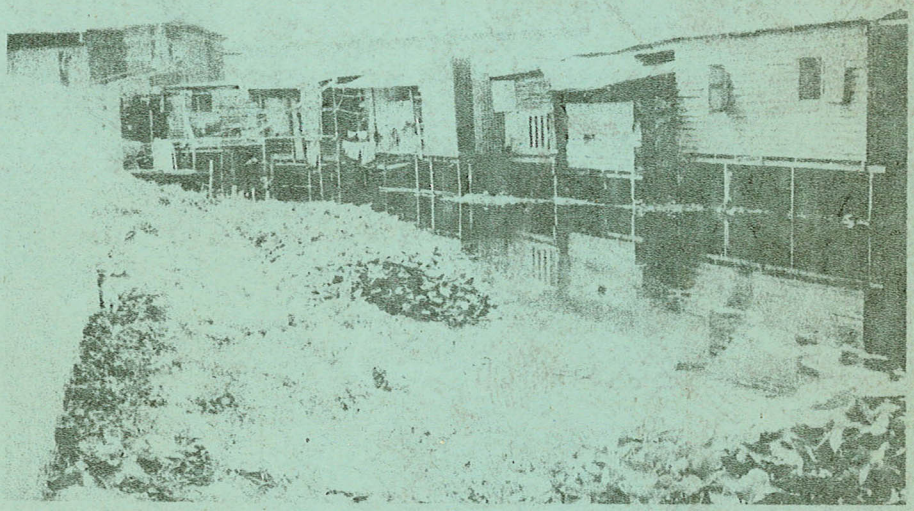
ENVIRONMENTAL PROBLEMS IN GREATER BANGKOK



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THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH

FINAL REPORT

ON

ENVIRONMENTAL PROBLEMS IN GREATER BANGKOK

FOR PRESENTATION AT UNESCO & UNEP'S ECOSYSTEM

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SYNOPSIS

Pollution and destruction of the environment in Bangkok have reached near-crisis proportions. The city suffers from polluted air, putrid water-ways and head-splitting noise from vehicles and industrial plants. The streets are congested with traffic while the remaining green spaces are being eaten away by uncontrolled urban sprawl. Garbage rises in mountains on land which is slowly subsiding. At the root of these problems is the high rate of population increase which raises the needs for industrialization, urbanization, higher agricultural productivity and exploitation of natural resources. The effects of these elements of economic development on the environment, and the nature and extent of various environmental problems are discussed in detail. The process of environmental quality control and various governmental measures, taken in an attempt to alleviate the problems, are explained. Recommendations on improvement of the environmental quality management are given.

ENVIRONMENTAL PROBLEMS IN GREATER BANGKOK

INTRODUCTION

Figure 1 is a map of Thailand showing the location of Bangkok and the major cities and rivers. The country occupies an area of 510,000 square kilometers, of which 24 per cent is agricultural land and 63 per cent is forest area, of great a variety of topographies. The most fertile part of the country is the central alluvial plain where the capital city of Greater Bangkok is situated with a population of 4.5 million.

The area of Bangkok has increased by 16 times from an original area of 296.6 square kilometers to 1,549.4 square kilometer in 1973, after the decision to amalgamate the municipal areas of Bangkok on the east side of the Chao Phraya River, and Thonburi on the west side, into a single Bangkok municipality.

The Bangkok Metropolis is divided into 24 districts. Most of the areas in Bangkok are residential areas, industrial sites and commercial buildings, while a number of paddy fields are located at the outskirts of the city. The main economic activities in Bangkok are commerce, services and industry. The main industrial activities include the chemical industry, automobile assembly plants and spare parts industry, petroleum industry, and electrical applicance industry. Industry has recorded the growth of 8.7 percent during the second half of 1975. The growth rate during the 1976 performance was 7.2 per cent higher than in 1975. It is expected in the next 2 years would be higher than the previous years[1].

Bangkok, although it is the most developed city in the country, is also facing several problems especially environmental problems. The deterioration of environment is to great extent due to rapid population growth and expansion of industry. Lack of proper wastewater collection and treatment facilities, illicit disposal of untreated domestic and industrial wastes into waterways and on public ground, excessive use of pesticides and fertilizers, heavy traffic congestion, uncontrolled emission of air pollutants from industry and vehicles, and innumerable other factors are the immediate causes of the deterioration in environmental quality in Bangkok Metropolis.

It is the purpose of this report to describe the causes, nature and extent of varicus environmental problems in Greater Bangkok, especially water and air pollution, to discuss various efforts being made to alleviate the problems and factors responsible for the unsatisfactory progress in environmental quality control, and lastly to spell out the city's needs in its campaign to conserve its environment.

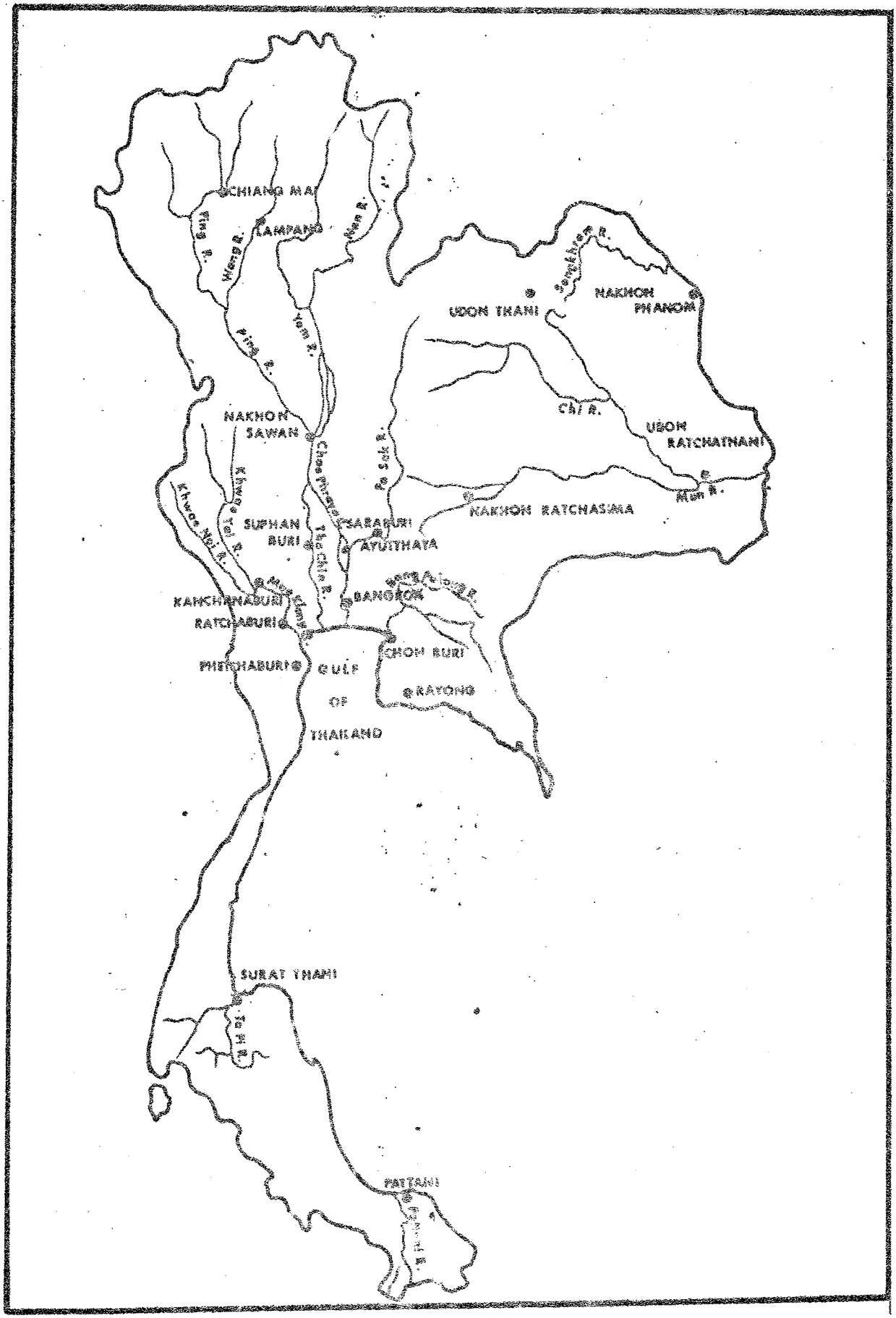


Fig. 1 - Map of Thailand

CAUSE OF ENVIRONMENTAL PROBLEMS IN GREATER BANGKOK

The real root of the various environmental problems in a city like Bangkok, is the high rate of population increase. In 1969 the population of Bangkok was about 2.8 million which was about 56 per cent of the total urban population. From 1960 to 1967 the urban population increased by 43 per cent while the corresponding increase of rural population was only 22 per cent[2]. In 1976, the population of Bangkok was recorded at 4.35 million. The population growth rate is around 4.1 per cent, which is twice as high as the average growth rate of other provinces. The population density averages 10,581 persons per square kilometer. This indicates the rapid progress in urbanization of the country. However, these figures might be misleading since the increase in urban population was mainly confined to Greater Bangkok, while the ratio between the rural population and that of other towns and cities remain practically unchanged. It can be inferred from this that economic development in the other areas apart from Bangkok, has not successfully progressed.

At present, Greater Bangkok is the centre of industry, administration, commerce, and education. Lack of economic development in other parts of the country creates problems of unemployment and as a result, a great number of people in other areas migrate into the capital to seek better jobs and opportunities, causing a rapid increase in population in the city. Figure 2 shows the population of Greater Bangkok for the years 1952 to 1976. The population increase from 1,081,964 in 1952 to 4,351,000 in 1976, representing an average annual rate of population increase of 12.59 per cent based on the 1952 population. However, the rate of population increase is expected to decrease since the government is speeding up birth control programmes and economic development in other parts of the country. Overall, birth control efforts have been a successful, since Thailand has reduced its population growth rate from a high 3.2 per cent in 1972 to 2.6 per cent at the end of 1976, according to the National Statistics Office of the Government of Thailand. Despite this, the population of Greater Bangkok is predicted to rise to about 6.5 million by 1990.

Rapid population growth means increasing needs for industrialization, urbanization, agricultural productivity, and exploitation of natural resources, in attempts to increase per capita income and the standard of living. Unfortunately, in the course of this development. Their impact on the environment are usually ignored because of unawareness, and lack of financial resources and technological knowledge. The rapid increase in industrialization and urbanization in and around Greater Bangkok has already created serious problems of water pollution and other environmental problems in the city, as diagramatically illustrated in Figure 3. The problems, if they remain untackled, will get worse as the population increases.

Industrialization:

Industrialization is recognized as the most effective way of improving the country's economy. However, wastes materials produced in manufacturing processes can, if improperly handled, degrade quality of the environment through pollution of air, water and soil. In addition, excessive noise from some industries can be a public nuisance and cause psychological damage to the public

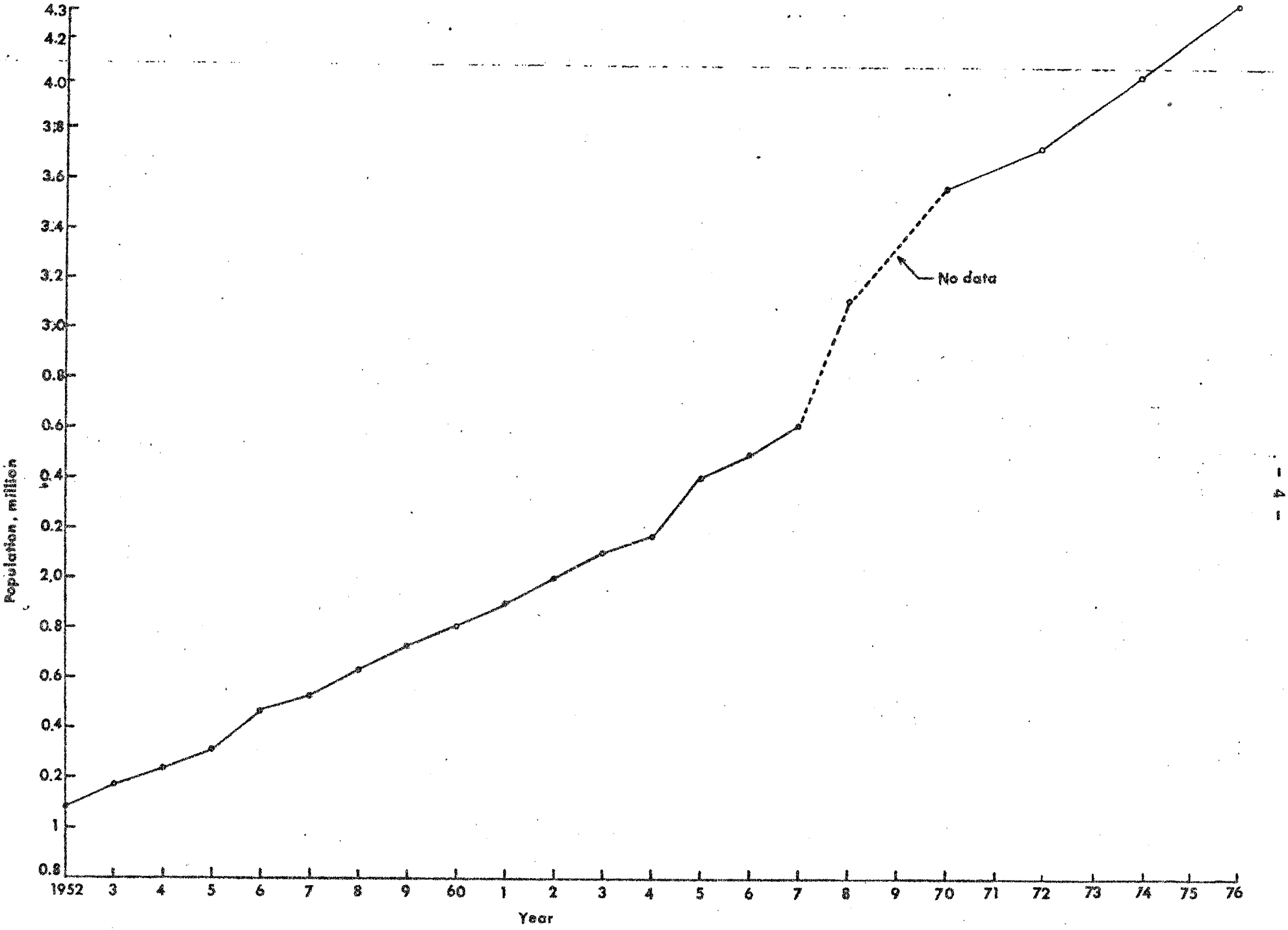


Fig. 2 – Records of Greater Bangkok Population

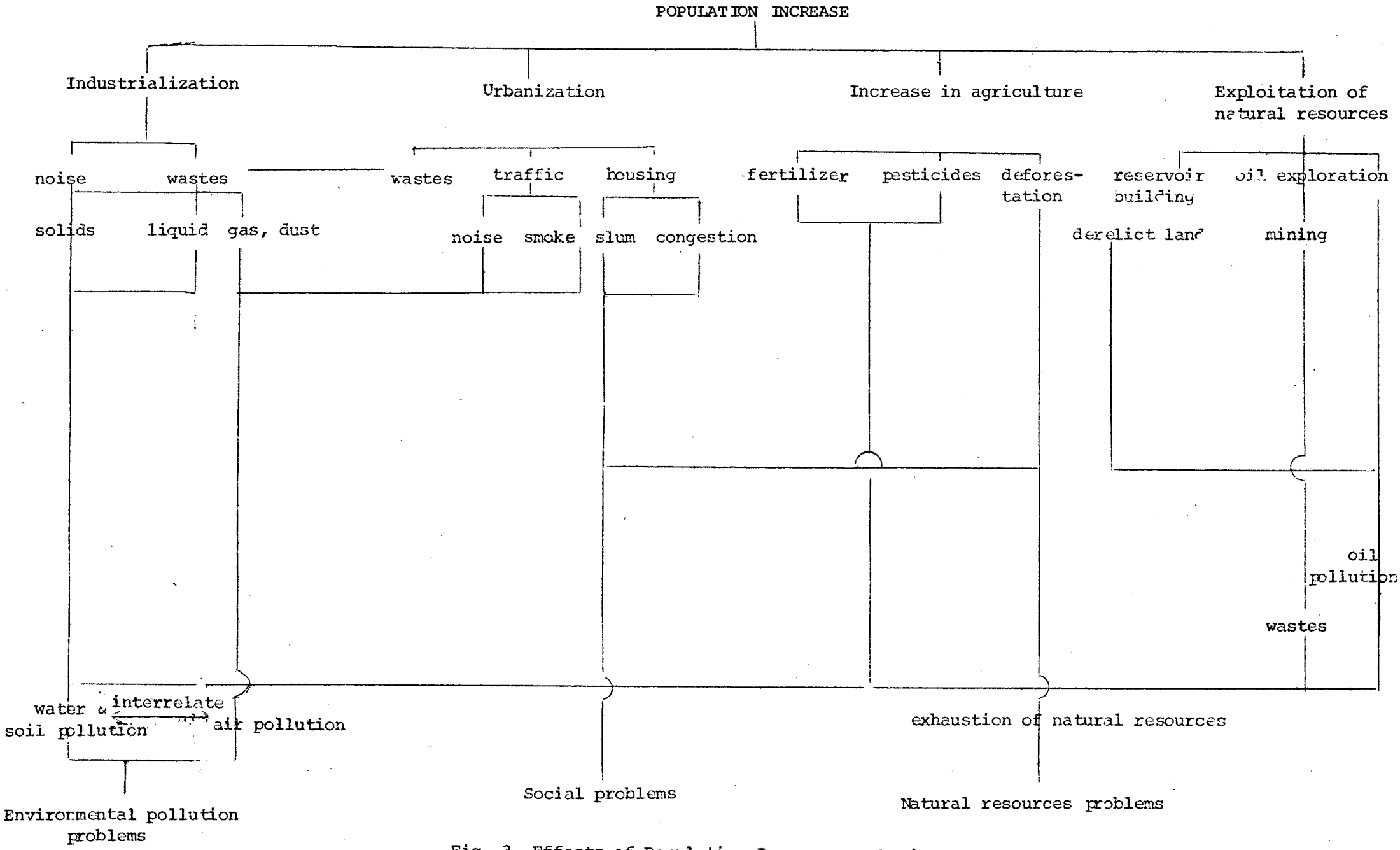


Fig. 3 Effects of Population Increase on Environment

In the past decade, the number of factories has increased considerably, with most of industries concentrated around the city. These industries include textiles, brewery, distillery, tannery, soap, detergent, soft-drink, dairy, paper, phamaceutical, food, metal etc. Up until now, over 2,000 factories have been registered with the Ministry of Industry(3). However, most of these factories are of small and medium sizes and a great percentage of them can be regarded as family industries.

At present, industrial wastes are causing serious problems of water pollution in various parts of the city.

Urbanization:

Urbanization is usually associated with industrialization and population increase and it can have deleterious consequences on the environment, if in properly planned. Unfortunately the process of urbanization in Thailand is virtually uncontrolled, and does not occur according to any plan, due to lax enforcement of the urban planning laws. Industrial, commercial, and residential areas are indiscriminately mingled. The municipalities always fail to provide essential community facilities such as sewage system, low-income housing, water supply etc., at a fast enough rate to cope with the rapid increase in urban population. As a result, environmental pollution, poor sanitation, excessive noise, destruction of scenic amenities, congestion, lack of availability of open space and recreational opportunities, and slum areas are prevalent problems in most cities in Thailand and the problems seem to be most critical in Greater Bangkok.

The National Social Welfare Council conducted a survey of slums in 1966 and found 39 slum areas in Greater Bangkok comprising 17,300 houses with 106,200 residents(2). If a slum area is more strictly defined, as an over-populated area with poor sanitation and low-income and poorly educated people, at present there would be about 300 slums in Bangkok metropolitan area, inhabited by about 25 per cent of the population.

Increase in Agricultural Productivity:

Rapid increase in population raises needs for agricultural production. This can be achieved through an increase in agricultural area or by the application of fertilizers and pesticides. In the case of Greater Bangkok, agricultural area is limited and becomes smaller day by day because of modern urbanization. Consequently, increase in agricultural production can be only achieved through application of fertilizers and pesticides. Unutilized residues of these chemical will become waste materials and will be leached off the land into natural water courses, thus causing water pollution. However, this pollution problem probably has less impact on Bangkok's environment compared to the impact of domestic wastes and industrial wastes.

NATURE AND EXTENT OF THE EXISTING PROBLEMS

Bangkok, like most other large cities which have become great markets for the world's many modern conveniences, also suffers from the insidious and pervading effects of pollution. Unfortunately, quantitative information on the extent of various environmental problems in the city is very limited due to lack of systematic collection and compilation of relevant data. However, what data on water and air pollution that is available at present indicates clearly the critical problems of water and air pollution in many parts of the city.

The following are general description of the pollution problems in Bangkok, for the purpose of outlining the nature and extent of the problems as background for subsequent discussion.

Water Supply:

Thailand is fortunate in its abundant water resources. There are many large rivers in the country, as shown in Fig. 1, and these are of the utmost importance to agriculture, communication, transportation, fisheries, industrial development, and daily living of the people. The majority of people in Thailand especially those residing out side municipal areas, have not been provided with tap-water. Even in Greater Bangkok, only about 60 per cent of the total population, have access to a piped water supply[2,4]. Consequently, large percentage of Thai people still has to rely on surface water for various domestic uses such as washing, cleaning, bathing and even drinking, when rain water or ground water is not available.

Bangkok city's principal water supply is taken from the Chao Phraya River at Samlae, a point 89 kilometers from the river mouth where the salt content of the river water is insignificant even at low river flows. Each day around 1 million cubic meters[5] of water are pumped from the river along Klong Prapa to water treatment plants in Sam Sen and Thonburi.

Recently,[6] an announcement made by the Metropolitan Water Works Authority (MWWA) indicated that it is currently capable of producing 1.2 million cubic meters of water daily. The MWWA will have increased its production capacity of running water to two million cubic meters a day by the end of July, 1979. With that production capacity MWWA will be able to serve about three million city people upto the year 1982.

It was mentioned that the city's population now is, and will be in the future, supplied with treated water originally taken from the Chao Phraya River at Samlae, Unfortunately, up stream of this point is the city of Ayuthaya, which discharges untreated wastes directly into the river, and the Province of Pathumthani which is rapidly developing industrially. Many factories including a large paper mill discharge large quantities of industrial wastes containing mercury into the river. Another hazard is that of pesticide and herbicide build up in the river water, which would again be a threat to Bangkok's population, even if only due to a long term exposure to low concentrations of pollutants. Up stream of Samlae is the major rice bowl of Asia and increasing use is being made of pesticides and herbicides, although it is still at a modest level because of costs. Irrigation return waters will contain these persistent materials and at low river flows it is possi-

ble that undesirable levels might occur in the future. This could therefore become a real danger to the 4.5 million people in Bangkok.

Water Pollution:

As previously mentioned, the city of Bangkok is situated in the delta of Chao Phraya River (the largest in Thailand), some 50 kilometres up-stream from its point of discharge into the Gulf of Thailand, in an area which was previously rice paddies (Figure 4). The average elevation is only about one meter above sea-level, hence the city is very flat and at best the natural drainage is very slow and poor. The drainage pattern is fixed by a system of man-made canals built by excavating the earth (a tight clay) in the early history of the area, primarily to provide transportation and for military protection (Figure 5).

In earlier times the system of canals together with the river into which the canals discharge were adequate to receive and dispose of the waste of the city in an acceptable manner, and the canals contributed greatly to the aesthetic charm of the community. However, this system with its limited capacity for assimilating wastes has become greatly overtaked by the increasing community growth. Today the entire system of canals and the river is heavily polluted from the sanitary wastes of the population, plus garbage and refuse thrown into the canals and river from nearby dwelling and commercial establishments, plus discharges of wastes from industries scattered throughout the city.

Up to the present time, the city have only a few integrated sewage systems and sewage treatment systems, constructed by the National Housing Authority for its housing projects. There are many private housing villages, but none of them have sewage treatment system. Most of the household wastewaters arising from cooling, bathing and washing are discharged through street drains or sewers which are eventually drained into nearest receiving water bodies. Toilet wastes usually receive only rudimentary treatment in cesspits or septic tanks. The accumulated sludge is periodically removed and disposed of in a municipality lagoons. The septic tank effluent seeps through the soil and should be rendered harmless before reaching underground water or water courses. However, this is not always done especially in the areas in and around Greater Bangkok. These areas are alluvial plane and the water tables are high. Consequently, the septic tank effluent from houses contiguous to the water course can still be a significant pollution source.

The pollution of surface waters in Bangkok is in most cases, organic in nature. One important effect of the organic pollution on the surface waters is the depletion of dissolved oxygen which is vital to metabolic activities of aquatic life. If the level of dissolved oxygen is too low, most species of fish and other aquatic animals will not be able to survive. The exhaustion of dissolve oxygen will result in anaerobiosis and the water may become septic, giving off unpleasant adours.

Toxic industrial wastes and pesticide residues in runoff from agricultural land around Bangkok, have not created serious problems of water pollution, although there have been occasional complaints over damage to fisheries, crop plantation, and domestic uses of the surface waters, caused by some toxic industrial wastes. The problems are on a small scale and can be regarded as minor compared with the problems of organic water pollution.

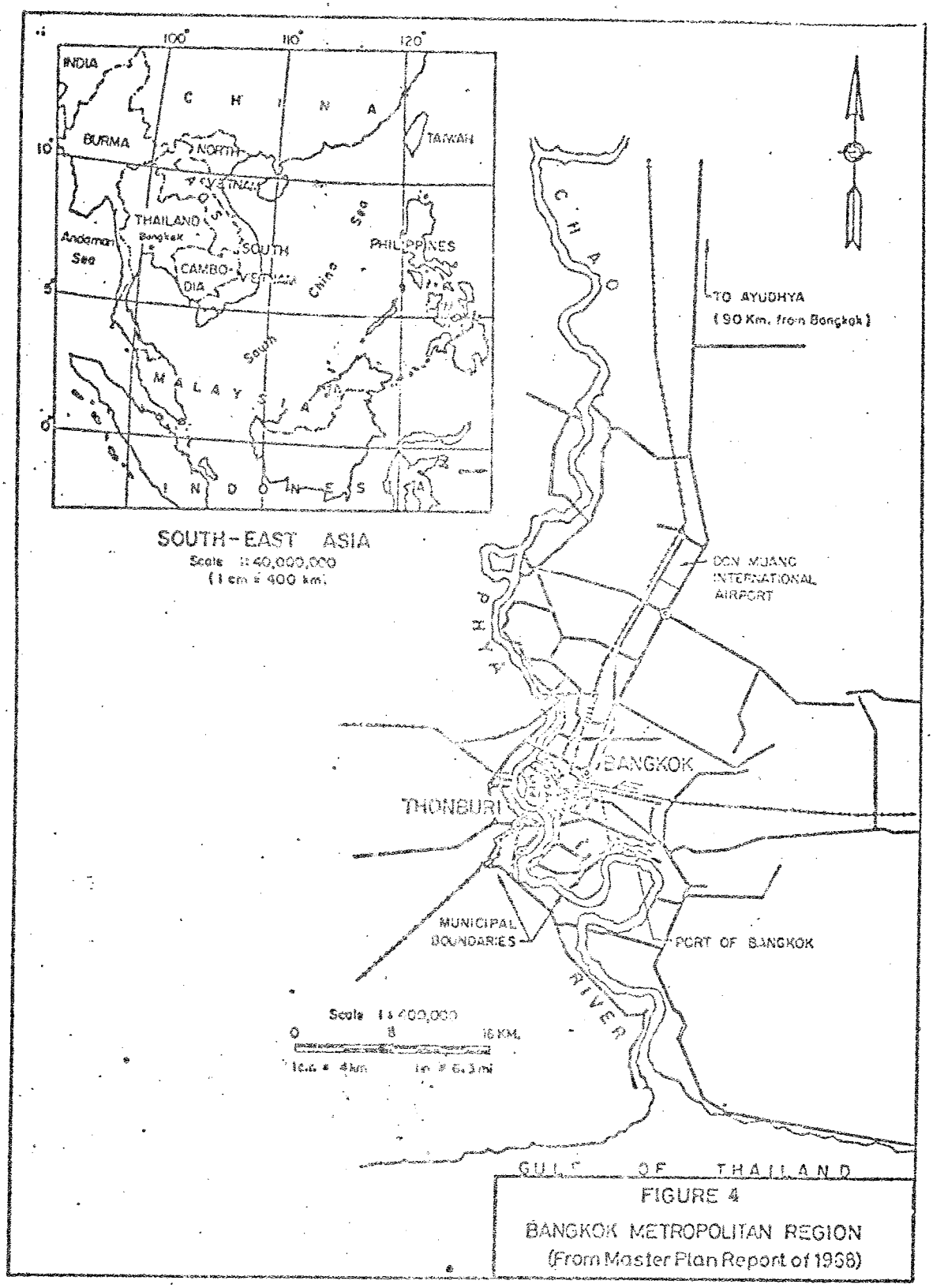
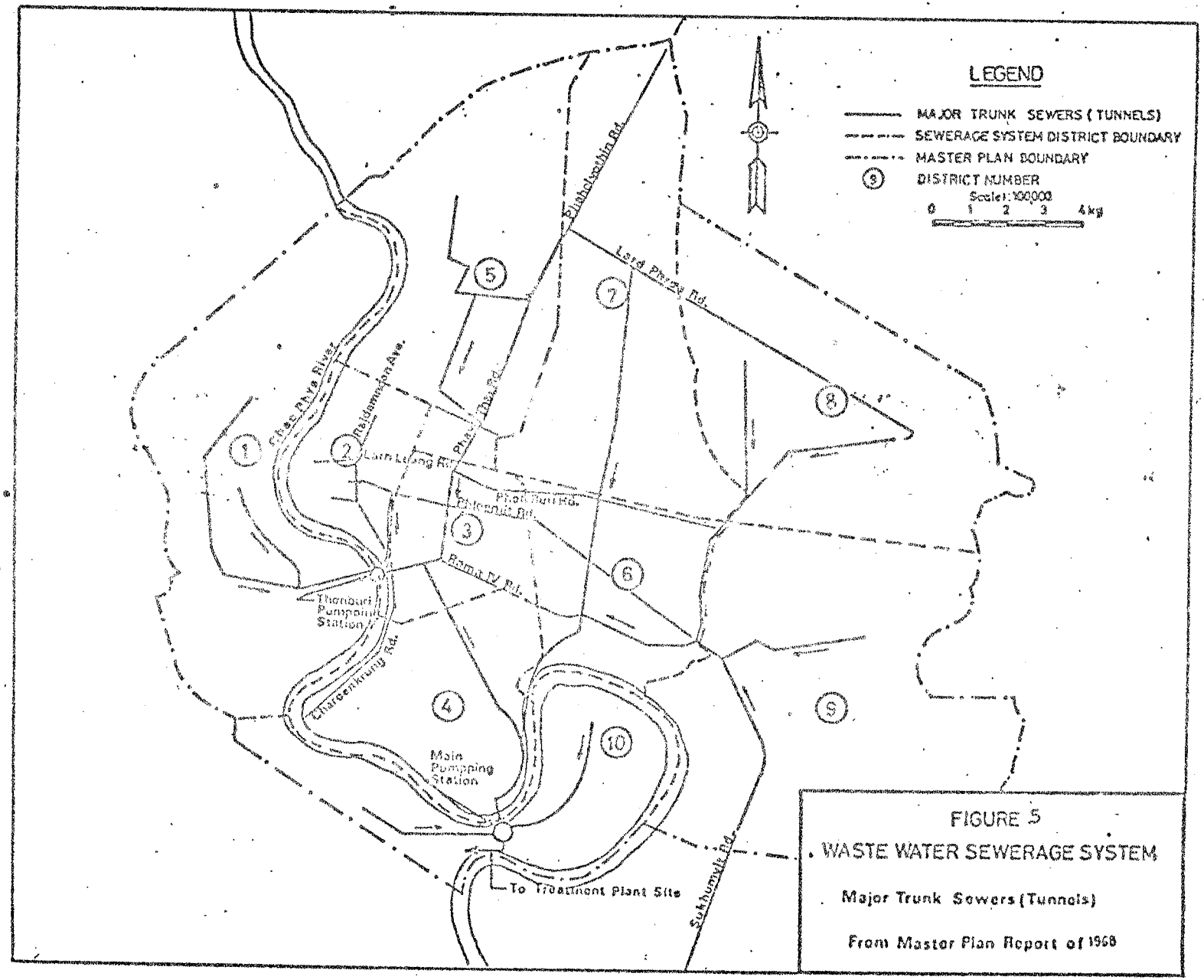


FIGURE 4

BANGKOK METROPOLITAN REGION

(From Master Plan Report of 1968)


LEGEND
MAJOR TRUNK SEWERS (TUNNELS)
SEWERAGE SYSTEM DISTRICT BOUNDARY
MASTER PLAN BOUNDARY
DISTRICT NUMBER
Scale: 100,000
0 1 2 3 4 kg
Chao Phya River
Phaholyothin Rd.
Lard Prao Rd.
Phahonyothin Ave.
Phaholyothin Rd.
Lam Luang Rd.
Phahonyothin Rd.
Chidlom Rd.
Rama IV Rd.
Thonburi Pumping Station
Charoenkrung Rd.
Main Pumping Station
To Treatment Plant Site
Sukhumvit Rd.
1
2
3
4
5
6
7
8
9
10
FIGURE 5
WASTE WATER SEWERAGE SYSTEM
Major Trunk Sewers (Tunnels)
From Master Plan Report of 1968

Pollution in canals: There are no sanitary sewers in Bangkok, only street drains which receive surface runoff and also, by indirect flow, much of the effluents from the septic tank systems serving individual buildings. Because of the tight clay-type of soil, little of the septic tank effluent percolates downward and therefore finds its way into the drains and canals. Also, because septic tanks do not effect much removal of organic material, most of the organic pollution from the entire population eventually reaches the canals and the river.

The organic loadings reaching the canals from septic tanks are supplemented by solid wastes from nearby buildings. Although, throwing refuse into the canals is illegal, many of these buildings are not serviced by the municipal refuse pick-up trucks because of access difficulties. Results of field investigations conducted by the Ministry of Public Health[7] during the period June 1969 - May 1970, indicated that the BOD concentration in the canals ranged from 30 to 206 mg/l. The total BOD discharge from the canals to the river was about 77,000 kg/day in a total flow of about 15 m^3/s (cubic metre per second), and the total sanitary waste discharge to the canals was estimated at 6.7 m^3/s

With respect to industrial wastes, the Bangkok City represents the largest concentration of industry in Thailand, and many of these produce wastes which create serious local pollution problems despite efforts to require industries to treat their own wastes. While some of the larger industries do create and intensity local pollution problems, the total organic loading produced by all of the industries is small, less than 5% of the total loading originating from people[2,5].

Owing to the flatness of the hydraulic gradient considerable "in canal" biological treatment take place in the canals on the way to the river. Hence, the canals serve not only for purposes of transportation, recreation, bathing etc., but also as open sewers and as partial sewage treatment systems. MOst of canals are septic (devoid of oxygen) most of the time, and often black in colour and odor-producing and objectionable aesthetically. They are also heavily polluted from the public health point of view, with coliform concentrations almost always at high levels.

The sanitation problem in the canals has been further intensified by gradual decrease in the hydraulic capacity of the canals over the years, due to numerous factors including regulation of the river by dams upstream (which has tended to reduce or eliminate flushing of the canals during high river flow), filling in of some of the canals, and a gradual depreciation of the regular cleaning program. Hence, the sanitation problems in the canals are serious not only in the dry season but also in the rainy season due to a gradual worsening of the capability of the canal-drainage system to remove surface waters following rains.

The Master Plan Report[8,9] included the first systematic study attempting to estimate pollution in the canals and the Chao Phraya River, and confirmed the existence of gross pollution in many of the canals, with worst conditions occurring at low tide. Of the canals studied, those in the central Bangkok were in the worst condition. The report stated further that pollution in the canals constitutes a "definite health hazard and a substantial aesthetic nuisance".

Chao Phraya River Estuary: The Chao Phraya River is formed by four major tributaries; the Ping, Wang, Yom and Nan Rivers, which finally converge at Nakorn Sawan and flow to the Gulf of Thailand (See Fig. 1). Because of tidal fluctuations in the Gulf, the lower reach of the river is estuarine (Figure 6), the extent of this influence being a function of fresh water flow in the river. At low discharge conditions (100 m^3/sec. or less) the estuarine reach may extend upto 160 kilometres from the river mouth[5,10], where as under flood conditions (4,000 m^3/sec. or more), tidal fluctuations may affect only about 75 kilometres of the river. The natural (unregulated flow of the Chao Phraya River average more than 1,000 cms.), ranging from about 25 cms. to 4,000 cms[11]. The critical period, with respect to pollution occurs during the dry season.

The condition of the river, on reaching the Bangkok Region may be described as "partially polluted", i.e. its oxygen content is appreciable but not at saturation levels, due both to waste discharges and surface runoff upstream. The effect of pollution discharge from the Bangkok Region, during the dry season is to use up most of oxygen reserves of the river, resulting in a "sag" in the dissolved oxygen concentration below the region. Previous pollution surveys[10,12], of the river have shown that the estuarine reach of the river is in the worst condition from the point of view of pollution. In addition, the major cause of pollution is organic matter discharged in domestic and industrial wastes, as evidenced by the serious depletion of dissolved oxygen, especially between Rama VI Bridge and Bangkok Port (Klong Toey) during low river flows as shown in Figure 7. It can be seen that the condition of the estuary has been steadily deteriorating since 1966 due to increase in population and industries. Since 1970 the estuarine has been completely devoid of dissolved oxygen between these points for several months in the dry season, giving rise to anaerobic conditions and noxious odours. This state of affairs has often been blamed on industry. While it can not be denied that many industrial plants discharge organic wastes, and contribute to the problem (among which, Government factories are no exception), the contribution of sewage from the huge population in the Metropolitan area must still be the largest source of organic material reaching the river. As previously mentioned, Bangkok is not sewered and most household wastes receive, if any, only rudimentary treatment in septic tanks and/or cesspits (seepage pits). Ultimately, most of the organic material discharged finds its way into the canals and eventually into the river.

On average each person in an urban environment produces approximately 50 grams of organic matter (as Biochemical Oxygen Demand, BOD) per day[5,10]. The Bangkok population, approximately 4.5 million people at present, would thus release an average of 250,000 kilograms of BOD per day, of which a high portion would find its way into the river. In addition, downstream from the Bangkok Region another urban/industrial complex is developing, and it seems likely that eventually there will be a continuous metropolitan zone or megalopolis stretching along the river from Bangkok to the Gulf of Thailand. Hence, conditions in the river downstream from Bangkok can be expected to become progressively worse. Consequently, therefore, it will not surprising if the estuary becomes devoid of oxygen when industrial discharges are added to the already heavy load from the urban population. Preventing industry from discharging wastes to the river without complete treatment will

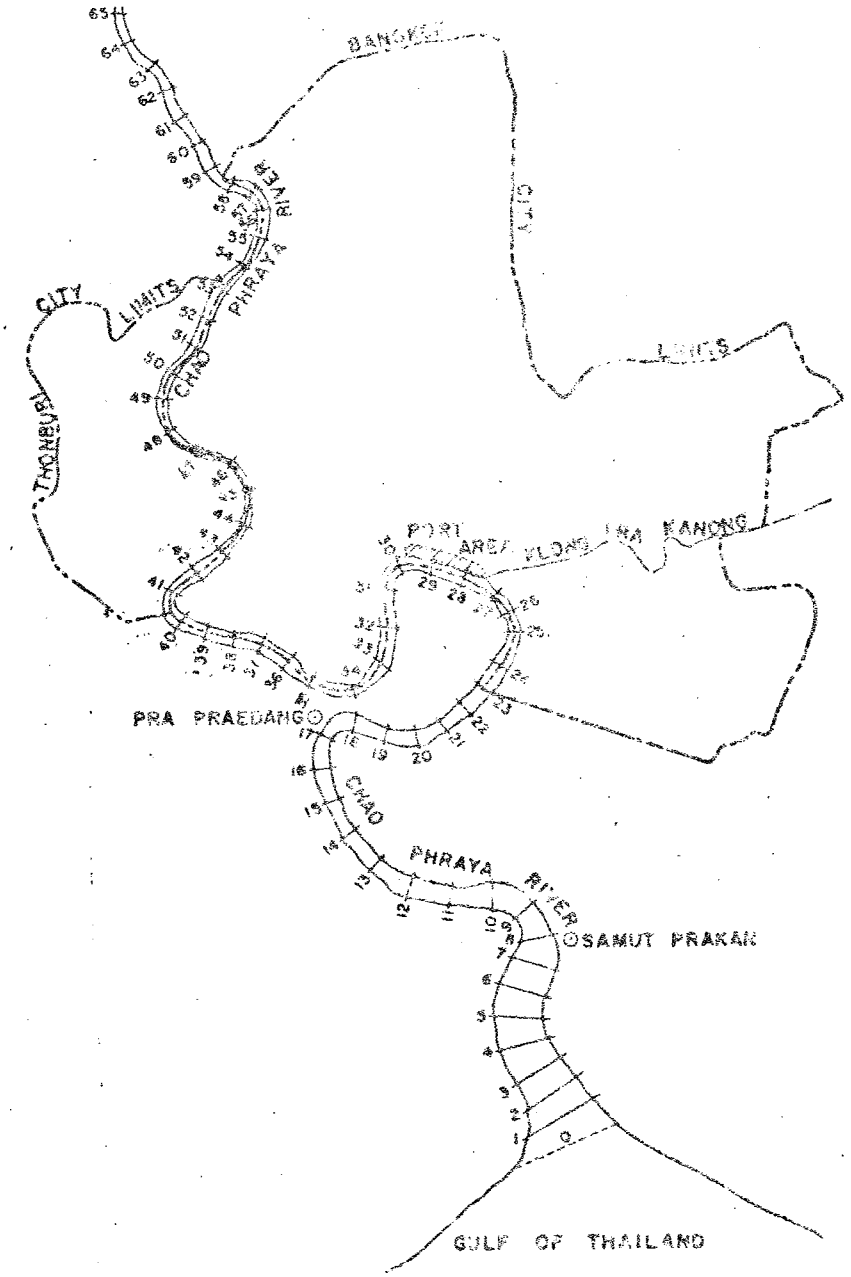


FIG. 6 —LOWER CHAO PHRAYA ESTUARY

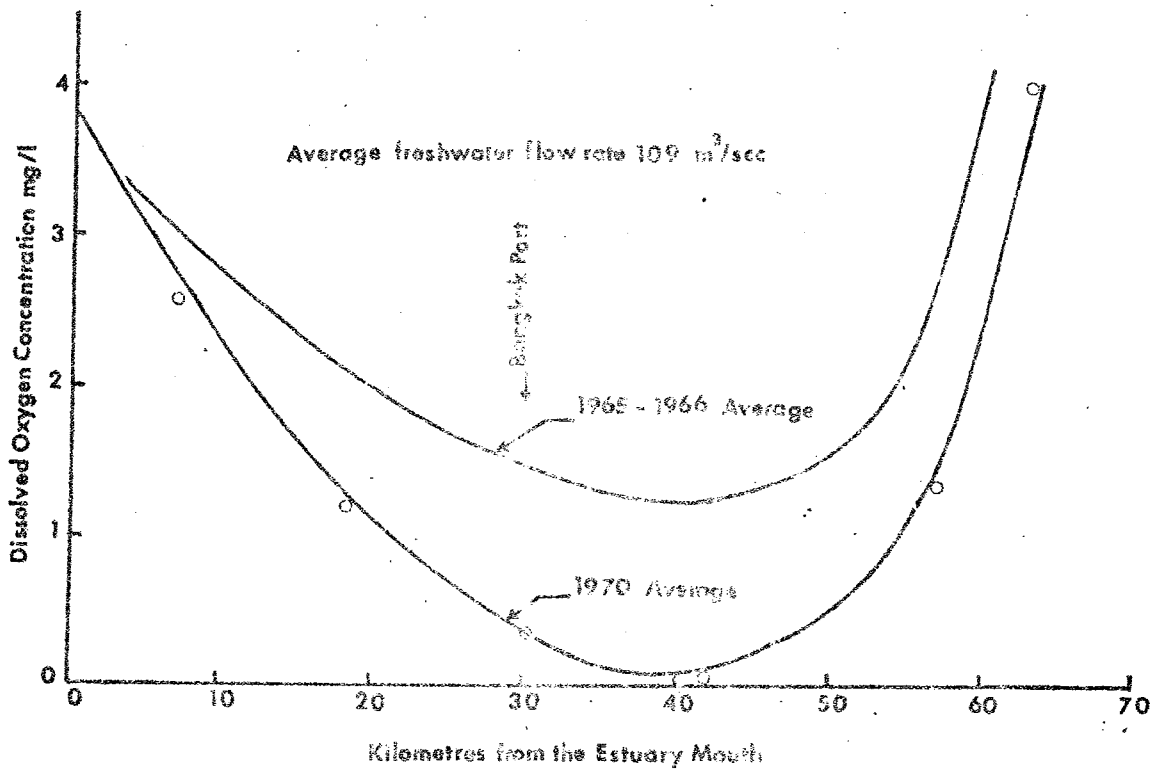


Fig. 7 - Records of Dissolved Oxygen Condition of the Chao Phya River

not, in itself, solve the pollution problems in the estuary.

Toxic industrial wastes and pesticide residue in runoff from agricultural land, have not created serious problems of water pollution. However, results from recent investigations[13] of the distribution of copper, zinc, cadmium, lead and mercury in water, sediment and biological samples of the Chao Phraya Estuary in 1976 indicated an increasing trend in the concentration of some heavy metals in the estuary and the upper parts of the Gulf of Thailand. The concentration of dissolved cadmium, lead, and mercury were higher than the average world concentrations of these metals in stream water, while the dissolved copper and zinc levels were lower. The concentration of cadmium in sediment was found to be generally higher than the average world concentration. Other heavy metals concentrations were either comparable or lower than the world averages. Of these five metals, only the lead content in biological samples showed an increasing tendency during the past 4-5 years. Nevertheless, the concentration of the five metals in the biological samples were still within the limits for safe consumption. Table 1 and 2 summarise the results of this investigation.

Upper Gulf of Thailand: Another of concern, in considering water pollution problems in the Bangkok Region, is the upper portion of the Gulf of Thailand. This area is important both for recreational uses and commercial fishing, especially shellfishing. The Upper Gulf is characterized by extensive estuarine zones (including extensive mud flats) which are the habitats of commercially important clam and mussel species and also shrimp (the most important marine fishery of Thailand), and also are the breading areas for commercially important finfish in the Gulf. Pollution from the Chao Phraya and Mae Klong rivers (see Fig. 1) has already resulted in serious damage to shellfishing and will probably also have long-range implications on finfish. The Mae Klong River, due to industrial waste discharges (mostly sugar cane mill wastes), is heavily polluted every year during the dry season, resulting in severe effects on the cockle clam industry in the vicinity of the river mouth.

Amount of some toxic heavy metals found in the Upper Gulf of Thailand are already shown in Table 1 and 2

Air Pollution

Air pollution problems in Thailand are almost exclusively confined to the Greater Bangkok area where traffic congestion is a chronic and seemingly unsolveable problem. As far as the sources of air pollution in Bangkok are concerned it has been estimated that 75-85 per cent comes from vehicles, 10-15 per cent from burning (trash, charcoal etc.) and 5-10 per cent from industry[15] consequently, the major problems of air pollution in Bangkok are caused by exhaust fumes. Detail research has re-vealed that the gasoline engine is a far greater polluter than the diesel engine, in regard to emitting substances which are toxic to man. Since over 90 per cent of Bangkok's traffic is powered by gasoline engines, and as over half of these vehicles are cars, it is quite obvious that public enermy number 1, as far as air pollution in Bangkok is concerned, is the automobile. During the

Table 1. Concentration of dissolved, particulate, and total heavy metals in the water of the Chao Phraya River estuary, in ppb. (average)

Heavy Metal	Sampling Points						Average World Concentration (dissolved) (14)
	Upper stream just above Bangkok Region (dissolved)	Bangkok Region			Upper Gulf of Thailand (dissolved)	Sea (dissolved)	
		Dissolved	Particulate	Total			
Copper (Cu)	1.08	2.17	2.62	4.79	2.97	1.30	7.0
Zinc (Zn)	2.5	4.10	388	392.1	3.18	2.30	20
Cadmium (Cd)	0.25	0.52	1.58	2.10	0.38	0.10	-
Lead (Pb)	2.0	3.63	25.13	28.76	3.43	2.80	3.0
Mercury (Hg)	0.063	0.284	0.041	0.325	0.405	0.021	0.07

Table 2. Average heavy metal concentration in the top layer of sediments (0-10 cm.) and in fish and shellfish (variation range) of the Chao Phraya River estuary, in ppm.

Sampling Point	Cu	Zn	Cd	Pb	Hg
Sediments					
in the sea	0.539	1.104	0.363	0.436	0.012
Upper Gulf of Thailand	1.381	4.439	0.368	1.733	0.165
Bangkok Region	2.261	3.763	0.270	0.571	0.210
Just above Bangkok Region	1.921	1.683	0.172	0.217	0.092
Natural content of World Sediments	0-20	0-1000	0.16	0-20	0.30*
Biological Samples (fish & shellfish)	0.073-23.75	0.450-18.60	0.010-0.274	0.080-3.458	0.009-0.205

* Acceptable limit

past decade, traffic volume has increased enormously. There are at present over 400,000 vehicles (private cars, buses, trucks, motorcycles etc.) in the city, on streets with a total length of only 1,000 kilometers. Too many cars and insufficient road surface are two obvious factors responsible for the severe traffic congestion that occurs on most streets in the city.

Apart from economic damage, traffic congestion also deteriorates air quality due to the accumulation of vehicle exhaust fumes over a period of time. Among many pollutants contained in the emitted exhaust fumes compounds which are potential health hazard include carbon monoxide, 3-4 benzopyrene, nitrogen oxides, and lead compounds[2, 15, 16]. Automobiles in Bangkok with petrol engines emit mainly carbon monoxide (57.11%), unburnt hydrocarbon (5.15%), nitrogen oxide (2.2%), sulfur dioxide (0.19%) and lead (0.24%). Diesel powered vehicles chiefly expel soot particulates (black smoke), unburnt hydrocarbons (2.16%), nitrogen oxides (2.72%), carbon monoxide (0.92%) and sulfur dioxide (0.54%). Consequently, the carbon monoxide levels emitted by petrol powered cars are about 62 time higher than those by diesel driven vehicles.

Carbon monoxide is the easiest measurable car exhaust gas and therefore it has been often used as an approximate indicator of the air pollution level inside a city. The level of carbon monoxide in the atmosphere over some busy streets in Greater Bangkok has been measured since 1963 and the results are summarized in Table 3[17, 18].

From Table 3, the sampling place and time, and number of measurement for each year during 1963-1971 were not consistent. Therefore, it would be erroneous to compare the data for each year to delineate a definite pattern of time variation of carbon monoxide level. The data for the year 1972, 1973/74 and 1977 are the most reliable indicators of carbon monoxide concentrations because of the a large number of measurement taken (both location and frequency), and due to better measuring equipment. Especially in the years 1973/74 and 1977, the day time maximum hourly carbon monoxide concentration exceeded considerably the U.S. National Primary Air Quality standard of 35 p.p.m. The data also shows an increasing trend in the carbon monoxide level since 1972.

Besides carbon monoxide, other toxic air pollutants in Bangkok are heavy metals. Recent study by the Environment Research Institute of Chulalongkorn University found that there are 0-600 microgram/m^3 of lead, 0-135.4 microgram/m^3 of cadmium, 0-88.1 microgram/m^3 of copper, and 0-114.0 microgram/m^3 of zinc in respirable air particulates[19].

Soil Pollution:

Soil may be polluted by domestic and industrial wastes directly dumped on the ground, residues of pesticides and fertilizers used in agriculture, and excreta of farm-animals. The major causes of soil pollution in Bangkok area are domestic and industrial wastes directly dump onto the ground.

The most important aspect of soil pollution is its direct link with water pollution and its detrimental effects on public health. Runoff from polluted land can become a significant cause of surface water pollution, and if it

Table 3 Ambient carbon monoxide concentration in Bangkok area

Year	Number of Samples	Ambient CO - concentration in p.p.m. for average time of				Study Carried out by
		few minutes		1 hour		
		mean	maximum	mean	maximum	
1963	34	196	920			Government Committee
1964	60	167	700			"
1965	81	77	300			"
1968	18	47	60			"
1969	35	80	150			"
1970	24	40	80			"
1971	42	92	330			"
1972	140	-	-		33	AIT
1973/74	1,000			14	54	AIT
1977	263			17.6	46	BMA and National Environment Board (NEB)

seeps into the ground it can pollute ground water. Solid wastes deposited on the ground, if containing putrifying organic materials, will cause soil pollution, give off unpleasant odour and will help in spreding diseases carried by rats, mice and flies.

Soil pollution in the municipal area in Bangkok is mainly due to haphazard dumping or tipping of refuse, garbage, and other solid wastes. This usually occurs in slum areas and some inaccessible places where daily refuse collection by the municipality does not occur. Rapid increases in population impose severe strains on municipal collection service. This is compounded by increase in the per capita solid wastes volume. Between 1958 and 1970 refuse disposal rate climbed from 1 to 1.8 litre per capita per day(2). At present, it is estimated that over 8,000 cubic metres of garbage are produced daily and of this only about 4,000 cubic metres (weighing approximately 1,200 tons) are collected, by the fleet of over 300 trucks. The inefficiency of this collection system is due to the inadequate numbers of garbage collecting trucks, traffic congestion which reduces the number of collecting trip for each truck, and the incessibility of some areas. Consequently, much of the garbage that is produced is privately dumped into public water courses and onto public lands, thus damaging the soil and urban environment.

Noise Pollution: Another danger to health in Bangkok is the noise emitted by traffic and workshops in the inner city area. It has been shown that people subject to constant loud noise tend to become easily tired, irritable and prone to insomnia and high blood pressure. Traffic noise in many parts of the city already exceeds the danger level of 90 decibels (db) set by WHO(20). Culprits in the noise pollution problem are motorcycles, car without exhaust pipes, freight truck with their awesome air-horns and long-tailed boats on the river.

Children in some schools along main roads are exposed to noise levels of between 75-80 db for an average of six or eitht hours a day. Recently, in 1977, some 3,000 students of Phra-Nakhon Teacher's College located about 5 kilometers from Don Muang International Airport, complained to the BMA about another noise pollutant - over-flying jet aircraft. As there are some 20 jet aircraft landing and taking off daily at the airport, and flying over the college, the students get a huge dose of noise pollution every day which interferes with their studies and taxes their sanity.

Subsidence of areas and floods:

As previously mentioned, the city of Greater Bangkok situating on the deltaic plain is no more than 1.50 metres above sea level. After a heavy rainfall, most area in the city are flooded for a significant period of time, and some places remain under water throughout the rainy season. Poor drainage system was originally blamed solely for this flooding problem until recently, when enough evidence was gathered by the Asian Institute of Technology (AIT) to show that the problem is also partly due to subsidence of the city area due to excessive abstraction of ground water in the last 2 decades.

Data in 1972 showed that at that time the Metropolitan Water Work Authority pumped about 652,800 m^3/day of deep well water to be used as a water supply. In addition, therewere at least 1,000 private wells in use throughout the city with abstraction rates ranging from 1.5 to 400 m^3/hr.(2). This has already lowered the standing water level in the main supply aquifer to 8-10 metres below the natural surface and this level is still dropping rate of 1-2 metres per years(21).

The overall region has already subsidided to about 10 to 20 centimeters below the base level. However, despite warnings on this matter from experts, the MWWA continues its pumping activities.

ECONOMIC IMPLICATIONS

Deleterious effects of environmental quality degradation on economic progress of the Greater Bangkok are subtle, and difficult to evaluate in monetary terms. Poor environmental quality can be a public health hazard, can damage properties, and can destroy the aesthetic value of the city and its environment.

No assessment has ever been made of the economic damages resulting from existing environmental problems in Thailand. It is important, however, that the effect of environmental degradation be expressed in monetary values and balanced against the costs of maintaining the required environmental quality standards. This cost evaluation is essential if environmental engineers and scientists are to persuade politicians that budgeting for environmental quality control is necessary.

As previous mentioned, in Greater Bangkok only about 60 percent of the inhabitants are provided with public water supply. Poor people, who can not afford to install private water supply system such as wells, have to rely to a great extent on river or canal water for various domestic uses such as washing and bathing. Thus, it is obvious that water pollution can be a major public health hazard. In addition to being a potential health hazard, detrimental effects of water pollution on fisheries, especially in the Gulf of Thailand, are also very important.

It is known that air pollution can cause respiratory diseases and can damage properties and plantations. At present, though, serious cases of economic damage due to air pollution have not been experienced. Traffic congestion on the other hand, the major source of air pollution in Bangkok, causes direct economic damage in term of energy lost through inefficient use. It was recently reported that petroleum products worth eight million baht were burned by Bangkok motorists every day, and half of this amount could be saved if the traffic were able to flow freely (20).

Putrescible solid waste deposited on the ground can be a breeding place for flies, rats, and mice, thus being a potential health hazard. In addition, obnoxious odours from the putrifying solid wastes are a source of air pollution. At the time of heavy rainfall, organic pollutants in the solid wastes will be leached into the water courses, hence causing water pollution.

ENVIRONMENTAL QUALITY CONTROLS

In developing countries, the necessity for conservation and protection of the environment has just recently been realized. Governments usually take the initiative in controlling the environmental quality upon motivation from public demand for a clean environment through various mass media. In spite of the available financial resources and manpower, control is often inefficient and uneconomical due to mis-management of control schemes and lack of cooperation among the concerned authorities.

Organizations Concerned with Environmental Quality Control:

Table 4 gives the list of governmental agencies and their responsibilities concerning environmental quality control. These organizations are concerned with environmental quality control not only in Greater Bangkok but also for the entire kingdom.

Environmental quality control in Thailand has been existence for some time. Various governmental agencies are responsible for the enforcement of laws concerning the protection and conservation of environment.

Before a national policy on environmental quality control can be formulated it is essential that a survey of the extent of existing environmental problems be conducted to determine their order of priority. To set up the objectives, preferably in terms of environmental quality standards, various uses of the environment must be thoroughly investigated. It is essential that the standards which will be promulgated, are appropriate to local conditions. In developing countries it is advisable that the standards should be lenient as possible to conform with the economic states of the countries.

Technological and economic feasibility of any economic development projects in Thailand have to be considered by the National Economic and Social Development Board. Before 1975, there was no authority responsible for evaluating the impact on the environment of economic development projects, until early 1975 when the National Environment Board (NEB) was established. The principle duties of NEB (see detail in Appendix 1) are to coordinate the various governmental agencies and propose administrative and legislative measures to the government. Under the Promotion and Preservation of the National Environment Act (1975), there is a full time organization reporting to NEB called the Office of NEB. The Office of NEB is responsible for collecting data, monitoring environmental quality, and evaluating environmental impact of all major development projects.

The establishment of the NEB could be considered as the most significant step towards a systematic control of environmental quality.

Standards:

There are two kinds of standard in environmental quality control; source standards which relate to the destructive actions of the pollutant at its point of discharge to the environment; and ambient standards which pertain to the environment as a whole.

Table 4 Government Agencies Involved in Environment Quality Control

Agency	Function and Responsibility
1. Office of Prime Minister	national environmental policy planning, coordinating, advisory and setting up national environmental quality standards (National Environment Board)
2. Ministry of Interior	providing community, services on sanitation, pollution control (Bangkok Metropolitan), traffic control, vehicle licensing (Department of Police)
3. Ministry of Public Health	national environmental quality survey, environmental quality criteria and standards (Department of Health). Medical research (Dept. of Medical Service and Dept. of Medical Science)
4. Ministry of Industry	Pollution control in industries, setting-up emission standards (Dept. of Industrial Works)
5. Ministry of Communication	transport vehicles licensing (Dept. of Land Transportation)
6. Bureau of State University	research, academic education (e.g. The Institute of Environmental Research, Chulalongkorn University)
7. Ministry of Science & Technology (newly established in May 1979)	research for industrial development (Thailand Institute of Science and Technological Research)
8. Ministry of Agriculture	research of environmental effects on plants and agricultural products (Dept. of Agri.) protection and conservation of forest (Dept. of Forestry)
9. Ministry of National Development	protection and development of water resources (Dept. of Irrigation) exploration of mineral resources (Dept. of Mineral Resources)
10. Ministry of Education	general environmental education.

Standards of environmental quality will have to be established taking into account all beneficial uses of the environment, social and technological, and also the economic conditions of the country. Benefit-cost studies are essential to derive the optimum standards. Standards for pollutants or activities destructive to the environment will then be set up based on these standards of environmental quality. The fact that these two kinds of standards have a great effect on the cost of quality control is often overlooked by control authorities. Standards imposed are usually copied from the developed countries. This often leads to uneconomical or inpracticable solutions to peoblems due to the great environmental differences that exist between the developed and developing countries. In practice, these standards tend to be no more than a show case since compliance with them can never be achieved in view of the economic and technological conditions in the developing countries.

So far, Thailand has not established official standards of environmental quality. The standards that are most sorely needed at present are standards for surface water quality because water pollution control is the most urgent problem as far as environmental quality is concerned. Suggested stream standards for tropical countries according to controlling water use are presented in Appendix 2[22].

Recommended water quality standard for the Chao Phraya River estuary are as follow [8].

(1) Dissolved oxygen not less than 3.0 mg/l

(2) Coliform bacteria not more than 5,000 per 100 ml.

(3) No toxic materials in concentrations high enough to inhibit the biological life of the estuary.

(4) No oil, grease or other floating materials in quantities sufficient to constitute a nuisance or to be aesthetically objectionable.

(5) Turbidity not in excess of 5 JTU, excepting that resulting from natural causes.

It should be noted that these standards are only provisional. Research on the effects of pollution on various uses of the waters will be needed before authoritative standard can be promulgated.

In 1970 the Ministry of Industry established working standards for effluent discharge into inland streams, as shown in Table 5. The standards are expressed in terms of maximum allowable concentration regardless of the waste assimilation capacity of the receiving water body and the type of industry. It was pointed out that these standards would not be practical for some industries and a new set draft standards was proposed based on the type of industry and the waste assimilation capacity of the receiving water body expressed in terms of the degree of treatment[23].

Standards for air quality control, especially in Bangkok area, are also urgently needed. The NEB presumably has been well equiped with legislative power to set up national air quality standards. A newly - drafted bill to control air and noise pollution motor from vehicles has been proposed to a subcommittee of the NEB headed by the deputy prime minister.

Table 5 Working Standard for Effluent Discharging into Inland Streams Issued by Ministry of Industry

BOD (5 day 20°C)	max.	20	mg/l
Suspended solids	max.	30	mg/l
Dissolved solids	max.	2,000	mg/l
pH value	between 5 and 9		
Permanganate value	max.	60	mg/l
Sulfide (as H_2S)	max.	1	mg/l
Cyanide (as HCN)	max.	0.2	mg/l
Oils and grease	none		
Tar	none		
Formaldehyde	max.	1	mg/l
Phenol and creats	max.	1	mg/l
Free chlorine	max.	1	mg/l
Zinc, Chromium, Arsenic, Silver, Selenium, Lead, Nickel	individually or in total, max.	1	mg/l
Insecticides	none		
Radioactive materials	none		
Temperature	max.	40°	C

No disagreeable taste and odour

Standard for sewage effluents discharging to inland stream of high dilution ratio

Volume of dilution	Max. permitted suspended solids mg/l
8 - 150	30
150 - 300	60
300 - 500	150

The Department of Labour in 1976, included concentration standards for 431 substances in working environments in their by-law.

The Ministry of Interior (Division of Traffic Control) and the Ministry of Communication (Department of Harbour) are able to instigate by-laws stating what levels of hazardous or unhealthy smoke are permitted and defining measuring techniques. Levels for dark smoke have already been specified. To emit dark exhaust fumes of over 40 per cent on the Bosch Smokemeter scale is subject to penalty. None-theless, enforcement has been sporadic.

The Ministry of Industry espuse their enthusiasm about development of industrial emission standards. However, lack of technical information as well as economic and political factors complicate such a process.

The Ministry of Public Health suffers from a severe lack of legislative power. The Public Health Act. promulgated in 1941 is technically obsolete and discourages enforcement. Effective revision would be difficult. Consequently, an effort to draft a completely new bill has been initiated.

Approaches to the problems:

Deleterious consequences of economic development on the environment are not usually recognized in most countries, until the environment is damaged to a considerable extent. This is true of Thailand. At present, serious environmental problems exist in the Greater Bangkok area.

Realizing the deteriorating environmental quality, the government has been taking various appropriate measures to alleviate the problems. Recognizing that rapid population growth is the root of all environmental problems, the government is at present supporting voluntarily family planning programmes as previously mentioned.

The high rate of Bangkok population growth is mainly due to the migration of rural people into the city due to the lack of employment in rural areas. In its attempt to discourage rural people from moving into the city, the government has been trying to decentralize and to hasten the pace of economic development in rural areas. Effort have been made to help the farmers to increase their income and standard of living. These efforts include such measures as rendering technical assistance to modernize their methods of farming, and giving low interest loans for necessary investment. More attention is also being paid to the development of agro-industry. It is hoped that these measures will help to slow down the migration of rural people.

To tackle slum problems, the government has been doing its best in financing the construction of low-income housing. The government approved a project in 1972 aimed at building 170,000 flats within 10 years.

Existing laws and regulations in Thailand concerning environmental pollution and waste discharges are neither clearly defined nor appropriate for the present situation. Their revision, amendment, and strong enforcement are indispensable for protecting the country's environment.

At present, the drainage of buildings in Greater Bangkok is controlled by Municipal By-Laws, section 8 of which deals with sanitation. This section

states ambiguously that sewage should be treated to the satisfaction of the Municipality before it is discharged to a public waterway. This implies that human excreta or toilet wastes are not allowed to be discharged into the sewer or the water course. This is justified on public health and aesthetic grounds. At present a septic tank is considered an acceptable form of treatment although the effluent can seep through the soil and pollute water courses.

Other types of domestic wastewaters such as kitchen wastewater, are at present discharged directly or indirectly into water courses. They are a more important pollutional source than septic tank effluent. However, the public can not be held responsible for having polluted the water courses by their domestic wastewaters since it is the responsibility of the Municipality to provide sewerage and waste treatment systems for the public.

Disposal of solid wastes into the water courses has been an illegal practice for a long time. Although this is not an important cause of dissolved oxygen depletion it is an aesthetic nuisance. Inspite of the heavy fines threatened, garbage and other unsightly materials can still be seen in the urban canals. This is due to the inefficiency of the refuse collection system and the sheer ignorance of the public.

The problem of drainage, sewerage and sewage disposal for Greater Bangkok, has received attention from previous governments. Various proposals on the problem were put forward and in the lastest Master Plan Report of Camp, Dresser, and McKee, the cost of a sewerage system was estimated at $US 188 million[8]. So far only a small part of the Master Plan has been implemented. In view of the country's economy, complete implementation of the plan would not be possible in the foreseable future.

Discharge of industrial wastes into public waterways is controlled by the Factory Act. This legislation imposes the restruction that wastes discharge must not create nuisance to people using the waterways or people in the neighbourhood. Nuisance, in this context, can have a great number of meanings, however, so this represents a very inadequate definition. Appendix 3 presents the rules and regulations concerned with waste waters established by the Ministry of Industry, for factory establishment and extension.

In Bangkok, the disposal of untreated liquid industrial wastes into surface waters has created serious water pollution in various parts of the city. Although industries are required by the Ministry of Industry to install waste treatment facilities, only a number of them have, so far, complied with this requirement. Industries obviously have no incentive to treat their wastes since they do not suffer from the pollution they cause. An extra investment inwaste treatment will undoubtedly increase the cost of production and, for some industries, the investment would put them out of business. The country's economy will suffer when this happens. The Ministry of Industry is, therefore, in a dilemma and always has to compromise.

Several government agencies, including the Industrial works Department, the National Housing Authority, Industrial Estate Authority of Thailand (IEAT), Town Planning Office and the National Environment Board are coordinating their efforts in plans for the dispersal of factories from the city to the suburbs. The IEAT will set up more industrial sites in the suburbs for new and relocated factories.

The government's move would not only mean the solution of the pollution problem in the city, but is also designed to ease traffic jams caused by factory workers, staff, and freight trucks loaded with products of the plants.

Hand in hand, the Ministry of Interior, through its Town Planning Office, is at the moment conducting a study of the metropolis based on pollution density, not only for the relocation of factories but also to provide recreational facilities for city dwellers.

Carbon monoxide is produced as a result of incomplete combustion in engines. Generally, the concentration of carbon monoxide emitted from an old engine is much higher than that from a new one. Therefore, the only way to cope with this problems is to impose a test on engines restricting carbon monoxide emission. It is known that the soot content in exhaust fume also increases with the age of an engine. Since measurement of carbon monoxide is laborious and time-consuming, a standard of 40 per cent of soot reading on a Bosch smolemeter was established for use in controlling air pollution due to vehicle exhaust fumes. There is also a public campaign through various mass media to make people realize the health hazard caused by vehicle exhaust fume so that they will cooperate by improving the condition of their cars voluntarily.

Research and Investigation:

Obviously, efficient and Economic control and management of environmental quality requires a thorough understanding of the various factors affecting the environment. Various governmental organizations are, in one way or another, engaged in research on environmental problems. Unfortunately, the research and study carried out by the concerned authorities is often inefficient and piecemeal since they lack financial resources, and qualified and experienced staff.

Education in Environmental Science and Engineering:

At present, there are 4 acadamic institutes in Thailand which offer post-graduate study in sanitary or environmental engineering, or environmental science. In addition, there are also a number of students receiving academic or practical training overseas every year. A great percentage of them are working with the sanitary Engineering Division, Ministry of Public Health and Industrial Works Department Ministry of Industry. However, only few of them are now actively involved in research activities. Apparently, the number of engineers in this particular field is still insufficient to cope with the growing environmental pollution problems. In addition to engineers, chemists and biologists specially trained in the field of environmental science and technology are sorely needed.

CONCLUSIONS:

There is no doubt that many environmental problems exist in Greater Bangkok to varying degree of severity. At the root of all problems is the rapid rate of population growth, which is about 2.6 per cent per annum at present.

Rapid population growth creates many environmental problems apart from being a major obstacle to economic development of the country. Associated with rapid population increase are increasing needs for urbanization, industrialization, higher agricultural productivity, and more exploitation of natural resources. These elements of economic development have deleterious impacts on the environment, thus creating many environmental problems such as water, air, soil and noise pollution, traffic congestion, lack of recreational areas, destruction of scenic amenities and the emergence of slum areas.

At present, pollution of surface waters is the most serious environmental problem in Greater Bangkok. Lack of a proper sewage collection and treatment system, and industrial waste treatment facilities, are the major causes of water pollution. All urban canals, as well as the Chao Phraya estuary, are now in an appaling condition. Anaerobic conditions are experienced in these water courses especially during low flows.

No economic assessment has ever been made of the damage of water pollution to public health, fisheries, agriculture and the aesthetic values of the water.

Air pollution problem in Bangkok is a chronic and seemingly unsolvable problem. As far as the sources of air pollution in Bangkok are concerned, vehicle exhaust fumes are the biggest. Too many cars but insufficient road surface are the main factors responsible for the severe traffic congestion that exists on the most streets in the city. Apart from the economic damage, traffic congestion also deteriorates air quality due to the accumulation of vehicle exhaust fumes over a considerable period of time. The most harmful air pollutants in Bangkok air are carbon monoxide and lead-compounds.

It is important that the damaging consequences of environmental problems should be evaluated, expressed in monetary terms, and compared with the costs of environmental quality control. In a developing country like Thailand, which is pressed by many other needs in economic development, it is hard to get financial support for a programme of environmental quality control if it can not be proved justifiable in terms of monetary values.

The government is fully aware of its responsibility in the protection and conservation of the country is environment. Various measures have been taken to prevent the existing problems from worsening. However, the progress in environmental quality control has not been great, so far, due to the scarcity of financial resources and manpower.

Various government organizations are now involved, in one way or another, in environmental quality control. However, a proper system of environmental quality control does not exist. The formation of the National Environment Board in 1975. could be regarded as the first significant step in the right direction.

Appropriate ambient and source standards are urgently needed. The standards should be flexible taking into account all uses of the environment, its absorptive capacity, and the technological and economic conditions of the country. Study of various uses of the environment is necessary in the establishment of appropriate standards.

The difference in environmental, technological and economic conditions between the developed and developing countries must be realized. Any solutions to the environmental problems in tropical developing countries should not be adopted from the developed countries without careful thought as to their appropriateness and, if necessary, modification.

Research on various problems of environmental degradation in the developing countries should receive more support from the government and international organizations. Efforts should be concentrated on research and development to find appropriate answers to many environmental problems hindering the economic progress of the developing countries.

RECOMMENDATIONS:

For effective protection and control of environmental quality in Thailand, especially in Greater Bangkok, it is recommended that:

(1) As rapid population growth is the root of all environmental problems it is necessary that the rate of pupulation increase be brought under control. Projects on family planning should be strongly supported, and if necessary compulsory birth control should be introduced. To combat the problem of over-population in Bangkok, BMA should speed up its project to develop more settlelite towns to relieve the city of its population, pollution and transportation problems.

(2) To curb the problems of unorganized urban growth, urban planning laws should be strictly enforced, and the migration of rural population into urban areas should be slowed down by improving economic conditions in the rural areas.

(3) Town planning concepts should be used to anticipate and combat environmental pollution.

(4) De-trimental effects of all economic development projects on the environment must be fully considered in addition to their technical and economic feasibility.

(5) Existing laws pertaining to the protection and conservation of environmental quality should be revised, amended, and strictly enforced.

(6) Concerned authorities should cooperate and coordinate in enforcing the laws concerning environmental quality control.

(7) Economic assessment of all damages caused by environmental degradation should be made. Environmental pollution problems in Thailand or in Bangkok have not been considered economically, thus little is really known of their cause, effect and cost relationships. More money must be spent by the government for environmental pollution research and control. Although the cost of pollution control will be expensive, a curve now would be, in a long run, more effective and cheaper than a series of temporary solutions. This cost will ultimately be paid by both polluters and consumers, but governmental assistance is necessary to initiate the effort.

(8) Financial support should be given for research on various prevailing environmental problems. There is an urgent need to set up appropriate environmental quality standards taking into account local economic, technological, social and environmental conditions. The NEB must adopt strict pollution control measures and standards, and allocate sufficient funds for pollution research.

(9) Before suitable environmental pollution standards and anti-pollution laws can be enforced, the authorities must have accurate information about the extent of the problems.

(10) To import the strict standards used to control industrial pollution abroad would not be appropriate. Industry in Thailand or in Bangkok is much less sophisticated and excessively strict standards would not be enforced and would delay progress in improving the environmental quality. Standards must be flexible, phased for step-by-step implementation with adequate time for industry to respond.

(11) Initiate a nationwide campaign via the mass media, schools, clubs, etc. to inform the Thai people of the causes, effects, and solutions to all manifestations of environmental pollution in the Kingdom. The NEB must organize and support a public campaign against pollution. This would include the re-education of all officials, teachers, industrialists, parents etc.

(12) Establish and conduct basic studies for quantifying water quality parameters in the canals, in the Chao Phraya River estuary, and in the Upper Gulf, and as this information becomes available, delineate the essential benificial uses of these waters and establish the associated minimum water quality standards.

(13) Based on the information from (12), comprehensive plans for water pollution control in the canals, the Chao Phraya River estuary, and Upper Gulf, are required.

(14) Furnish a full-time expert on industrial wastes to assist the Ministry of Industry in improving its program for control of industrial wastes, preferably through one of the international assistance programs.

(15) Proceed with the enlargement of the scope of duties of MWWA to include responsibility for sewerage, drainage and flood protection.

(16) Protecting the water supply of Bangkok residents seems to be a commendable objective and one which has a degree of urgency.

(17) Strict river water quality standards must be enforced in the reach of Chao Phraya River, upstream of Samlae, to protect the city's water supply because conventional water treatment processes will not necessarily remove toxic and dengerous materials present in only trace amount.

(18) Costs of sewerage system and central domestic treatment facilities for the city of Bangkok are considerable. The government can not allocate sufficiently large amounts of money to implement such project in only a few years. The only possibility to reduce the degree of the detrimental effects of water pollution caused by domestic wastes is to provide annually small-scale waste treatment facilities for accessible community. For private housing villages, they should be obliged to establish domestic waste treatment facilities for their own communities. Of course, for this, environmental quality standards and enforcement laws for authorities concerned, are required.

(19) Reduce the number of cars in Bangkok, increase the road surface, improve traffic systems, and improve public transportation services. These measures should help to relieve the traffic congestion problems and enventually reduce the concentration of air pollutants in the city of Bangkok.

(20) Banning cars from central part of the city would be the quickest and most effective means to rid Bangkok of most the toxins in the air. Every effort should be made by government to discaurage the use of car in Bangkok and to eventually phase out private transportation in the city.

(21) As soon as pollution control systems and non-polluting engines are available in Thailand, struct emission standards should be established and enforced for both petrol and diesel powered vehicles.

(22) Reconsider the development of bridges, roads, parking lots, etc. in the city with a view to benefitting the majority of the population.

(23) Give serious attention to developing a monorail system, and improve the bus system for public transportation in Bangkok.

(24) Filter or after burning systems could be installed on new cars to reduce the pollutants in car exhaust fumes. The motorist should be made to bear the social cost of their motoring.

(25) Ban the sale of leaded fuel, increase the import tax on cars, increase the cost of petrol and introduce a corresponding decrease in the cost of diesel fuels.

(26) Speed up the construction of an 8-lane expressway around the city, (total distance of 46.5 kilometers) and build more expressways. This will serve to ease the traffic congestion in the city because daily commuters will not have to travel through the city any more.

(27) Public parks or recreational areas should be established more by BMA or private sector to absorb air pollutants and to serve the public.

(28) Increasing the capacity of garbage and solid waste recycling facilities in Bangkok, is strongly recommended because it is a modern means of controlling environmental pollution, conserving natural resources, and an economical means.

(29) Noise pollution in city of Bangkok, can be easily controlled especially traffic noise, but public cooperation and strict enforcement are necessary.

(30) The number of deep-wells should be limited to prevent further subsidence of the Bangkok area.

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Appendix 1

The National Environment Board

1. The National Environment Board has the duties to:

(1) Submit policy and opinions concerning the environment and conservation of environmental quality to the cabinet,

(2) Consider the implementation of policy in respect of the drawing out of projects and schemes concerning environmental quality,

(3) Consider and give opinion on projects of government agencies, state enterprises and private sector, which may have adverse effects on environmental quality, to the Cabinet or government agencies concerned,

(4) Submit plans for development, enhancement and conservation of environmental quality to the Cabinet,

(5) Recommend standards of environmental quality on matters including measure to be adopted for the inspection thereof and to recommend sanction against violators to the Cabinet,

(6) Submit annual report on the national environmental quality situation to the Cabinet,

(7) Coordinate the activities of governmental agencies, state enterprises and private sector on matters concerning environmental quality,

(8) Consider any other matters concerning the environmental quality as the Cabinet or the Prime Minister may request,

(9) Perform other functions as may be designated by law to be those of The National Environment Board.

2. Powers of the Board:

The National Environment Board has no executive powers as such, but has to refer to the relevant governmental agencies or Cabinet for action, neither has the Board any penal powers.

3. Office of the National Environment Board:

Also under provisions of the Act, there is the Office of the National Environment Board within the Prime Minister's Office to serve as the secretariat to The National Environment Board. The Secretary-General of the Office is ex-officio secretary of the Board, thus the legislation is appropriately administered by the Office.

4. Duties of the Office:

The Office of the National Environment Board has duties to:

(1) Carry out works as entrusted by the Board,

(2) Study and analyse the environmental conditions and quality for use in the planning and determination of the standard of the National environmental quality as well as to formulate guidelines for the quality enhancement of the national environment,

(3) Recommend to the National Environment Board for the adoption of any measure with a view to enhancing and improving the quality of the national environment,

(4) Supervise governmental agencies, state enterprise and private sector to ensure that they comply with the quality standards of the national environment,

(5) Receive, for consideration and remedy, the petition of any person who has been aggrieved or damaged by an act which has an adverse effect on the environmental quality,

(6) Perform duty as the coordination and public relations centre in respect to environmental quality within the country and with foreign countries,

(7) Encourage or carry out the study, research and propagation of problems of environmental quality in cooperation with educational establishments and other agencies,

(8) Promote and encourage the study of envoronmental quality at every level of education,

(9) Perform other functions as prescribed by law to be those of the Office of the Nation Environment Board.

5. Organization:

The organizational structure of the National Environment Board is shown in Figure 8. Brief description of the responsibilities of the key divisions are as following.

(1) Office of the Secretary

This office is responsible for correspondence, accounting, personnel, procurements and general administrative and support services. It also has a legal section to handle legal matters as well as complaints from the general public.

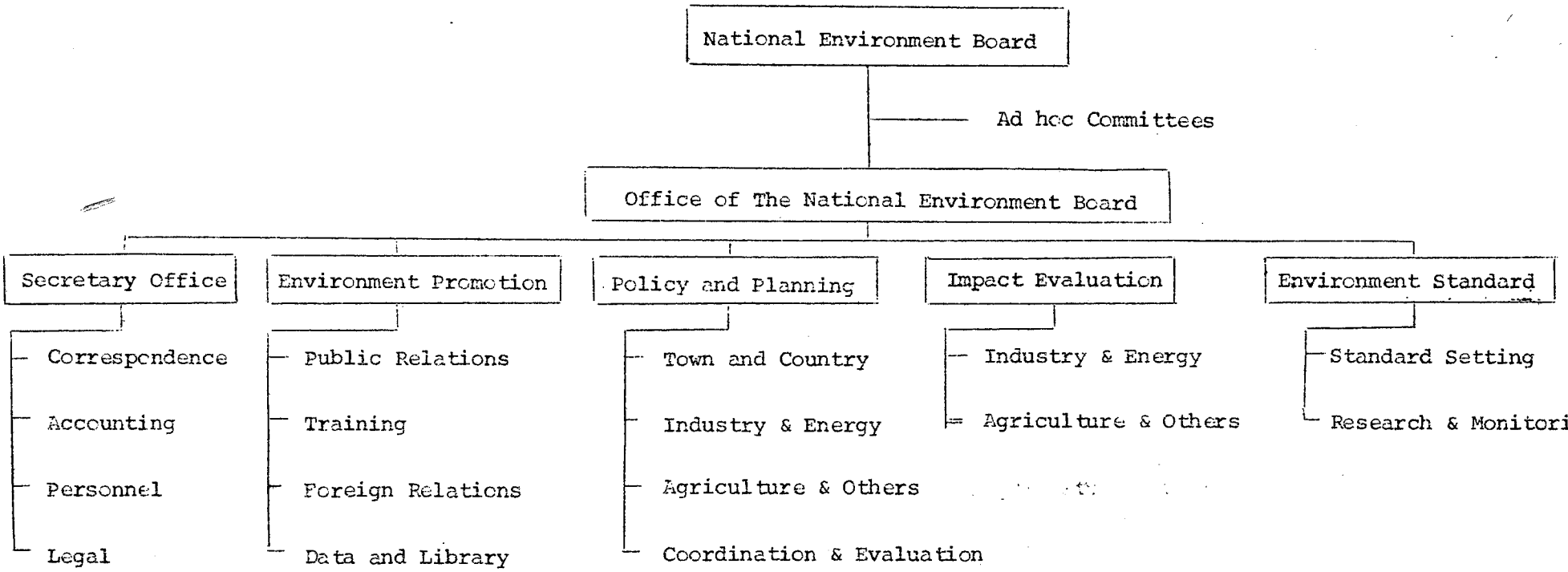

Fig. 8 Environmental Protection and Management Administrative Structure

(2) Environmental Quality Promotion Division

This Division is responsible for dissemination environmental information. It represents the Office in relations with the press, television, radio and other information media. This Division is also responsible for promoting the development of environmental education programs and systems; preparing and distributing materials to the general public; management of information systems, and automatic data processing. The Foreign Relations Section of this Division is responsible for bilateral programs and international cooperations.

(3) Environmental Policy and Planning Division

This Division is responsible for the overall program planning activities of the office, including developing and initiating new programs and goals. This Division directs the development of national policy for dealing with environmental problems, including land use patterns.

(4) Environmental Impact Evaluation Division

This Division is responsible for assessing environmental impact generated by man-made works such as major resources developments and evaluating the assimilative capacity of the environment. Environmental assessment ranks equally with technical and economic feasibility studies, and must be made prior to any development action.

(5) Environmental Quality Standard Division

This Division is responsible for the setting of standards and regulations for the protection and enhancement of the national environment.

This Division is also responsible for environmental research and monitoring programs; and in the case of any disputes on environmental considerations, this Division will carry out investigation for the purpose of arbitrating.

Appendix 2

Suggested Stream Standards for Developing Country Accerding to Controlling Water Use

Controlling Water Use	Stream Standard	
	Quality Parameter	Suggested Level
Potable Water Supply	Most Probable Number of Coliforms (MPN)	90% of samples examined throughout any year < 10/100 ml., no sample > 20/100 ml.
	pH	6.5 - 8.5
	Dissolved Oxygen (DO)	> 2 mg/l
	Arsenic	< 0.2 mg/l
	Chromium (Hexa valent)	< 0.05 mg/l
	Cyanide	< 0.01 mg/l
	Lead	< 0.1 mg/l
Irrigation	Total Dissolved Solids (TDS)	< 400 mg/l - poor drainage < 1,000 mg/l - good drainage
	Electrical Conductivity (EC)	< 759 micromhos per cm. - poor drainage < 2,250 micromhos per cm. - good drainage and low SAR
	Sodium-Adsorption - Ratio (SAR)	< 10 - high mineral content or poor drainage < 18 - low mineral content or good drainage
	Boron	< 1.25 mg/l - Sensitive crops < 3.75 mg/l tolerant crops
Fishing	Dissolved Oxygen (DO)	> 2 mg/l
	Pesticides DDT	< 0.002 mg/l
	Endrin	< 0.0004 mg/l
	DHC	< 0.21 mg/l
	Methyl Parathion	< 0.10 mg/l
	Malathion	< 0.16 mg/l
	Carbon Dioxide (CO_2)	< 12 mg/l
	pH	6.5 - 8.2
	Cyanide	< 0.01 mg/l
	Arsenic	< 1.0 mg/l
	Chromium	< 0.05 mg/l
Waste Disposal	Dissolved Oxygen (DO)	> 0 mg/l

Appendix 3

Rules and Regulations for Factory Establishment and Extention Dealing with Waste Waters Issued by Ministry of Industry

For the purpose of the prevention of nuisance caused by water pollution discharged by industrial factories, the factories are obligated to perform the following duties.

1. Location and area of factory must be:-

   (1) In suitable places for discharge of waste water or in the places allocated by the government.

   (2) Enough area for waste water treatment or reservation.

2. Treatment process

   (1) Suspended solids must be separated from waste.

   (2) Sludge separated from waste water must be treated properly in order to avoid further nuisance.

   (3) pH value and alkalinity must not be too high or too low.

   (4) Any poisonous matter which may be dangerous to public health must not be discharged from the factory without proper treatment.

   (5) Waste water treatment process must be shown by drawing together with the plant layout.

   (6) Waste water must be treated properly, the method of treatment should be approved by government official.

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FINAL REPORT ON ENVIRONMENTAL PROBLEMS IN GREATER BANGKOK.