CHAPTER 5 INSTITUTIONAL AND LEGAL ASPECTS

5.1 Outline

The Team surveyed national and local governments as well as private organizations in order to study institutional and legal aspects of air pollution control in Jabotabek. This chapter covers its findings and recommendations, as summarized below:

a) BAPEDAL is in short of human resources and is far from its supposed authority. BAPEDAL had better utilize talented personnel from other agencies to fill its vacant positions. It should be placed in a position superior to other ministries on environmental issues in order to secure coordination among them. Thus, it can solve the duplicated roles with Ministry of Internal Affairs (DPD) and have capacity to estimate and adjust national budgets for environmental issues. EMC is expected to expand training of personnel from national and local governments on environmental issues and to conduct exhibitions and public education.

b) The number of AMDAL qualification holders should be increased, with governmental supports to PSLs in universities, subsidies for examination fees, and reinforcement of employment in private sectors.

c) Each ministry concerned should have its own organization for environmental issues which can represent the ministry to negotiate with BAPEDAL. The AMDAL committee of each ministry can be expanded for the purpose.

d) BAPEDALDA (Local Environmental Management Agency) should be established before long and staffed with AMDAL qualified personnel to fulfill its duty of environmental monitoring and instituting lawsuits locally. Local agencies including KPPL should have planning and coordinating capacity for environmental policies of local governments.

e) The revisions of the Basic Provisions for the Management of the Living Environment, Act No. 4-1982 under consideration should include provisions for the above items, and further as follows:
- to impose on industries the obligation of voluntary execution of environmental inspections and reporting on the results to BAPEDAL,
- to strengthen local agencies for dealing with environmental issues,

- to oblige national and local governments to report environmental issues in their territories to BAPEDAL, etc.

5.2 Administrative Organizations

5.2.1 National Government Agencies

(1) Supervisory Agency - BAPEDAL

BAPEDAL, (see Organization in Appendix 7.1), established in 1990 in accordance with the Decree of the Ministry of Environment, is an organization under the direct control of the President. The agency is composed of three departments and two centers, with approximately 200 staffs, of whom ten are in charge of air pollution control. The Minister of Environment also acts as chief of the agency. BAPEDAL has four regional offices in Indonesia and one local office in each of the country's 27 provinces. The regional offices; the West Office (Pakanbaru), the Central Office (Denpasar), the East Office (Ujung Pandang), and the Java Kalimantan Office (Jakarta), support the local offices. The local offices are classified into first-class city administration BAPEDAL (BAPEDALDA Tk. I) and second-class city administration BAPEDAL (BAPEDALDA Tk. II). The provincial government controls the local office, which takes charge of environmental monitoring and instituting lawsuits on environmental pollution. The local offices are responsible for the execution of environmental pollution control measures.

BAPEDAL is empowered to coordinate the ministries and agencies on all kinds of environmental issues, in accordance with the Presidential Decree 77 of 1994 (Ref. 114) based on the Basic Provisions for the Management of the Living Environment, Act No. 4-1982. However, as the Ministries of Industry, Mining & Energy, and Transportation, had independently established and executed environmental policies before the promulgation of the Presidential Decree, it became difficult for BAPEDAL to exercise its power to act as a coordinator.

This situation is being gradually improved by the implementation of new measures. For instance, emission standards (Ref. 110) were introduced in the industries of steel, cement, pulp, electric coal power, and others in 1995. In the process of establishing these standards, BAPEDAL acted as a coordinator for the ministries concerned. In 1994, the Environmental Planning and Information Center was established, and the campaign of Langit Biru (Blue Sky Program) was launched, with the cooperation of the ministries concerned.

BAPEDAL is currently not a superior agency. It is therefore recommended that the Ministry of Environment and BAPEDAL be given a superior position, for the purpose of their environmental administration priority over other ministerial environmental policies.

For organizational strengthening, it would be effective for BAPEDAL to amalgamate with other agency, or fully utilize talented personnel from other agencies.

(2) Ministries and Agencies Enforcing Environmental Measures

PPEK (Ecology Health Research Center, Ministry of Health) has been conducting environmental monitoring in the fourth floor of its building and in the Pulogadung industrial zone, with the cooperation of KPPL and BMG. PPEK, having approximately 100 staffs, conducts research in five fields: environmental sociology, environmental biology, environmental health, environmental health indicators, and environmental regulation. In November 1994, PPEK started epidemiological examination for junior high school students. Coughing seems more significant in students in Jakarta than that in other cities.

BPPI (Agency for Research and Development, Ministry of Industry and Trade - see Organization in Appendix 7.2) has 9 central research institutes and 13 provincial R&D centers, and approximately 500 staffs are engaged in research and development in various fields. Air pollution, however, has not been studied. For the last five years, training on industrial pollution control was conducted twice a year for BPPI personnel. BPPI intends to encourage its personnel to improve their competence and to furnish equipment, in order to support in environmental problems solving.

BAKOREN (Energy Regulation Agency) is in charge of executing policies regarding energy saving under Presidential KPUTUSAN No. 43 issued in 1991 (Ref. 195). Various decrees of the Minister of Industry have been issued for industries. From 1995 to 2000, a saving of 17% of energy consumption by the industrial, residential and commercial, and transportation sectors has been targeted.

BLT (Environment and Technology Bureau, Ministry of Mines and Energy - see Organization in Appendix 7.3) established two years ago, has about 30 staffs specializing in biology, industrial chemistry and petrochemistry, and is engaged in the evaluation of AMDAL data and the preparation of measures and standards regarding environmental issues related to petroleum and gas. BLT is a member of the AMDAL Committee, and compiles the AMDAL results to publish four times a year. Energy saving leads directly to reduction of air pollutant emissions.

BLT allows the use of coal, though it recognizes the necessity of promoting cleaner energy such as natural gas. It is reported that exporting natural gas is more favorable than consuming it domestically from the economic viewpoint. However, this would not stop the use of coal in private houses. More studies seem necessary from the standpoint of pollution. Possibly it would be better to use coal in large facilities fully equipped with emission control apparatuses.

PU (Ministry of Public Works - see Organization in Appendix 7.4) consists of the General Directorate of Roads, the Housing Department, the General Directorate of Irrigation and the R&D Center. Each of them has AMDAL personnel. The AMDAL Central Committee has been organized in the R&D Center and is engaged in weekly environmental coordination for the projects of the Ministry of Public Works. In 1991, landscape personnel was assigned within the General Directorate of Roads to establish a standard for tree planting for controlling noise and air pollution along national roads. Tree planting is carried out based only on experience, because BAPPENAS (National Development Planning Agency) has not approved a budget appropriation for establishing a tree-planting standard. The Strategic Urban Road Infrastructure Project (assisted by the World Bank) is being implemented for greenery conservation and promotion, and Phase I of the project is under way in the north by-pass in Semarang. As total suspended particle loads in ambient air were found exceeding the current national standard in some places by the Study, tree-planting along roads would be better to continue without cutting the budget for it.

HUB (Ministry of Communication - see Organization in Appendix 7.5) introduced an automobile inspection system in 1992, with the revision of the Road Traffic Act. Commercial cars such as buses and taxis and container cars are subjected to automobile inspections once in every six months. In 1993, the Ministry of Environment issued an emission standard for controlling exhaust gas under this automobile inspection system. Inspections are conducted by Road Traffic Department (DLLAJR) of the provincial governments. The officers who inspect the cars hold certificates of automobile inspection. HUB provides the provincial governments with measuring instruments for inspection. The ministry provides seven mobile inspection units for Nusa, Tenggara, Timur, etc. where the number of automobiles is small. In its specific plan for air pollution control, MOT reportedly intends to stop using small-sized buses and gradually replace them by large-sized buses which use natural gas as fuel. The ministry is said to be considering a revision of the Road Traffic Act, for severer penal regulations against those who violate the emission standards and the noise standards.

BAPEDAL has not sufficiently coordinated the air pollution control measures taken by other ministries, such as the Ministry of Health, the Ministry of Industry and Trade, the Ministry of Mining and Energy, the Ministry of Public Works, and the Ministry of Transportation. It is necessary not only to strengthen the organization and human resources of BAPEDAL but also to establish an exclusive organization for integrated environmental measures in each ministry concerned. It is practical for the time being to expand the secretariats of the AMDAL Committees of the ministries concerned to be the organization for the integration.

(3) Ministries and Agencies Managing Organizational Structure

DPD (Ministry of International Affairs - see Organization in Appendix 7.6) established the Environmental Management and Guidance Office of the General Directorate of Regional Development in 1992 to provide the following services:

- Execution of Prokasih (Clean River Program)
- Awarding of Adipura Prize (Clean River Program: given to the cleanest town of the 27 provinces)
- Execution of AMDAL
- Establishment of BAPEDALDA in first-class and second-class city administrations

Although no BAPEDALDA has been established so far because the Ministry of Interior has not made a decision to do so, it is planned to be opened simultaneously in eight provinces, with equipment and personnel being provided by the Ministry of Interior. Personnel is to be assigned from various divisions and departments of each provincial government, because it is an established policy not to increase public officers. As each provincial government already has an AMDAL Committee, it is expected that environmental issues will be dealt with more substantially.

As some of the services provided by the Office of DPD are the same as those by BAPEDAL, restricting the Office's services to the establishment of and guidance for BAPEDALDA will stimulate the earlier opening of BAPEDALDA. In this case, full cooperation with BAPEDAL is necessary in various fields such as training of DPD personnel in environmental management and guidance. Discussion between DPD and BAPEDAL is mandatory to solve the duplication.

(4) Agency in Charge of Budgetary Measures

BAPPENAS has seven vice-ministers who are in charge of making budgetary appropriations to the ministries and agencies. Appropriations for environmental management are made to the Ocean, Space, Environment and Science Department of BAPPENAS. The department is controlled by the fourth vice-minister of BAPPENAS who is in charge of human resources. As mentioned below, appropriations to BAPEDAL have been increased every year during the last five years.

1993	Rp.4 billion
1994	Rp.8 billion
1995	Rp.18 billion
1996	Rp.25 billion
1997	Rp.33 billion

The budget for environmental management (distributed among 21 ministries and agencies) is given higher priority in the Sixth Five-year Plan (starting in 1994). The top priority is given to the implementation of measures for the relief of the poor, followed by the establishment and improvement of infrastructure (in the fields of education and health) and the implementation of environmental measures. In 1995, the field of environmental management was actually given the eighth largest appropriation, while the fields of transportation, education and mining were given the largest appropriations in that order.

BAPPENAS applies a system of starting an environmental project by giving independent appropriations to BAPEDAL (Estimate Adjustment System). There are, however, some difficulties in implementing this system from the viewpoint of human resources and the present organizational conditions of BAPEDAL, as mentioned below.

1) There is an insufficiency of personnel empowered to make decisions (personnel of the director class) in BAPEDAL. Half of its 30 positions remain *vacant*. These positions should be desirably occupied by personnel from other ministries and agencies, which often refuse requests for dispatching personnel, and this produces a bottleneck.

2) It is only a short time since BAPEDAL was established. It is not yet equipped with a system and competence for regulating and unifying the environment departments of the ministries and agencies.

BAPEDAL should be supplied with human resources, as BAPPENAS has pointed out. As mentioned earlier, amalgamation with BPPT or dispatch of a large number of staffs from BPPT should be considered.

5.2.2 Local Governments

(1) KPPL (Urban Environment R&D Center, DKI Jakarta)

KPPL, being controlled by the provincial governor, has 85 staffs now, and the number will be increased to 170 in the year 2000, for strengthening its evaluation and analysis functions. KPPL has four laboratories, namely chemistry, biology, toxicology, and air pollution laboratories. Five people are engaged in air pollution monitoring. KPPL coordinates standards received from ministries and agencies, and decides a provincial standard. The Jakarta City Government has been implementing the Blue Sky Program, with a budget of Rp.40 million.

Although KPPL is under the direct control of the governor of DKI, it is only a local research institute in character. It is necessary that KPPL be equipped with more competence in planning and coordinating DKI's environmental policies.

(2) Resources & Environmental Division of BAPPEDA (Regional Planning Agency, DKI Jakarta)

This division is in charge of budgetary planning for resources and environment for the local government. It evaluates and appraises budgets from KPPL. Concerning environmental issues, it conducts environmental monitoring in connection with transportation. Priority is given to budgets for education and medical care, and appropriations for environmental management are often given lower priority, reportedly.

In the national five-year plan, environmental measures are given the third priority, but they are left over, as a matter of fact. For the purpose of improving the situation as much as possible, it is necessary that BAPEDAL be empowered to estimate and adjust environment-related budgets.

(3) Bekasi BLH (Environmental Monitoring Division, Bekasi City Environment and Health Department, West Java)

In the Bekasi Province, the Environmental Monitoring Division was established in 1993, with eight staffs. Now 15 staffs are engaged in air pollution monitoring, water analysis, waste treatment, and environmental protection. The division conducts on-the-spot inspections of about 700 large factories and 1,400 small and medium ones in the province, by organizing a monitoring team jointly with the Ministry of Industry and the Ministry of Labor. The division conducts simple measuring, and entrusts analysis to the ministries concerned. There are approximately 500 factories which must report environmental conditions based on AMDAL once in every three months. Among the personnel of the Environmental Monitoring Division, three staffs have the AMDAL (A) qualification, and one has the AMDAL (A), (B) and (C) qualifications. The others are graduates of the university engineering faculty. As the acquisition of the AMDAL (A) qualification requires 32 days and costs as high as Rp.2.5 million, the city government grants subsidies to those who attend the AMDAL (A) course.

For substantiating environmental measures in local governments, it is necessary that a sufficient number of staffs be assigned so that they can visit all the factories that are subjected to inspection, that an analysis institution be established, and that personnel be more encouraged to acquire AMDAL qualifications. For the time being, it is recommended that the Local Environmental Management Agency (BAPEDALDA) be established as early as possible by the Ministry of Interior. It is also recommended that those who have AMDAL qualifications be employed preferentially.

5.2.3 Industrial Sector

I Mobile Co., which is seemingly one of the most environmental by cautious entities in Jabotabek, has no exclusive environmental management organization, and its power department manages drainage facilities as spare-time work. It is therefore impossible for the department to conduct environmental monitoring by itself. It has issued environmental reports to the local government four times in a year in accordance with the AMDAL regulations, by entrusting the monitoring work to an outside firm. Presently the staffs of the general affairs department prepare reports, but this job is a great burden for them. The quality control department was established in 1995, with 18 staffs, under the guidance of the Japanese Head Office. There has been reportedly no instruction from the Head Office on environmental management.

For substantiating environmental measures in factories, it is necessary to assign an environmental manager in each factory. The AMDAL system should be utilized for the present, and it would be possible to make it mandatory to assign those who have AMDAL (A), (B) and/or (C) qualifications, according to scales and kinds of factories.

It is recommended that the revision of Basic Provisions for the Management of the Living Environment, Act No. 4-1982 includes articles for making it mandatory for managers of factories to report on their own emissions. It is practical for the time being to conduct inventory surveys by BAPEDAL with a help of local agencies and also to utilize RPL (Environmental Monitoring Program) under which factory managers are required to make regular reports based on AMDAL.

5.3 Legal Matters

(1) Basic Provisions for the Management of the Living Environment, Act No. 4-1982

As the revision of the Basic Provisions for the Management of the Living Environment, Act No. 4-1982 is now under way, major revisions are as follows:

a) The concept of zoning is to be defined clearly. Environmental measures will be promoted in industrial and housing zones in accordance with location, especially while permitting the construction of factories.

b) The Ministry of Environment is to make a report on environmental conditions once in every two years.

c) The provincial governments have to adopt a permission system for the construction of factories and industries, and shall not give a permit if the environment is affected greatly.

d) The discarding of waste is to be prohibited, as a general rule. Waste can be discarded only where the Ministry of Environment permits to do so.

e) In empowering local governments to conduct on-the-spot inspections, it is to define clearly that the provincial governments conduct them placing importance on business activities, while municipalities conduct them from the environmental viewpoint.

f) If disobedience of the improvement order is found by an on-the-spot inspection, the provincial governments or municipalities can order suspension of business.

g) All factories are required to conduct environmental monitoring voluntarily. The Ministry of Environment makes the results public.

The revised Environmental Conservation Basic Act will tighten regulations for factories. Local governments need organizational strengthening for the observation of these regulations. Specifically it is recommended to make it mandatory to assign those who have the AMDAL (C) qualification in the secretariats of the local AMDAL committees and give them qualification benefits.

(2) AMDAL (Environmental Impact Assessment) System

An assessment system was introduced in accordance with the government ordinance on environmental impact assessment in 1985. The system has been abbreviated as AMDAL. AMDAL designates qualifications as follows.

AMDAL (A) :

Those who have a basic knowledge on environmental impact assessment, can appear at an examination to obtain this qualification, after receiving training for 32 days in an environmental institute, such as Bogor University of Agriculture. Ten examinations are conducted annually. An amount of Rp.2.5 million is charged for the examination.

AMDAL (B) :

Those who are able to prepare reports on environmental impact assessment, can sit for an examination to obtain this qualification, after receiving training for 11 days in an environmental institute, such as the University of Indonesia. Two examinations are conducted annually. An amount of Rp. 975,000 is charged for the examination.

AMDAL (C) :

Those who are able to evaluate reports on environmental impact assessment and who have completed the B course, can appear at an examination to obtain this qualification, after receiving training for six days in an environmental institute. One examination is conducted annually. An amount of Rp. 650,000 is charged for the examination.

Those who have these qualifications are registered with BAPEDAL. Approximately 10,000 people have AMDAL (A), and about 5,000 have AMDAL (B). AMDAL (C) is possessed by several scores of people, who are either members of the AMDAL Committee or personnel of environment departments in national or local governments.

Targets of AMDAL are divided into two, namely, regional development and complex development comprising a number of elements. An example of the latter is the construction of a golf course within a residential area. Ten to 15 cases of the latter category are filed annually with the AMDAL Committee.

It is recommended that this AMDAL qualification system be expanded in the private sector, for the purpose of training environmental technicians in the sector.

Specifically, it is recommended to make it mandatory for those factories which are required to report regularly based on AMDAL's RKL (Environmental Management Program) and RPL (Environmental Monitoring Program) to employ personnel who possess the AMDAL (B) qualification.

5.4 Ambient Air Quality Standards and Emission Standards

(1) National ambient air quality standards

Law No. 4, the Basic Provisions for the Management of the Living Environment enacted in March 1982, provides the umbrella for governmental regulations and ministerial decrees regarding the management of the environment in Indonesia. Under this law a ministerial decree on environmental standards has been issued in 1986 which established, among others, the national ambient air quality standards (Table 5.4.1). At present new national ambient air quality standards are proposed to supersede the old ones as shown in Table 5.4.2 to ensure protection of the receptors from both acute and chronic exposures. The current ambient air quality standards of DKI Jakarta are also shown in Table 5.4.2.

Table 5.4.1 National Ambient Air Quality Standards - Current in March, 1997

Parameter	Time Measured	Standards $\mu g/m^3$ (ppm)	Recommended Analytical Methods
Sulfur dioxide	24 hours	260 (0.10)	Absorptiometry (p-rosaniline)
Carbon monoxide	8 hours	22,600 (20)	Nondispersive Infrared Absorp.
Nitrogen dioxide	24 hours	92.5 (0.05)	Absorptiometry (Salzman)
Ozone	1 hour	200 (0.10)	Chemiluminescence
TSP	24 hours	260	High Volume Sampler
Lead	24 hours	60	Atomic Absorption
Hydrogen sulfide	30 minutes	42 (0.03)	Absorptiometry (Hg Thiocyanate)
Ammonia	24 hours	1360 (2)	Absorptiometry (Nestler)
Hydrocarbons	3 hours	160 (0.24)	FID Gas Chromatography

Source : State Minister Decree for Population and Environment No. 02/1988 (Ref. 191)

Table 5.4.2 National (Draft) and DKI Jakarta Ambient Air Quality Standards

Parameter	Time of measurement	Standards	
		National - Draft	DKI Jakarta
Sulfur dioxide	1 hour 24 hours 1 year	900 μ g/m³ (0.34 ppm) 300 μ g/m³ (0.11 ppm) 60 μ g/m³ (0.02 ppm)	900 μ g/m³ 300 μ g/m³ 60 μ g/m³
Carbon monoxide	1 hour 8 hours 1 year	30,000 μ g/m³ (26 ppm) 10,000 μ g/m³ (9 ppm)	26,000 μ g/m³ 9,000 μ g/m³ 9,000 μ g/m³
Nitrogen dioxide	1 hour 24 hours 1 year	400 μ g/m³ (0.21 ppm) 150 μ g/m³ (0.08 ppm) 100 μ g/m³ (0.05 ppm)	400 μ g/m³ 150 μ g/m³ 100 μ g/m³
Oxidant as O_3	1 hour 24 hours 1 year	160 μ g/m³ (0.08 ppm) - -	200 μ g/m³ 50 μ g/m³ 30 μ g/m³
Suspended Particulates (TSP)	24 hours 1 year	230 μ g/m³ 90 μ g/m³	230 μ g/m³ 90 μ g/m³
Suspended Particulate Matters (SPM)	24 hours 1 year	- -	180 μ g/m³ 60 μ g/m³
Lead	24 hours 1 year	2.0 μ g/m³ -	6 μ g/m³ 1 μ g/m³
Hydrocarbon	3 hours	160 μ g/m³ (0.24 ppm)	150 μ g/m³

Note : Values are based on the atmospheric conditions of temperature: 25 °C and pressure 1 atmosphere.

It is necessary to establish an air monitoring system, for the purpose of ascertaining whether the air quality standard is observed or not, and what would be the effects of air pollution control measures. Local governments must be provided with organizations and appropriations for this purpose. The results of the monitoring should be made public annually. It may be possible to insert these articles in the draft revision of the Basic Provisions for the Management of the Living Environment, Act No. 4, 1982. BAPEDALDA (Local Environmental Management Agency), now being organized by the Ministry of Interior, is considering installation of environment monitoring stations. BAPEDAL should be involved and consulted for the installation and appropriations for the management of these stations.

(2) Emission standards for stationary emission sources

The Decree of the State Minister 'Emission standards for stationary emission sources' (KEP-13/MENLH/3/1995; Ref. 110) regulates emissions from four (4) prime industries (iron & steel, pulp & paper, cement, and coal fired steam power plants) and all other industries. The Standards are in effect in two (2) target years of 1995 and 2000 as shown in Table 5.4.3.

Table 5.4.3 Maximum Limit of Emissions from Selected Stationary Sources

(Unit : mg/m^3)

Sources		TSP	SO_2	NO_2
Four Prime Industries	Electric Arc Furnace	600 (150)	- -	- -
	Power Boiler (ex. Power Ind.)	400 (230)	1,200 (800)	1,400 (1,000)
	Power Ind. Boiler (Coal)	300 (150)	1,500 (750)	1,700 (850)
	Cement Kilns	150 (80)	1,500 (800)	1,800 (1,000)
Other Industries		400 (350)	1,500 (800)	1,700 (1,000)

Notes : 1) Nitrogen Oxides is expressed as NO_2.
2) Gas volume is on dry basis at a standard conditions of temperature: 25 °C and pressure = 1 atmosphere.
3) The standards shall be met in 95% of the time during a normal operation computed over a period of three months, except 'other industries'.
4) Oxygen correction is different for each facilities.
5) Figure in brackets are values to be effective in 2000, otherwise already effective since 1995.

Source: State Minister Decree for Environment of the Republic of Indonesia (Ref. 110)

It seems unfair that facilities of the same type, for example boilers, have different emission factors in different industries. It is recommended, therefore, that inventory surveys be conducted to understand the whole situation of facilities in Jabotabek.

(3) Emission standards for vehicle emission gas

Emission standards for vehicles emission gas (Ref. 104) as given in Table 5.4.4 regulate the permissible limit of polluted matters emitted from the vehicles. The standards are applied for both new and presently used cars.

Table 5.4.4 Standards for Emission Gas of Motor Vehicles

Items	Standards
CO	up to 4.5%
HC	up to 3,000 ppm (2 Wheel, 2 Stroke) up to 2,400 ppm (2 Wheel, 4 Stroke) up to 1,200 ppm (4 Wheel)
Black Smoke	no more than 50%

Notes : 1) Concentration of CO and HC is measured in idling condition.
2) Concentration of Black Smoke is measured at free acceleration.
Source: Ambang Batas Emisi Gas Buang Kendaraan Bermotor KEP-35/MENLH/10/1993 (Ref. 104)

5.5 Training System

5.5.1 Environmental Education

(1) PSL (Environmental Research Center)

In 1985, a year before the implementation of AMDAL, AMDAL training courses were established at PSL in the University of Indonesia. The first PSL was founded in 1972 as the Ecological Institute in Padjadjaran Bandung University. Then, environmental institutes were established one after another in universities, and BKPSL (Environmental Research Center Community), a network involving 50 PSLs, was organized in 1985. Now the country has 65 PSLs, including that of the University of Indonesia, under BAPEDAL's assistance.

AMDAL training consists of the AMDAL-A course (basic course), the AMDAL-B course (report preparation course) and the AMDAL-C course (evaluation course). PSL of the University of Indonesia has already given the instruction for the A course 68 times, the B course 18 times, and the C course 7 times. Although almost same contents of training are given in the PSLs, it is characterized by universities' locations. In the University of Indonesia, for instance, importance is laid on urban development issues. Thirty-five staffs are in charge of training, while the teaching staff of the university's departments and qualified people other than the teaching staff are invited as lecturers. The expenses are covered by training fees.

PSLs play a very important role as the qualification organization in the AMDAL system. However, they are not assisted by the government in human resources and financing. The fact that PSLs have operated only with training fees is not a situation desirable for their further expansion and development. It is necessary to give the PSLs official assistance, because the spread of the system cannot be expected as long as training fees are so high.

(2) EMC (Environmental Management Center)

EMC was established in 1993 as the BAPEDAL's supporting facility for reference laboratory, environmental monitoring, environmental information management, and environmental training. Training is given every year in the form of workshop. So far, Technical training has been given mostly to EMC personnel. EMC is expanding full scale training to personnel of ministries and agencies concerned, and of local governments. In addition, exhibition facilities and environmental public education should be provided, for the purpose of promoting environmental education in NGOs and schools. EMC is expected to play the role of an environmental education center.

After the organizational reform in 1994, EMC became an organization directly controlled by the Head of BAPEDAL. EMC is expected to have capability of giving technical support to the whole organization of BAPEDAL. EMC may supply human resources to BAPEDAL Headquarters which is in shortage of the resources currently.

5.5.2 Utilization of ISO 14000

The Guideline for the Execution of Environmental Inspection was compiled in accordance with the Notification No. 42 of the Ministry of Environment, in November 1994, and the following lines were defined:

- "Environmental inspections shall be conducted voluntarily by the person in charge in an organization."
- "Environmental inspections shall be conducted in accordance with the Guideline."
- "The results of environmental inspections shall be reported, with external certification, and the environmental management system and the environmental management results being defined."

BAPEDAL arranged a seminar in August 1995 under the title of "Is It Possible to Implement ISO 14000 in Indonesia or Its Implementation is Only a Dream?" BAPEDAL organized six groups to study environmental management systems (EMS), environmental inspection, etc., in order to introduce ISO 14000, which was implemented in September 1995. An action program was prepared in November 1996 jointly by BAPEDAL and DSN (National Standard Conference). The program includes the following plans to be implemented by March 1998.

1) Conducting clean production and EMS on a trial basis
2) Establishing a certification and registration system
3) Enforcing an environmental inspection system
4) Preparing a training curriculum on ISO 14000
5) Evaluating EMS-demonstrating industries
6) Comprehensive evaluation of EMS

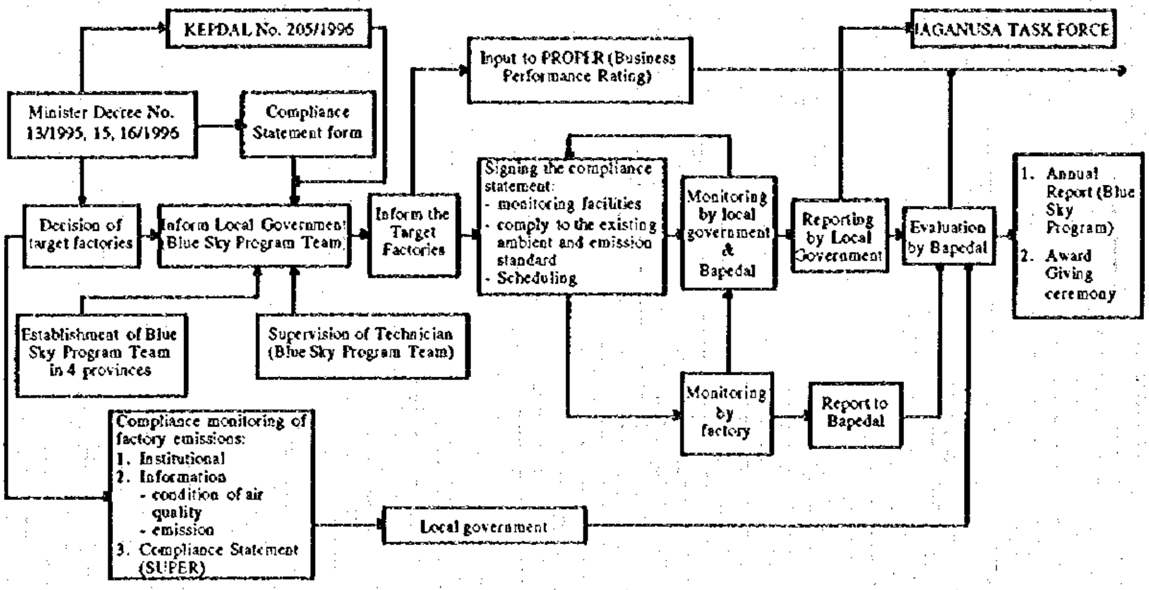
INKINDO (Local Consultant Association) presently gives a seminar on environmental inspection, for introducing external inspection. BAPEDAL is preparing for establishing the Technical Certification Committee (KAIT), a certification organization, so that it can conduct ISO 14000 inspections. BAPEDAL also gives training in the Human Resources Development and Environment Institute (PPSML) of the University of Indonesia, for the purpose of internal environmental inspection. Training lasts for 10 days, with a fee of Rp.1,250,000.

As the introduction of ISO 14000 is expected, it is recommended that the voluntary execution of environmental inspections by industries be made mandatory by the revision of Environmental Conservation Basic Act. Specifically, voluntary environmental inspections shall be conducted first of all in the large-scale factories which are required to make reports based on RKL and RPL in accordance with AMDAL. It is also recommended that an environmental inspector and examiner training course be conducted in PSLs as a new certification system.

5.6 Blue Sky Program

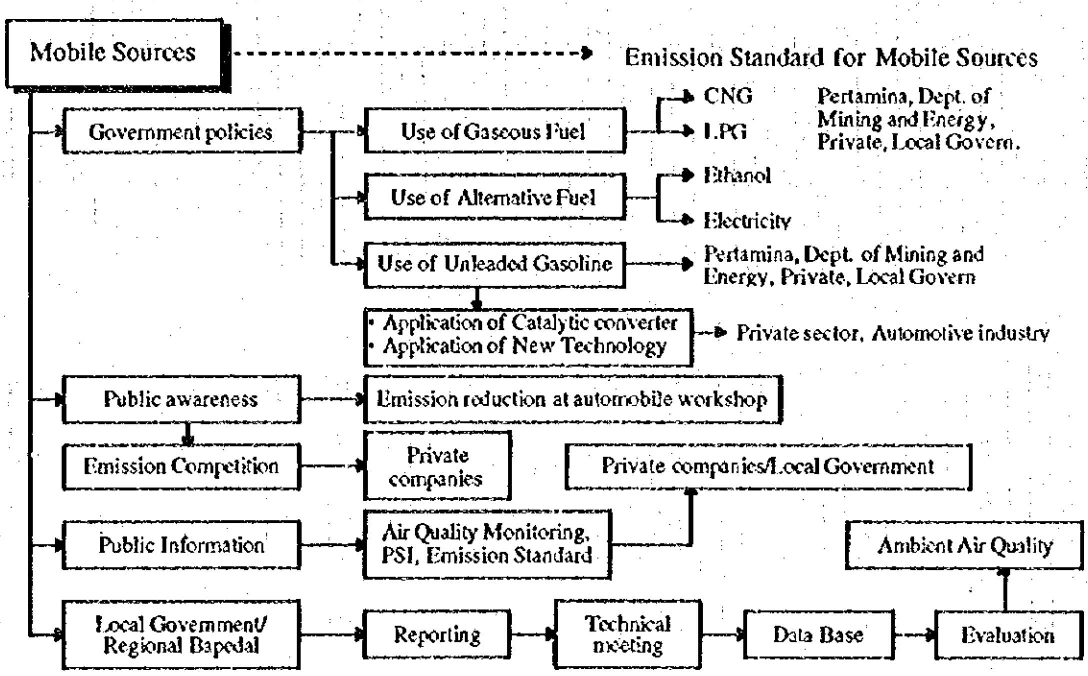
BAPEDAL responded to the increasing air pollution problems by introducing the air pollution control program, Blue Sky Program, in July 1992. The Blue Sky Program was aimed at restoring air quality to meet the designated air quality standards and the improving air quality. At first, the Blue Sky Program was implemented in four provinces, Jakarta, West Jawa, Central Jawa, and East Jawa. This will be expanded shortly to other provinces.

The Blue Sky Program deals with two separate sources of air pollution, stationary and mobile sources. With regards to stationary sources, the Blue Sky Program determines target areas for each source of pollution, targets reductions of emissions from industries in the designated areas, and implements law enforcement, improvement of institutional capacity, development of annual reporting systems, and performance assessment as shown in Figure 5.6.1. As for mobile sources, the Blue Sky Program monitors and implements control of measures including technological advancement, energy policies such as the application of gas fuel and unleaded gasoline, monitoring of emissions from vehicles, law enforcement, development of annual reporting system, and performance assessment as shown in Figure 5.6.2.



Source : The Blue Sky Program, BAPEDAL

Figure 5.6.1 Stationary Emission Source Control



Source : The Blue Sky Program, BAPEDAL

Figure 5.6.2 Mobile Emission Source Control

5.7 Existing Ambient Air Monitoring System

Monitoring of the air pollution in Jabotabek was started in the 1970s by the Meteorological & Geophysical Agency (BMG), followed by the Ministry of Health (MOH), Research Center for Urban Development (KPPL), and the Environment Management Center (EMC). The monitoring stations are as follows :

BMG	7 stations
MOH	4 stations
KPPL	12 stations
	6 stations (continuous and automated monitoring and 4 of them are monitoring stations in the Study)
EMC	1 station (continuous and automated monitoring and this station is monitoring station in the Study)

a) BMG

The BMG headquarters located in the center of DKI Jakarta measures SO_2, NOx, TSP and O_3 for 24 hours every 6 days. The other 6 stations measure only TSP in the city and rural area.

b) MOH

MOH measures SO_2, NOx and TSP for 24 hours every 6 days at 2 stations by the Directorate of Environmental Health (BTKL) and at the other 2 stations by the Health Ecology Research Center (PPEK). The 2 stations of PPEK, which were transferred to BTKL recently, are included in the stations of the Global Environment Monitoring System under WHO.

c) KPPL

KPPL measures SO_2, NO, NO_2, TSP and Pb for 24 hours every 8 days (Pb is measured once a month) in 12 stations relocated in 1995. Continuous and automated monitoring is carried out for SO_2, NO, NO_2, CO, SPM, Ox(O_3) and HC at 4 stations, which are Pulogadung, Pluit, Thamrin and KPPL under this Study in addition to 2 other stations, Gambir and Ragunan/Pasar Minggu.

d) EMC

EMC located in Serpong, 25 km southwest of Jakarta, measures SO_2, NO, NO_2, CO, SPM, Ox and HC by continuous and automated monitoring. EMC plans to set up a new station in Tangerang.

CHAPTER 6 ANALYSIS OF AIR POLLUTION MECHANISM

6.1 Outline

This chapter describes the Dispersion Simulation Model and Chemical Mass Balance (CMB) method used in the analysis of air pollution.

The Dispersion Simulation Model is based on Gaussian plume and puff equations. The model relates pollutants emitted from sources and their environmental concentrations. To establish the relation, accurate source inventory and adequate meteorological data are necessary. With those accurate and adequate data, the properly adjusted model can give the simulation result soundly representing the relation of the sources and the concentration. The purpose of this simulation is to clarify the relation between each source, as well as its pollutant emission amount, and environmental concentration.

Dispersion simulation represents the phenomena with computer that the pollutants emitted from the source such as factories, motor vehicles etc. are diffused by the wind. With more accurate source information data, meteorological data and measured actual concentrations, the accuracy of the simulation model become higher.

Study Team developed the Dispersion Simulation Model for Jabotabek area using collected source information, environmental concentrations and meteorological data.

This simulation model clarify the following features;

a) This simulation model can be used for the calculation of present and future concentration in whole Jabotabek area.
b) The result of calculation for present concentration shows that the concentration of one grid exceeds the proposed National AAQS for SO_2, and also 3 grids exceed for NO_2, and CO concentration satisfy the standard at all calculated grids.
c) For SPM, the influence of unknown sources are relatively high, so the model can not be used for the prediction of SPM concentration.

The simulation for the Jabotabek district was introduced in this Study. BAPEDAL is expected to accumulate higher quality source inventory and precise meteorological data representing the district.

The CMB method calculates the effect of each source contribution to SPM concentration in the ambient air, by solving the equation using individual elements from ambient air and from sources. The CMB method may be placed as complementary to the Dispersion Simulation model. Also, as indicated in Section 3.4, additional useful results were obtained. However, CMB method can estimate contributions from sources only at sampling points and can not estimate the spatial distribution of SPM in the whole Jabotabek area.

The CMB method clarify the following features;

a) Calculated values are around 70 % of the measured SPM and TSP concentrations as averages at each sampling site, and the remainders are contributions from unknown sources.
b) Around 45 % of SPM are caused by diesel vehicles and around 35 % to 45 % of TSP by soil.

6.2 Dispersion Simulation

6.2.1 Dispersion Simulation Model

(1) Objectives of the Jabotabek Air Pollution Simulation Model

The Team was provided with a simulation model system 'KILDER' by NILU. The Team decided to reconstruct it to a new model for improvement of the following items :

- Graphic Interface:
  Can show some graphs like scatter diagram, concentration map etc. on display and print them on any printers supported by Windows 95
- Operation:
  Can be operated easily by mouse clicks
- Line Source Dispersion Model for Roadside Pollution:
  Include line source dispersion model for motor vehicles
- Calm wind case:
  Include Gaussian puff equation for calm condition
- Oxidation to NO_2:
  Include exponential conversion model for NO_2 estimate
- 4 stability classes, 4 wind speed ranks and 12 wind directions:
  Expand to 11 stability classes, 8 wind speed ranks, and 16 wind directions

Accordingly, the Simulation Model called 'SURASH' was developed to emulate the air pollution in Jabotabek, by comparing with the actually monitored ambient air qualities. The notable features of the model are as follows:

- Simulated air pollutants are SO_2, NO_x, NO_2, and CO;
- Calculated value is annual average concentration;
- Pollutant sources are motor vehicles, factories and establishments (including power plants, cement factory, etc.), ships, aircraft, households; and
- Target area is Jabotabek.

(2) Methodology

The model is outlined below:

- Input data are meteorological data, ambient air quality data, and pollutant source data
- CONCAWE Equation (Ref. 217) and Briggs Equation (Ref. 217) for the height of the plume rise, and
- Gaussian Plume Equation and Gaussian Puff Equation for the dispersion model

The simulation procedure is shown in Figure 6.2.1.

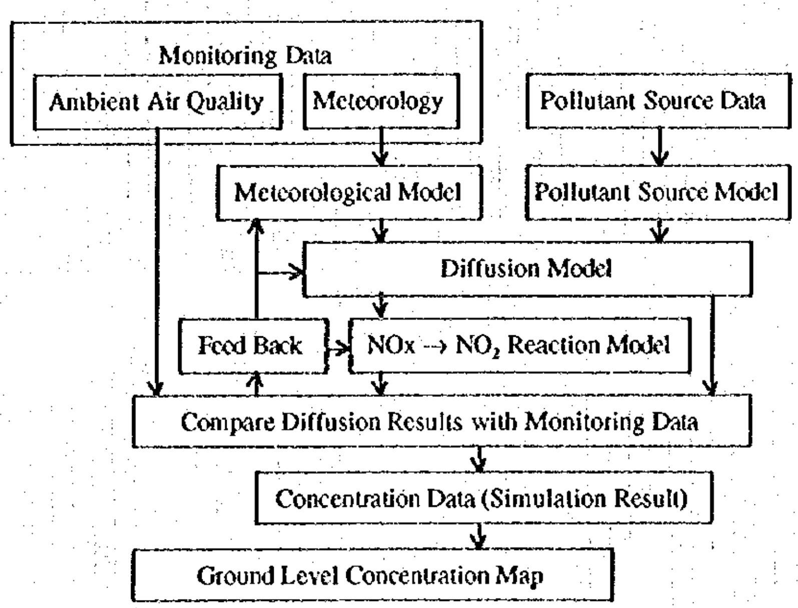


Fig. 6.2.1 Flow Chart of Diffusion Simulation

(3) Target Years

The target years are 1995 for the present case, and 2010 for the future case.

(4) Averaging Time of Concentration

Long-term average (annual average) of concentration is calculated to omit hourly, daily and seasonally drifts and errors.

To simulate concentration of annual average, first, the meteorological information was grouped by the matrix of 16 wind-directions, 8 ranks of wind-speed and 11 stability classifications for each matrix of 4 seasons and 4 time zones. Second, dispersion of pollutants per source was calculated for average condition of each matrix. Third, it is summarized to average concentration by each season-time zone. Finally, annual average was calculated, using the following equation:

$$C_y = \sum_t \left(\sum_s \left(\sum_{rm} F(Q_s, W_{rm}) \cdot f_{rm} \right) \cdot f_t \right)$$

where

C_y	: Yearly average of concentration
t	: Matrix of season and time zone
s	: Pollutant source
rm	: Representative meteorology
$F()$	: Dispersion equation
Q_s	: Quantity of pollutant from each source
W_{rm}	: Meteorological information of each representative meteorology
f_{rm}	: Frequency of each representative meteorology compared with each season and time zone
f_t	: Ratio of each time zone compared with one year

(5) Pollutant Sources

Targets of pollutant sources in this Study are motor vehicles, factories & establishments (including power plants, cement factories etc.), ships, aircraft and households.

(6) Area of Simulation

Area of simulation is the whole area of Jabotabek (around 105 km long in the east-west direction and around 100 km in the north-south direction). Calculation was made for more than 6,600 center points of 1 km by 1 km meshes.

(7) Season and Time Zoning

Season was defined in order to consider the seasonal variation of effectual factors for diffusion, e.g. primary wind direction.

There is also daily variation of effective factors, e.g. solar and net radiation as well as traffic volume variation. To take them into account, one (1) year was divided into four (4) time zones by the variation of traffic volume and the concentration variation of air pollutant. The determined zones are shown in Table 6.2.1.

Table 6.2.1 Seasons and Time Zones

Seasons	Month
Rainy Season	January to March
Transition 1	April to June
Dry Season	July to September
Transition 2	October to December

Time Zones	Time
Morning	6:00 to 10:00
Afternoon	10:00 to 17:00
Night	17:00 to 24:00
Midnight	0:00 to 6:00

(8) Applied Meteorological Data

BMG data had been referred for, and EMC and Pulo Gadung were selected for the simulation. After examination of wind roses and diurnal changes of wind speed, wind data at EMC for Botabek area and Pulo Gadung for Jakarta area were used. Net radiation was observed only at EMC. Based on the data, atmospheric stability was evaluated by Senshu Method, and the details are included in Appendix 4.1.1. Vertical zoning, correction of wind speed with vertical zones, and meteorological classification are also included in Appendix 4.1.1.

(9) Source Type

Sources with quantitative air pollutants were modeled as point or line sources individually. Sources with small pollutants were compiled to area sources. The definition of modeling is shown in Table 6.2.2.

Table 6.2.2 Source Type

Source Category	Size/Condition	Source Types for Simulation
Factory & Establishment	Large Small	Point Area
Household	All	Area
Motor Vehicle	Major Road Minor Road	Line Area
Ship	Mooring Cruising	Point Area
Aircraft	Approach & Climb Out Take Off Idling & Taxiing	Point (Series) Line Area

(10) Dispersion Model

1) Effective Stack Height

Effective stack height was calculated for point sources and set for line and area sources. The CONCAWE equation was used for windy condition and the Briggs equation for calm condition as shown below. Settings for line and area sources are included in Appendix 4.1.1.

The CONCAWE equation (Ref. 217) is as follows:

$$H_e = H_0 + 0.175 \cdot Q_H^{\frac{1}{2}} \cdot u^{-\frac{3}{4}}$$

where

H_e : Effective stack height (m)
H_0 : Actual stack height (m)
Q_H : Released heat (cal/s)

$$Q_H = \rho \cdot C_p \cdot Q \cdot (T_G - T_A)$$

where

ρ : Air density at 0°C (1.293×10^3 g/m^3)
C_p : Isopiestic specific heat (0.24 cal/K/g)
Q : Volume of emitted gas (m^{3}N/s)
T_G : Temperature of exhaust gas (°C)
T_A : Temperature of atmosphere (28 °C)
u : Wind speed at stack top (m/s)

The Briggs equation (Ref. 217) is as follows:

$$H_e = H_0 + 1.4 \cdot Q_H^{1/4} \cdot (d\theta / dz)^{-3/8}$$

where

$d\theta / dz$: Temperature gradient (0.005 °C/m for daytime, and 0.010 °C/m for nighttime)

2) Diffusion Equations

Gaussian plume model equation and gaussian puff model equation were selected for diffusion formulas, as shown in Table 6.2.3.

Table 6.2.3 Diffusion Formulas

Source	Windy	Calm
Point	Simplified Gaussian Plume Equation	Simplified Gaussian Puff Equation
Line	Simplified Gaussian Plume Equation	Simplified Gaussian Puff Equation
Area	Simplified Gaussian Plume Equation	Simplified Gaussian Puff Equation

a) Gaussian Plume Equation

The original formula of gaussian plume model is as follows :

$$C(x,y,z) = \frac{Q_p}{2\pi\sigma_y\sigma_z u} \cdot \exp\left(-\frac{y^2}{2\sigma_y^{\ 2}}\right) \cdot F$$

where

$$F = \left\{\exp\left[-\frac{(z-He)^2}{2\sigma_z^{\ 2}}\right] + \exp\left[-\frac{(z+He)^2}{2\sigma_z^{\ 2}}\right]\right\}$$

C : Concentration at calculation point.

x : Distance from source to calculation point along wind direction (m).

y : Distance from source to calculation point upright to wind direction (m).

z : Height of calculation point (m).

Q_p : Emission rate of pollutant (m^3N/sec).

u : Wind speed (m/sec).

He : Effective stack height

σ_y : Diffusion width upright to wind direction (m)

σ_z : Vertical diffusion width (m)

Because the original formula is time consuming in the practical use, this formula was simplified as the next one by Holland (Ref. 217) with the assumption that frequency inside each 16 wind direction ranks is constant, which is applied for the Jabotabek simulation model.

$$C(R,z) = \sqrt{\frac{1}{2\pi}} \frac{Q_p}{\frac{\pi}{8} R \sigma_z u} \cdot F$$

where

R : Distance from source to calculation point (m)

b) Gaussian Puff Equation

On the other hand, the formula of original gaussian puff model is as follows :

$$C(x,y,z) = \frac{Q_p}{(2\pi)^{3/2} \sigma_x \sigma_y \sigma_z} \cdot \exp\left(-\frac{(x-ut)^2}{2\sigma_x^{\ 2}} - \frac{y^2}{2\sigma_y^{\ 2}} \right) \cdot F$$

where

t : Time from stack or exhaust gas pipe (sec)

Others : same as the Plume Equation Section

It is also time consuming in the practical use and its simplified equation, which is used in Jabotabek simulation model, is as follows :

$$C(R,z) = \frac{Q_p}{(2\pi)^{3/2} \gamma} \cdot \left\{ \frac{1}{R^2 + \frac{\alpha^2}{\gamma^2}(He - z)^2} + \frac{1}{R^2 + \frac{\alpha^2}{\gamma^2}(He + z)^2} \right\}$$

where

$\alpha = \sigma_x / t = \sigma_y / t$ (t : 3600 sec)

$\gamma = \sigma_z / t$ (t : 3600 sec)

Diffusion width values for the plume and puff equations and diffusion index for stability classes are included in Appendix 4.1.1.

(11) Conversion Model from NOx to NO_2

Conversion model from NOx to NO_2 follows the exponential approximation model of Yamamoto, Yokoyama, et al. (Ref. 217). The equation is :

$$[NO_2] = [NOx]_D \left[1 - \frac{\alpha}{1+\beta} \{\exp(-Kt)+\beta\}\right]$$

where

$[NO_2]$, $[NOx]_D$: Concentration of NO_2 and NOx
α : NO/NOx ratio near pollutant source
β : NO/NOx ratio far from pollutant source
t : Time from stack/ exhaust gas pipe (sec)

$$K = F_K \cdot u \cdot [O_3]_B \cdot F_{O3}$$

where

F_K : Experimental constant
u : Wind Speed (m/s)
$[O_3]_B$: Background Concentration of O_3 (ppm)
F_{O3} : O_3 Background Correction Factor

Details on settings for the exponential approximation model are included in Appendix 4.1.1.

6.2.2 Simulation of Air Quality in 1995

(1) Evaluation of Simulation Model

Scatter diagrams of simulated results and actual measurement at monitoring stations are shown in Figure 6.2.2. Correlation coefficients were 0.67 for SO_2, 0.96 for NOx, 0.92 for NO_2, and 0.94 for CO. Background (Actual mean minus calculated mean) concentrations were -3.12, -1.69, 0.18, and 858.71 ppb, respectively. SO_2 was overestimated to some extent and CO was underestimated. Then, the simulation model can be used for the present and the future prediction for these pollutants and background values should be added to CO simulation values.

On the other hand, correlation coefficient and background value of SPM simulation were 0.15 and 72.87 ppb, so the model was not used for SPM prediction.

Source contributions to pollutant concentrations of SO_2 and NO_2 at monitoring stations are shown in Table 6.2.4. For SO_2 concentrations, factory contribution was high at Pluit and automobile contribution was high at Thamrin. For NO_2 concentrations, automobile was the largest polluter at all stations.

To increase the accuracy of stationary and mobile source inventory is the most important way for improvement of the dispersion simulation model. Accumulation of the basic data like emission measurements and locations of factories, emission factor measurement of automobiles, and traffic counting data of the major roads and so on is necessary for the establishment of more accurate dispersion simulation model.

Table 6.2.4 Source Contributions at Monitoring Stations

(Unit : ppb)

SO_2	Factory	Automobile	Home	Others	Total
EMC	1.7	0.1	0.3	0.0	2.1
Pulo Gadung	2.8	1.2	1.3	0.1	5.4
Pluit	9.4	1.5	1.2	0.1	12.2
Thamrin	3.8	7.7	1.9	0.1	13.4
KPPL	3.2	4.2	1.6	0.0	9.7
NO_2	Factory	Automobile	Home	Others	Total
EMC	0.9	1.4	0.3	0.0	2.6
Pulo Gadung	1.3	7.9	1.0	0.1	10.3
Pluit	2.1	8.3	0.9	0.1	11.5
Thamrin	1.6	35.6	1.3	0.1	38.6
KPPL	1.4	24.3	1.1	0.1	27.0

(2) Concentration Map of 1995

To predict the spatial distribution of air pollution in Jabotabek, calculation was conducted for center points of each of more than 6,600 grid cells. The height of calculated points was set as 1.5 m above ground. To avoid the very local effect from near pollutant sources of less than 30 m, calculation points were offset at distance of 30 m from the sources. The setting is reasonable because the sources are treated as point or line, but some offsets like road width or boundary to the outside exist in real situation.

The average concentrations for each season and time zone were calculated and weighted averaged to obtain the annual average concentrations. The concentrations at each grid are summation of each emission sources, which is more than 22,000 in Jabotabek for the present condition.

Concentration maps of SO_2, NO_2 and CO are shown in Figures 6.2.3 to 6.2.5, and maps of NOx and SPM are included in Appendix 4.1.2. The results should be compared with the annual values of the proposed National AAQS (Table 5.4.2). The calculations and comparisons were made in ppb unit because the factors in $\mu g/m^3$ by ppb are different from theoretical conversion factors to some extent. The conversion factor of SO_2 from ppb unit to $\mu g/m^3$ unit is 2.618, but the factor in Table 5.4.2 is 3.0 and so on.

Then, the calculated results were compared with 20 ppb for SO_2, 50 ppb for NO_2 of the proposed AAQS, and 8,100 ppb (9,000 $\mu g/m^3$) for CO using DKI Jakarta AAQS converted with the ratio of the proposed National AAQS.

The areas with relatively high SO_2 concentrations (more than 10 ppb) mainly spread in Jakarta Utara, Jakarta Pusat, Jakarta Barat, Cibinong, Kota Tangerang. Most of the concentrations are below the standard, and the concentration of only one grid at Grogol exceeded the standard (Figure 6.2.3). Power plants and glass factory at harbor side affect the SO_2 concentration in wide area of Jakarta Utara, Jakarta Pusat, and Jakarta Barat. Cement factories at Cibinong, and medium/small factories in Kota Tangerang and Kota Bekasi also caused the relatively high SO_2 concentration (Figure 6.2.4). Seven patchy grids more than 10 ppb SO_2 were caused by heavy traffic of automobiles. Two grids with relatively high SO_2 concentrations are caused by ships at Tanjung Priok Port (Figure 6.2.5).

The NO_2 concentrations in DKI Jakarta, Kota Tangerang , and Kota Beksi were generally higher than the concentrations in the other areas. Six spots with relatively high NO_2 concentrations (more than 30 ppb) gathered in Jakarta Pusat. However, three grids with high NO_2 concentrations more than the standards located beside the roads with heavy traffic in Jakarta Barat, Jakarta Timur, and Jakarta Utara, and NO_2 pollution was said to be local problem in 1995 (Figure 6.2.6). Contributions from stationary sources to NO_2 concentrations were only 3.5 ppb as a maximum and not so important (Figure 6.2.7). Most of the contributions to NO_2 came from automobiles (Figure 6.2.8).

CO concentrations are much below the standard and no problem in 1995 (Figure 6.2.9).

The causes of relatively high SO_2 concentrations were;

- Some factories like power plants, glass factories and so on
- Heavy traffic with relatively high sulfur diesel oil

- Ship activity with relatively high sulfur diesel oil

SO_2 concentrations exceeded the standard in only one grid. However, expansion of the factories and increase of road traffic and ship activity would cause SO_2 problem in the future. The impacts of some factories spread in wide area, and are more important than the ones of automobiles and ships.

The cause of relatively high NO_2 concentrations is exclusively the heavy traffic of automobiles. NO_2 concentrations exceeded the standard in only three grids in 1995. However, increase of road traffic would cause NO_2 problem in wide area like DKI Jakarta.

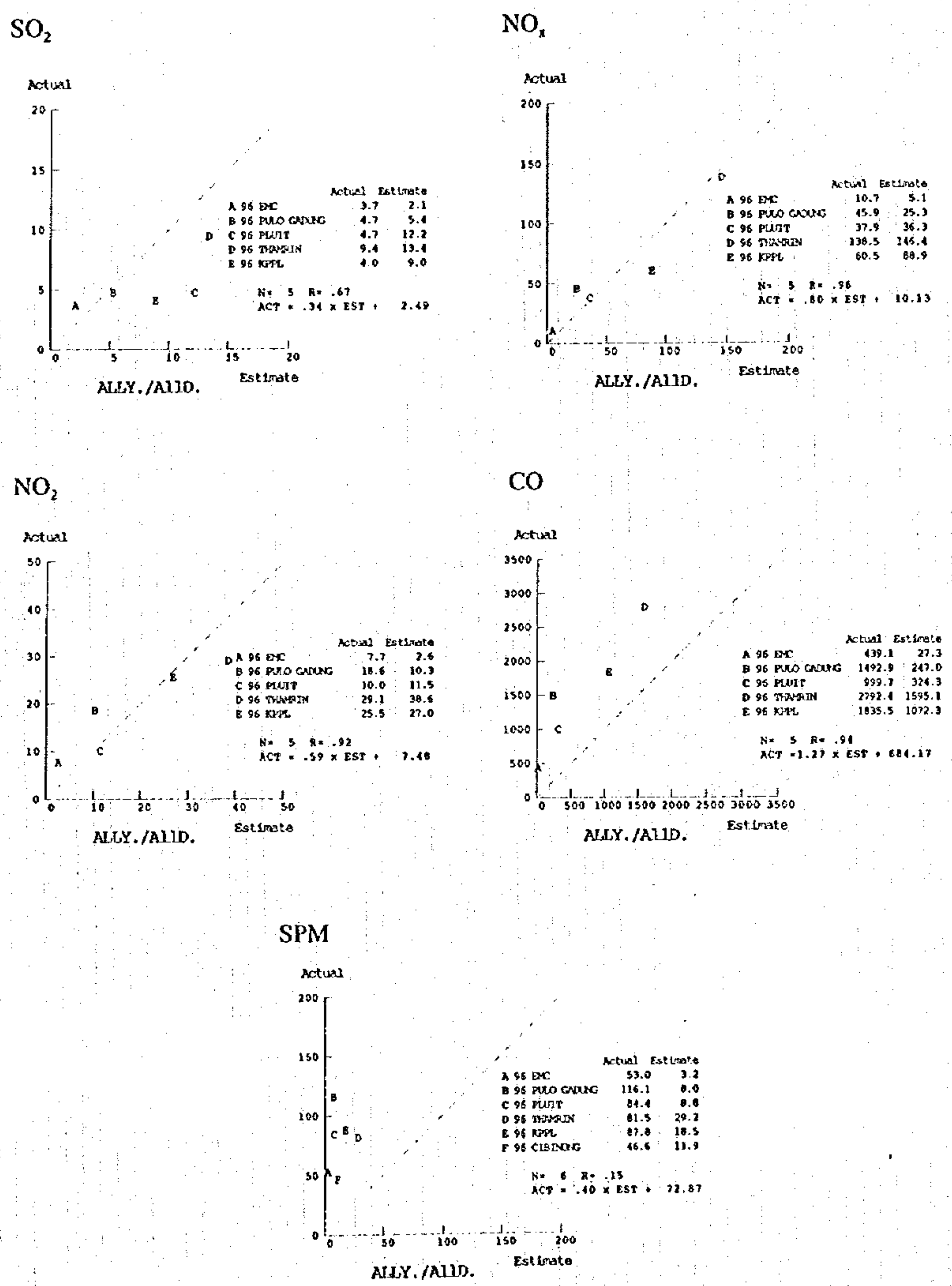
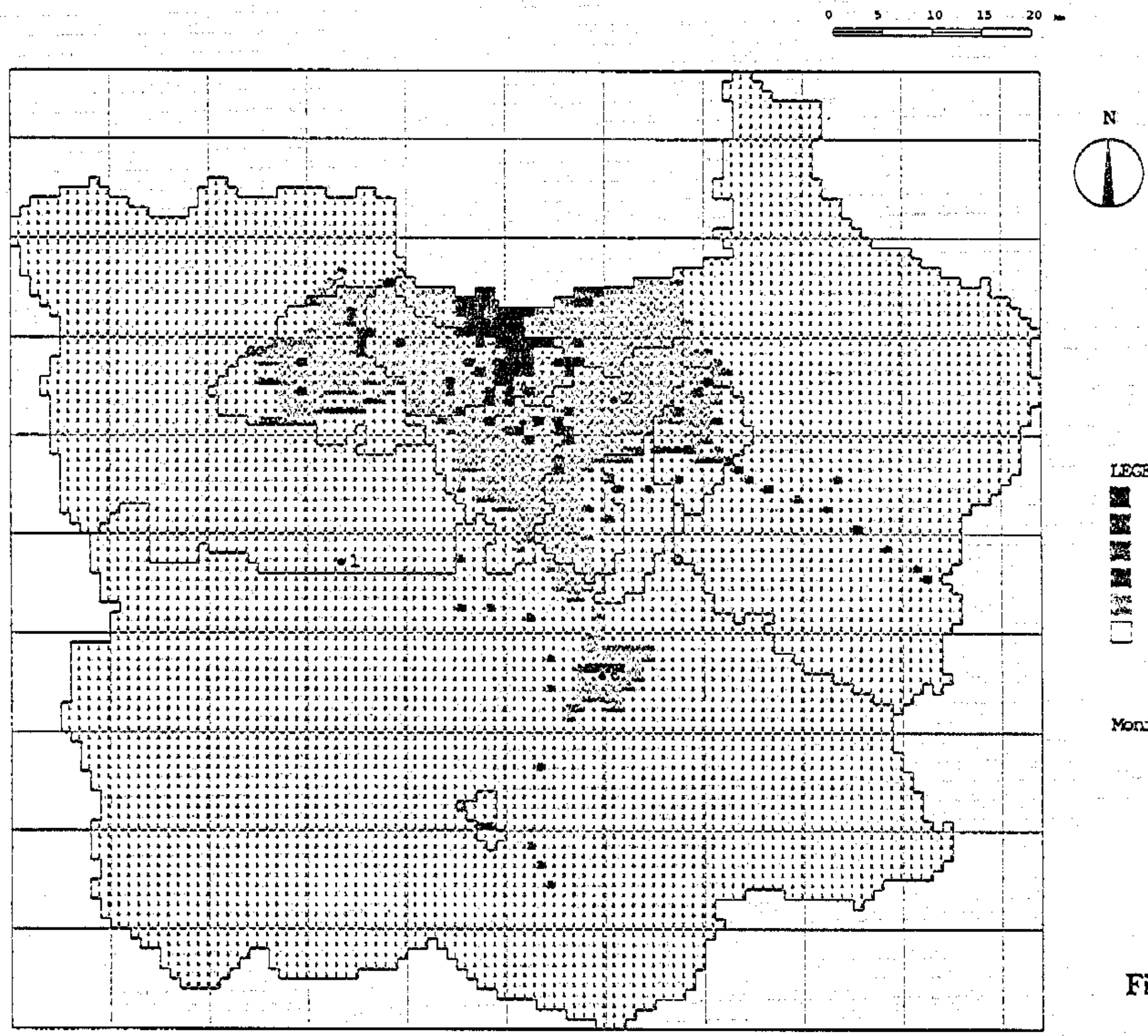


Figure 6.2.2 Scatter Diagrams of Calculation and Measurement

Present Condition (1995)



LEGEND

40. < x <=	80. (ppb)	0 grids
20. < x <=	40. (ppb)	1 grids
15. < x <=	20. (ppb)	8 grids
10. < x <=	15. (ppb)	92 grids
5. < x <=	10. (ppb)	748 grids
0. < x <=	5. (ppb)	5833 grids

Monitoring Stations
1 EMC
2 Pulo Gadung
3 Pluit
4 Thamrin
5 KPPL
6 Cibinong

Figure 6.2.3 Concentration Map of SO_2 from All Sources

SO2 ppb Annual Average

C MAX= 20.4ppb
Background Concentration: 0.ppb

Present Condition (1995), Stationary Sources

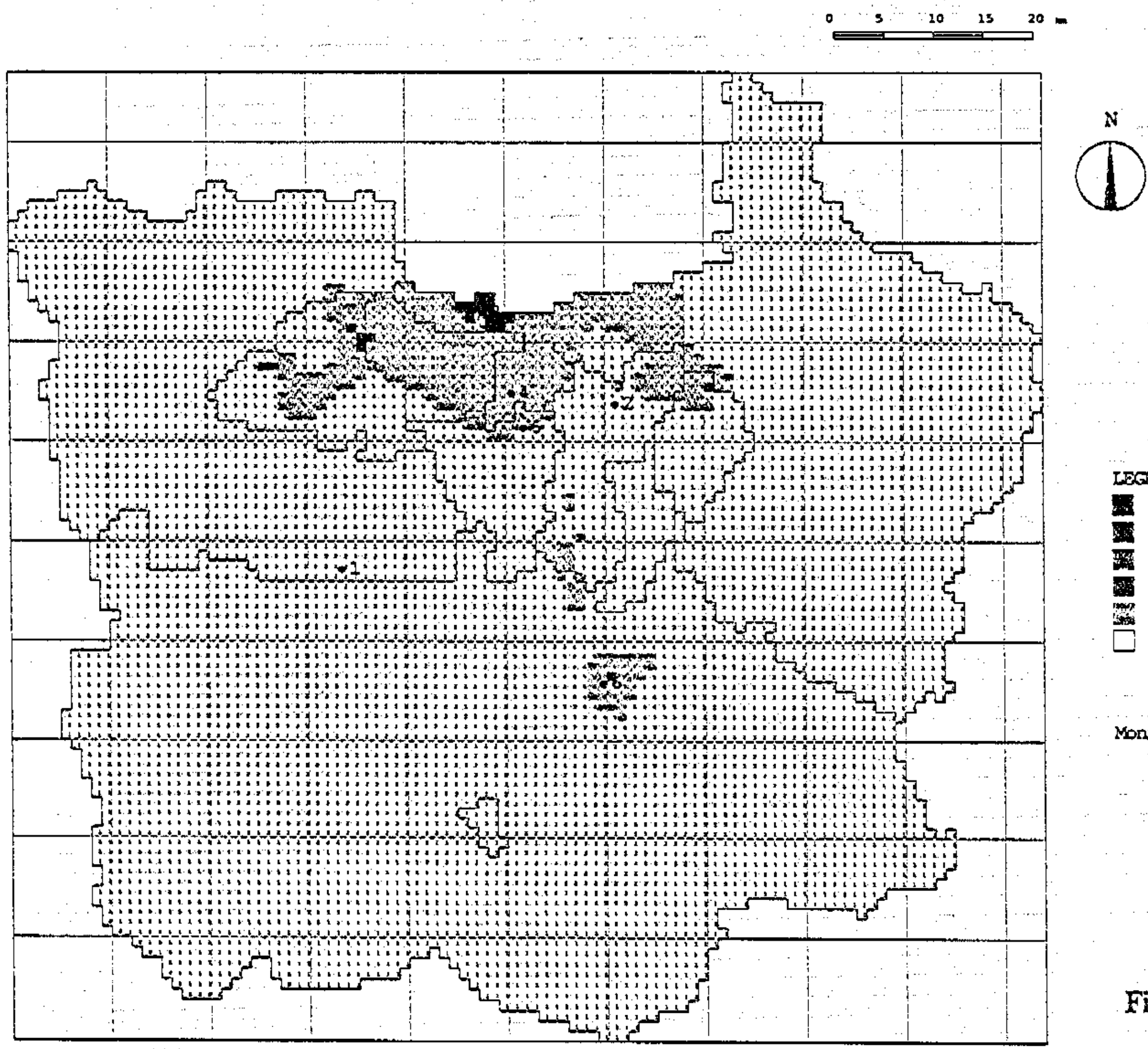
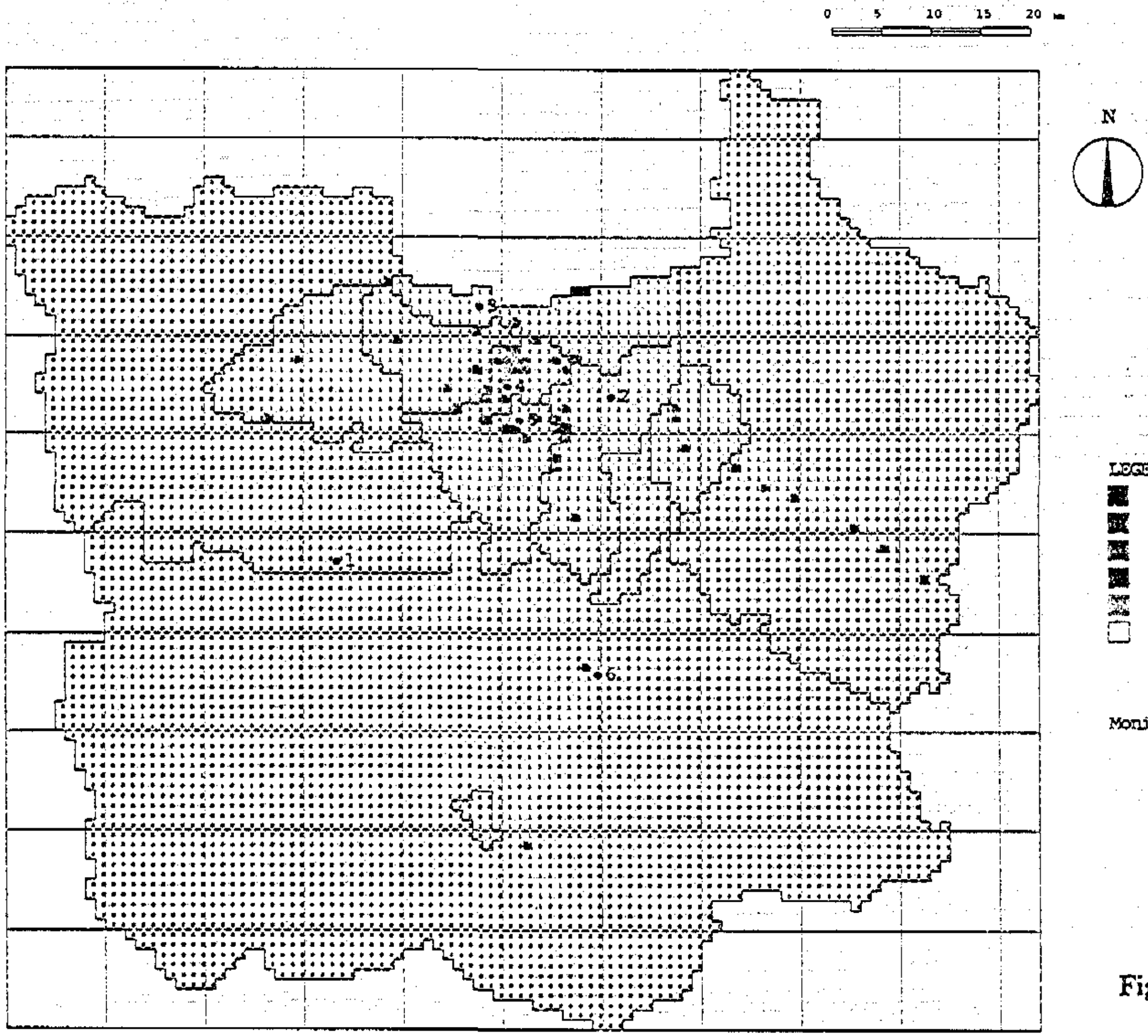


Figure 6.2.4 Concentration Map of SO_2 from Stationary Sources

Present Condition (1995), Mobile Sources



LEGEND

40. < x <=	80. (ppb)	0 grids
20. < x <=	40. (ppb)	0 grids
15. < x <=	20. (ppb)	1 grids
10. < x <=	15. (ppb)	8 grids
5. < x <=	10. (ppb)	43 grids
0. < x <=	5. (ppb)	6630 grids

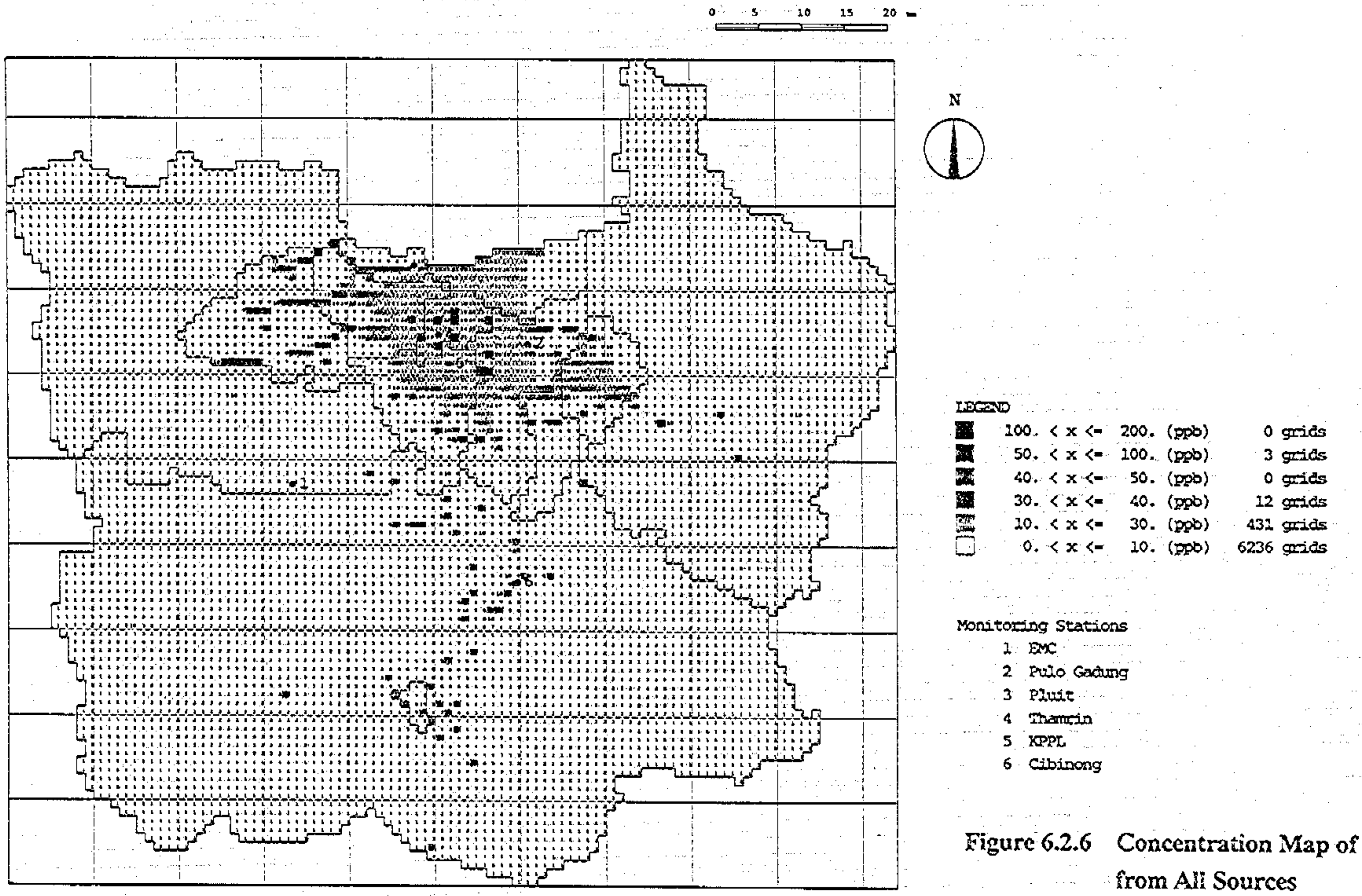
Monitoring Stations
1 EMC
2 Pulo Gadung
3 Pluit
4 Thamrin
5 KPPL
6 Cibinong

SO2 ppb Annual Average

C MAX= 15.0ppb
Background Concentration: 0.ppb

Figure 6.2.5 Concentration Map of SO_2 from Mobile Sources

Present Condition (1995)

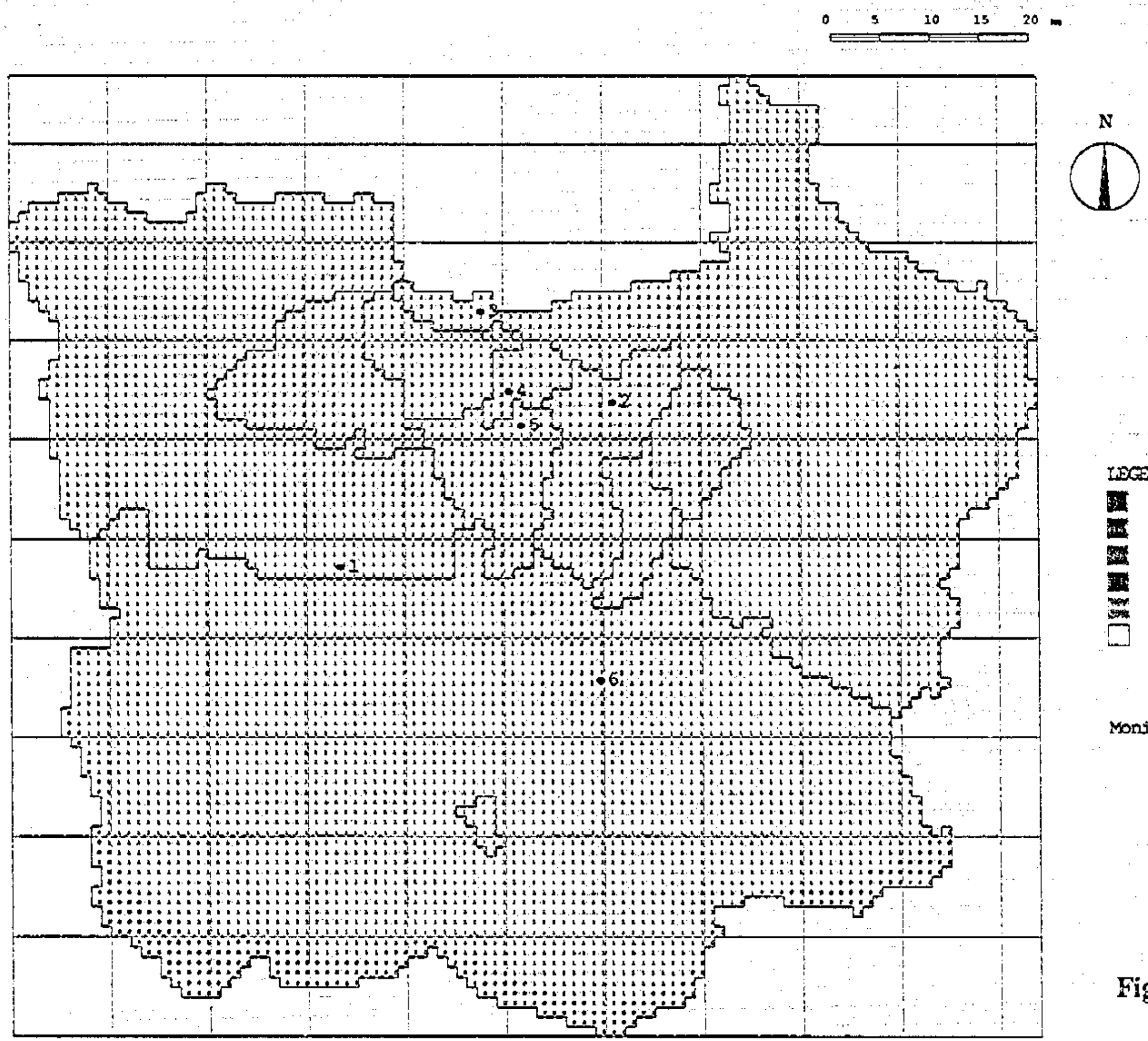


NO2 ppb Annual Average C MAX= 80.9ppb

Background Concentration: 0.ppb

Figure 6.2.6 Concentration Map of NO_2 from All Sources

Present Condition (1995), Stationary Sources



LEGEND

	100. < x <= 200. (ppb)	0 grids
	50. < x <= 100. (ppb)	0 grids
	40. < x <= 50. (ppb)	0 grids
	30. < x <= 40. (ppb)	0 grids
	10. < x <= 30. (ppb)	0 grids
	0. < x <= 10. (ppb)	6682 grids

Monitoring Stations
1 EMC
2 Pulo Gadung
3 Pluit
4 Thamrin
5 KPPL
6 Cibinong

Figure 6.2.7 Concentration Map of NO_2 from Stationary Sources

NO2 ppb Annual Average

C MAX= 3.5ppb
Background Concentration: 0.ppb

Present Condition (1995), Mobile Sources

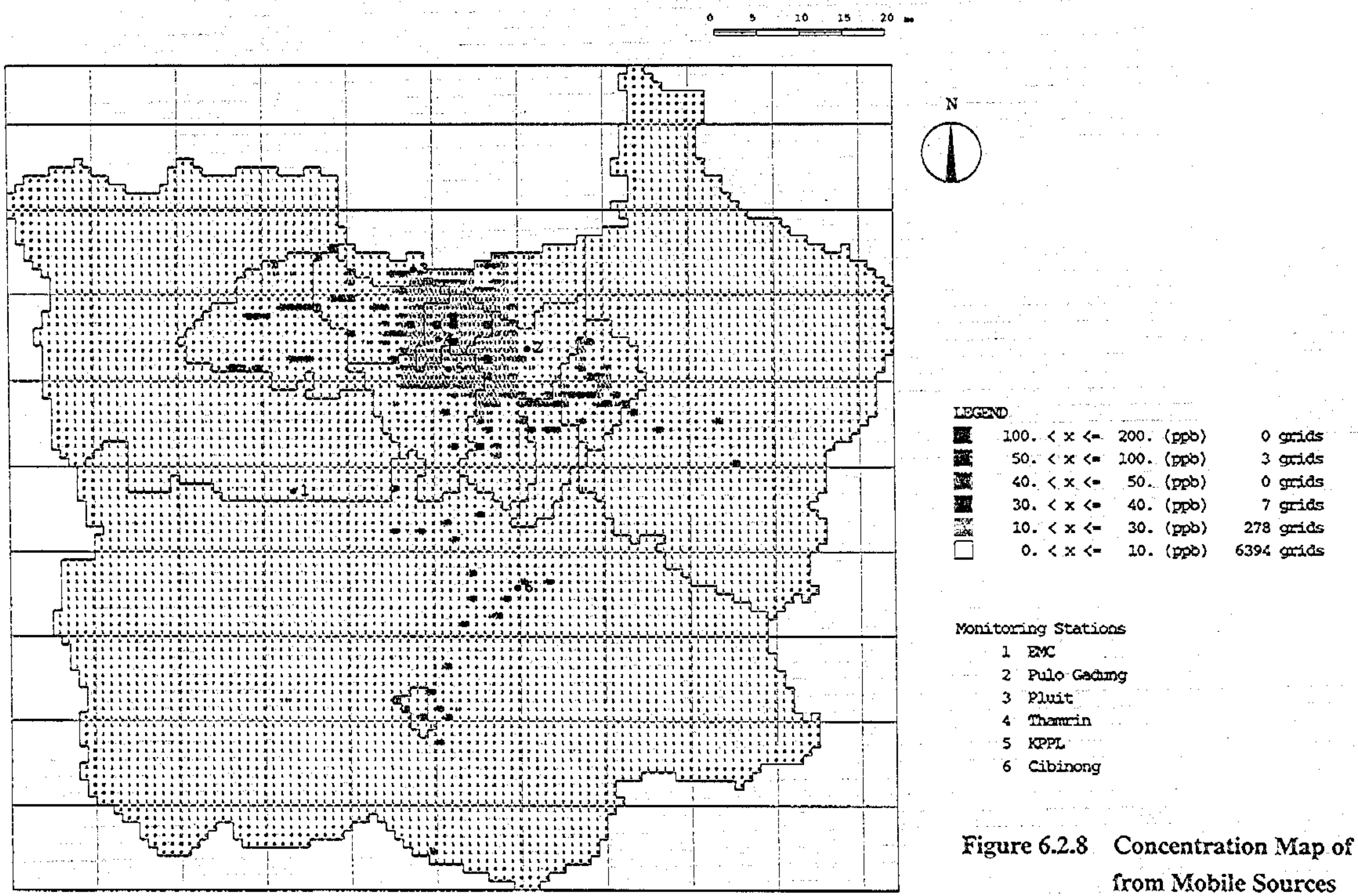


Figure 6.2.8 Concentration Map of NO_2 from Mobile Sources

NO2 ppb Annual Average

C MAX= 78.8ppb

Background Concentration: 0.ppb

Present Condition (1995)

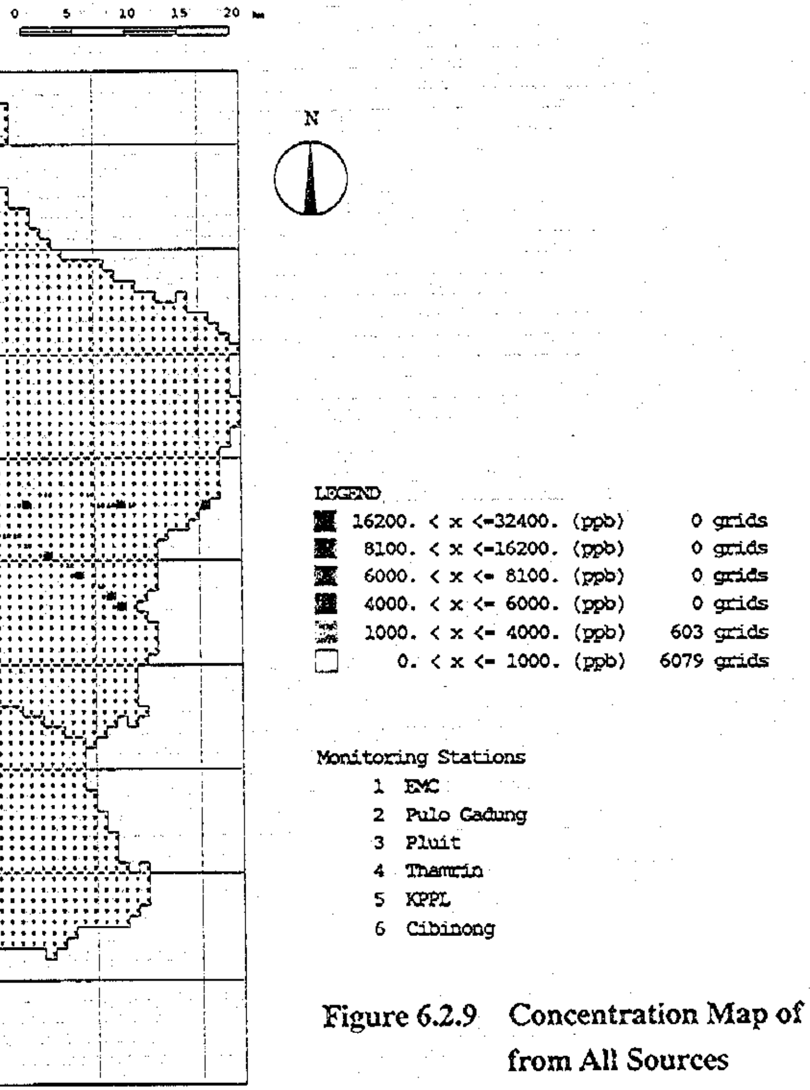


Figure 6.2.9 Concentration Map of CO from All Sources

CO 100ppb Annual Average

C MAX= 3077.3ppb

Background Concentration: 860.ppb

6.3 Chemical Mass Balance Method

6.3.1 Outline of CMB Method

CMB (Chemical Mass Balance) method is a type of receptor model and statistical model to estimate the contributions from sources to ambient SPM concentration. The sources of SPM are divided into artificial sources and natural ones. The former includes the different kinds of factories, various types of motor vehicles, etc. The latter includes soil particles, sea salt particles, and others. One special feature of SPM component is the high contribution by natural sources and it is therefore very difficult to establish a completely physical model for estimating SPM due to natural processes. Hence, the CMB method provides an alternative way to effectively estimate the contributions by artificial and natural processes.

The particles are categorized into primary particles and secondary particles. The primary particles are those emitted in particulate form, but the secondary particles are those emitted in gaseous form and then converted to particulate form. For example, some parts of SO_2 are converted to SO_4 and finally to sulfuric acid or some forms of sulfate. CMB method targets the primary particles and the contributions by the secondary particles are estimated from their chemical components.

The mathematical formulation of CMB method is explained in the following. The receptor model for estimating the contributions by pollution sources is based on the law of conservation of mass. For example, assuming that (p) numbers of emission sources exist and suppose no interaction follows where mass change occurs, SPM concentration (C) measured at the receptor is obtained by taking the sum of contributions (S_j) of each emission source as in equation (1).

$$C = \sum_{j=1}^{p} S_j \qquad (1)$$

Similarly, concentration (C_i) of component (i) in the SPM is expressed by equation (2). Here, (a_{ij}) is the mass fraction of source contribution (j) possessing component (i) at receptor.

$$C_i = \sum_{j=1}^{p} a_{ij} S_j \qquad (2)$$

Assuming that (n) numbers of components are analyzed at the sources and receptors, then an equation is set up for each component. If the number (n) is greater than or equal to a number (p), we could obtain the answer by solving the set of p linear equations.

When the number (n) is greater than (p), a set of accurate values is obtained by minimizing the value (χ^2) expressed in equation (3).

$$\chi^2 = \sum_{i=1}^{n} \frac{\left(C_i - \sum_{j=1}^{p} a_{ij} S_j \right)^2}{w_i^{-2}} \qquad (3)$$

Here, (w_i) is the weight according to the extent of errors in measurement.

Equation (4) is the matrix from expression of equation (2).

$$C=AS \qquad (4)$$

Here (C) is n-dimensional vector of component concentration, and (A) is n by p matrix of mass fraction of sources, and (S) is n-dimensional vector of contributions by sources.

Generally, the solution by the least squares method is as follows:

$$S=({}^tAWA)^{-1}\,{}^tAWC \qquad (5)$$

Here, (W) is a diagonal matrix with diagonal components of w_i^2. ${}^tA$ is transpose of matrix A and X^{-1} is inverse matrix of matrix X. Errors of estimations for the source contributions depend on the way the weights (w_i) are chosen.

6.3.2 Analysis of PM Emission Source for CMB Method

To conduct the CMB method, the elemental components of particulates emitted from sources are necessary.

The samples analyzed were the following:

Automobile:	three (3) gasoline engines, three (3) diesel engines
Factories:	ten (10) boilers, four (4) furnaces, three (3) generators, two (2) cement kilns
Open burning:	four (4)
Soil:	two (2)

The particulates emitted from gasoline vehicles contain high concentrations of lead (Pb) and bromine (Br), and carbon contents dominate in particles from diesel vehicles.

The specific elements for various facilities were as follows:

Oil burning facilities:	Vanadium (V) and zinc (Zn)
Lead melting furnace:	Lead (Pb) and antimony (Sb)
Steel facilities:	Iron (Fe), manganese (Mn) and other heavy metals
Cement:	Calcium (Ca)

The results of analysis are included in Appendix 4.2.1.

6.3.3 Source Contribution by CMB Method

Ambient SPM and TSP concentrations (Appendix 2.4) were analyzed by CMB method. Following major sources of SPM/TSP were selected:

- Soil
- Sea salt
- Steel
- Oil burning
- Incineration
- Diesel vehicle
- Gasoline vehicle

The elemental profiles of major sources are based on analysis results of the samples in Jabotabek and arranged by the existing data in Japan (Ref. 246). The profiles of each source are compiled in Table 6.3.1. Selected elements for CMB method are Na, Al, K, Ti, V, Mn, Fe, Zn, Br, Pb, and elemental carbon. Source contributions at each sampling point are shown in Table 6.3.2 and Table 6.3.3.

Calculated values are around 70% of the measured SPM and TSP concentrations as average at each sampling site, and the remainders are contributions from unknown sources. Around 45% of SPM were caused by diesel vehicles at JICA Office and EMC and around 35% to 45% of TSP by soil at KPPL, Pulo Gadung, and Pluit. Diesel vehicles were major contributors for SPM and soil and diesel vehicles dominated in TSP.

Table 6.3.1 Elemental Profiles of Major Sources (1/2)

Element	Soil at EMC		Soil-Thamrin		Sea Salt		Steel	
	%	Error	%	Error	%	Error	%	Error
OC	0	0	0	0	0	0	0	0
EC	0.83333	0.16667	0.83333	0.01667	0	0	0.5	0.5
C	0	0	0	0	0	0	0	0
NH4+	0	0	0	0	0	0	0	0
NO3-	0	0	0	0	0	0	0	0
NA	0.01083	0.00043	0.14167	0.00283	30.4	1.52	1.36	0.272
AL	12.5	0.25	10	0.7	0.00003	0	0.999	0.2
SI	0	0	0	0	0.0087	0.00087	0	0
SO4-	0	0	0	0	0	0	0	0
S	0	0	0	0	2.6	0.26	4.79	0.958
CL	0.00833	0.00833	0.01667	0.00667	55.1	2.75	3.41	0.682
K	0.04167	0.01667	0.16667	0.06667	1.1	0.11	1.32	0.264
CA	0.33333	0.13333	0.83333	0.33333	1.17	0.0585	4.51	0.902
SC	0.00258	0.00005	0.00225	0.00005	0	0	0.00013	0.00003
TI	0.79167	0.095	0.625	0.06875	0	0	0.1	0.02
V	0.0225	0.00135	0.01917	0.00077	0.00001	0	0.0125	0.0025
CR	0.00158	0.00019	0.00225	0.00016	0	0	0.316	0.0632
MN	0.425	0.051	0.19167	0.02492	0.00001	0	2.2	0.22
FE	6.41667	0.12833	6.25	0.125	0.00003	0.00001	15.7	1.57
CO	0.00308	0.00003	0.00258	0.00005	0	0	0.0044	0.0044
NI	0.00042	0.00042	0.00075	0.0003	0	0	0.29	0.29
CU	0.08333	0.0225	0.225	0.0315	0	0	0.37	0.37
ZN	0.01083	0.00162	0.03333	0.00233	0	0	5.15	1.03
AS	0.00061	0.00002	0.00048	0.00002	0	0	0.0103	0.0103
SE	0.00008	0.00004	0.00003	0.00003	0.00001	0	0.00511	0.00511
BR	0.00049	0.00004	0.00392	0.00012	0.19	0.0095	0.0144	0.0144
RB	0.00033	0.00013	0.00083	0.00022	0.00035	0.0001	0.00768	0.00768
AG	0.00004	0.00004	0.00004	0.00004	0.00001	0	0.00542	0.00542
CD	0.00025	0.0001	0.00008	0.00008	0	0	0.0252	0.0252
SN	0.0025	0.001	0.00125	0.00125	0.00001	0	0.281	0.281
SB	0.00003	0	0.00013	0.00001	0	0	0.009	0.009
I	0.0025	0.001	0.00167	0.00067	0.17	0.017	0	0
CS	0.00021	0.00001	0.00021	0.00001	0	0	0	0
BA	0.01667	0.00183	0.02083	0.00208	0.00009	0.00003	0	0
LA	0.00225	0.00005	0.00142	0.00003	0	0	0.00097	0.00097
CE	0.00533	0.00021	0.00425	0.00017	0	0	0.00687	0.00687
SM	0.00053	0.00002	0.00033	0.00001	0	0	0.00002	0.00002
EU	0.00019	0.00001	0.00011	0.00001	0	0	0	0
YB	0.00026	0.00001	0.00017	0.00001	0	0	0	0
LU	0.00004	0	0.00003	0	0	0	0	0
HF	0.00042	0.00001	0.00042	0.00001	0	0	0	0
TA	0.00005	0.00001	0.00007	0.00001	0	0	0	0
W	0.00008	0.00003	0.00002	0.00002	0	0	0.00474	0.00474
HG	0	0	0	0	0	0	0.00858	0.00858
PB	0	0	0	0	0	0	1.44	1.44
TH	0.00067	0.00002	0.00064	0.00002	0	0	0	0

Table 6.3.1 Elemental Profiles of Major Sources (2/2)

	Fuel Oil		Waste		Diesel Vehicle		Gasoline Vehicle	
Element	%	Error	%	Error	%	Error	%	Error
OC	3.5	0.7	0	0	8.91667	1.16667	3.47	0.694
EC	80.3	16.1	0.5	0.5	63.83333	4.08333	80	16
C	83.5	16.8	0	0	72.75	5.25	83.5	6.35
NH4+	0	0	0	0	0	0	0.0272	0.00272
NO3-	0	0	0	0	0.65	0.13333	0.0246	0.00246
NA	0.354	0.354	12	1.2	0.08333	0.03333	0.186	0.037
AL	0.337	0.337	0.42	0.084	0.2	0.08333	0.1	0.05
SI	0	0	0	0	0	0	0	0
SO4-	0	0	0	0	6.41667	1.83333	0.425	0.0425
S	0	0	13	1.3	0	0	0	0
CL	0.156	0.156	27	2.7	0	0	0.21	0.042
K	2.44	2.44	20	2	0.075	0.02	0.05	0.05
CA	0.197	0.197	1.1	0.22	0.16667	0.125	0.05	0.05
SC	0.00003	0.00003	0.00005	0.00001	0.00003	0.00001	0.00002	0.00001
TI	0.0831	0.0831	0.09	0.018	0.01583	0.0125	0.1	0.1
V	0.36	0.36	0.0027	0.00054	0.0008	0.00021	0.00045	0.00045
CR	0.00875	0.00875	0.085	0.085	0.001	0.00025	0.003	0.00078
MN	0.00389	0.00389	0.033	0.033	0.00367	0.00117	0.011	0.00165
FE	0.3	0.3	0.61	0.61	0.09167	0.03333	0.22	0.044
CO	0.00142	0.00142	0.0021	0.0021	0.00006	0.00005	0.0028	0.0002
NI	0.217	0.217	0	0	0	0	0.012	0.0024
CU	0.0407	0.0407	0.36	0.072	0	0	0.03	0.03
ZN	0.025	0.025	2.6	0.52	0.03917	0.0275	0.14	0.0042
AS	0.00666	0.00666	0.015	0.015	0.00023	0.00005	0.00035	0.00035
SE	0.00684	0.00684	0	0	0	0	0.0001	0.0001
BR	0.00438	0.00438	0.083	0.0166	0.00317	0.00175	1.2	0.171
RB	0	0	0.026	0.026	0.00016	0.00012	0.0005	0.0005
AG	0.00064	0.00064	0.015	0.015	0	0	0.00025	0.00025
CD	0.0009	0.0009	0.05	0.05	0	0	0.0015	0.0015
SN	0	0	0.3	0.3	0	0	0.005	0.005
SB	0.00032	0.00032	0.061	0.061	0.00039	0.00003	0.00002	0.00002
I	0	0	0	0	0	0	0.002	0.002
CS	0.00004	0.00004	0.0012	0.0012	0.00002	0.00001	0.00001	0.00001
BA	0.0288	0.0288	0.039	0.039	0	0.00167	0.035	0.035
LA	0.00056	0.00056	0.00077	0.00077	0.00009	0.00003	0.0002	0.0002
CE	0.00026	0.00026	0.017	0.017	0.00017	0.00007	0.00035	0.00035
SM	0.00003	0.00003	0.00005	0.00005	0.00001	0	0.00005	0.00005
EU	0	0	0	0	0	0	0.00002	0.00002
YB	0	0	0	0	0	0	0.00005	0.00005
LU	0.00001	0.00001	0	0	0	0	0.00001	0.00001
HF	0.00004	0.00004	0	0	0	0	0.00015	0.00015
TA	0	0	0.00008	0.00008	0	0	0	0
W	0.00087	0.00087	0	0	0	0	0.005	0.002
HG	0	0	0.0084	0.0084	0	0	0	0
PB	0.00442	0.00442	1.7	0.34	0	0	10.4	2.08
TH	0.00004	0.00004	0	0	0.00001	0.00001	0.00001	0.00001

Table 6.3.2 Source Contributions to SPM

SPM at EMC

(Unit : ug/m^3)

	Obs.	Cal.	Cal/Obs (%)	Soil	Sea Salt	Steel	Fuel Oil	Waste	Diesel	Gasoline
Jan.	64.0	27.0	42	8.1	2.0	-	-	1.4	15.1	0.3
Feb.	38.4	32.9	86	7.2	2.6	3.4	0.5	2.5	15.9	0.8
May	14.6	11.1	76	0.9	0.2	-	0.1	1.1	8.5	0.3
Jun.	54.5	34.7	64	0.6	-	0.2	1.0	2.9	28.7	1.3
Jly.	38.9	26.0	67	0.6	0.1	0.2	0.9	2.0	21.4	0.8
Aug.	34.3	24.9	72	3.0	-	-	1.0	2.2	17.9	0.9
Sep.	47.4	32.5	69	0.9	0.3	-	0.5	3.4	24.5	3.0
Oct.	47.3	33.4	70	3.7	0.5	-	0.5	2.2	21.5	5.0
Nov.	17.5	7.9	45	0.8	0.9	-	0.1	0.2	5.8	0.1
Dec.	8.7	6.6	76	1.9	1.0	-	-	0.3	3.3	0.1
Avg.	36.6	23.7	64.8	2.8	1.0	1.3	0.6	1.8	16.3	1.3
Percentage to Observed Value				7.6	2.6	3.5	1.6	5.0	44.5	3.4

SPM at JICA

(Unit : ug/m^3)

	Obs.	Cal.	Cal/Obs (%)	Soil	Sea Salt	Steel	Fuel Oil	Waste	Diesel	Gasoline
Feb.	45.1	37.4	82	-	2.8	3.4	1.2	1.6	21.2	7.3
Mar.	52.9	44.1	83	4.2	0.5	7.0	0.4	1.1	26.4	4.5
May	64.5	41.6	64	1.5	-	1.5	0.8	1.6	34.4	1.9
Jun.	29.3	23.3	79	0.3	0.2	1.1	0.4	1.2	17.4	2.7
Jly.	8.0	72.9	67	-	-	3.7	1.4	3.5	60.4	3.8
Aug.	163.0	57.4	91	3.2	-	0.7	0.8	2.9	44.3	5.3
Oct.	153.0	97.1	63	21.3	0.7	3.3	1.6	3.4	61.7	5.2
Nov.	55.6	31.2	56	6.7	2.0	2.4	-	1.3	13.9	5.0
Dec.	64.2	36.8	57	15.5	0.9	0.5	0.4	1.3	14.8	3.4
Avg.	70.6	49.1	69.5	7.5	1.2	2.6	0.9	2.0	32.7	4.3
Percentage to Observed Value				10.7	1.7	3.7	1.2	2.8	46.3	6.2

Table 6.3.3 Source Contributions to TSP (1/2)

TSP at JICA Office (Unit : ug/m^3)

	Obs.	Cal.	Cal/Obs (%)	Soil	Sea Salt	Steel	Fuel Oil	Waste	Diesel	Gasoline
Jan.	83.0	59.7	71	30.3	1.5	1.2	-	1.4	20.7	4.6
Percentage to Observed Value				36.5	1.8	1.4	-	1.7	24.9	5.5

TSP at KPPL

	Obs.	Cal.	Cal/Obs (%)	Soil	Sea Salt	Steel	Fuel Oil	Waste	Diesel	Gasoline
Jan.	166.0	150.0	90	74.9	1.3	1.2	-	2.3	64.3	6.0
Feb.	125.0	86.8	69	24.6	2.2	10.5	0.5	1.8	38.1	9.1
Mar.	210.0	159.8	76	97.3	3.4	1.9	-	2.9	45.7	8.6
Apr.	132.0	110.5	84	66.9	3.9	0.6	-	2.3	32.0	4.9
May	176.0	114.1	65	51.1	2.2	3.0	0.1	3.0	51.4	3.4
Jun.	323.0	233.5	72	107.5	4.9	8.0	1.3	6.0	73.9	31.8
Jly.	276.0	217.6	79	110.5	2.8	5.1	0.6	9.3	83.5	5.8
Aug.	142.0	110.0	77	52.4	0.7	-	1.3	4.5	44.5	6.8
Sep.	195.0	139.9	72	80.2	5.0	4.9	-	4.6	43.5	1.7
Nov.	79.4	65.3	82	22.4	-	2.8	0.2	4.2	24.8	10.9
Dec.	-	111.1	-	55.4	2.3	2.9	0.9	2.0	38.4	9.3
Avg.	182.4	136.2	74.7	67.6	2.9	4.1	0.7	3.9	49.1	8.9
Percentage to Observed Value				37.0	1.6	2.2	0.4	2.1	26.9	4.9

TSP at Pulo Gadung

	Obs.	Cal.	Cal/Obs (%)	Soil	Sea Salt	Steel	Fuel Oil	Waste	Diesel	Gasoline
Jan.	131.0	99.2	76	47.8	2.0	4.6	-	2.7	40.6	1.5
Feb.	139.9	101.1	73	20.5	1.6	8.9	0.5	2.5	62.3	4.9
Mar.	166.0	113.7	68	45.2	4.4	13.1	1.8	3.0	41.6	4.6
Apr.	191.0	152.3	80	78.8	6.9	5.6	-	4.2	54.4	2.5
May	223.0	148.6	67	73.0	2.2	7.4	0.7	3.9	57.8	3.5
Jun.	259.0	223.1	86	130.0	3.5	3.7	0.5	5.5	74.2	5.7
Jly.	193.0	154.8	80	79.3	1.7	7.0	4.6	7.6	51.9	2.7
Aug.	149.0	139.5	94	67.7	0.8	4.5	0.9	5.4	57.1	3.1
Sep.	321.0	247.2	77	129.1	4.3	3.0	1.0	10.2	96.7	2.9
Oct.	328.0	268.6	82	149.3	2.0	10.7	2.2	7.0	87.9	9.4
Nov.	169.0	126.8	75	61.2	1.9	9.8	1.1	3.0	45.8	4.1
Dec.	-	41.7	-	13.5	0.9	0.4	0.1	2.0	22.7	0.2
Avg.	206.4	151.4	73.4	74.6	2.7	6.6	1.3	4.8	57.8	3.8
Percentage to Observed Value				36.2	1.3	3.2	0.6	2.3	28.0	1.8

Table 6.3.3 Source Contributions to TSP (2/2)

TSP at Pluit

	Obs.	Cal.	Cal/Obs (%)	Soil	Sea Salt	Steel	Fuel Oil	Waste	Diesel	Gasoline
Jan.	123.0	108.5	88	59.0	2.9	3.4	-	3.5	37.8	1.9
Feb.	67.3	48.9	73	31.1	4.7	-	0.0	1.6	11.3	0.2
Mar.	69.2	48.9	71	11.9	2.1	11.7	1.0	1.3	19.3	1.5
Apr.	171.0	140.0	82	99.6	6.7	0.6	-	6.0	26.8	0.3
May	113.0	84.4	75	39.2	3.1	3.7	0.4	3.6	28.3	6.0
Jun.	188.0	122.1	65	98.8	5.3	7.2	0.3	5.3	3.9	1.3
Jly.	194.0	149.2	77	87.5	4.6	1.7	4.0	6.7	43.3	1.3
Aug.	224.0	176.9	79	90.3	3.3	0.3	1.6	8.7	68.2	4.3
Sep.	234.0	183.2	78	95.8	8.0	2.9	0.6	9.3	63.8	2.7
Oct.	303.0	265.8	88	160.6	4.3	5.6	3.3	7.9	81.2	2.9
Avg.	168.7	132.8	78.7	77.4	4.5	4.1	1.4	5.4	38.4	2.2
Percentage to Observed Value				45.9	2.7	2.4	0.8	3.2	22.8	1.3

CHAPTER 7 ESTIMATE OF FUTURE AIR QUALITY WITHOUT COUNTERMEASURES

7.1 Outline

This chapter aims at estimating the future ambient air quality in the Jabotabek region. For this purpose, at first, present conditions and future trends of some socio-economic factors most likely affecting the region's air quality were reviewed and analyzed, based on the existing study reports as well as official statistical documents. The finalized socio-economic scenario toward 2010 is summarized in Table 7.2.10, including population, GRDP, industrial land, fuel consumption and person-trip generation.

Secondly, future air pollutant emissions from stationary sources (factories and households) as well as mobile ones (automobiles, ships and aircraft) were predicted in line with the selected future socio-economic scenario for Jabotabek, as shown in Tables 7.3.7, 7.3.10, 7.4.1, 7.4.3 and 7.4.5.

Finally, air quality levels in Jabotabek were simulated for the target year 2010. The simulated air pollutants consist of SO_2, NO_2, and CO (Figures 7.5.1 to 7.5.3) in addition to NOx and SPM (Appendix 5.1.2). This simulation was carried out under the "without-measures" condition where no new countermeasures against air pollution would be implemented.

7.2 Future Socio-economic Framework

In order to provide a baseline to predict the future air pollution level and to formulate a preventive strategy covering the Jabotabek region, the Team proposes a future development scenario of the region in this section.

Major official projects or plans related to Jabotabek including "Jabotabek Urban Development Project", "Jabotabek Metropolitan Development Plan (JMDP)", and "Urban Arterial Road System Development Project in Jakarta Metropolitan Area" have been reviewed to obtain reliable information and quantified data concerning the future socio-economic aspects related to air pollution in Jabotabek.

The Team also collected and reviewed qualitative and quantitative data related to the future socio-economic aspects for the Jabotabek region, including population, employment level, gross regional domestic product (GRDP), work commuters, fuel consumption, development trend and required land.

7.2.1 Important Future Trend in Jabotabek

The Jabotabek region is and will be the national focus for economic activities such as trade and commerce, with a significant manufacturing and investment base, where a large and rich agricultural hinterland is also rapidly being urbanized.

The detailed methodology of forecasting the important future trend is given in Appendix 5.2.

(1) Forecast of Population Growth

The Jabotabek region had a population of some 17 million people in 1990 (about 9.5 % of the national population), and it is forecasted to increase to around 30 million by the year 2010. Jakarta had a population of around 8.21 million in 1990 and this will reach 11.2 ~ 11.5 million by 2010, during which time Botabek's population level is forecasted to increase from more or less 8.8 million to 18.5 ~ 18.7 million people. The regional population growth is averaging about 2.9 % p.a. over the period.

(2) Expected Growth in Employment Level

The region's labor force is forecasted to grow at an average rate of about 3.9% p.a. The labor force in Jabotabek in 1991, including those at work, unemployed and seeking work was around 6.7 million in total (3.1 million residents in Jakarta, and 3.6 million residents in Botabek). These figures indicate that employment (the employed labor force) can be expected to grow considerably faster than the total population over the 20-year period, at an average annual growth rate of 3.9 %/year for the whole Jabotabek area. There are two major reasons for such a rapid growth of work force/employment:

- changes in age structure resulting from the effects of continued fertility decline which means an increasing share of total population in the working ages (10 year old and over), and

- increasing participation of working age females in economic activities.

The working proportion of the regional population is or will be as follows :

aged 10 and over : 77% in 1990 to 84% in 2010

female participation to female population aged 10 and over :

30% in 1990 to 41% in 2010

male participation : constant at 68%

(3) Trends in Jabotabek Economy and Future GRDP

The agricultural sector is now less important in Jabotabek's economy (0.9% of Jakarta's GRDP and 12% of Botabek's in 1992), and this is in part due to the rapid urbanization of remaining parts of Jakarta's fringe with development encroachment well into the adjoining fringe areas of Tangerang, Bekasi, and Bogor. On the other hand, the manufacturing sector is now very important (26% of Jakarta's GRDP and 30% of Botabek's in 1992) and is continuing to expand as a prime share of economic activity. It is particularly so in the Bekasi-Jakarta-Tangerang east/west corridor, which has access and other locational advantages for industry. The service sector continues to provide many jobs, especially due partly to Jakarta's role as national capital and as a result of the region's focus on national and foreign investment. Domestic product ratio of Jabotabek to national GDP was about 15 % in 1992.

Based on 25-year development plans (PJP) and 5-year development plans (Replita), the future GRDP in DKI Jakarta was re-forecasted by the JICA Feasibility Study Team on Urban Arterial Road System Development Project in Jakarta Metropolitan Area to 7.5% per year for the period of 2000 to 2010.

(4) Journey Forecast of Commuters

Metropolitan fringe development patterns have reinforced the trend of commuting, with many of the middle and upper income households now living in the new residential fringe development areas and traveling to Jakarta each day to work. As centers and employment nodes develop in Botabek and more residents commute from these new residential areas to the employment nodes, it is also likely that there will be growth in internal commuting within Botabek. Forecasts of the JMDPR study suggest that there could be at least some 500,000 commuters traveling to Jakarta to work in 2010, in addition to the internal commuters within Botabek.

(5) Future Fuel Consumption

The consumption of energy is projected to grow to meet the requirements of the expanding economy in the Jabotabek region. Demand for petroleum products will grow, mainly driven by the growth in transportation, for which alternative fuels are too expensive. The demand for electricity is expected to increase as a result of the growing share of electrification in manufacturing, increasing shift into higher technological and value-added products, and rising standard of living of the population with attendant demand for additional lighting, electrical appliances and the comforts of air conditioning.

(6) Key Development Tendency

Much of the private sector developments which are on-going or "in the pipeline" will set the pattern for development in Jabotabek for this decade and the next one. This is especially relevant in residential, urban, industrial and transportation development.

(7) Required Land for Industry and Urbanization

Official figures from the relevant planning bodies in DKI Jakarta and the Kabupaten/Kotamadya indicate that there is presently some 15,200 ha of land for industry in the Jabotabek region.

Based on job creation forecasts and typical levels of floor space and land area provisions, projections have been made of the land area required to accommodate those key activities using industrial land, over which the regional strategic plan should have some degree of influence in terms of location and extent of development.

From 'Jabotabek Metropolitan Development Plan Review', it is estimated that, in Jabotabek region, industrial area would become around 31,800 ha in 2010.

The urban areas shown in the existing maps were measured to estimate the scale of urbanization in 2010. The urban agglomeration areas estimated for 1990 and 2010 based on the JMDPR were also measured. According to that study, the total urban area in 2010, would be between 226,400 and 289,600 ha from the 1995 value of 70,900 ha.

7.2.2 Future Scenarios

There are several studies or documents on the future forecast for the Jabotabek region. Although various socio-economic factors have been predicted as referred to in Section 7.2.1, the 4 parameters given below are used to draw the future picture of Jabotabek as a whole or only Jakarta :

1) Population,

2) Per capita gross regional domestic product (GRDP),

3) Net in-commuter population from Botabek to Jakarta, and

4) Industrial land

These parameters have been selected primarily because they are most likely concerned with or affecting the air-pollution situation and data on future forecast of these factors have been more easily available than other socio-economic factors. The following 3 future socio-economic scenarios are established towards the study target years 2000 and 2010 based on values of those factors :

- Low-growth future scenario,
- High-growth future scenario, and
- Medium-growth future scenario

These are proposed as baselines to predict air pollution level and to formulate preventive measures and strategies.

(1) Future Low-growth Scenario

For this scenario, lowest figures or levels of the selected 4 socio-economic factors have been chosen from the respective tables in Section 7.2.1, or are developed based on these reported values. Thus, Table 7.2.1 shows a future frame of Jabotabek in case that the region's growth in terms of economy, population and development will be comparatively at a lower level.

Table 7.2.1 Future Low-Growth Scenario in Jabotabek

Factor/Area	2000	2010
Population in Jabotabek (Unit : persons)		
DKI Jakarta	9,730,000	11,178,000
Bekasi	3,348,000	4,066,000 [1]
Tangerang	4,506,000	5,504,000 [1]
Bogor	5,469,000	6,533,000 [1]
Botabek	13,323,000	16,103,000
Total (Jabotabek)	23,053,000	27,281,000
Per Capita Gross Regional Domestic Product (GRDP) in Jabotabek (Unit : Rp/year)		
DKI Jakarta	1,908,000 [2]	3,483,000 [3]
Botabek	1,487,000 [4]	3,483,000 [3]
Average (Jabotabek)	1,697,500	3,483,000
Net In-Commuter Population from Botabek to Jakarta (Unit : persons)		
from Bekasi	72,200 [5]	142,618
from Tangerang	44,900 [5]	91,326
from Bogor	70,400 [5]	117,180
Total (from Botabek)	187,500	351,124
Industrial Land in Jabotabek (Unit : ha)		
DKI Jakarta	4,519 [6]	6,859 [7]
Botabek	10,662 [6]	16,142 [7]
Total (Jabotabek)	15,181	23,001

Notes :
1) 2005 figures estimated by the JICA Team on Urban Arterial Road System Development Project (Ref. 173)
2) 2003 target value for Indonesia set in PJP II
3) 2013 target value for Indonesia set in PJP II
4) 1998 target value for Indonesia set in PJP II
5) 1993 figures estimated by the JICA Team on Urban Arterial Road System Development Project (Ref. 173)
6) 1990 value estimated in JMDPR (Ref. 134)
7) Total of 1990 value and 1990 ~ 2000 required land

(2) Future High-growth Scenario

For this scenario, highest figures or levels of the selected 4 socio-economic factors have been chosen from the respective tables in Section 7.2.1, or are developed based on these reported values. Thus, Table 7.2.2 shows a future frame of Jabotabek in case that the region's growth in terms of economy, population and development will be comparatively at a higher level.

Table 7.2.2 High-Growth Future Scenario in Jabotabek

Factor/Area	2000	2010
Population in Jabotabek (Unit : persons)		
DKI Jakarta	10,055,000	11,500,000
Bekasi	3,589,000	4,802,000
Tangerang	4,631,000	6,523,000
Bogor	5,674,000	7,407,000
Botabek	13,894,000	18,732,000
Total (Jabotabek)	23,949,000	30,232,000
Per Capita Gross Regional Domestic Product (GRDP) in Jabotabek (Unit : Rp/year)		
DKI Jakarta	3,177,000	5,703,000
Botabek	1,908,000 [1)]	5,525,000 [2)]
Average (Jabotabek)	2,542,500	5,614,000
Net In-Commuter Population from Botabek to Jakarta (Unit : persons)		
from Bekasi	110,700	203,100
from Tangerang	70,200	130,000
from Bogor	99,900	166,900
Total (from Botabek)	280,800	500,000
Industrial Land in Jabotabek (Unit : ha)		
DKI Jakarta	6,859 [3)]	9,099
Botabek	16,142 [3)]	22,842
Total (Jabotabek)	23,001	31,941

Notes : 1) 2003 target value set in PJP II
2) 2008 target value set in PJP II
3) Total of 1990 value and 1990 ~ 2000 land requirement estimated in JMDPR (Ref. 134)

(3) Future Medium-growth Scenario

As far as the existing survey reports and other forecast documents are concerned, it could be roughly said that the future socio-economic pictures of the Jabotabek region will be mostly between the low- and high-growth levels mentioned above. A fixed scenario should be applied so that the Team can simulate future air-quality levels as well as to assess the effectiveness of proposed countermeasures and strategies. So, simply taking the medium levels of each factor between the future low- and high-growth scenarios, a "future medium-growth scenario" was formulated by the Team as shown in Table 7.2.3.

Table 7.2.3 Future Medium-Growth Scenario in Jabotabek

Factor/Area	2000	2010
Population in Jabotabek (Unit : persons)		
DKI Jakarta	9,892,500 (42 %)	11,339,000 (39 %)
Bekasi	3,468,500	4,434,000
Tangerang	4,568,500	6,013,500
Bogor	5,571,500	6,970,000
Botabek	13,608,500 (58 %)	17,417,500 (61 %)
Total (Jabotabek)	23,501,000 (100 %)	28,756,500 (100 %)
Per Capita Gross Regional Domestic Product (GRDP) in Jabotabek (Unit : Rp/year)		
DKI Jakarta	2,542,500	4,593,000
Botabek	1,697,500	4,504,000
Average (Jabotabek)	2,052,400 [1)]	4,538,710 [2)]
Net In-Commuter Population from Botabek to Jakarta (Unit : persons)		
from Bekasi	91,450	172,859
from Tangerang	57,550	110,663
from Bogor	85,150	142,040
Total (from Botabek)	234,150	425,562
Industrial Land in Jabotabek (Unit : ha)		
DKI Jakarta	5,689	7,979
Botabek	13,402	19,492
Total (Jabotabek)	19,091	27,471

Notes : 1) 2,542,500 x 0.42 + 1,697,500 x 0.58
2) 4,593,000 x 0.39 + 4,504,000 x 0.61

7.2.3 Future Development Scenario Selected for Air Pollution Simulation

The Team proposed three scenarios for Jabotabek, i.e. "Future low-growth scenario", "Future high-growth scenario" and "Future medium-growth scenario". It was agreed between the Indonesian and Japanese sides that the Medium-growth future scenario would be applied to this Study.

(1) Present Level of Socio-economic Factors in Jabotabek

For necessary calculation of growth rates from the present to the future, the past (1990 or 1993) or present level (1995) on the selected parameters most related to air pollution such as population, GRDP, in-commuter population and industrial land have been estimated or taken from the actual data and documents including "Population Census"(BPS, 1990) and 'Feasibility Study on Urban Arterial Road System Development Project in Jakarta Metropolitan Area" (JICA, 1995). But in case that multiple figures from different sources are available, the middle-level ones have been selected so that they can be compatible to the Medium-growth future scenario. Tables 7.2.4 ~ 7.2.7 show the estimated past/present levels.

Table 7.2.4 Medium-Growth Past and Present Levels of Population in Jabotabek

(Unit : persons)

Area	1990	1995
DKI Jakarta	8,235,000	9,062,500 (45 %)
Bekasi	2,099,000	2,738,500
Tangerang	2,757,500	3,595,000
Bogor	3,990,500	4,764,500
Botabek	8,847,000	11,098,000 (55 %)
Total (Jabotabek)	17,082,000	20,160,500 (100 %)

Note : Figures are estimated by calculating averages between high- and low-growth present levels as follows ;

Area	1990		1995	
	High-Growth 1)	Low-Growth 2)	High-Growth 1)	Low-Growth 2)
DKI Jakarta	8,260,000	8,210,000	9,161,000	8,964,000
Bekasi	2,125,000	2,073,000	2,780,000	2,697,000
Tangerang	2,791,000	2,724,000	3,620,000	3,570,000
Bogor	4,032,000	3,949,000	4,805,000	4,724,000
Botabek	8,948,000	8,746,000	11,205,000	10,991,000
Jabotabek	17,208,000	16,956,000	20,366,000	19,955,000

1) Highest values for 1990 and 1995 are shown in Table 5.2.1 in Appendix 5.2
2) Lowest values for 1990 and 1995 are shown in Table 5.2.1 in Appendix 5.2

Table 7.2.5 Medium-Growth Present Levels of GRDP in Jabotabek

(Unit : Rp/year)

Area	1995
DKI Jakarta	1,697,500
Botabek	1,337,500
Average	1,517,500

Note : "Average" = 1,697,500 x 0.45 + 1,337,500 x 0.55. Figures are estimated by calculating averages between high- and low-growth present levels as follows ;

Area	1995 High-Growth	1995 Low-Growth
DKI Jakarta	1,908,000 [1)]	1,487,000 [2)]
Botabek	1,487,000 [2)]	1,188,000 [3)]

1) 1999 ~ 2003 value in Table 5.2.3 in Appendix 5.2

2) 1994 ~ 1998 value in Table 5.2.3 in Appendix 5.2

3) 1989 ~ 1993 value in Table 5.2.3 in Appendix 5.2

Table 7.2.6 Medium-Growth Past Levels of Net In-Commuter Population from Botabek to Jakarta

(Unit : persons)

Area	1993 *
from Bekasi	72,200
from Tangerang	44,900
from Bogor	70,400
Total (from Botabek)	187,500

Note : * = 1993 estimate in Table 5.2.5 in Appendix 5.2

Table 7.2.7 Medium-Growth Past Levels of Industrial Land in Jabotabek

(Unit : ha)

Area	1990 *
DKI Jakarta	4,519
Botabek	10,662
Total (Jabotabek)	15,181

Note : * = 1990 values in Table 5.2.7 in Appendix 5.2

(2) Past, Present and Future Levels of Fuel Consumption and Trip Generation

Socio-economic factors such as fuel consumption and person-trip generation had not been included into the selected medium-growth future scenario. However, significance of these factors have been confirmed by both the JICA and Counterpart Teams later on, especially for prediction of future air pollutant emission from mobile sources (Section 7.4). The following part of this section thus presents the past/present and predicted future levels of these 2 factors to be added to the final development scenario in the next section.

1) Fuel consumption

The World Bank's prediction of fuel consumption related to road transport in DKI Jakarta is cited from Table 6 in Appendix 5.2, as summarized in Table 7.2.8.

Table 7.2.8 Past and Future Levels of Fuel Consumption by Road Transport in DKI Jakarta

(Unit : mil. kl)

Fuel	1990	1998	2008	2018
Gasoline	1.1	2.0	3.7	6.3
ADO	0.3	0.6	1.1	1.9
Total	1.4	2.6	4.8	8.2

Source : Energy and the Environment, A Plan of Action for Pollution Control (Ref. 45)
Note : ADO = automotive diesel oil

2) Person-trip generation

The most reliable and updated data for person-trip generation in Jabotabek have been collected from the Final Report of "Feasibility Study on Urban Arterial Road System Development Project in Jakarta Metropolitan Area" (JICA, January 1995). Table 7.2.9 shows the past and future levels of person-trip generation in the Jabotabek area.

Table 7.2.9 Past and Future Person-trip Generation in Jabotabek

(Unit : 1,000 trips)

Area	1993	2010
DKI Jakarta	16,435	22,782
Botabek	16,175	33,932
Total	32,610	56,714

Source : Feasibility Study on Urban Arterial Road System Development Project in Jakarta Metropolitan Area, Final Report (Ref. 173)

(3) Future development scenario finalized with past/present levels

Table 7.2.10 summarizes the past, present and forecasted future states of major socio-economic elements along with "fuel consumption" and "person-trip generation" in Jabotabek, in the medium-growth scenario. This finalized scenario has been selected with the agreement of the BAPEDAL counterparts. Following the estimate of various growth rates based on the future socio-economic levels given in this table, future air emissions from stationary as well as mobile sources has been predicted as mentioned in Sections 7.3

and 7.4. And further, air quality levels have been simulated and economic analysis conducted in accordance with the countermeasures and strategies proposed by the Team.

Table 7.2.10 Finalized Future Scenario for Jabotabek

Factor/Area	1990	1993	1995	2000	2008	2010
Population in Jabotabek (Unit : persons)						
DKI Jakarta	8,235,000	---	9,062,500	9,892,500	---	11,339,000
Bekasi	2,099.000	---	2,738,500	3,468,500	---	4,434,000
Tangerang	2,757,500	---	3,595,000	4,568,500	---	6,013,500
Bogor	3,990,500	---	4,764,500	5,571,500	---	6,970,000
Botabek	8,847,000	---	11,098,000	13,608,500	---	17,417,500
Total (Jabotabek)	17,082,000	---	20,160,500	23,501,000	---	28,756,500
Per Capita Gross Regional Domestic Product (GRDP) in Jabotabek (Unit : Rp/year)						
DKI Jakarta	---	---	1,697,500	2,542,500	---	4,593,000
Botabek	---	---	1,337,500	1,697,500	---	4,504,000
Average (Jabotabek)	---	---	1,517,500	2,052,400	---	4,538,710
Net In-Commuter Population from Botabek to Jakarta (Unit : persons)						
from Bekasi	---	72,200	---	91,450	---	172,859
from Tangerang	---	44,900	---	57,550	---	110,663
from Bogor	---	70,400	---	85,150	---	142,040
Total (from Botabek)	---	187,500	---	234,150	---	425,562
Industrial Land in Jabotabek (Unit : ha)						
DKI Jakarta	4,519	---	---	5,689	---	7,979
Botabek	10,662	---	---	13,402	---	19,492
Total (Jabotabek)	15,181	---	---	19,091	---	27,471
Fuel Consumption by Road Transport in DKI Jakarta (Unit : mil.kl)						
Gasoline	1.1	---	---	---	3.7	---
ADO	0.3	---	---	---	1.1	---
Total (Jakarta)	1.4	---	---	---	4.8	---
Person-trip Generation (Unit : 1,000 trips)						
DKI Jakarta	---	16,435	---	---	---	22,782
Botabek	---	16,175	---	---	---	33,932
Total (Jabotabek)	---	32,610	---	---	---	56,714

Note : ADO = automotive diesel oil

7.3 Estimate of Future Air Pollutant Emissions from Stationary Sources

7.3.1 Prediction of Future Emissions from Factories

(1) Production and Fuel Consumption in the Past

Air pollutant emission from factories is closely related to the production and fuel consumption. Experience between 1981 and 1990 showed that the average annual growth rate in the country's energy consumption was 6.1%. However, the growth rate from 1986 to 1991 reached a height of 9.7% (Ref. 47). A rapid expansion of production has also been seen in Jabotabek; the average annual growth rate of total electricity generation between 1990/91 and 1994/95 was 19.4% (Table 7.3.1), that of the cement production between 1986 and 1995 was 8.7% (Table 7.3.2), and that of the consumption of HSD, IDO and natural gas by caloric excluding their consumption by the electricity supply industry from 1986 to 1994 was 11% (Tables 7.3.3 and 7.3.4).

Table 7.3.1 Electricity Generation in Jabotabek

	(MWh)					Average annual
	90/91	91/92	92/93	93/94	94/95	growth rate (%)
PRIOK	0	1,483,873	1,204,714	1,504,518	3,222,208	29.5
MUARA KARAN	3,456,939	3,697,449	4,394,513	6,044,835	3,802,233	2.3
Total	3,456,939	5,181,322	5,599,227	7,549,353	7,024,441	19.4

Source : Power Generation of Muara Karang and Priok (Ref. 210)

Table 7.3.2 Cement Production in Jabotabek

	(1,000 ton/year)										Annual average
Cement	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	growth rate (%)
production	5,026	5,779	6,126	6,972	7,924	8,013	8,657	9,944	10,624	10,612	8.7

Source : Annual Cement Production in Jabotabek (Ref. 219)

Table 7.3.3 Consumption of Natural Gas by Industries Except Electricity Supply Industry (Jabotabek)

	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/1996
Natural gas	227,178	298,199	373,478	696,023	884,436	1,097,005	1,307,891	1,135,851	1,548,658	1,982,149

Sources : Realisasi Pemanfastan Gas Bumi DKI Jakarta, Bogor, Bekasi dan Tangerang (Ref. 213) and Data pemakaian Gas Untuk Wilayah Jakarta, Bekasi dan Tangerang (Ref. 214)

Table 7.3.4 Total Energy (HSD, IDO and Natural Gas) Consumption by Industries Except Electricity Supply Industry (Jabotabek)

Total energy	(unit: 10**12 kcal)									Annual average growth rate (%)
	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	
	12.14	12.24	13.09	16.56	19.67	22.58	28.44	27.63	29.99	10.9

Note: Calculation from Table 4.3.1, "Realisasi Penjualan BBM, LPG, dan BBG" (Ref. 162), "Realisasi Pemanfastan Gas Bumi DKI Jakarta, Bogor, Bekasi dan Tangerang" (Ref. 213) and "Data Pemakaian Gas Untuk Wilayah Jakarta, Bekasi Dan Tangerang" (Ref. 214)

(2) Relation between GNP and Final Energy Consumption

Table 7.3.5 shows a comparison of GNP to consumption of final energy by industry in Japan. Between 1955 and 1970 GNP increased rapidly at an average annual rate of 10%, while in the same period the consumption of final energy by industry expanded at a rate over 13%.

Table 7.3.5 GNP and Consumption of Final Energy in Japan

Fiscal year	Consumption of final energy by all sectors (10**10 kcal)	Share (%)			Consumption of final energy by industry (10**10 kcal)	Average annual growth rate (%)	Gross national production (billion yen)	Average annual growth rate (%)
		Industry	Residence/ commerce	Transpor-tation				
1955	41,102	57.1	24.9	17.9	23,469		42,943	
1960	65,271	63.0	19.4	17.6	41,121	12.8	65,145	9.7
1965	108,538	65.2	17.2	17.6	70,767		100,821	
1970	211,226	67.4	16.4	16.2	142,366		171,293	

Sources: General Energy Statistics of Japan, 1995 (Ref. 223) and Handbook on Economy of Japan, 1995 (Ref. 224)

(3) Setting An Index for Predicting Air Pollutant Emission in the Future

GRDP of Jabotabek until 2010 (Table 7.3.6) shows a high growth and the same is expected in Tangerang, Bekasi, and Bogor. The average annual growth rate of GRDP of the whole Jabotabek area is also high at about 10%. As no concrete information has been obtained on the plans until 2010 for electricity supply, cement production or output by industry, it was assumed from experience in Japan that a high growth rate of GRDP (10%) of Jabotabek will be accompanied by an identical high growth rate of fuel consumption by all industries and factories.

Table 7.3.6 Gross Regional Domestic Product of Jabotabek

GRDP	trillion Rp/year		
	1995	2000	2010
DKI Jakarta	15.4	25.2	52.1
Bogor	6.4	9.5	31.4
Tangerang	4.8	7.8	27.1
Bekasi	3.7	5.9	20.0
Jabotabek	30.2	48.3	130.5

(4) Air Pollutant Emission in the Future

Emissions from factories in 2000 and 2010 were predicted using the corresponding year's ratio of GRDP to that of 1995 (Table 7.3.7). Total emission of each pollutant in 2010 is estimated 4.32 times that in 1995: 184,000 tons of SOx, 159,000 tons of NOx, and 59,000 tons of PM.

7.3.2 Prediction of Future Emissions from Households

To estimate future air pollutant emission from households, population growth was used. Tables 7.3.8 and 7.3.9 show future population and population increase in Jabotabek respectively. Total population in Jabotabek is expected to grow from 20 million in 1995 to 24 million in 2000 and 29 million in 2010. Table 7.3.10 gives the future air pollutant emission from households. Total annual emission in Jabotabek from 1995 to 2010 will increase as follows: 4,000 tons to 6,000 tons of SOx, 5,000 ton to 7,000 tons of NOx, 600 tons to 900 tons of PM.

Table 7.3.7 Future Air Pollutant Emissions from Factories (Jabotabek)

Year	Industry	GRDP (ratio to 1995)	(ton/year) SOx	NOx	PM
1995	Electricity	1.00	15,096	20,088	760
	Cement		6,379	5,740	2,009
	Other		21,222	11,004	10,812
	Total		42,697	36,832	13,581
2000	Electricity	1.60	24,153	32,141	1,215
	Cement		10,206	9,185	3,215
	Other		33,955	17,606	17,299
	Total		68,314	58,932	21,729
2010	Electricity	4.32	65,215	86,781	3,281
	Cement		27,557	24,799	8,680
	Other		91,679	47,537	46,708
	Total		184,450	159,117	58,669

Table 7.3.8 Future Population in Jabotabek

(Unit : 1,000 persons)

District		1995	2000	2010
Jakarta	Barat	2143.3	2480.0	2842.6
	Pusat	962.1	853.7	978.5
	Utara	1558.8	1753.6	2010.0
	Selatan	2019.6	2110.7	2419.3
	Timur	2378.7	2694.5	3088.5
	Sub-total	9062.5	9892.5	11338.9
Bogor	Kota	287.4	304.2	380.6
	Kabu	4477.1	5267.3	6589.4
	Sub-total	4764.5	5571.5	6970.0
Tangerang	Kota	1190.1	1503.5	1979.1
	Kabu	2404.9	3065.0	4034.4
	Sub-total	3595.0	4568.5	6013.5
Bekasi	Central(*1)	898.9	1222.9	1563.3
	Other	1839.6	2245.6	2870.7
	Sub-total	2738.5	3468.5	4434.0
Jabotabek	Total	20160.5	23501.0	28756.4

Note: Estimate from Table 7.2.8, "Proyksi Penduduk Indonesia per kabupaten/kotamadya 1990-2000" (Ref. 209) and "Kabupaten Bekasi Dalam Angka 1994" (Ref. 154)

Table 7.3.9 Population Increase in Jabotabek

(Unit : 1,000 persons)

District		1995	2000	2010
Jakarta	Barat	1.00	1.16	1.33
	Pusat		0.89	1.02
	Utara		1.12	1.29
	Selatan		1.05	1.20
	Timur		1.13	1.30
	Sub-total		1.09	1.25
Bogor	Kota		1.06	1.32
	Kabu		1.18	1.47
	Sub-total		1.17	1.46
Tangerang	Kota		1.26	1.66
	Kabu		1.27	1.68
	Sub-total		1.27	1.67
Bekasi	Central*		1.36	1.74
	Other		1.22	1.56
	Sub-total		1.27	1.62
Jabotabek	Total		1.17	1.43

Note: Central part of Bekasi includes Bekasi Timur, Bekasi Selatan, Bekasi Barat and Bekasi Utara.

Table 7.3.10 Air Pollutant Emissions from Households (Jabotabek)

(Unit : ton/year)

District		SOx			NOx			PM		
		1995	2000	2010	1995	2000	2010	1995	2000	2010
Jakarta	Barat	449	519	595	527	610	700	68	79	90
	Pusat	201	179	205	237	210	241	31	27	31
	Utara	326	367	421	384	432	495	50	56	64
	Selatan	423	442	506	497	519	595	64	67	77
	Timur	498	564	647	585	663	760	76	86	98
	Sub-total	1,897	2,071	2,374	2,230	2,435	2,791	288	315	361
Bogor	Kota	60	64	80	71	75	94	9	10	12
	Kabu	937	1,103	1,379	1,102	1,296	1,622	142	168	210
	Sub-total	997	1,166	1,459	1,173	1,371	1,715	152	177	222
Tangerang	Kota	249	315	414	293	370	487	38	48	63
	Kabu	503	642	845	592	754	993	77	98	128
	Sub-total	753	956	1,259	885	1,124	1,480	114	145	191
Bekasi	Central (*1)	188	256	327	221	301	385	29	39	50
	Other	385	470	601	453	553	706	59	71	91
	Sub-total	573	726	928	674	854	1,091	87	110	141
Jabotabek	Total	4,220	4,920	6,020	4,962	5,784	7,077	642	748	915

Note *1 : Central Bekasi includes Bekasi Timur, Bekasi Selatan, Bekasi Barat and Bekasi Utara

7.4 Estimate of Future Air Pollutant Emissions from Mobile Sources

7.4.1 Future Air Pollutant Emissions from Automobiles

(1) Outline of Future Traffic Estimate

The future trip ends for Jabotabek could not be identified directly from the available information sources, as seen in Table 7.2.10 of Jabotabek future scenario. But among its socio-economic factors, "fuel consumption of road transport" as well as "person-trip generation" are most related to the trip ends in accordance with past experiences. The both factors' annual growth rates toward the future could be calculated as below :

Growth Rate of Fuel Consumption of Road Transport in Jakarta

Total Consumption (Unit : mil.kl)		1990 ~ 2008 Annual Growth Rate
1990	2008	
1.4	4.8	0.071 (7.1 %)

Note : Annual growth rate = (2008's consumption / 1990's consumption) $^{1/(2008-1990)}$ - 1

Growth Rate of Person-trip Generation in Jabotabek

Total Person-trip Generation (Unit : 1,000 trips)		1993 ~ 2010 Annual Growth Rate
1993	2010	
32,610	56,714	0.033 (3.3 %)

Note : Annual growth rate = (2010's trips / 1993's trips) $^{1/(2010-1993)}$ - 1

As the predicted annual growth rate of fuel consumption (7.1 %) and that of person-trip generation (3.3 %) are quite estranged, those were regarded as upper limit and lower one respectively. And it is reasonable that the growth rate for the total trip-ends finally applied to the mobile emission prediction should reflect the future trend of the both parameters. So the midpoint rate (5.2 %) between 3.3 % and 7.1 %. were used as the total trip ends.

The total 'trip ends' in Jabotabek in 2010 will be 2.139 times that of 1995, corresponding to an annual average growth rate of 5.2% between 1995 and 2010, as calculated below:

<u>Ratio of total trip ends for 2010 to 1995</u>

$= (1 + 0.052)^{2010-1995} = 2.139 = 213.9$ % increase in 2010 compared to 1995's trips

Traffic volume in 1995 was estimated by traffic counting data and traffic assignment results. The traffic assignment method was used again for estimating future major road traffic, and growth rates by each link were obtained from comparison of present and future traffic volumes. Then, traffic volumes at existing links were calculated by the following equation.

Future Traffic = Present Traffic × Future Assignment/Present Assignment

Traffic volumes at new links in the future were estimated by the future traffic assignment results. For minor road traffic, future traffic was estimated to be 2.139 times the present traffic.

(2) Future OD Tables

Future OD tables for the year 2010 were calculated applying the growth rates of 1995 - 2010 to the present OD tables. Growth rates of trip ends are different by vehicle type, taking the forecast on vehicle ownership in UARSDP into consideration. Annual growth rates for passenger cars, trucks, and buses are 4.6%, 5.3%, and 8.0%, respectively. Growth rates are also different by area. While growth rate for DKI Jakarta is lower than the average, that for Botabek is higher.

As the future public transport mode, mass rapid transit (MRT) between Kota and Fatmawati is considered. According to the report on the ridership forecasts by the MRT project, passenger demand for MRT in 2010 was estimated to be 739,000 persons per day. In this Study, 90% of these passengers were estimated to be diverted from buses and the rest from passenger cars. Considering the above modal split, future OD tables were calculated.

(3) Future Road Network

The future road network consists of the present road network, roads under improvement projects, and roads planned to be constructed. Ongoing road improvement projects and the road development plan described in UARSDP include:

- Inner Ring Road,
- Outer Ring Road and its frontage road,
- Jakarta-Serpong Tollway,
- North-South Axis Tollway (4 to 6-lane, design speed: 80 km/h), and
- East-West Axis Road (10-lane, design speed: 60 km/h).

(4) Future Air Pollutant Load from Automobiles

Future running kilometers were estimated based on future traffic assignment results, future road network, and the same pollutant emission factors as those at present. The results are shown in Table 7.4.1.

If the price difference of gasoline and diesel continues, the share of diesel vehicles would increase. The increase of diesel vehicles would cause more emissions of NOx, SOx, and PM.

Table 7.4.1 Future Air Pollutant Load from Automobiles

(Unit Pollutant: ton/year, Running km: 10^6km/year)

	CO	HC	NOx	SOx	PM	Running Km
Year 2010	1,154,492.8	196,879.5	223,913.0	18,991.5	21,964.3	80,286.7
Year 1995	564,292.0	97,970.6	98,738.3	8,142.3	9,563.0	38,576.6
2010/1995	2.05	2.01	2.27	2.33	2.30	2.08

7.4.2 Future Air Pollutant Emissions from Ships and Aircraft

(1) Future Air Pollution Load from Ships

Trend and forecast of ship calls at Tanjung Priok Port are shown in Table 7.4.2. Regression analysis was done using the extrapolated data to the year 2010. Finally, the growth rate during the period of 1995 - 2010 was determined at 1.318. Future air pollutant emission at the port was estimated with this growth rate as shown in Table 7.4.3.

Table 7.4.2 Trend and Forecast of Ship Calls at Tanjung Priok Port

Year	1991	1992	1993	1994	1995
Ship Calls	12,106	12,359	13,525	13,733	13,109
Year	1996	1997	1998	1999	2000
Ship Calls	13,451	13,831	14,194	14,670	15,102

Source: Cabang Pelebuhan Tanjung Priok, KEPALA

Table 7.4.3 Future Air Pollutant Emission Load from Ships

SO_x (ton/year)	Mooring at Berth	751.3
	Mooring Offshore	231.2
	Cruising	82.6
	Total	1,065.0
NO_x (ton/year)	Mooring at Berth	1,674.4
	Mooring Offshore	475.3
	Cruising	432.7
	Total	2,582.5

(2) Future Air Pollutant Load from Aircraft

Forecast of ship calls at Soekarno-Hatta and Halim Perdanakusuma Airports are shown in Table 7.4.4. Regression analysis was done with the extrapolated data to the year 2010. Finally, the growth rate during the period of 1995-2010 was determined at 4.192 for Soekarno-Hatta and 3.142 for Halim. Future air pollutant emission at the airport was estimated with this growth rate as shown in Table 7.4.5.

Table 7.4.4 Forecast Flight Numbers

Year	Soekarno	Halim
1998	128,679	18,150
2003	175,775	24,269
2013	372,135	44,191

Source: IATS Study

Table 7.4.5 Future Air Pollutant Emission Load from Aircraft

SOx (ton/year)	Idling	187.2
	Take-off	47.5
	Climb-out	122.4
	Approach	79.7
	Total	436.8
NOx (ton/year)	Idling	495.0
	Take-off	1,244.4
	Climb-out	2,580.1
	Approach	626.7
	Total	4,946.3

7.5 Simulation of Air Quality without Countermeasure in 2010

Concentration maps of SO_2, NO_2 and CO are shown in Figures 7.5.1 to 7.5.7, and maps of NO_x and SPM are included in Appendix 5.1.2.

The areas with high SO_2 concentration exceeding the standards widely spread in Jakarta Utara, Jakarta Pusat, Jakarta Barat to Kota Tangerang, Jakarta Timur to Kota Bekasi, and Cibinong. Total number of the grids exceeding the standards is 441 and 20 grids show very high SO_2 concentration (two times higher than the standards). All of DKI Jakarta, Kota Tangerang, and Kota Bekasi were covered with relatively high SO_2 (more than 10 ppb). In the other word, 6.6 % (= 441 grids / 6682 grids) of whole Jabotabek area is exposed to problematic SO_2 concentration (Figure 7.5.1) . The main cause of the high SO_2 concentrations is the factories like power plants, cements, and so on. Two hundreds (200) of grids out of 441 grids which show high SO_2 concentrations are exclusively caused by the stationary sources (Figure 7.5.2). The impacts from automobiles and ships are limited in certain local spots. Six grids with high SO_2 concentrations are caused by automobiles and the distribution is patchy (Figure 7.5.3).

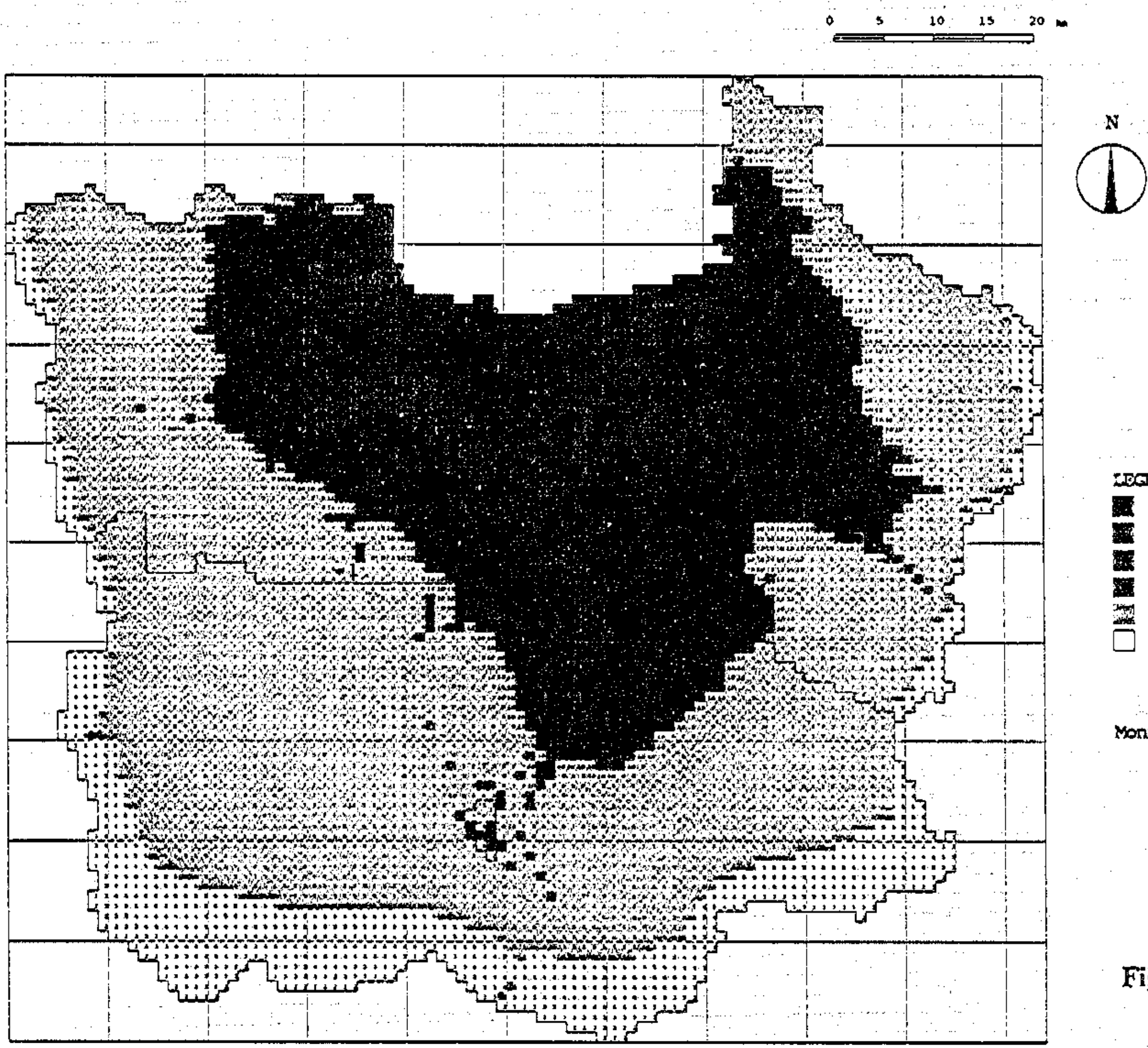
The grids with high NO_2 concentration exceeding the standards mainly appear in DKI Jakarta, Kota Tangerang, and Kota Bekasi and gathered especially in Jakarta Pusat. Total number of the grids exceeding the standards is 47 and two grids show very high NO_2 concentration (two times higher than the standards). Most of the areas inside the outer ring road is exposed to relatively high NO_2 concentrations (more than 30 ppb) (Figure 7.5.4). The main cause of the high NO_2 concentrations is the automobiles at heavy traffic roads and half of the grids with high NO_2 concentrations are exclusively caused by the automobiles (Figure 7.5.5). The impacts from factories are not so high NO_2 and around 10 ppb of NO_2 concentrations are caused by power plants and glass factories at the harbor side (Figure 7.5.6).

CO concentrations are below the standard even in 2010 (Figure 7.5.7).

SO_2 pollution spread widely in Jabotabek and the main cause is the certain factories. The prime target of the countermeasure for SO_2 is such kind of the problematic factories. Adding to that, reduction of sulfur contents of diesel vehicles and ships may be necessary to satisfy the standards.

NO_2 pollution spread inside of the outer ring road and local problem occurred beside of major roads with heavy traffic. If the traffic of automobiles increase in 2010, NO_2 problem happen with a certain probability beside the major roads. For this case, emission reduction of each automobile may be the best choice from the technical point of view. For NO_2 pollution, countermeasure to the automobiles is considered as necessary and sufficient.

Future Condition (2010)



LEGEND

40. < x <=	80. (ppb)	20 grids
20. < x <=	40. (ppb)	421 grids
15. < x <=	20. (ppb)	579 grids
10. < x <=	15. (ppb)	1368 grids
5. < x <=	10. (ppb)	3474 grids
0. < x <=	5. (ppb)	820 grids

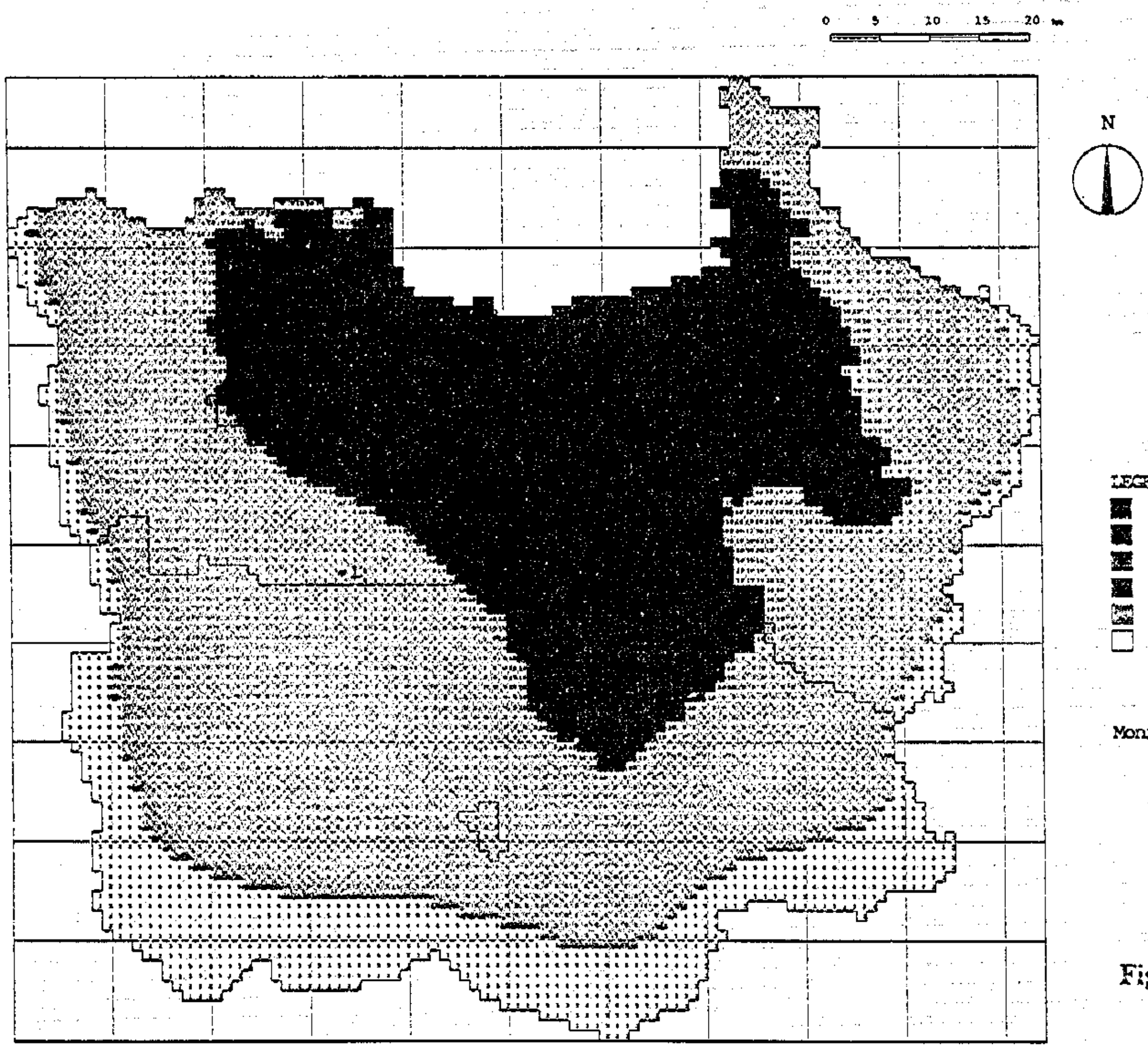
Monitoring Stations
1 EMC
2 Pulo Gadung
3 Pluit
4 Thamrin
5 KPPL
6 Cibinong

Figure 7.5.1 Concentration Map of SO_2 from All Sources

SO2 ppb Annual Average

C MAX= 51.9ppb
Background Concentration: 0.ppb

Future Condition (2010), Stationary Sources



LEGEND

	40. < x <=	80. (ppb)	11 grids
	20. < x <=	40. (ppb)	189 grids
	15. < x <=	20. (ppb)	442 grids
	10. < x <=	15. (ppb)	1523 grids
	5. < x <=	10. (ppb)	3572 grids
	0. < x <=	5. (ppb)	945 grids

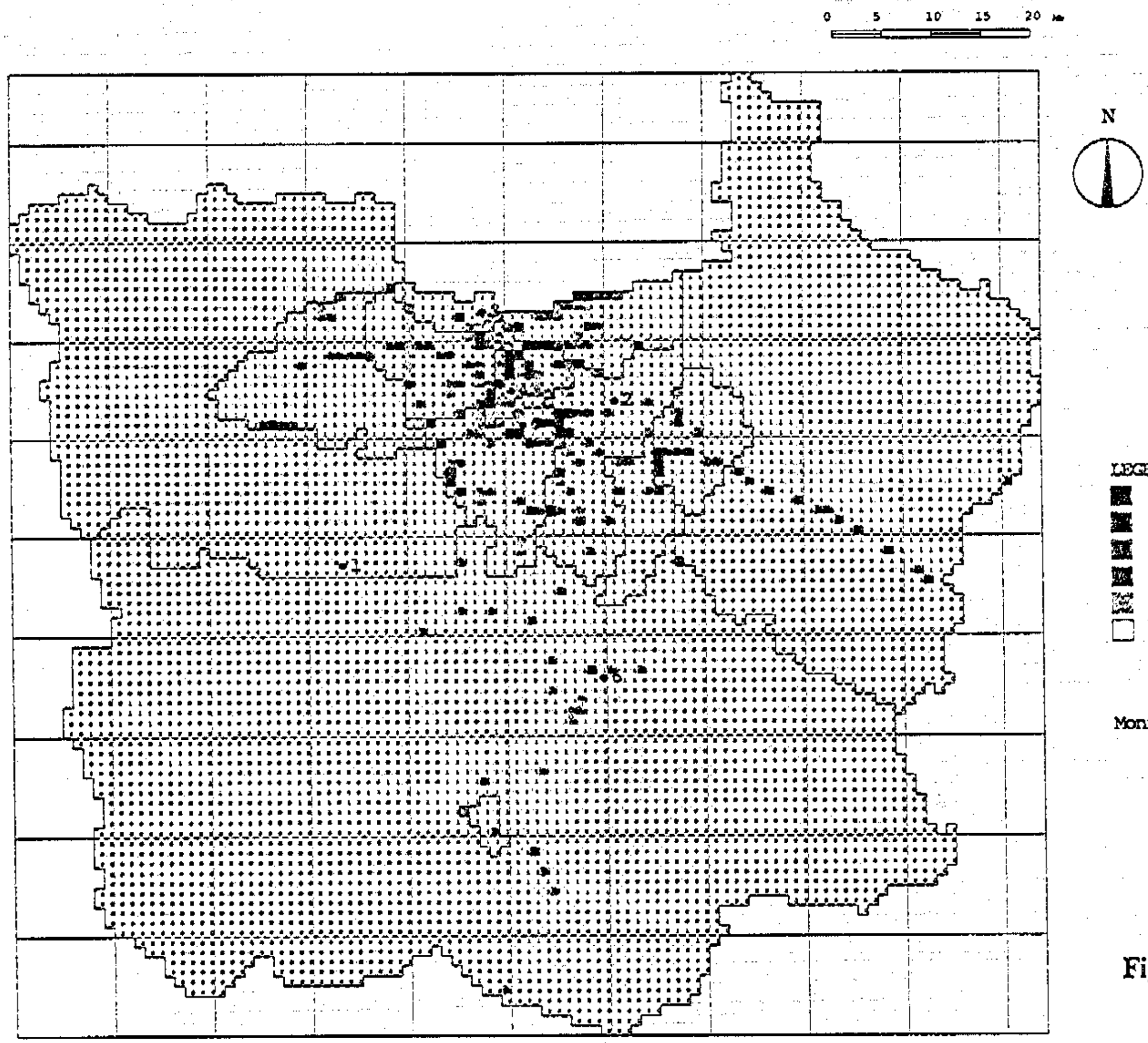
Monitoring Stations
1 EMC
2 Pulo Gadung
3 Pluit
4 Thamrin
5 KPPL
6 Cibinong

SO2 ppb Annual Average

C MAX= 50.2ppb
Background Concentration: 0.ppb

Figure 7.5.2 Concentration Map of SO_2 from Stationary Sources

Future Condition (2010), Mobile Sources



LEGEND

40. < x <=	80. (ppb)	0 grids
20. < x <=	40. (ppb)	6 grids
15. < x <=	20. (ppb)	14 grids
10. < x <=	15. (ppb)	40 grids
5. < x <=	10. (ppb)	173 grids
0. < x <=	5. (ppb)	6449 grids

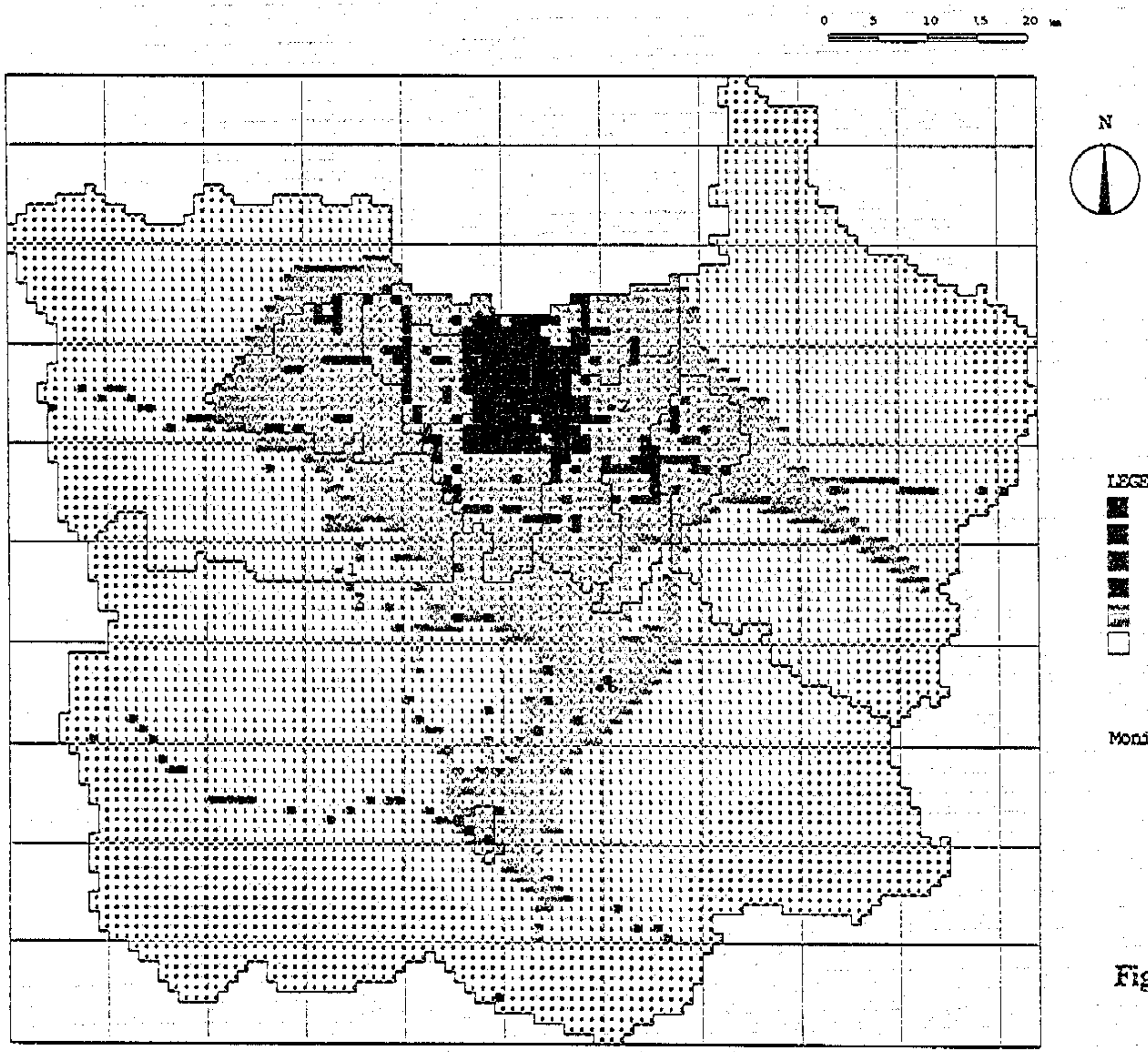
Monitoring Stations
1 EMC
2 Pulo Gadung
3 Pluit
4 Thamrin
5 KPPL
6 Cibinong

Figure 7.5.3 Concentration Map of SO_2 from Mobile Sources

SO2 ppb Annual Average

C MAX= 37.7ppb
Background Concentration: 0.ppb

Future Condition (2010)



LEGEND

■	100. < x <= 200. (ppb)	2 grids
■	50. < x <= 100. (ppb)	45 grids
■	40. < x <= 50. (ppb)	70 grids
■	30. < x <= 40. (ppb)	178 grids
▒	10. < x <= 30. (ppb)	1531 grids
□	0. < x <= 10. (ppb)	4856 grids

Monitoring Stations

1 EMC
2 Pulo Gadung
3 Pluit
4 Thamrin
5 KPPL
6 Cibinong

Figure 7.5.4 Concentration Map of NO_2 from All Sources

NO2 10ppb Annual Average

C MAX= 143.3ppb
Background Concentration: 0.ppb

Future Condition (2010), Stationary Sources

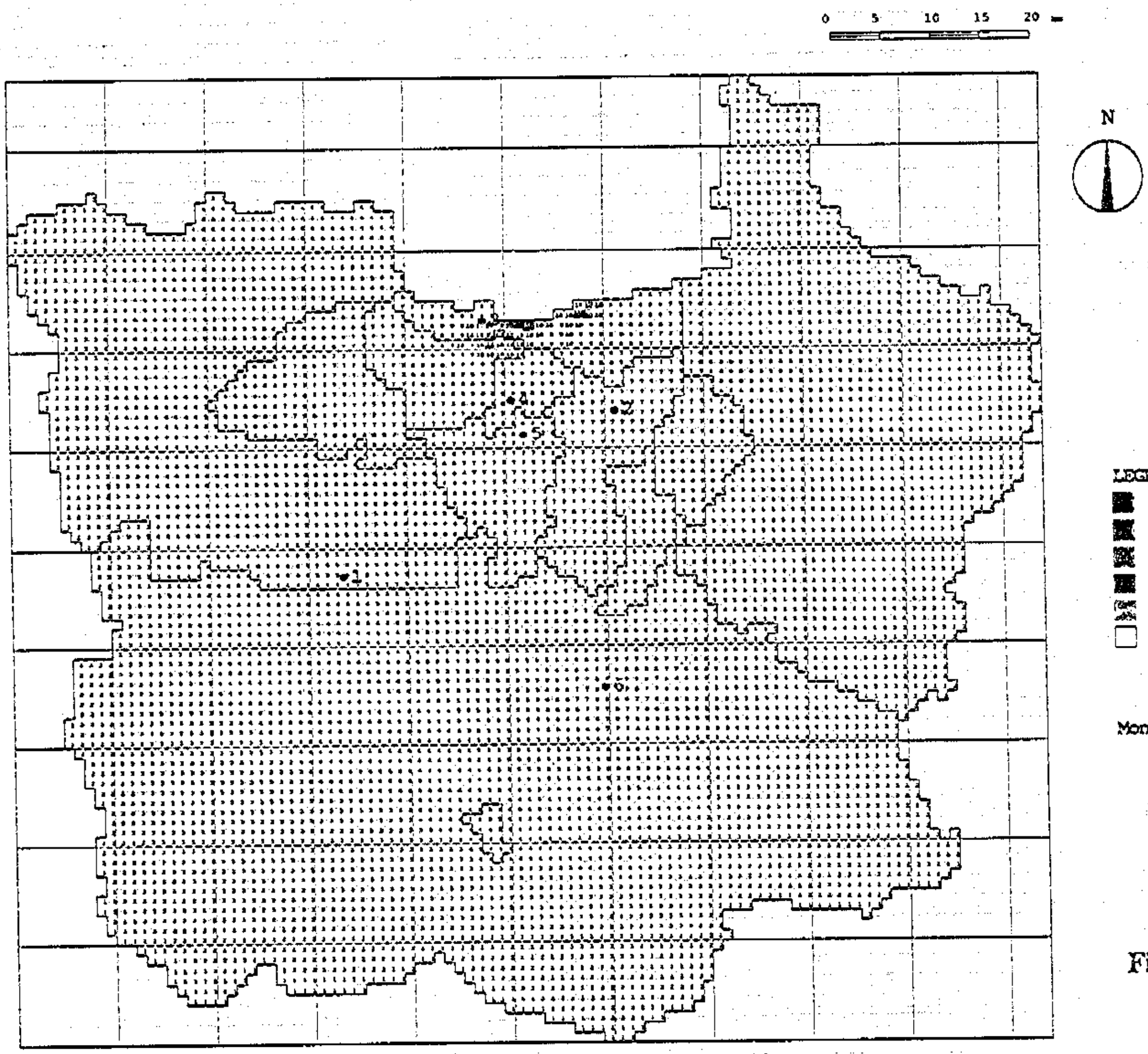
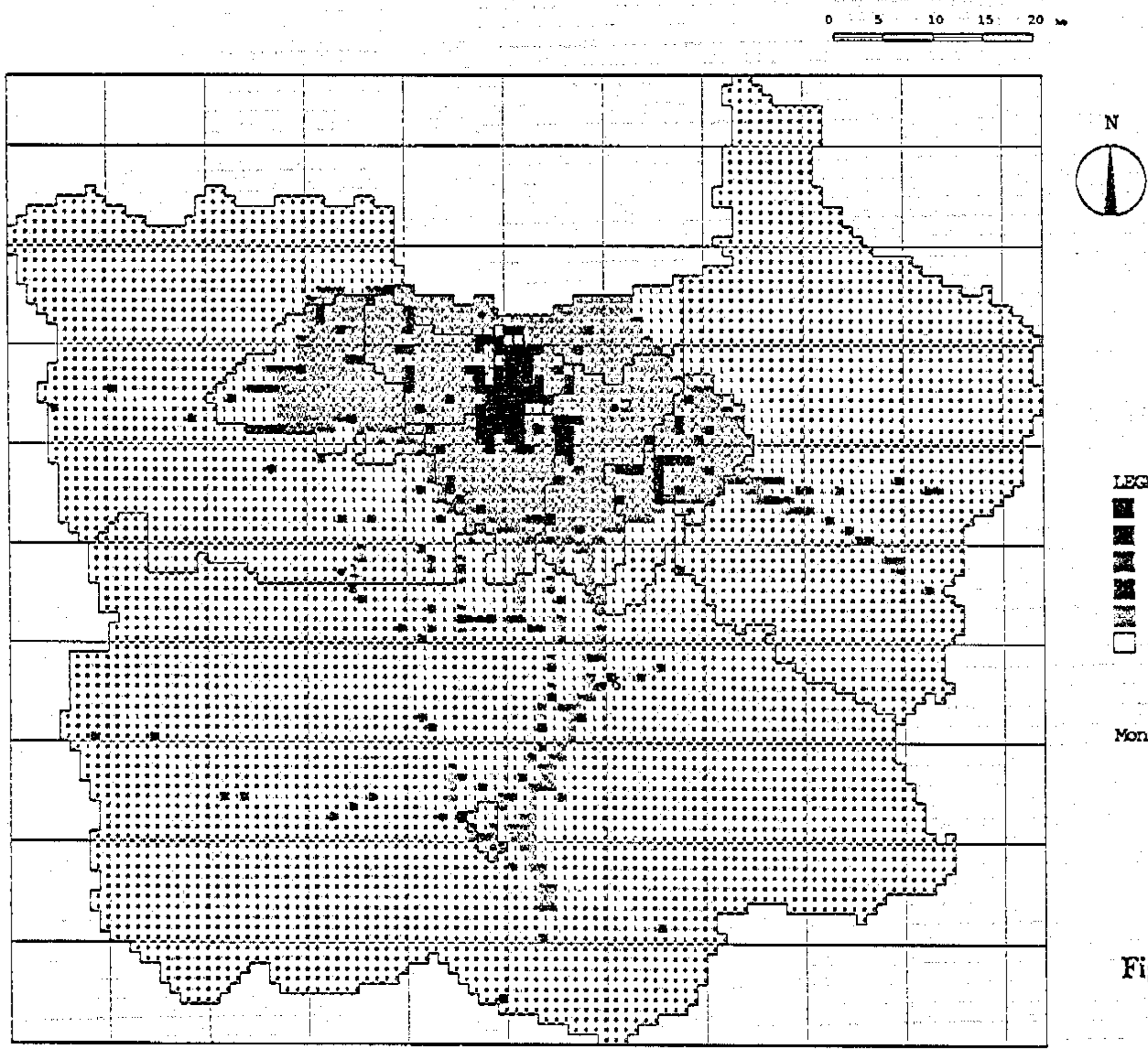


Figure 7.5.5 Concentration Map of NO_2 from Stationary Sources

NO2 ppb Annual Average

$_{\square}$C MAX= 10.6ppb
Background Concentration: 0.ppb

Future Condition (2010), Mobile Sources



LEGEND

100. < x <=	200. (ppb)	2 grids
50. < x <=	100. (ppb)	21 grids
40. < x <=	50. (ppb)	38 grids
30. < x <=	40. (ppb)	81 grids
10. < x <=	30. (ppb)	886 grids
0. < x <=	10. (ppb)	5654 grids

Monitoring Stations

1 EMC
2 Pulo Gadung
3 Pluit
4 Thamrin
5 KPPL
6 Cibinong

Figure 7.5.6 Concentration Map of NO_2 from Mobile Sources

NO2 10ppb Annual Average

C MAX= 134.7ppb
Background Concentration: 0.ppb

Future Condition (2010)

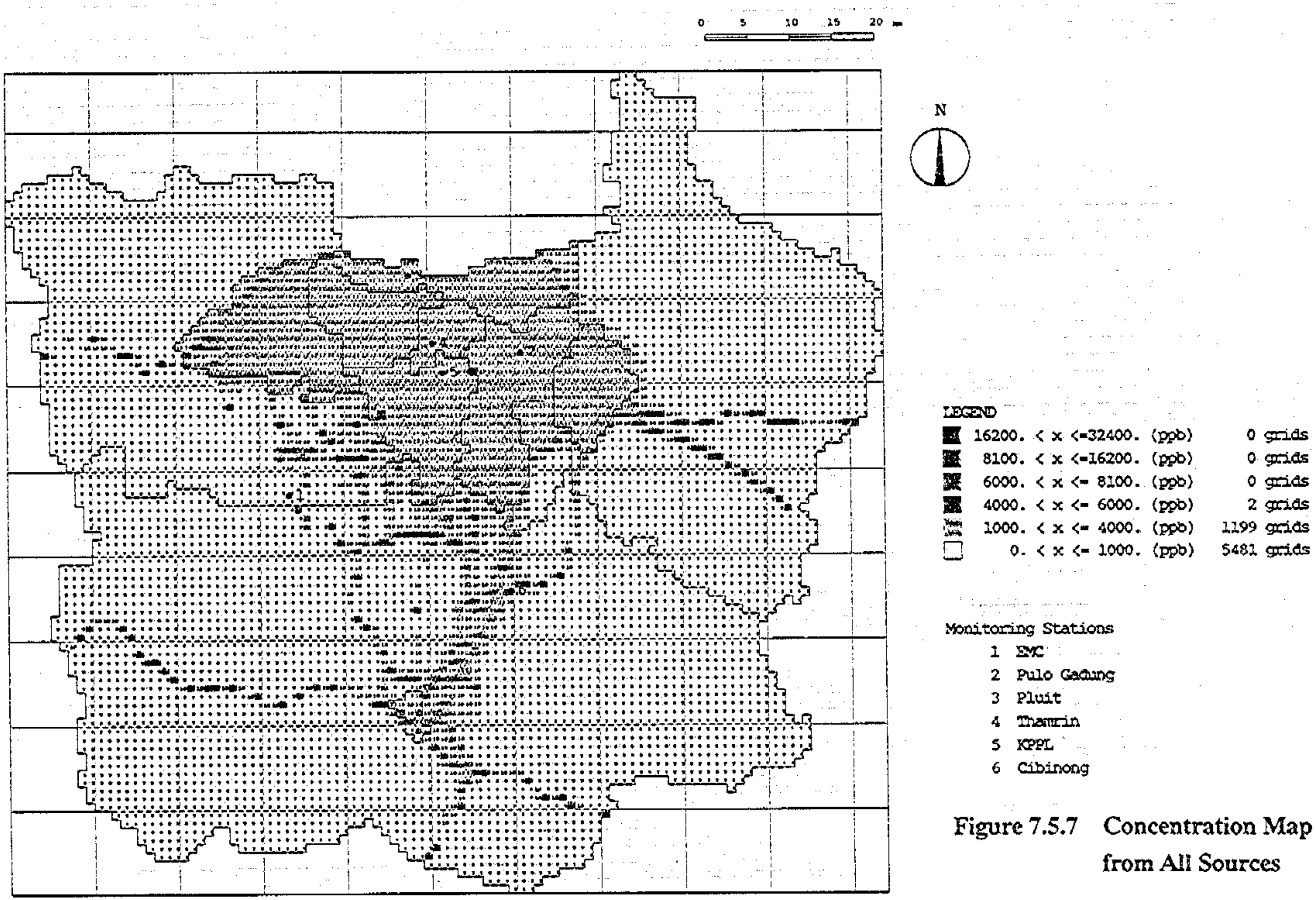


Figure 7.5.7 Concentration Map of CO from All Sources

CO 100ppb Annual Average

C MAX= 4098.1ppb
Background Concentration: 860.ppb