel tax, road pricing and cordon pricing were also taken and their effects were evaluated. Among these measures, EDSA cordon pricing was taken as an experimental case in order to investigate its effect on air pollutant reduction. As a result, air pollutants in the case of “Master Plan” with EDSA cordon pricing were reduced up to about 6% with regard to “Master Plan.” It seems that air pollutant reduction would be very significant in the case of heavier vehicle tax.

Undoubtedly, an integrated package approach will contribute to traffic congestion reduction and air quality improvement in Metro Manila.

FIGURE 5.5
CO EMISSIONS

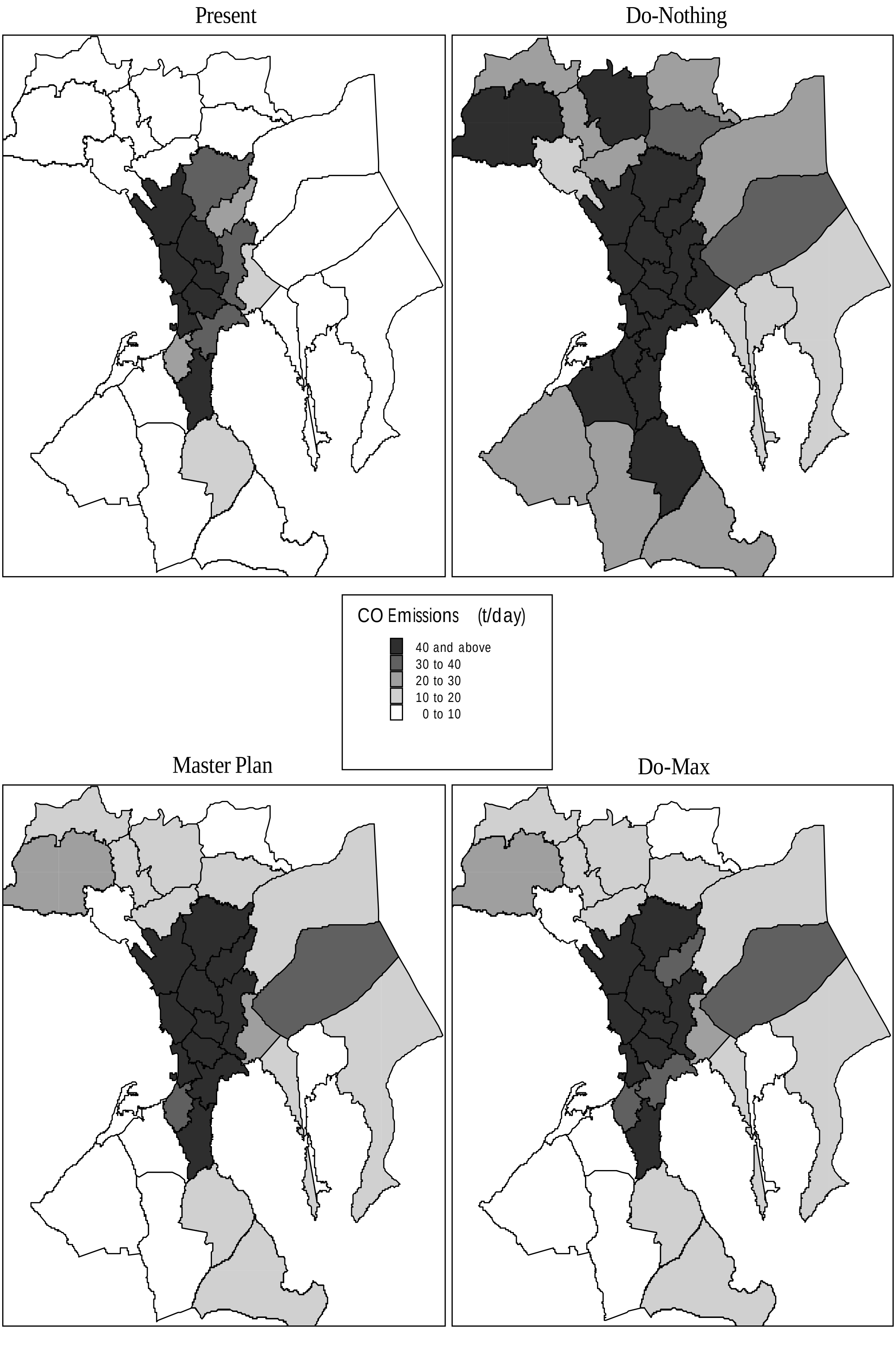


FIGURE 5.6
NOX EMISSIONS

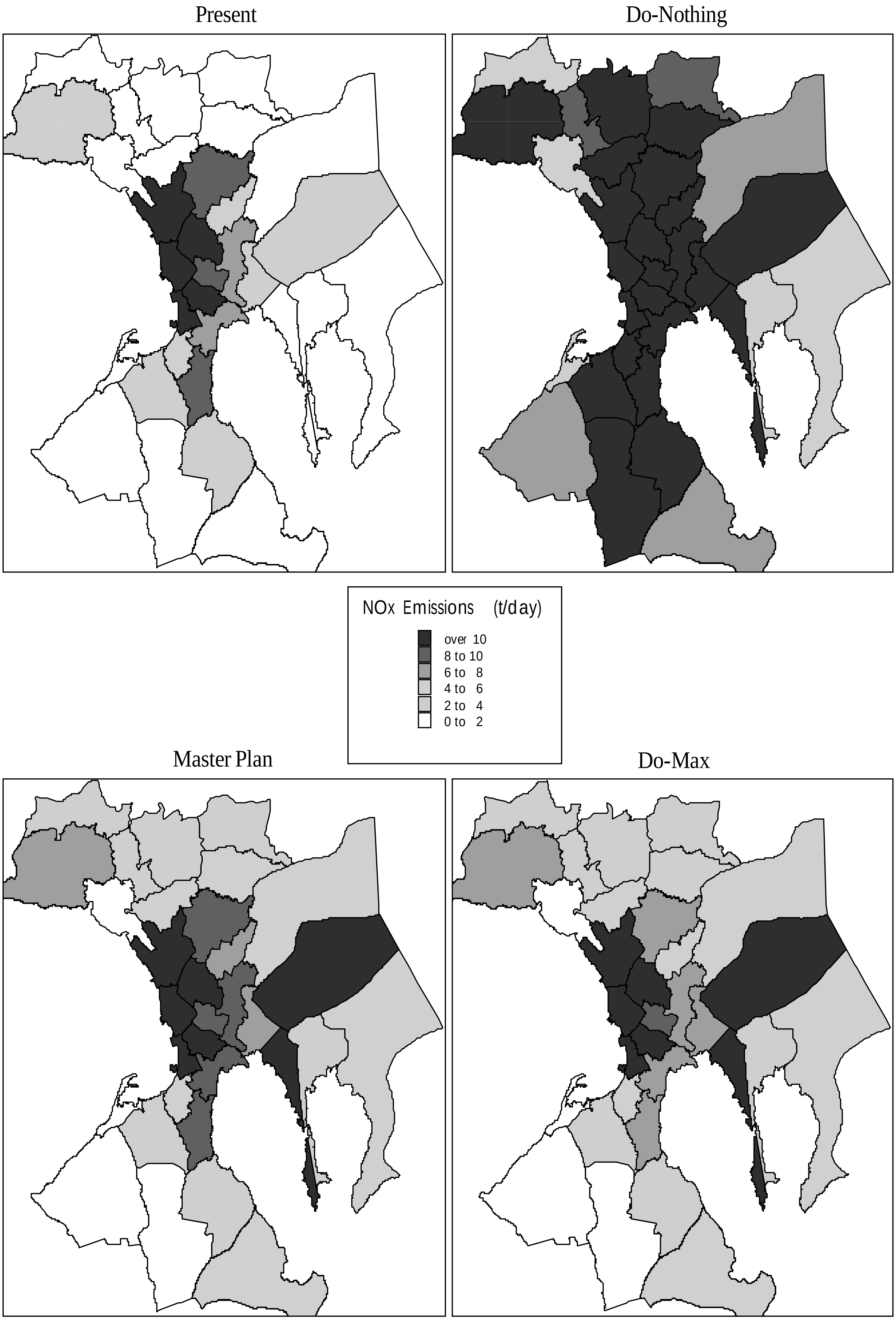


FIGURE 5.7
SOx EMISSIONS

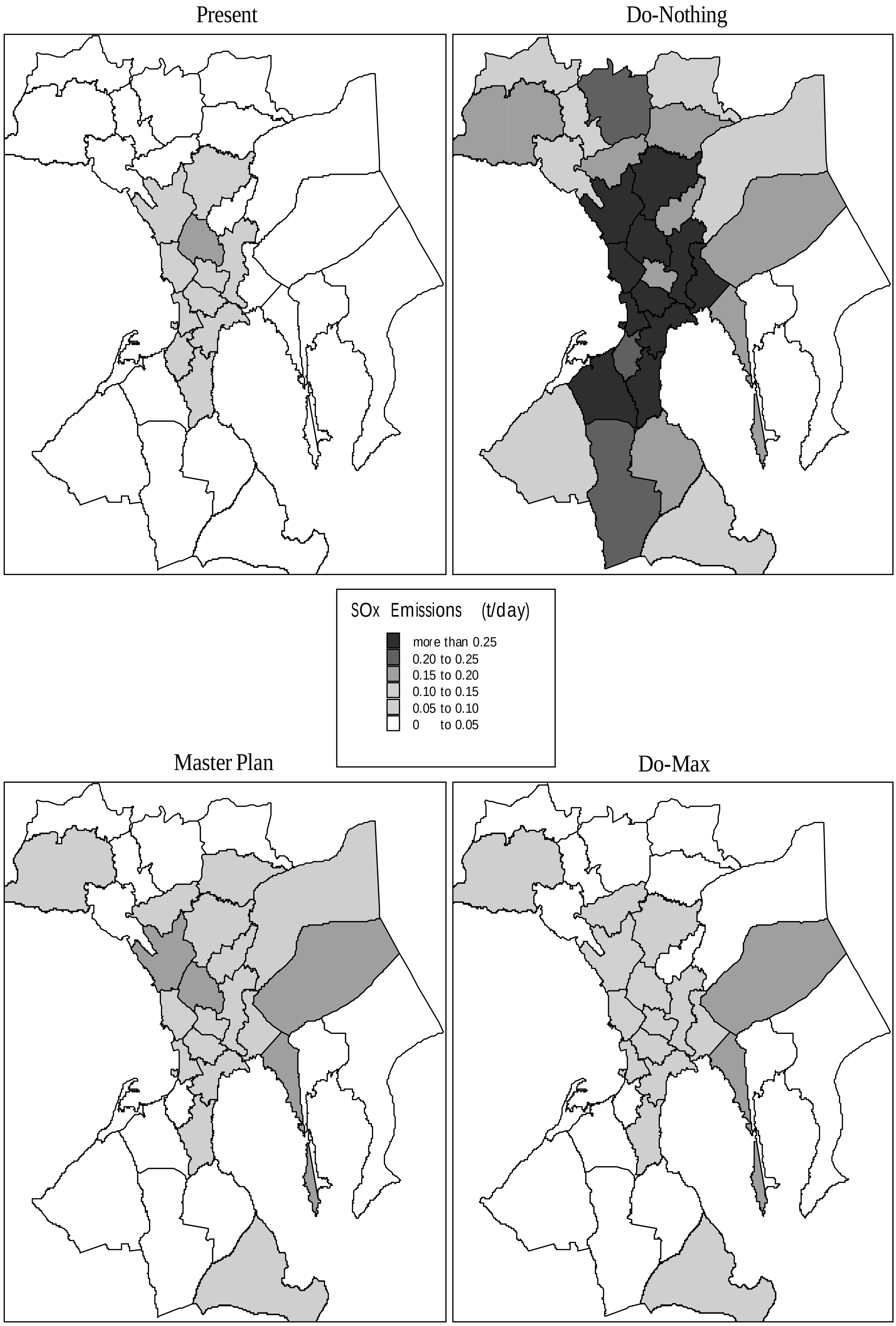
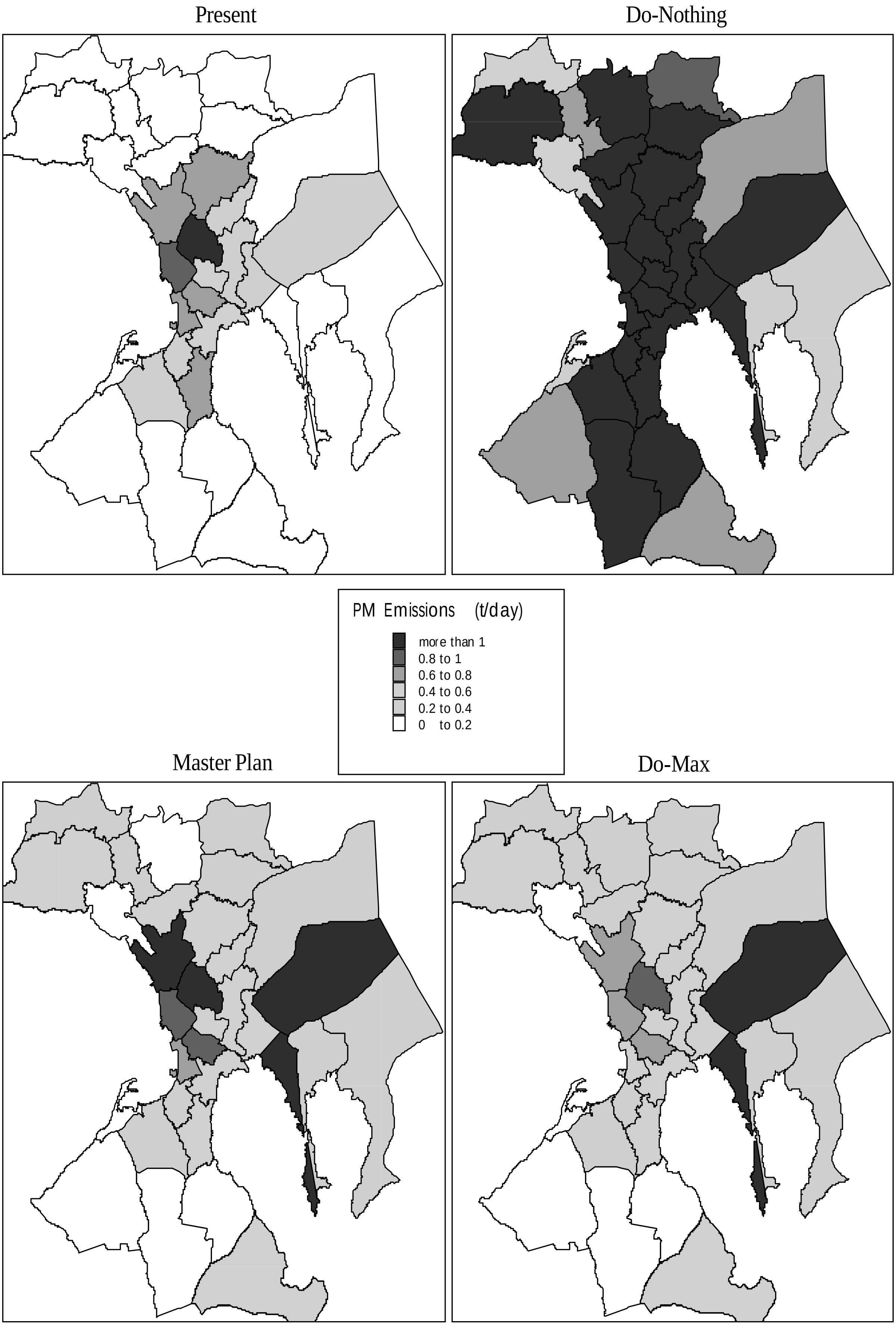


FIGURE 5.8
PM EMISSIONS



APPENDICES

SUMMARY OF TRAVEL SPEED SURVEY BY ROUTE, 1996

Route Name	Section		Length (m)	No. of Samples				Travel Speed (km./h)				No. of Stoppings (no./km)				Ratio of Stopping Time (%)			
	From	To		AM	Off	PM	Total	AM	Off	PM	Total	AM	Off	PM	Total	AM	Off	PM	Total
Aurora Blvd.	Katipunan	E. Rodriguez	2970	4	9	7	20	10.5	10.8	6.0	8.4	3.8	3.6	5.1	4.2	44.8	49.5	64.0	53.6
Part 1	E. Rodriguez	Katipunan	2970	4	9	5	18	12.2	7.1	10.1	8.6	2.8	5.1	3.8	4.2	40.2	53.5	53.8	50.6
Aurora Blvd.	Nagtahan	E. Rodriguez	3840	6	6	5	17	9.1	8.6	6.9	8.2	3.5	3.5	4.2	3.7	39.1	37.2	50.8	41.9
Part 2	E. Rodriguez	Nagtahan	3840	6	6	6	18	9.3	9.2	7.4	8.5	3.2	2.8	4.2	3.4	41.6	33.7	43.1	39.5
Ayala Blvd.	Mendiola	P. Burgos	2590	9	8	8	25	13.6	10.9	11.4	11.9	2.6	3.4	2.8	2.9	36.5	45.5	41.0	40.8
	P. Burgos	Mendiola	2590	9	8	8	25	16.4	12.8	11.9	13.5	2.0	2.0	2.1	2.0	38.6	35.7	46.8	40.3
Ayala Ave.	Sen Gil Puyat	EDSA	1985	10	10	8	28	9.4	9.0	6.7	8.3	2.9	3.1	4.1	3.3	57.1	54.7	66.2	58.8
	EDSA	Sen. Gil Puyat	1985	11	10	8	29	8.9	8.4	5.8	7.6	2.6	2.7	4.5	3.2	58.9	62.8	69.9	63.3
C3	R-10	Rizal Ave.	3330	13	13	13	39	32.2	32.3	28.0	30.7	0.2	0.3	0.7	0.4	7.4	5.9	12.3	8.5
Part 1	Rizal Ave.	R-10	3655	13	13	13	39	26.4	27.5	23.8	25.8	0.2	0.3	0.8	0.4	2.2	2.7	6.6	3.8
C3	N. Domingo	Rizal Ave.	7450	9	8	8	25	18.3	15.0	11.6	14.6	0.9	1.4	1.6	1.3	39.4	44.8	44.0	42.6
Part 2	Rizal Ave.	N. Domingo	7450	9	8	8	25	17.2	12.1	13.0	13.9	1.1	1.7	1.2	1.3	39.8	54.0	37.7	43.7
C5	Kalayaan	SSH	7300	12	15	13	40	72.6	76.4	67.6	72.2	-	-	-	-	1.1	-	-	0.3
Part 1	SSH	Kalayaan	7300	12	15	13	40	41.4	63.1	29.4	41.2	0.3	0.1	0.5	0.3	31.6	14.1	39.5	27.6
C5	Libis	Gonzales	3480	6	6	6	18	16.7	18.6	15.2	16.7	2.0	1.8	2.7	2.2	49.6	44.6	54.7	49.7
Part 2	Gonzales	Libis	3480	6	6	6	18	14.2	16.5	15.7	15.4	2.9	2.4	3.1	2.8	50.9	48.1	53.4	50.8
C.M. Recto	Legarda	Delpan	3230	8	8	6	22	10.2	9.4	6.3	8.5	2.7	3.2	4.6	3.4	39.5	40.4	42.4	40.6
	Del Pan	Legarda	3230	8	8	6	22	8.0	7.7	6.2	7.3	3.7	4.0	4.7	4.1	50.1	47.4	48.4	48.7
Commonwealth	T. Sora	Quirino H-way	10580	8	8	9	25	33.2	30.0	25.5	29.1	0.2	0.2	0.4	0.3	3.8	7.5	8.0	6.5
Ave. Part 1	Quirino H-way	T. Sora	10580	8	8	9	25	26.2	25.1	23.3	24.7	0.5	0.5	0.5	0.5	10.5	16.9	23.9	17.4
Commonwealth	EDSA	T. Sora	5080	11	11	14	36	30.1	32.6	26.0	29.0	0.7	0.4	0.7	0.6	20.0	14.3	25.1	20.2
Ave. Part 2	T. Sora	EDSA	5080	11	11	14	36	22.2	36.7	20.0	24.1	0.9	0.5	1.1	0.9	39.4	13.5	36.8	30.5
Costal Road	MIA Rd.	Talaba	7910	9	10	9	28	52.4	50.4	46.1	49.5	0.1	0.1	0.1	0.1	6.0	5.7	2.0	4.6
	Talaba	MIA Rd.	7910	9	10	9	28	19.6	38.4	22.8	25.1	0.7	0.2	0.4	0.4	36.5	19.0	36.3	30.2
EDSA North	Monumento	Santolan	10230	6	6	6	18	17.1	16.6	18.7	17.4	1.1	1.3	1.1	1.2	45.3	46.1	40.2	43.9
	Santolan	Monumento	10230	6	6	6	18	20.7	20.5	18.5	19.8	0.9	1.0	1.0	1.0	38.3	33.4	38.4	36.7
EDSA South	Santolan	Roxas Blvd.	12850	3	3	3	9	15.8	17.7	14.0	15.7	1.5	0.2	1.7	1.5	37.5	35.3	41.0	37.9
	Roxas Blvd.	Santolan	12850	3	3	3	9	19.3	17.4	11.1	15.0	1.1	1.2	1.4	1.2	40.0	38.6	31.5	36.7
Quezon Av.	Lawton	EDSA	9030	2	2	2	6	16.9	17.0	10.0	13.8	1.5	1.4	2.8	1.9	37.7	27.4	41.8	35.6
Espana	EDSA	Lawton	9130	2	2	2	6	9.3	19.3	18.3	14.0	3.0	1.5	1.3	1.9	40.0	28.7	24.7	31.1
Erodriguez	Quezon Ave	EDSA	5340	9	10	10	29	17.4	13.5	13.5	14.5	1.6	2.4	2.3	2.1	31.9	35.8	39.1	35.7
	EDSA	Quezon Ave.	5340	9	10	10	29	14.5	15.8	14.3	14.8	2.2	2.0	2.2	2.1	36.1	35.7	38.9	36.9
J.A. Santos	C.M. Recto	Monumento	5730	9	9	9	27	12.3	11.5	7.6	10.0	2.6	2.8	4.1	3.2	29.4	35.7	41.6	35.6
	Monumento	C.M. Recto	5730	9	9	9	27	10.1	12.8	12.4	11.6	3.0	2.7	2.7	2.8	31.3	33.1	33.4	32.6

(CONT'D)

Route Name	Section		Length (m)	No. of Samples				Travel Speed (km./h)				No. of Stoppings (no./km)				Ratio of Stopping Time (%)			
	From	To		AM	Off	PM	Total	AM	Off	PM	Total	AM	Off	PM	Total	AM	Off	PM	Total
J.P. Rizal	Pedro Gil	EDSA	4600	5	6	6	17	15.1	13.8	12.1	13.5	1.4	1.6	2.0	1.7	13.2	16.6	20.9	17.1
	EDSA	Pedro Gil	4600	5	6	6	17	15.6	14.6	14.1	14.7	1.7	1.5	1.5	1.6	15.7	14.5	18.1	16.1
Ortigas Ave.	E. Rodriguez	Aurora	5960	5	6	7	18	12.4	15.1	12.1	13.1	1.8	2.1	2.0	2.0	52.7	43.7	49.4	48.3
Part 1	Aurora	E. Rodriguez	5960	5	6	7	18	8.4	12.4	10.5	10.3	2.0	1.8	1.8	1.9	65.9	53.1	56.3	57.9
Ortigas Ave.	Cainta Junction	E. Rodriguez	2320	10	12	9	31	10.1	7.4	6.6	7.8	1.4	2.7	3.3	2.5	37.0	35.6	38.3	36.8
Part 2	E. Rodriguez	Cainta Junction	2320	10	12	9	31	9.1	8.1	6.5	7.8	2.6	2.7	2.8	2.7	19.1	28.8	28.7	25.6
Pres. Quirino	Roxas Blvd	Nagtahan	4480	8	6	6	20	11.6	10.3	10.3	10.8	2.4	2.7	3.1	2.7	52.8	54.8	51.0	52.9
	Nagtahan	Roxas Blvd	4480	8	6	6	20	11.4	9.9	9.3	10.2	2.9	3.2	3.4	3.1	43.8	48.9	55.2	48.8
Quirino H-way	EDSA	Sarmiento	8440	5	5	5	15	16.0	19.6	14.7	16.5	1.2	0.4	1.1	0.9	21.1	5.8	19.5	15.5
Part 1	Sarmiento	EDSA	8440	4	5	5	14	16.0	16.6	18.3	18.0	1.3	0.6	0.8	0.9	13.7	8.1	11.5	10.9
Quirino H-way	Susano Rd.	Regalado	3290	6	7	4	17	15.2	10.6	6.0	9.9	1.8	1.8	2.7	2.0	19.8	26.5	43.7	28.2
Part 2	Regalado	Susano Rd.	3290	8	8	4	20	9.5	8.6	5.1	7.8	2.3	2.4	3.0	2.5	29.1	35.6	55.3	36.9
R. Magsaysay	Nagtahan	R-10	5180	7	8	7	22	14.2	14.7	11.4	13.3	1.8	1.9	2.5	2.1	28.7	25.9	38.4	30.8
	R-10	Nagtahan	5180	7	8	7	22	10.8	13.4	11.7	11.9	3.1	2.2	2.5	2.6	42.2	36.8	39.0	39.2
Roxas Blvd.	MIA Rd.	C.M. Recto	9770	4	5	6	15	18.8	22.8	16.0	18.6	1.1	0.6	1.0	0.9	34.9	26.2	33.6	31.5
	C.M. Recto	MIA Rd.	9770	4	4	4	12	16.8	15.2	18.4	16.7	1.5	1.1	1.1	1.2	48.1	32.2	45.4	41.9
McArthur	EDSA	Pablo St.	4100	3	2	4	9	21.2	15.8	20.0	19.2	1.0	1.8	1.6	1.4	10.9	15.0	14.6	13.5
	Pablo St.	EDSA	4100	3	2	4	9	20.4	14.4	19.4	18.3	1.1	2.7	1.6	1.7	9.4	15.9	13.3	12.6
Sen. Gil Puyat	Roxas Blvd.	SSH	1900	9	12	8	29	7.5	10.0	7.9	8.5	3.2	2.9	4.0	3.3	66.2	51.8	53.8	56.8
Part 1	SSH	Roxas Blvd.	1900	9	12	8	29	14.4	10.4	9.1	10.9	2.1	3.1	3.5	2.9	38.4	48.1	50.6	45.8
Sen. Gil Puyat	EDSA	SSH	3230	9	8	8	25	9.3	8.4	7.2	8.2	2.0	2.4	3.2	2.5	59.6	57.3	55.2	57.5
Part 2	SSH	EDSA	3230	9	8	8	25	10.7	12.0	11.1	11.2	2.0	2.0	2.2	2.1	56.6	52.1	52.6	53.9
Shaw Blvd.	Aurora	Kalengtong	1630	19	19	18	56	15.5	14.6	12.0	13.9	1.1	1.3	1.7	1.4	27.0	31.1	36.4	31.4
Part 1	Kalengtong	Aurora	1630	21	19	18	58	11.6	14.6	10.0	11.8	1.4	1.3	1.9	1.5	36.6	29.3	37.9	34.6
Shaw Blvd.	C5/E. Rodriguez	Kalengtong	5570	11	11	10	32	9.7	9.0	7.8	8.8	2.4	2.0	1.8	2.1	54.6	53.3	53.1	53.7
Part 2	Kalengtong	C5/E. Rodriguez	5570	11	11	11	33	12.4	11.8	9.3	11.0	2.0	1.9	1.9	1.9	39.9	45.9	41.4	42.4
South Super	Pres. Quirino	Alabang	18685	2	2	1	5	50.2	41.1	20.2	36.2	0.3	0.3	1.1	0.5	11.9	15.1	31.8	17.2
Highway	Alabang	Pres. Quirino	18685	2	2	1	5	13.7	18.2	17.5	16.0	0.8	0.8	1.3	0.9	26.2	33.9	38.6	31.8
SSH East Service	Pres. Quirino	Alabang	19120	3	3	3	9	14.6	20.1	21.6	18.2	0.7	0.4	0.6	0.6	27.7	19.4	19.5	22.2
	Alabang	Pres. Quirino	19120	3	3	3	9	19.3	17.0	16.3	17.4	0.6	1.0	0.8	0.8	22.6	36.5	32.4	30.5
SSH West Service	Pres. Quirino	Alabang	18885	2	3	3	8	21.2	25.4	21.7	22.8	0.6	0.6	0.7	0.6	17.2	21.7	25.3	21.9
	Alabang	Pres. Quirino	18885	2	3	3	8	24.1	20.7	19.3	20.9	0.7	0.8	0.9	0.8	20.4	31.2	28.4	27.5
Taft Ave.	Lawton	EDSA	6200	2	6	5	13	9.0	7.1	7.4	7.5	3.1	4.2	4.0	4.0	43.4	47.6	48.5	47.3
	EDSA	Lawton	6200	2	6	4	12	10.3	8.8	7.5	8.5	2.7	2.8	3.4	3.0	40.3	46.8	50.7	47.0

VEH-KM AND AVERAGE SPEED BY ZONE (1996)

Zone No.	Area	Veh-km for Public	Ave. Speed for Public	Veh-km for Private	Ave. Speed for Private
1	Manila	1,046,089	40.8	2,656,671	41.3
2	Pasay / Paranaque	707,552	35.0	2,457,836	34.6
3	Makati / Pateros	729,696	37.9	2,302,089	38.8
4	Mandaluyong / Pasig	609,733	41.5	1,803,690	42.4
5	Quezon (EDSA)	1,245,696	39.4	3,624,878	39.9
6	Quezon (Northeast)	378,586	28.6	674,932	27.8
7	Quezon (North)	590,603	18.4	990,979	19.2
8	Caloocan / Malabon	786,232	32.1	1,900,870	33.7
9	Marikina / Pasig	405,008	27.0	1,135,577	28.4
10	Taguig	333,752	21.3	1,213,929	22.2
11	Muntinlupa / Las Pinas	514,222	24.4	1,760,201	24.8
12	Las Pinas / Paranaque	303,577	23.6	891,687	23.2
13	Marilao / Meycauayan	106,659	17.9	121,118	23.6
14	Obando / Bulacan	176,408	21.0	23,191	22.3
15	Bocaue / Balagtas	178,666	25.2	90,873	29.1
16	Malolos / Paombong	283,867	29.0	154,347	30.2
17	Plaridel / Pulilan	224,142	28.5	94,812	32.3
18	Sta. Maria / Pandi	64,901	30.2	258,876	30.1
19	San Jose Del Monte	128,963	29.6	108,541	29.6
20	Norzagaray	72,062	29.6	66,117	27.5
21	San Mateo / Rodriguez	51,167	31.4	118,856	31.3
22	Antipolo	132,606	17.4	256,926	17.1
23	Tayaty / Cainta	157,455	19.7	345,662	21.0
24	Angono / Binagonan	55,037	18.1	63,168	17.8
25	Cardona / Morong	44,900	31.8	78,209	32.0
26	Tanay / Pililia	59,872	30.7	158,208	30.5
27	Bacoor / Imus	113,448	16.2	215,425	15.6
28	Cavite City / Kawit	22,507	17.7	40,945	16.7
29	Gen. Trias / Tanza	63,828	25.2	158,684	24.9
30	Dasmarinas / Silang	90,538	18.8	189,373	19.1
31	Carmona / Gen. Alvarez	110,424	23.6	351,692	23.6
32	Cabuyao / Calamba	39,231	20.1	125,529	17.3
Total		**9,827,427**	**28.9**	**24,433,891**	**30.6**

VEH-KM AND AVERAGE SPEED BY ZONE (DO-NOTHING, 2015)

Zone No.	Area	Veh-km for Public	Ave. Speed for Public	Veh-km for Private	Ave. Speed for Private
1	Manila	1,455,187	25.4	7,015,700	24.6
2	Pasay / Paranaque	946,237	16.6	5,493,860	16.3
3	Makati / Pateros	1,011,567	21.0	5,582,505	21.7
4	Mandaluyong / Pasig	808,219	24.7	4,090,917	24.4
5	Quezon (EDSA)	1,730,903	24.9	7,845,681	24.3
6	Quezon (Northeast)	440,225	13.9	2,386,996	13.7
7	Quezon (North)	772,995	10.4	3,725,512	10.7
8	Caloocan / Malabon	1,430,768	15.6	6,123,030	14.7
9	Marikina / Pasig	614,004	13.5	3,363,479	13.3
10	Taguig	655,773	10.9	4,138,863	10.7
11	Muntinlupa / Las Pinas	949,909	11.3	6,266,781	11.2
12	Las Pinas / Paranaque	340,847	11.7	2,361,267	12.2
13	Marilao / Meycauayan	159,565	7.5	968,688	7.2
14	Obando / Bulacan	115,668	10.4	426,548	10.4
15	Bocaue / Balagtas	191,984	10.8	810.377	9.7
16	Malolos / Paombong	369,916	11.0	1,411,320	10.6
17	Plaridel / Pulilan	261,709	16.9	569,133	16.9
18	Sta. Maria / Pandi	278,147	8.4	1,549,385	8.6
19	San Jose Del Monte	224,825	8.5	1,118,670	8.4
20	Norzagaray	107,828	7.6	740,362	7.5
21	San Mateo / Rodriguez	134,792	9.8	776,162	9.8
22	Antipolo	211,800	7.9	1,146,406	7.5
23	Tayaty / Cainta	273,243	7.5	1,727,698	7.3
24	Angono / Binagonan	119,897	5.3	630,457	5.2
25	Cardona / Morong	91,041	13.4	302,293	13.9
26	Tanay / Pililia	130,878	16.0	560,235	15.6
27	Bacoor / Imus	251,020	6.5	1,263,229	6.1
28	Cavite City / Kawit	47,572	7.3	192,287	7.1
29	Gen. Trias / Tanza	175,892	10.0	635,037	9.8
30	Dasmarinas / Silang	252,999	6.9	885,747	7.1
31	Carmona / Gen. Alvarez	275,512	10.0	1,494,147	9.7
32	Cabuyao / Calamba	186,472	12.5	716,009	10.0
Total		**15,017,394**	**13.5**	**75,509,214**	**13.1**

VEH-KM AND AVERAGE SPEED BY ZONE (MASTER PLAN, 2015)

Zone No.	Area	Veh-km for Public	Ave. Speed for Public	Veh-km for Private	Ave. Speed for Private
1	Manila	569,636	29.5	4,765,656	31.0
2	Pasay / Paranaque	598,166	29.6	3,047,244	28.6
3	Makati / Pateros	592,956	27.4	3,747,442	27.1
4	Mandaluyong / Pasig	363,440	33.6	2,522,098	33.6
5	Quezon (EDSA)	785,098	31.2	5,830,554	29.7
6	Quezon (Northeast)	208,045	20.9	1,402,869	21.7
7	Quezon (North)	258,400	18.2	1,683,334	18.7
8	Caloocan / Malabon	606,125	21.6	3,812,380	20.6
9	Marikina / Pasig	234,674	18.7	1,878,614	20.6
10	Taguig	296,361	19.8	1,441,713	18.8
11	Muntinlupa / Las Pinas	213,606	22.7	2,285,734	24.2
12	Las Pinas / Paranaque	147,605	22.6	1,175,215	20.4
13	Marilao / Meycauayan	56,205	7.8	550,826	8.2
14	Obando / Bulacan	29,219	13.2	241,981	15.6
15	Bocaue / Balagtas	70,553	13.3	381,558	14.3
16	Malolos / Paombong	173,212	12.5	704,861	13.4
17	Plaridel / Pulilan	120,611	18.0	531,858	19.2
18	Sta. Maria / Pandi	81,758	19.8	347,546	18.1
19	San Jose Del Monte	74,431	9.6	453,171	11.2
20	Norzagaray	35,488	9.5	257,074	9.7
21	San Mateo / Rodriguez	70,316	11.1	670,045	11.2
22	Antipolo	162,427	7.1	1,263,601	7.3
23	Tayaty / Cainta	50,739	22.5	941,250	9.4
24	Angono / Binagonan	109,200	5.0	635,178	5.0
25	Cardona / Morong	84,723	13.0	294,581	13.3
26	Tanay / Pililia	125,586	14.7	575,566	14.6
27	Bacoor / Imus	62,431	11.7	288,208	11.8
28	Cavite City / Kawit	16,519	20.0	62,280	22.6
29	Gen. Trias / Tanza	55,938	20.2	268,006	12.1
30	Dasmarinas / Silang	15,043	22.0	149,024	22.8
31	Carmona / Gen. Alvarez	80,465	24.2	472,820	23.4
32	Cabuyao / Calamba	131,555	14.4	607,771	12.7
Total		**6,480,531**	**19.4**	**43,290,058**	**19.2**

VEH-KM AND AVERAGE SPEED BY ZONE (DO-MAX, 2015)

Zone No.	Area	Veh-km for Public	Ave. Speed for Public	Veh-km for Private	Ave. Speed for Private
1	Manila	439,281	30.5	4,183,291	33.6
2	Pasay / Paranaque	199,870	26.6	3,197,214	31.6
3	Makati / Pateros	308,897	29.6	3,658,983	30.3
4	Mandaluyong / Pasig	292,810	34.9	2,314,769	36.4
5	Quezon (EDSA)	676,411	34.5	5,046,018	31.8
6	Quezon (Northeast)	147,582	23.2	1,179,153	24.1
7	Quezon (North)	174,700	18.6	1,423,379	20.5
8	Caloocan / Malabon	475,964	25.2	3,161,309	23.9
9	Marikina / Pasig	215,782	21.1	1,780,398	22.3
10	Taguig	258,664	22.2	1,289,227	19.2
11	Muntinlupa / Las Pinas	184,613	23.8	1,974,745	26.5
12	Las Pinas / Paranaque	101,580	22.2	1,097,349	20.2
13	Marilao / Meycauayan	30,931	7.7	566,236	8.7
14	Obando / Bulacan	29,104	13.2	233,391	15.8
15	Bocaue / Balagtas	64,258	14.3	391,482	14.7
16	Malolos / Paombong	163,959	12.1	700,699	13.4
17	Plaridel / Pulilan	117,946	17.9	529,960	19.3
18	Sta. Maria / Pandi	84,050	14.8	432,950	14.6
19	San Jose Del Monte	57,457	10.0	377,264	12.3
20	Norzagaray	37,164	9.6	244,759	9.8
21	San Mateo / Rodriguez	76,132	12.6	534,751	12.1
22	Antipolo	116,817	7.1	1,249,236	7.5
23	Tayaty / Cainta	25,897	26.8	944,938	9.5
24	Angono / Binagonan	107,710	5.0	636,843	5.0
25	Cardona / Morong	83,517	13.1	293,859	13.4
26	Tanay / Pililia	125,050	14.7	575,509	14.6
27	Bacoor / Imus	46,066	9.5	238,281	12.6
28	Cavite City / Kawit	15,406	18.9	67,238	21.5
29	Gen. Trias / Tanza	47,046	21.7	195,110	19.2
30	Dasmarinas / Silang	7,430	20.6	151,583	20.8
31	Carmona / Gen. Alvarez	78,934	24.0	488,075	22.7
32	Cabuyao / Calamba	134,471	14.6	605,938	12.8
Total		**4,925,499**	**19.2**	**39,763,937**	**20.1**

CO EMISSION

Zone No.	Area	Present	Emission (ton / day)			% changes		
			Do-Nothing	Master Plan	Do-Max	Do-Nothing	Master Plan	Do-Max
1	Manila	91.0	215.2	138.0	120.0	136.4	51.6	31.8
2	Pasay / Paranaque	79.2	165.0	92.8	89.1	108.4	17.2	12.5
3	Makati / Pateros	75.5	168.5	111.4	103.5	123.3	47.6	37.1
4	Mandaluyong / Pasig	59.9	124.7	74.2	67.3	108.3	24.0	12.5
5	Quezon (EDSA)	120.7	242.7	170.6	147.5	101.1	41.3	22.2
6	Quezon (Northeast)	25.3	74.3	41.4	34.3	193.6	63.7	35.4
7	Quezon (North)	37.9	118.3	49.9	41.4	212.2	31.8	9.1
8	Caloocan / Malabon	65.9	197.8	113.4	93.5	200.3	72.2	41.9
9	Marikina / Pasig	38.1	104.6	54.7	51.7	174.6	43.5	35.6
10	Taguig	38.8	126.6	44.2	39.4	225.8	13.8	1.5
11	Muntinlupa / Las Pinas	56.9	190.5	65.1	56.2	234.9	14.4	-1.2
12	Las Pinas / Paranaque	29.7	71.3	34.2	31.2	140.5	15.4	5.4
13	Marilao / Meycauayan	5.3	29.9	16.1	15.9	464.2	204.5	200.8
14	Obando / Bulacan	4.0	14.2	7.2	6.9	251.5	77.2	71.5
15	Bocaue / Balagtas	5.9	26.3	11.9	12.0	347.6	102.0	104.1
16	Malolos / Paombong	9.6	46.7	23.0	22.7	385.5	139.2	135.8
17	Plaridel / Pulilan	6.9	20.3	16.5	16.4	195.1	140.6	139.2
18	Sta. Maria / Pandi	8.2	48.3	10.9	13.6	492.1	33.3	66.6
19	San Jose Del Monte	5.4	35.4	13.9	11.5	557.3	158.3	112.8
20	Norzagaray	3.2	22.5	7.7	7.5	612.0	144.9	135.8
21	San Mateo / Rodriguez	4.2	24.0	19.6	16.1	477.6	371.6	287.7
22	Antipolo	9.4	35.9	37.9	36.4	280.8	301.9	286.0
23	Tayaty / Cainta	12.3	53.0	26.2	25.8	33.2.3	113.9	110.6
24	Angono / Binagonan	2.8	19.8	19.7	19.7	621.1	617.5	617.8
25	Cardona / Morong	3.0	10.3	9.9	9.9	247.8	235.6	233.9
26	Tanay / Pililia	5.4	18.1	18.4	18.4	236.9	242.3	242.1
27	Bacoor / Imus	8.0	40.1	9.2	7.5	403.4	15.6	-6.1
28	Cavite City / Kawit	1.5	6.3	2.0	2.1	313.1	29.4	36.6
29	Gen. Trias / Tanza	5.5	21.2	8.3	6.1	288.3	51.0	11.9
30	Dasmarinas / Silang	6.8	29.9	4.3	4.2	339.4	-37.4	-38.5
31	Carmona / Gen. Alvarez	11.5	46.7	14.2	14.5	304.9	22.9	26.2
32	Cabuyao / Calamba	4.1	23.7	19.4	19.4	475.4	372.0	372.5
Total		**841.9**	**2372.1**	**1,286.2**	**1161.7**	**181.9**	**52.8**	**38.0**

Unit: ton/day

NOX EMISSION

Zone No.	Area	Present	Emission (ton / day)			% changes		
			Do-Nothing	Master Plan	Do-Max	Do-Nothing	Master Plan	Do-Max
1	Manila	14.37	33.08	17.46	14.89	130.2	21.5	3.6
2	Pasay / Paranaque	11.63	33.46	12.87	10.65	187.7	10.7	-8.4
3	Makati / Pateros	11.32	28.02	15.44	12.57	147.5	36.4	11.0
4	Mandaluyong / Pasig	9.11	19.18	9.61	8.56	110.5	5.5	-6.0
5	Quezon (EDSA)	18.44	38.11	21.95	18.90	106.7	19.0	2.5
6	Quezon (Northeast)	4.54	17.74	6.64	4.98	290.7	46.3	9.7
7	Quezon (North)	9.68	37.59	8.97	6.78	288.3	-7.3	-30.0
8	Caloocan / Malabon	10.52	45.78	18.66	13.74	335.2	77.4	30.6
9	Marikina / Pasig	6.19	25.58	8.97	7.88	313.2	44.9	27.3
10	Taguig	7.00	36.84	8.18	6.91	426.3	16.9	-1.3
11	Muntinlupa / Las Pinas	9.51	52.81	9.08	7.49	455.3	-4.5	-21.2
12	Las Pinas / Paranaque	5.33	18.29	5.37	4.77	243.2	0.8	-10.5
13	Marilao / Meycauayan	1.51	13.11	5.75	4.96	768.2	280.8	228.5
14	Obando / Bulacan	1.64	4.92	1.48	1.43	200.0	-9.8	-12.8
15	Bocaue / Balagtas	1.60	8.92	2.82	2.66	457.5	76.3	66.3
16	Malolos / Paombong	2.32	15.35	6.24	6.17	561.6	169.0	165.9
17	Plaridel / Pulilan	1.77	5.22	3.22	3.18	194.9	81.9	79.7
18	Sta. Maria / Pandi	1.16	18.44	2.10	3.09	1489.7	81.0	166.4
19	San Jose Del Monte	1.15	14.06	4.21	3.17	1122.6	266.1	175.7
20	Norzagaray	0.71	9.27	2.45	2.38	1205.6	245.1	235.2
21	San Mateo / Rodriguez	0.67	7.87	5.09	4.04	1074.6	659.7	503.0
22	Antipolo	2.46	15.42	15.92	13.98	526.8	547.2	468.3
23	Tayaty / Cainta	2.70	22.75	6.69	6.38	742.6	147.8	136.3
24	Angono / Binagonan	0.82	13.23	13.36	13.32	1513.4	1529.3	1524.4
25	Cardona / Morong	0.51	2.80	2.76	2.72	449.0	441.2	433.3
26	Tanay / Pililia	0.84	4.03	4.31	4.30	379.8	413.1	411.9
27	Bacoor / Imus	2.29	21.82	2.65	2.25	852.8	15.7	-1.7
28	Cavite City / Kawit	0.41	3.14	0.36	0.38	665.9	-12.2	-7.3
29	Gen. Trias / Tanza	0.98	7.79	1.94	1.12	694.9	98.0	14.3
30	Dasmarinas / Silang	1.60	16.00	0.62	0.60	900.0	-61.3	-62.5
31	Carmona / Gen. Alvarez	2.02	15.47	2.17	2.24	665.8	7.4	10.9
32	Cabuyao / Calamba	0.86	7.56	4.90	4.90	779.1	469.8	469.8
Total		**145.66**	**613.65**	**232.24**	**201.39**	**321.3**	**59.4**	**38.3**

Unit: ton/day

SOX EMISSION

Zone No.	Area	Present	Emission (ton / day)			% changes		
			Do-Nothing	Master Plan	Do-Max	Do-Nothing	Master Plan	Do-Max
1	Manila	0.123	0.285	0.131	0.110	131.7	6.5	-10.6
2	Pasay / Paranaque	0.096	0.337	0.103	0.077	251.0	7.3	-19.8
3	Makati / Pateros	0.094	0.256	0.124	0.091	172.3	31.9	-3.2
4	Mandaluyong / Pasig	0.077	0.166	0.073	0.064	115.6	-5.2	-16.9
5	Quezon (EDSA)	0.155	0.333	0.166	0.143	114.8	7.1	-7.7
6	Quezon (Northeast)	0.042	0.197	0.059	0.042	369.0	40.5	0.0
7	Quezon (North)	0.109	0.457	0.086	0.062	319.3	-21.1	-43.1
8	Caloocan / Malabon	0.091	0.510	0.168	0.115	460.4	84.6	26.4
9	Marikina / Pasig	0.055	0.286	0.082	0.068	420.0	49.1	23.6
10	Taguig	0.067	0.428	0.079	0.064	538.8	17.9	-4.5
11	Muntinlupa / Las Pinas	0.087	0.604	0.074	0.059	594.3	-14.9	-32.2
12	Las Pinas / Paranaque	0.051	0.206	0.047	0.041	303.9	-7.8	-19.6
13	Marilao / Meycauayan	0.018	0.165	0.068	0.055	816.7	277.8	205.6
14	Obando / Bulacan	0.021	0.062	0.016	0.015	195.2	-23.8	-28.6
15	Bocaue / Balagtas	0.018	0.109	0.032	0.029	505.6	77.8	61.1
16	Malolos / Paombong	0.024	0.190	0.074	0.073	691.7	208.3	204.2
17	Plaridel / Pulilan	0.019	0.059	0.032	0.032	210.5	68.4	68.4
18	Sta. Maria / Pandi	0.009	0.230	0.021	0.034	2455.6	133.3	277.8
19	San Jose Del Monte	0.011	0.177	0.051	0.037	1509.1	363.6	236.4
20	Norzagaray	0.007	0.115	0.029	0.028	1542.9	314.3	300.0
21	San Mateo / Rodriguez	0.006	0.095	0.056	0.045	1483.3	833.3	650.0
22	Antipolo	0.028	0.195	0.196	0.166	596.4	600.0	492.9
23	Tayaty / Cainta	0.029	0.284	0.067	0.062	879.3	131.0	113.8
24	Angono / Binagonan	0.010	0.180	0.180	0.179	1700.0	1700.0	1690.0
25	Cardona / Morong	0.005	0.034	0.033	0.033	580.0	560.0	560.0
26	Tanay / Pililia	0.007	0.044	0.048	0.048	528.6	585.7	585.7
27	Bacoor / Imus	0.028	0.286	0.032	0.028	921.4	14.3	0.0
28	Cavite City / Kawit	0.005	0.042	0.004	0.004	740.0	-20.0	-20.0
29	Gen. Trias / Tanza	0.009	0.099	0.020	0.011	1000.0	122.2	22.2
30	Dasmarinas / Silang	0.017	0.218	0.005	0.005	1182.4	-70.6	-70.6
31	Carmona / Gen. Alvarez	0.019	0.187	0.019	0.019	884.2	0.0	0.0
32	Cabuyao / Calamba	0.009	0.091	0.055	0.055	911.1	511.1	511.1
Total		**1.346**	**6.927**	**2.230**	**1.894**	**414.6**	**65.7**	**40.7**

Unit: ton/day

PM EMISSION

Zone No.	Area	Present	Emission (ton / day)			% changes		
			Do-Nothing	Master Plan	Do-Max	Do-Nothing	Master Plan	Do-Max
1	Manila	0.87	1.98	0.89	0.74	127.6	2.3	-14.9
2	Pasay / Paranaque	0.67	2.32	0.71	0.52	246.3	6.0	-22.4
3	Makati / Pateros	0.66	1.77	0.85	0.62	168.2	28.8	-6.1
4	Mandaluyong / Pasig	0.54	1.15	0.50	0.44	113.0	-7.4	-18.5
5	Quezon (EDSA)	1.10	2.32	1.14	0.97	110.9	3.6	-11.8
6	Quezon (Northeast)	0.30	1.42	0.41	0.28	373.3	36.7	-6.7
7	Quezon (North)	0.79	3.27	0.59	0.42	313.9	-25.3	-46.8
8	Caloocan / Malabon	0.64	3.71	1.15	0.79	479.7	79.7	23.4
9	Marikina / Pasig	0.39	2.05	0.56	0.47	425.6	43.6	20.5
10	Taguig	0.47	3.02	0.55	0.44	542.6	17.0	-6.4
11	Muntinlupa / Las Pinas	0.61	4.26	0.50	0.40	598.4	-18.0	-34.4
12	Las Pinas / Paranaque	0.36	1.45	0.32	0.27	302.8	-11.1	-25.0
13	Marilao / Meycauayan	0.13	1.15	0.47	0.37	784.6	261.5	184.6
14	Obando / Bulacan	0.15	0.45	0.11	0.11	200.0	-26.7	-26.7
15	Bocaue / Balagtas	0.13	0.78	0.23	0.21	500.0	76.9	61.5
16	Malolos / Paombong	0.17	1.37	0.54	0.53	705.9	217.6	211.8
17	Plaridel / Pulilan	0.14	0.42	0.23	0.22	200.0	64.3	57.1
18	Sta. Maria / Pandi	0.07	1.63	0.14	0.24	2228.0	100.0	242.9
19	San Jose Del Monte	0.08	1.25	0.36	0.26	1462.5	350.0	225.0
20	Norzagaray	0.05	0.80	0.20	0.20	1500.0	300.0	300.0
21	San Mateo / Rodriguez	0.04	0.67	0.39	0.31	1575.0	875.0	675.0
22	Antipolo	0.20	1.37	1.36	1.14	585.0	580.0	470.0
23	Tayaty / Cainta	0.20	1.99	0.44	0.41	895.0	120.0	105.0
24	Angono / Binagonan	0.07	1.29	1.29	1.28	1742.9	1742.9	1728.6
25	Cardona / Morong	0.03	0.25	0.24	0.24	733.3	700.0	700.0
26	Tanay / Pililia	0.05	0.32	0.35	0.35	540.0	600.0	600.0
27	Bacoor / Imus	0.21	2.01	0.23	0.20	857.1	9.5	-4.8
28	Cavite City / Kawit	0.03	0.30	0.02	0.03	900.0	-33.3	0.0
29	Gen. Trias / Tanza	0.07	0.71	0.14	0.07	914.3	100.0	0.0
30	Dasmarinas / Silang	0.12	1.56	0.04	0.03	1200.0	-66.7	-75.0
31	Carmona / Gen. Alvarez	0.13	1.33	0.13	0.13	923.1	0.0	0.0
32	Cabuyao / Calamba	0.06	0.65	0.40	0.40	983.3	566.7	566.7
Total		**9.53**	**49.02**	**15.48**	**13.09**	**414.4**	**62.4**	**37.4**

Unit: ton/day