5. RECOMMENDATIONS

5.1 System and Organization of Traffic Operation Plan

(1) System for Implementation of Traffic Operation Plan

To implement traffic operation projects, the long- and short-term plans of the DOH must be established. In the DOH Seventh Plan, the traffic safety project puts forward an investment framework which should be widened to cover traffic operations. In order to implement traffic safety projects systematically, the diagnostic sheet is a useful tool for the collection and analysis of traffic data.

(2) Organization for Traffic Operation Plan

For the implementation of the traffic operation plan, the organizational structure of the Traffic Engineering Division (TED) has got to be tightened, to perform its assigned and enlarged duties.

The following is a list of recommended sections to be created within the TED:

A. Traffic Control Section;
B. Traffic Safety Section;
C. Traffic Census Section;
D. Traffic Measure Standards Section;
E. Traffic Environment Section;
F. Road Administration Section.

Alongside these sections within the DOH, a traffic control section, to deal with traffic operation, should be established within each district office.

5.2 Recommendations for Future Traffic Operation Planning Policies

(1) Signal Control on High-standard Highways

High-standard highways such as R1 and R340, have no signals, except in the central part of Bangkok, because of DOH policy. In recent years, however, problems have arisen in the intersections of small streets and high-standard highways because of a marked increase in traffic volume. Therefore, it is proposed to install traffic signals on any sectors of the high-standard highways where signal-controlled traffic operation is desirable. If the installation of traffic signals is not accepted, large-

scale construction of grade separations will be needed at these problem intersections. It is necessary to conduct studies conducive to the installation of traffic signals at such sites.

(2) U-turn Traffic Operation

Intersection traffic operation on DOH highways has been based on the following principle: when a minor road has a small traffic volume, the through- and right-turning traffic from the minor road is required to make a left-turn first, then a U-turn in the U-turn zone beyond, in order to avoid directly intersecting the major road traffic.

U-turn traffic operation is highly effective if the U-turn traffic is properly regulated. However, in recent years with increasing traffic from minor roads, it is often noted that the U-turn traffic cannot be smoothly operated because of the large main road traffic in the U-turn zone. The installation of U-turn signals, or suitable U-turn lanes, is proposed for the cases where traffic exceeds the maximum traffic volume that can be coped with by U-turn traffic operation.

Considering the anticipated rapid increase of motor vehicle traffic in the coming years, it will be necessary to introduce such new measures. These measures should be evaluated on the basis of the installation standards defined in this Study.

(3) Arrangement of Pedestrian Overpasses

The construction of pedestrian overpasses is an important measure for ensuring the safety of pedestrians, and the DOH should conduct studies on the proper method of their construction and spacing. In the Bangkok suburban areas, where urbanization is proceeding at a rapid pace, pedestrian overpasses should be built at suitable intervals under a careful construction plan, taking into account the budget of the DOH, the desires of local inhabitants, changes in the construction of roadside facilities, and the development of hinterland areas.

The pedestrian overpasses on major highways in central Bangkok are spaced at an average of approximately 500 m in 1987. This average spacing will be used as a guideline for pedestrian overpass construction plans.

CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

Traffic volume has increased dramatically in Thailand in the last decade and this has resulted in deteriorating traffic conditions. Past efforts by the Government of the Kingdom of Thailand (GOKT) to deal with traffic problems have been dwarfed by this rapid traffic growth. In recent years, the GOKT has focused on the improvement of road and traffic facilities and this has been supported by a number of programmes, such as the Five Year Road Improvement Programme (1987-1991), partly financed by the World Bank. However, traffic problems have persisted, especially in urban areas which suffer from traffic congestion and high accident levels.

In order to find solutions for Thailand's road traffic problems, the Japan International Cooperation Agency (JICA) was requested by the GOKT to conduct a Traffic Operation Plan for Roads in the Kingdom of Thailand (the TOPR Study), from January 1989 to June 1990. The aims of the TOPR Study were to formulate: guidelines for setting up road safety devices; a traffic information system; and a traffic operation system, for all the Department of Highway (DOH) roads.

At present, the DOH is preparing the Seventh Highway Development Plan in the Seventh National Economic and Social Development Plan, with reference to the TOPR Study results. As part of the DOH Seventh Plan, JICA has been requested to produce an Aftercare Study on Traffic Operation Plan for Roads in the Kingdom of Thailand (herein referred to as the Study). The Study looks at traffic safety and traffic operation. Within this, the Study provides details and plans to facilitate the progress of the preparation works and the implementation of the Seventh Highway Development Plan. The Study also assists in technological transfer.

The decision was taken by the Government of Japan to undertake the Study in response to the request of the GOKT. The scope of work to be undertaken was agreed in September 12, 1990, based on the findings of meetings and discussions held between the Resident Representative Thailand Office JICA and the DOH.

JICA, the official agency responsible for the implementation of technical cooperation programs by the Government of Japan, has set up a study team (the Study Team) to undertake the Study.

The Study commenced April 9, 1991 with the arrival of the Study Team members, together with the JICA staff. Subsequently, the **Inception Report** was submitted on April 10, 1991 to the DOH.

The **Draft Final Report**, submitted on September 1991 to the DOH, included all the outcomes of the Study executed under the Scope of Works, including the recommendation for the traffic operation plan.

The contents of the Draft Final Report were reviewed after the submission to DOH mainly based on comments from DOH and the **Final Report** is compiled.

1.2 OBJECTIVES OF THE STUDY AND THE STUDY AREA

1.2.1 Objectives of the Study

The Objectives of the Study are:

(1) To formulate the traffic operation plan for reducing road traffic accidents in Thailand, from the engineering point of view;

(2) To recommend a suitable plan for the improvement of roads by applying the Study on the Traffic Operation Plan for Roads in the Kingdom of Thailand (TOPR);

(3) To transfer technology and training to Thai counterpart personnel in the course of the Study.

1.2.2 Study Area

The study area is defined as the roads predominantly under the jurisdiction of the DOH within the area of the Outer Ring Road of Bangkok.

Figure 1.1 shows the study area and the DOH road network.

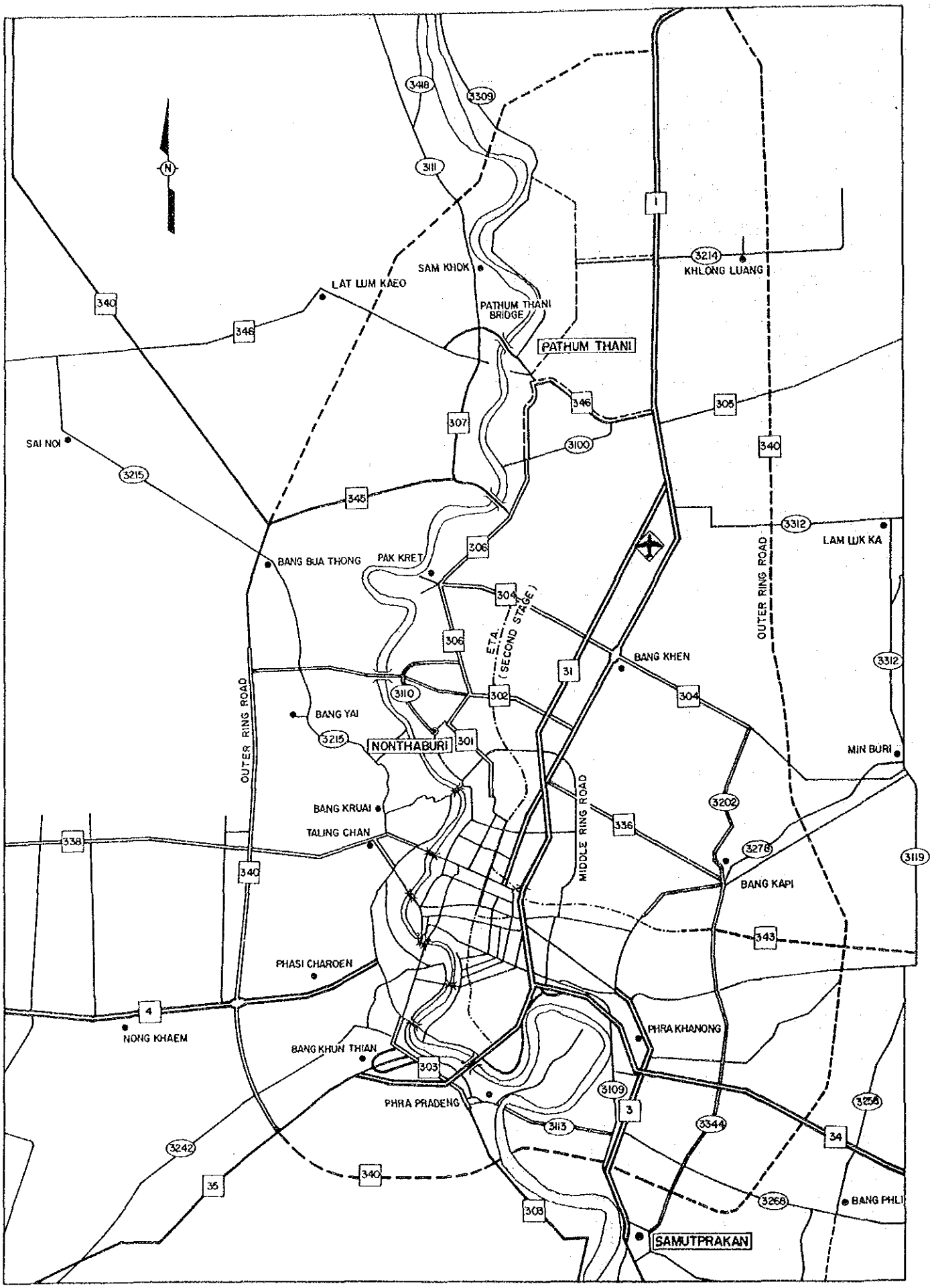


Figure 1.1 THE STUDY AREA AND THE DOH ROAD NETWORK

1.3 STUDY PROCEDURE

The general flow chart of the steps to achieve the study objectives is shown in Figure 1.2.

The following procedures accomplish the study objectives: the identification of traffic problems; the selection of measures for traffic control/ safety; and the preparation of improvement plans for problem locations requiring improvements. These procedures are outlined below:

(1) Review and Preparation of the Preliminary Survey

a) Review of the TOPR Study;

b) Analysis of the Seventh Highway Development Plan;

c) Review of road and traffic conditions in the Study Area;

d) Review of economic activities and land-use in the Study Area.

(2) Preparation of Improvement Plan

a) Collection and analysis of data;

b) Identification of traffic problems;

c) Selection of Study Sections for the preliminary designs;

d) Supplemental surveys;

e) Selection of measures for traffic control/safety;

f) Preliminary design;

g) Cost estimation.

(3) Recommendations for the Traffic Operation Plan

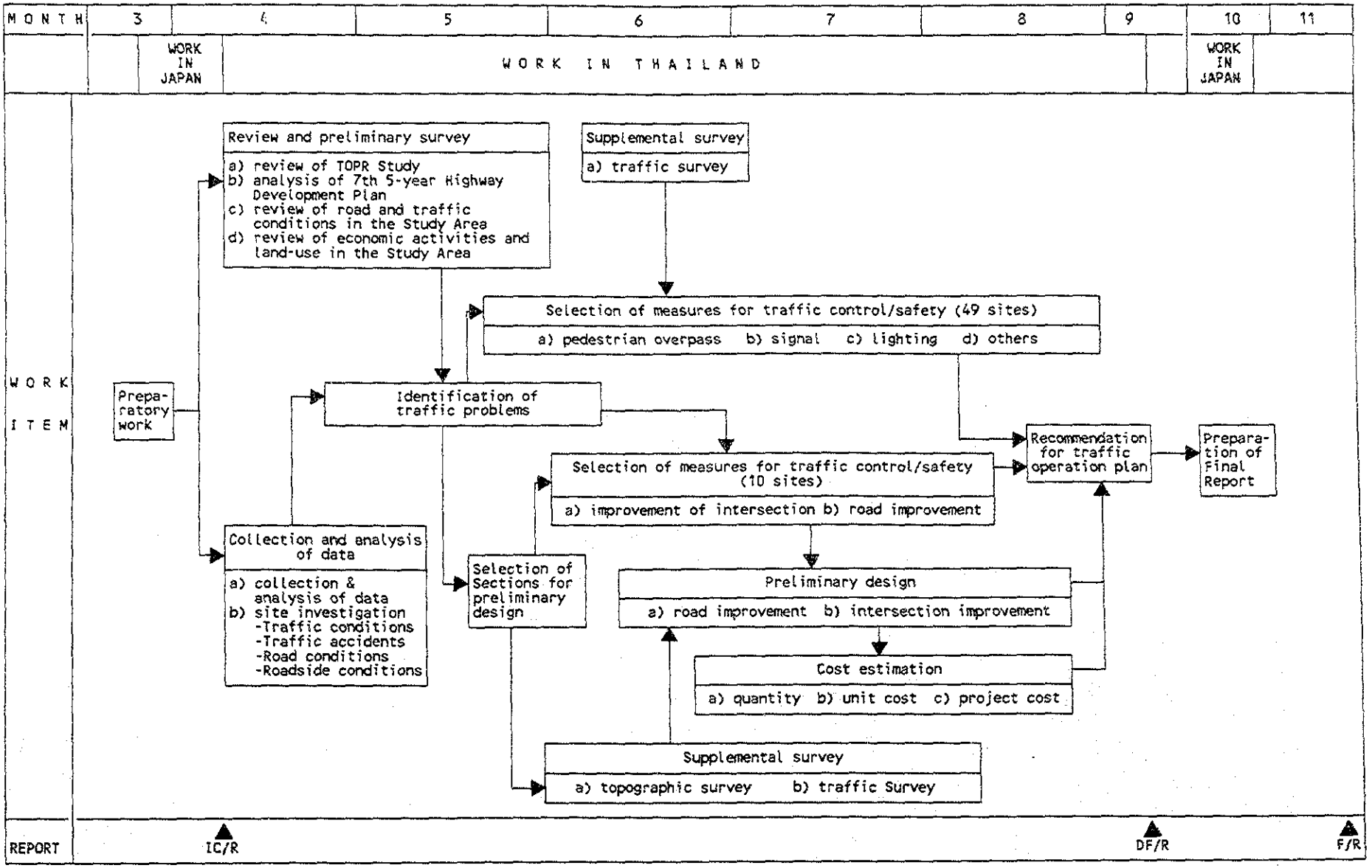


Figure 1.2 STUDY FLOW CHART

1.4 STUDY ORGANIZATION

The DOH and JICA are the agencies directly concerned with the Study. The schematic organizational chart for the implementation of the Study is shown in Figure 1.3.

The Study is being carried out by the Study Team, headed by Dr. Kaoru Ichihara. The Study Team is comprised of six experts, who are working closely with the counterpart personnel at the DOH.

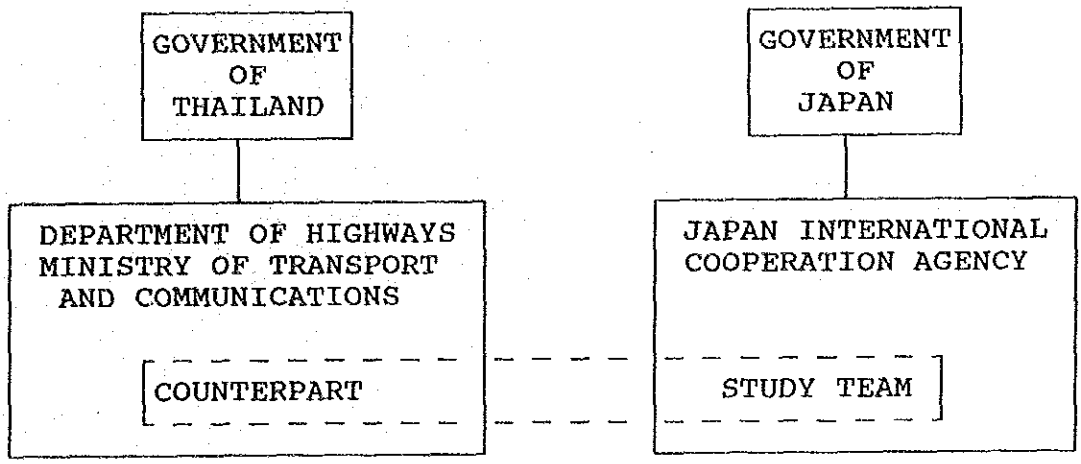


Figure 1.3 ORGANIZATIONAL CHART

(1) DOH

a) Project Officer

Mr. Kitipol ASAPARPORN	: Director, Traffic Engineering Division, Department of Highways

b) Counterpart Team

Mr. Jinda	MONGKHOLSAWASDI	: Member
Mr. Mongkhol	PAISALWATANA	: Member
Mr. Montri	THARESUWON	: Member
Mr. Vorasith	PRADITBATHUGA	: Member
Mr. Sujin	MUNGNIMITR	: Member
Mr. Sakchai	CHANTAPANISH	: Member
Mr. Kittiphan	PANCHAN	: Member
Mr. Poowanai	PAIBULSIN	: Member
Mrs. Pranee	VARIYACHAI	: Member
Mrs. Yada	PRAPONGSANA	: Member
Miss Isaranee	SIRITHALA	: Member

(2) JICA

a) Members of JICA Study Team

Dr. Kaoru	ICHIHARA	:	Team Leader
Mr. Koji	SUZUKI	:	Highway Planner
Mr. Yoshitaka	HIGUCHI	:	Highway Engineer
Mr. Masatoshi	YANAGISAWA	:	Highway Engineer
Mr. Akio	TATSUNO	:	Traffic Control Planner
Mr. Atsushi	NISHIMURA	:	Traffic Engineer/System Analyst

b) Members of JICA staff

Mr. Takanori ZIBIKI (Mr. Kazuo ISHII)	:	Director, 1st Development Study Division, Social Development Study Department, JICA
Mr. Toshio SUGIHARA	:	Deputy Director, 1st Development Study Division, Social Development Study Department, JICA
Mr. Shingo SAITO (Coordinator)	:	1st Development Study Division, Social Development Study Department, JICA

CHAPTER 2 CURRENT CONDITION OF THE DOH'S TRAFFIC OPERATION SET-UP

CHAPTER 2 CURRENT CONDITION OF THE DOH'S TRAFFIC OPERATION SET-UP

2.1 REVIEW OF THE TOPR STUDY

A review of the TOPR Study was carried out through discussions with the DOH and site investigations. The findings are summarized below.

2.1.1 Technical Guidelines and Engineering Specifications

(1) Technical Guidelines and Engineering Specifications Proposed in the TOPR Study

Technical guidelines, including a warrant, and engineering specifications on the following traffic safety and traffic control devices, have been prepared in the TOPR Study:

A. Median dividers, channelization and added lanes around intersections;

B. Climbing lanes, passing lanes and motorcycle lanes;

C. Traffic signals;

D. Traffic signs;

E. Pavement markings;

F. Crossing facilities for pedestrians;

G. Sidewalks and bicycle paths;

H. Street lighting;

I. Delineators;

J. Guard fences;

K. Pavement treatment;

L. Other facilities:

- vehicle detectors;
- road information systems;
- bus stop facilities;
- grade separations at railway crossings.

(2) Review of Findings

The requests for improvement works and/or remedy works, in locations which have traffic problems, are sent to the DOH headquarters from district offices and local peoples.

The DOH headquarter staff consider the location's required traffic safety and control measures and allocate the budget to the selected location accordingly.

In the above procedures, the guidelines and specifications outlined in the TOPR Study, have been used effectively at the DOH for the selection of countermeasures to improve traffic problems. No major problems in the utilization of the above guidelines and specifications have been raised since the submission of the Final Report of the TOPR Study.

2.1.2 Traffic Operation Systems

In the TOPR Study, the following traffic operation systems were recommended:

A. Traffic census system;

B. Traffic information system;

C. Road inventory system.

The following is a summary of the DOH's work to date on implementing the above traffic operation systems:

(1) Traffic census system and road inventory system

Parts of these systems, such as traffic volume counting and the compilation of accident and traffic data, are carried out by the DOH.

After the submission of the TOPR Study Final Report, the DOH has been considering ways of developing these systems based on the results of the TOPR Study. Preparatory work is being carried out to look at the requirements for the introduction and execution of these systems. These include logistical, financial and manpower requirements.

(2) Traffic information system

Preparatory works for the introduction and development of the traffic information system has begun.

In order to introduce this system on a wide scale, for example in the Bangkok Metropolitan Area, a good relationship between the BMA and the police department is essential. Discussions between the BMA and the DOH have begun on this matter.

In addition, the implementation plan for controlling the traffic flow by variable information boards on R34, has been prepared. Following this action, the execution of the case study in Chonburi will be approved in the Seventh Highway Development Plan.

2.1.3 Experimental Works and Case Studies

In the TOPR Study nine planning sections were selected and improvement plans were prepared to cope with the major traffic operational problems.

Proposed traffic operational measures were classified as shown in Table 2.1.

Table 2.1 Classification of Operational Measures in Experimental Works and Case Studies

Intersection	
a) Signalization	: Laksi*, Pathumthani*, Wang Noi
b) Improvement of intersection	: Ban Bung
c) Improvement of signalized intersection	: Bang Na, Chonburi, Sriracha
d) Grade separation	: Wang Noi, Laksi
Roadway Section	
a) Access control	: Wang Noi
b) Median	: Chonburi, Sriracha
c) Added lane	: Khon Kaen*, Pathumthani
d) Motorcycle treatment	: Khon Kaen*

Note --* : Experimental work section

(1) Experimental Works

Experimental works were carried out to evaluate the effectiveness of traffic control and safety measures. Implementation work was conducted by the DOH with their own budget.

In the TOPR Study, signalization and channelization at Pathumthani intersection, and a motorcycle lane at Khon Kaen, were evaluated through before-and-after surveys. These traffic operational measures proved to be effective.

Implementation works for the remaining two locations, Laksi roundabout and the passing lane at Khon Kaen, have been completed after the submission of the Final Report.

In the Study the review was carried out, through site investigations and discussions with the DOH, in order to evaluate the effectiveness of the measures under present traffic conditions.

The results of the review are summarized in Table 2.2. In general, each traffic operational measures has functioned well, with the exception of Laksi roundabout.

In Laksi roundabout the installed traffic signals are not operated, whilst the DOH are considering ways in which to minimize traffic delays.

Table 2.2 Summary of the Review on Experimental Works

Location number	Route number	Section name road configuration	Proposed major countermeasure	Present condition
E-1	R1 (R304)	Laksi - roundabout	* Signalization * Channelization	- Traffic control by traffic signal is not operated because the police worry about long queues caused by the traffic volume.
E-2	R346 (R3111)	Pathumthani - intersection	* Signalization * Channelization	- Traffic control by signals has been working well. - Traffic signal is required because of increased traffic volume.
E-3	R2	Khon Kaen - roadway	* Motorcycle (M/C) lane	- M/C lane has been functioning well owing to the users being used to the system in spite of a deterioration in pavement markings. - Utilization of M/C lane depends upon the smoothness of the pavement, therefore maintenance is required.
E-4	R2	Khon Kaen - roadway	* Passing lane	- Passing lane on R2 has been in operation from 4 April 1991. - Passing lane has functioned well under the increasing traffic volume by decreasing the length of the platoons. - The overtaking of heavy vehicles and mergings to ordinary lanes are completed smoothly in the passing lane section.

Motorcycle lanes and passing lanes are newly introduced measures in Thailand and their purpose seems to have been well understood by the road users. At present, there are plans to extend these measures to other sections and to other roads.

Alongside this, the DOH has approved the paving of the soft-shoulder of DOH roads within 50 kilometers of towns. This measure will aid the installation of motorcycle lanes in cities which have problems caused by increasing motorcycles volumes.

Shoulders of the DOH roads which have more than 1,000 vehicles average daily traffic volume, are more than 2.0 meters in width, and can be utilized as motorcycle lanes without any need of widening.

In the experimental work, the whole of the hard-shoulders of the roads were used for the motorcycle lanes. There are several factors which should be considered in determining the size of a motorcycle lane, for example: the width of the shoulders; the characteristics of the road traffic; the road right-of-ways; and pedestrian space requirements. In order to acquire a better understanding of motorcycle lane requirements and designs in Thailand, further experimentation is needed on the different types and widths of motorcycle lanes.

(2) Case Studies

Case studies were conducted at five planning sections as demonstrations of how to cope with major traffic problems. Improvement plans were prepared in the TOPR Study.

In the Study, these case studies were reviewed to determine the status of implementation at each planning section after submission of the Final Report.

The results of the review are summarized in Table 2.3. Of the five case study sections, implementation work has been completed in 1991 in three planning sections. Implementation of improvement work in the other sections has been approved for 1992 by the DOH.

Table 2.3 Status of Implementation of Improvement Work on Case Study Section

Location number	Route number	Section name road configuration	Kilo post	Classified area	Proposed major countermeasure in the TOPR Study	Status of implementation
C-1	R34 (R3, R3102)	Bang Na - Signalized intersection (under elevated road)	0+000-4+000	A	* Rehabilitation of pavement. * Improvement of visibility of signals. * Modification of signal phasing. * Extension of left turn lane.	- Improvement works carried out by 1992 year's budget after widening of R3.
C-2	R3 (R315, R344)	Chonburi - Signalized intersection roadway	92+000-94+100	B	* Improvement of channelization. * Installation of median. * Modification of signal phasing.	- Installation of median and pedestrian overpass are under construction.
C-3	R3	Sriracha - Signalized intersection (not operated)	95+100	B	* Improvement of visibility of signal. * Channelization. * Installation of median. * Access control of frontage road.	- The budget has been approved and improvement work will be completed in 1992.
C-4	R1 (R309, R3189)	Wang Noi - Intersection (with partial frontage road)	65+151-167	C	* Short-term plan - Signalization; - Improvement of frontage road; - Channelization. * Long-term plan - Grade separation.	- Traffic signal already installed. - Grade separation has been planned as the long term plan.
C-5	R344 (R331)	Ban Bung Klaeng - intersection	31+506	C	* Channelization. * Speed control.	- Traffic signal was installed due to strong request by inhabitants.

Classified Area A : Bangkok suburban area
B : Local city area
C : Inter city roadways

2.2 ANALYSIS OF THE SEVENTH HIGHWAY DEVELOPMENT PLAN

The Seventh Highway Development Plan is now under preparation. The target years are from October 1991 to September 1996. The main framework of this plan is described below.

2.2.1 Policy of the Seventh Highway Development Plan

The specific target/object for the development of land transportation in the DOH Seventh Plan is as follows:

A. To develop an expressway system between cities in the form of toll highways;

B. To raise the standards (increase number of lanes) of the national highways and the provincial highways;

C. To improve and maintain the national highway network, or the existing provincial highways, to high maintenance and safety levels;

D. To promote the improvement and construction of highways connecting specific development areas, such as, the Eastern Seaboard, the Southern Seaboard, and certain ports and airports;

E. To promote main city developments, such as bypass projects and upgrading road standards;

F. To develop provincial highway networks in poor areas and in isolated rural areas;

G. To promote traffic safety by constructing interchanges, and improving intersections by road lighting and traffic signals.

2.2.2 The Investment Framework

(1) The investment framework of the DOH Seventh Plan is as follows:

	Length km	Budget million baht
1. Construction of special highways or motorway projects	198	14,800
2. Rehabilitation/ Reconstruction	5,599	21,071
3. Road construction project		
- widening of existing roads (to four-lanes)	2,380	29,647
- new links and new routes	924	6,555
- interchanges and flyovers	- (33 locations)	5,364
- pavement of roads	5,001	14,994
4. Traffic safety project	-	2,000
Total	14,102 (33 locations)	94,431

The main projects in the Highway Development Plan are:

A. Construction of the Outer Ring Road of Bangkok (in eastern section);

B. Construction of Bangkok-Chonburi road;

C. Widening of Route 2 to four lanes (Nakhon Ratchasima-Nongkhai);

D. Widening of Route 1 and Route 11 to four lanes (Nakhon Sawan-Lampang, Lampang-Chiang Mai);

E. Widening of Route 4 to four lanes (Phetcha Buri-Hat Yai);

F. Construction of Ratthanathibet-Ban Pong road;

G. Construction of Buriram-Chantha Buri road.

(2) The Framework of the Total Budget of the DOH

The framework of the total budget of the DOH Seventh Plan 1991-1996 is as follows:

	Unit Cost million Baht
1. Seventh Highway /Development Plan (1991-1996)	94,431
2. Small Project Programme*	14,000
3. Administration Programme	16,000
4. Road Maintenance Programme	35,000
5. Projects continued from the 6th Plan	60,000
Total Budget	219,431

* Short route paving work, laterite road construction, pavement/improvement community area, construction /repair bridge, construction security road.

2.2.3 Policy of the Traffic Engineering Division in the DOH Seventh Plan

Traffic safety measures, such as signs, signals, street lighting, pedestrian overpasses, guard fences, etc., for 619 locations, will be constructed under the traffic safety project. Construction of passing and climbing lanes, and the installation of information facilities for the locations selected by the TOPR Study will also be included in this project. The investment for the traffic safety project is 2,000 million baht.

Grade separations and railway crossings will be implemented under the construction project. The bicycle lanes programme will be changed to the motorcycle lane programme and constructed under the road maintenance project.

The results of the Study will be presented in the Seventh Highway Development Plan.

2.3 REVIEW OF ROAD AND TRAFFIC CONDITIONS IN THE STUDY AREA

2.3.1 Road Conditions

Roads in Thailand are divided, for administrative purposes, into the following eight classes:

A. Special highways;
B. National highways;
C. Provincial highways;
D. Rural roads;
E. Municipal roads;
F. Sanitary roads;
G. Concession highways;
H. Expressways.

As a basic rule, the first three classes listed above are under DOH control.

Table 2.4 shows the status of the national and provincial highways in 1990, by region. The table indicates the following:

A. The total length of roads controlled by the DOH was approximately 52,300 km. in 1990. Of these, the central region covering the Study Area had the length of roads at approximately 12,900 km.

B. The total length of roads under construction, or planned for construction nation-wide, was roughly 6,900 km. in 1990 with approximately 1,300 km. scheduled for the central region.

Table 2.4 Status of National and Provincial Highways in 1990

Item	Northern	Northeastern	Central	Southern	Total
National Highway (km)					
- Paved	4,379	4,904	4,902	3,216	17,401
- Unpaved	30	17	33	5	85
- Under Construction	286	320	244	109	959
Sub-total	4,695	5,241	5,179	3,330	18,445
Provincial Highways (km)					
- Paved	7,515	5,427	5,481	4,108	22,531
- Unpaved	1,663	1,621	1,236	908	5,428
- Under Construction	2,707	1,472	1,018	704	5,901
Sub-total	11,885	8,520	7,735	5,720	33,860
Total (km)					
- Paved	11,894	10,331	10,383	7,324	39,932
- Unpaved	1,693	1,638	1,269	913	5,513
- Under Construction	2,993	1,792	1,262	813	6,860
Sub-total	16,580	13,761	12,914	9,050	52,305

Source : DOH, 1990

Figure 2.1 shows the road network administered by the DOH in the Study Area. The total length of roads within the Study Area is approximately 714 km. in length.

Figure 2.1 ROAD NETWORK IN THE STUDY AREA

2.3.2 Traffic Conditions

(1) Traffic Volume Growth

According to the traffic count surveys conducted periodically by the DOH, the traffic volume growth factor, between 1987 and 1990, was 1.73 for the Study Area as a whole. Figure 2.2 shows how trunk roads are calculated in the Study Area.

Traffic volume growth factors between 1987 and 1990 are greater than 2.0 on Route 303, 304, 340, 3035, 3104, 3110, 3111, 3215 and 3242. This indicates that the traffic volume on provincial highways has increased appreciably over the past three years.

(2) Traffic Characteristics

a) Traffic Volume

Figure 2.3 shows the daily traffic volume in the Bangkok area in 1990. As shown in this figure, traffic volume on Route 31 was approximately 180,000 vehicles per day, while Routes 1, 3, 34, 302, 304, 308, 346, 3113 and 3344 had more than 50,000 vehicles per day.

b) Hourly Fluctuation

Figure 2.4 shows the hourly fluctuation of traffic volumes on trunk roads in the Study Area. Although fluctuation patterns vary widely, the average peak-hour factor is approximately 7.2%.

c) Vehicle Type Composition

Figure 2.5 shows the average vehicle type composition on roads in the Study Area between 1987 and 1990. This figure indicates that there have been no marked changes. The only notable change was that the volume of passenger cars increased slightly, while that of motorcycles decreased slightly. The 1990 data indicates that passenger cars made up 47% of all vehicle types, buses comprised 11%, trucks 35%, and motorcycles (including bicycles) 7%.

Figure 2.6 shows the vehicle type composition on trunk roads for 1990. Passenger cars on Route 1, 31, 304 made up more than 50% of all vehicle types. Heavy truck ratios on Route 34, 303, 304, 307, 338 are comparatively high.

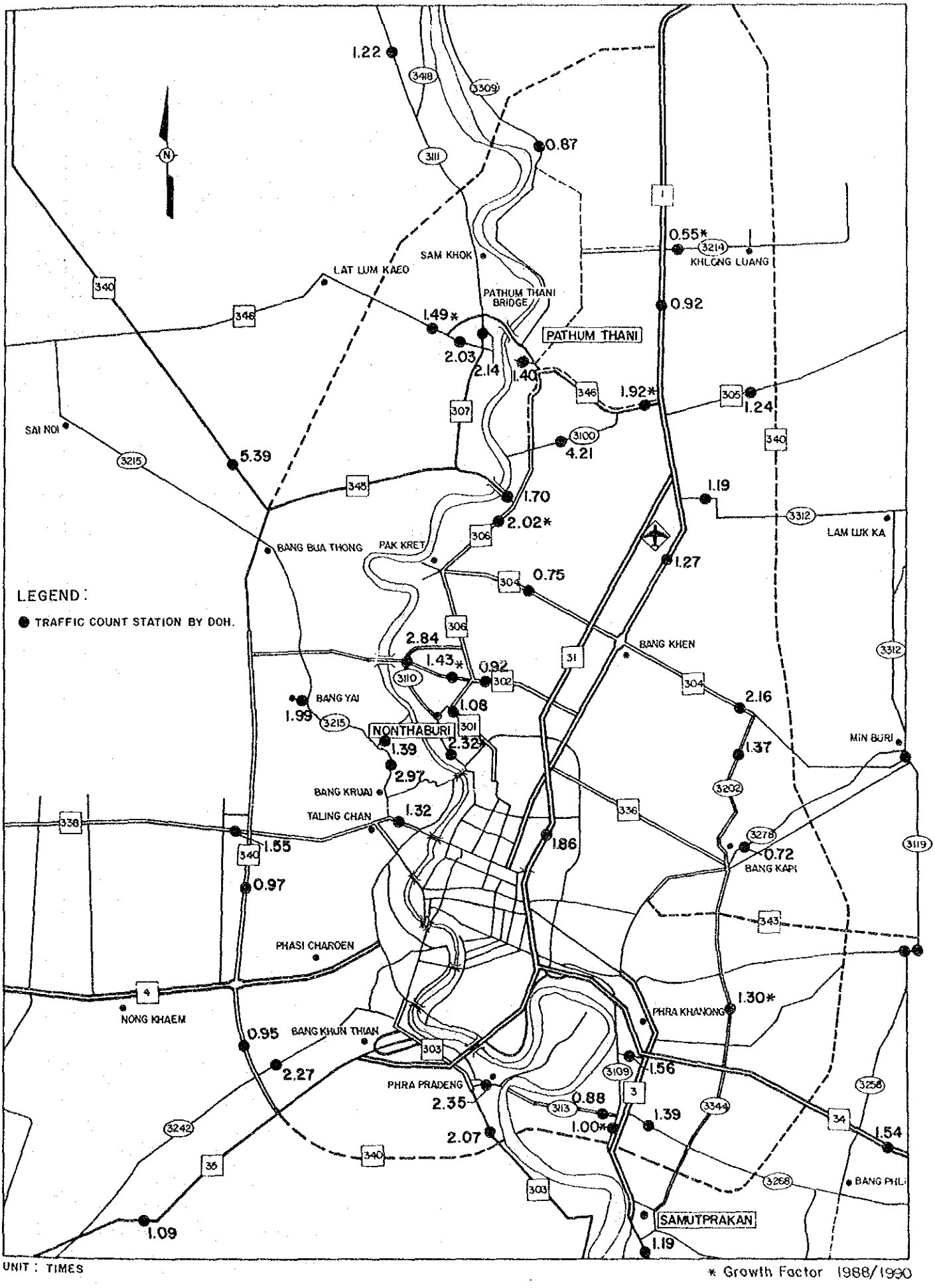


Figure 2.2 ANNUAL TRAFFIC VOLUME GROWTH FACTOR (1987-1990)

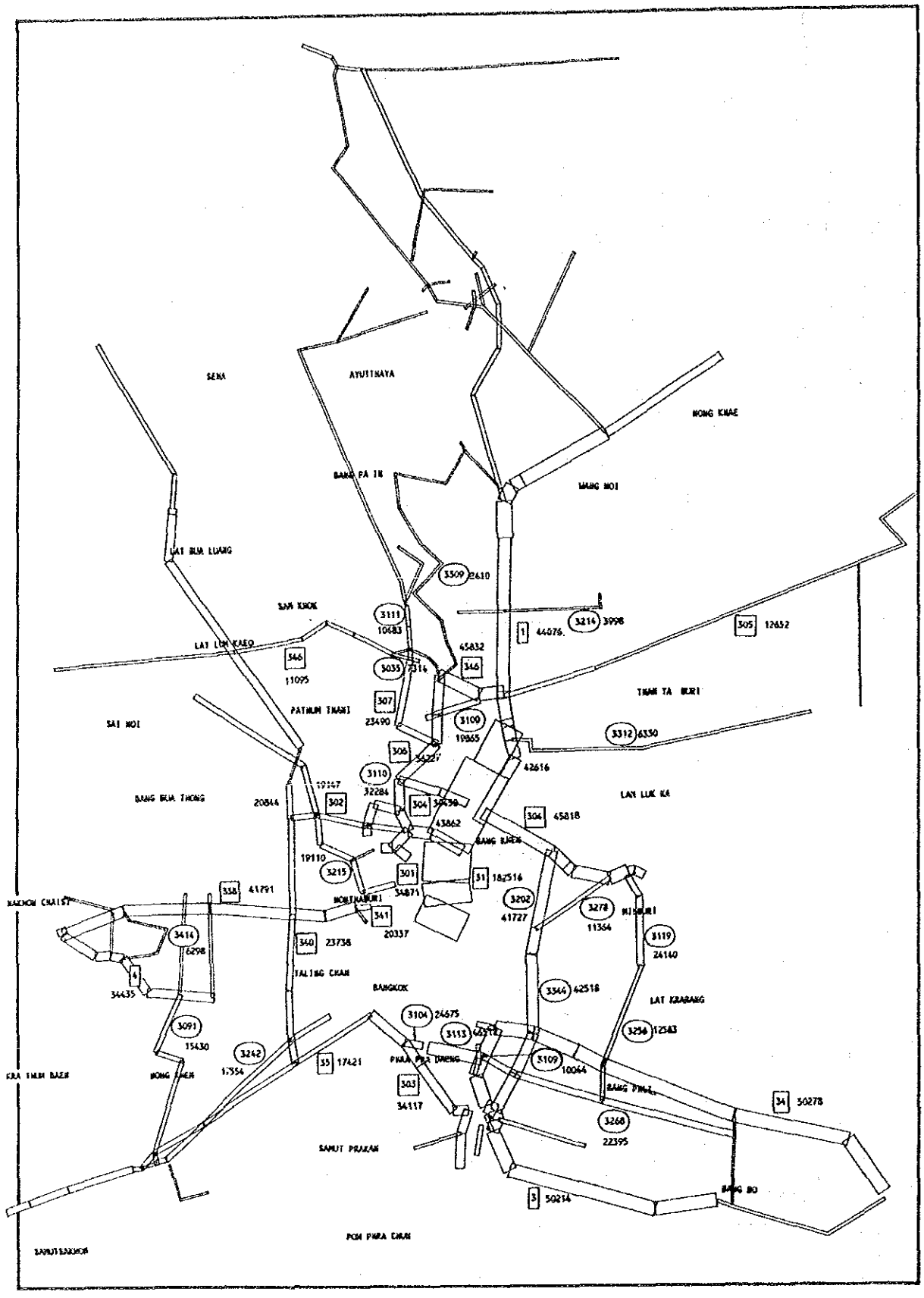
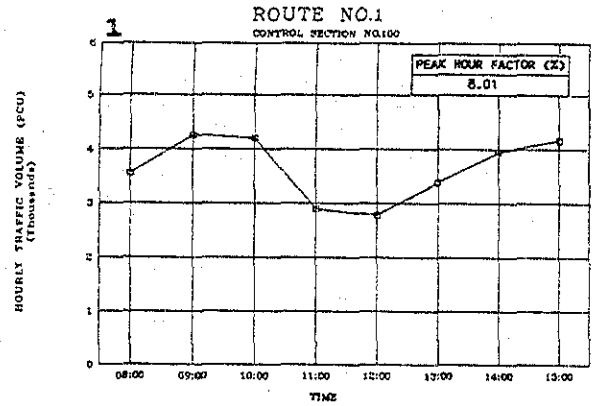
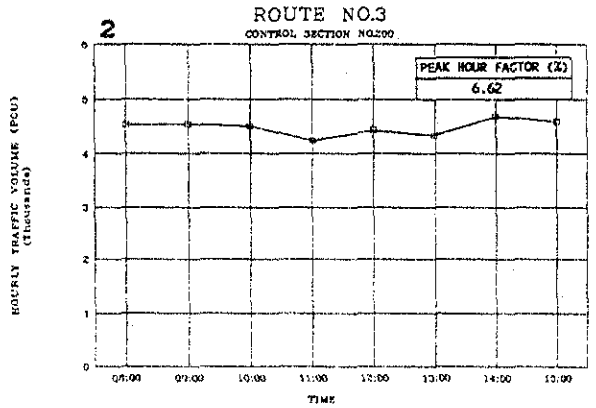
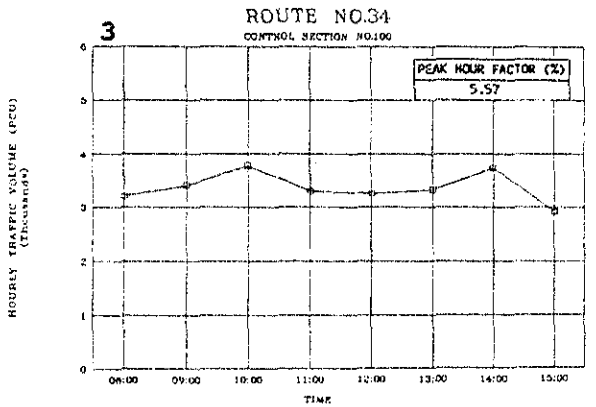
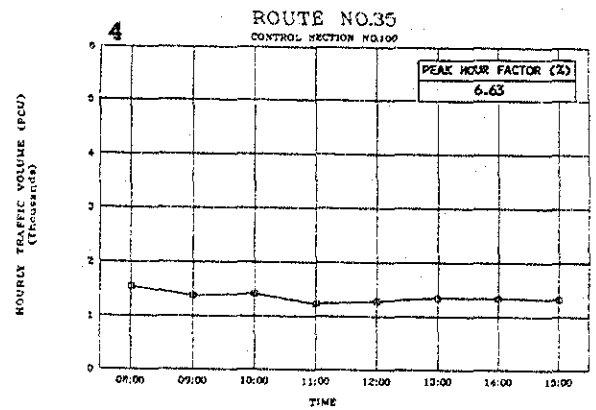


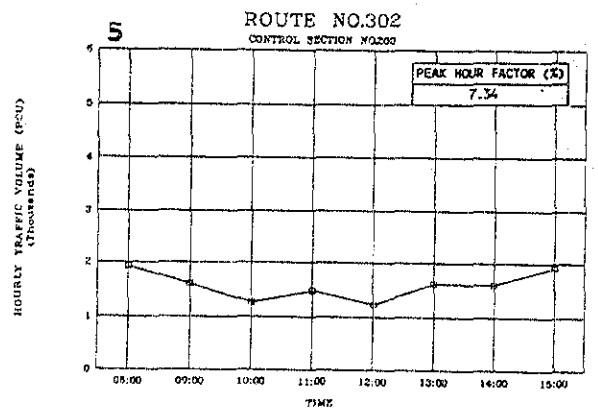
Figure 2.3 DAILY TRAFFIC VOLUME IN BANGKOK AREA (1990)

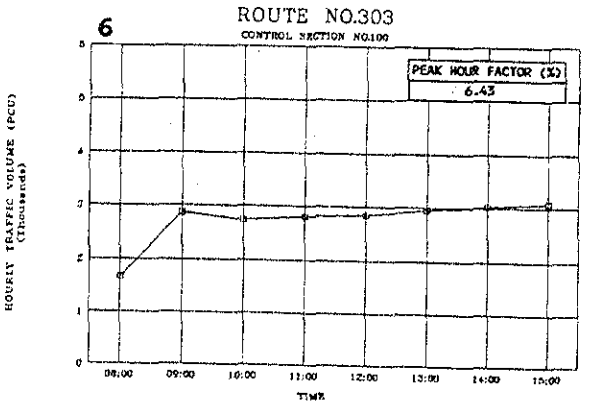




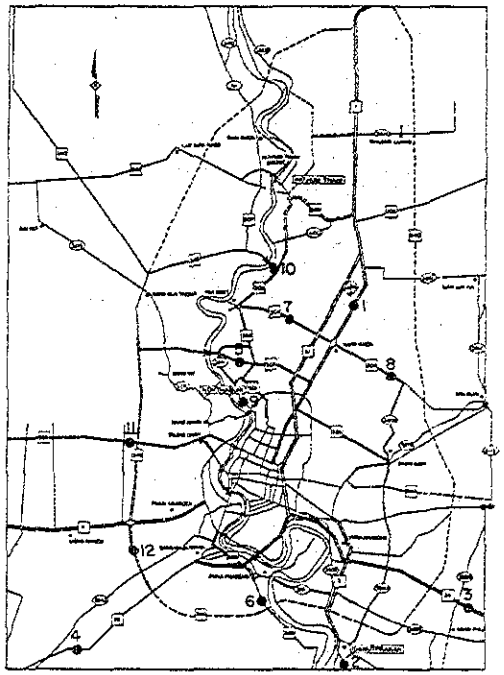






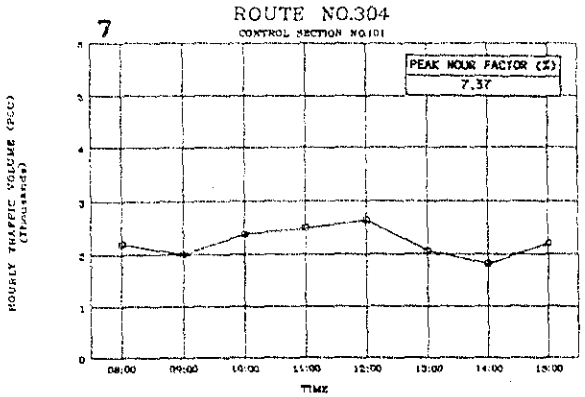


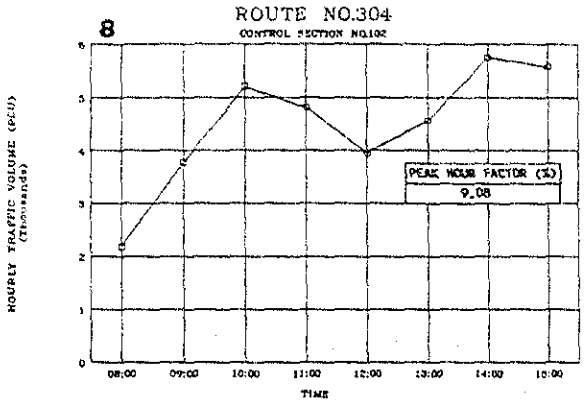
AVERAGE PEAK HOUR FACTOR IN THE STUDY AREA (%)
7.18

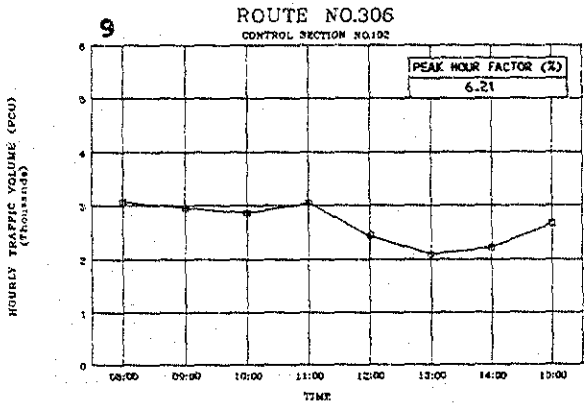


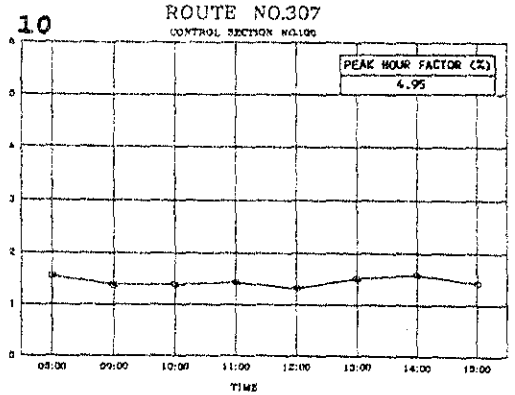
LOCATION MAP

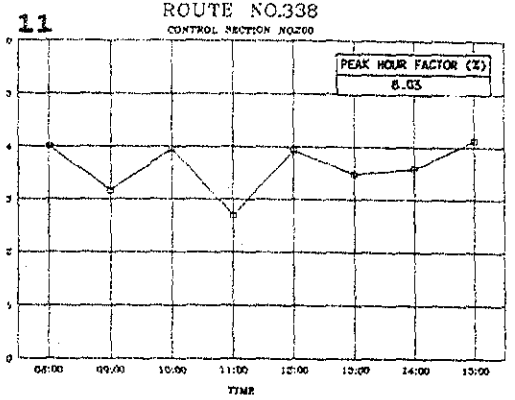
Figure 2.4 HOURLY FLUCTUATION OF TRAFFIC VOLUMES (1)

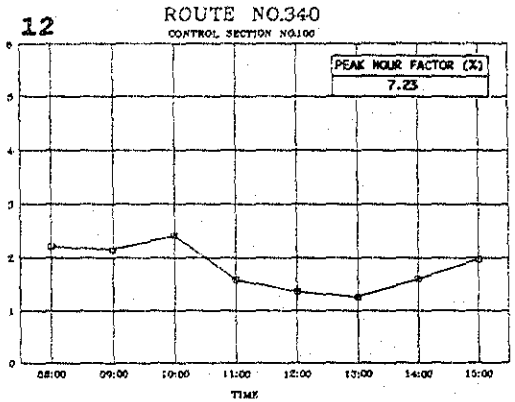




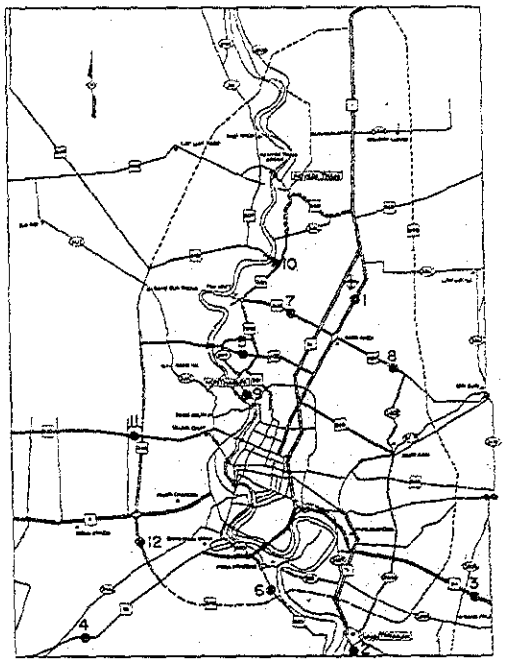








AVERAGE PEAK HOUR FACTOR IN THE STUDY AREA (%)
7.18



LOCATION MAP

Figure 2.4 HOURLY FLUCTUATION OF TRAFFIC VOLUMES (2)

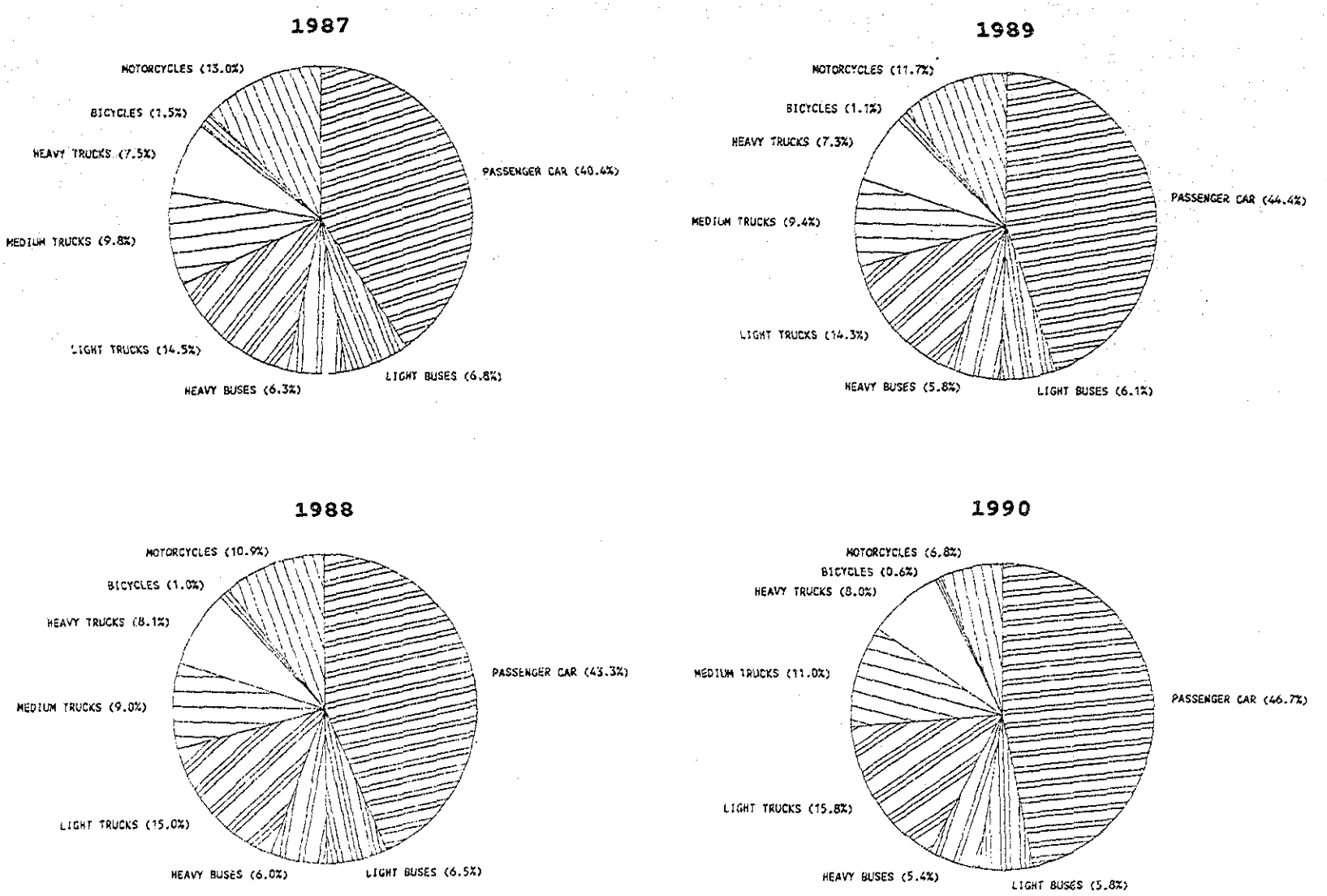


Figure 2.5 TREND IN VEHICLE TYPE COMPOSITION IN THE STUDY AREA

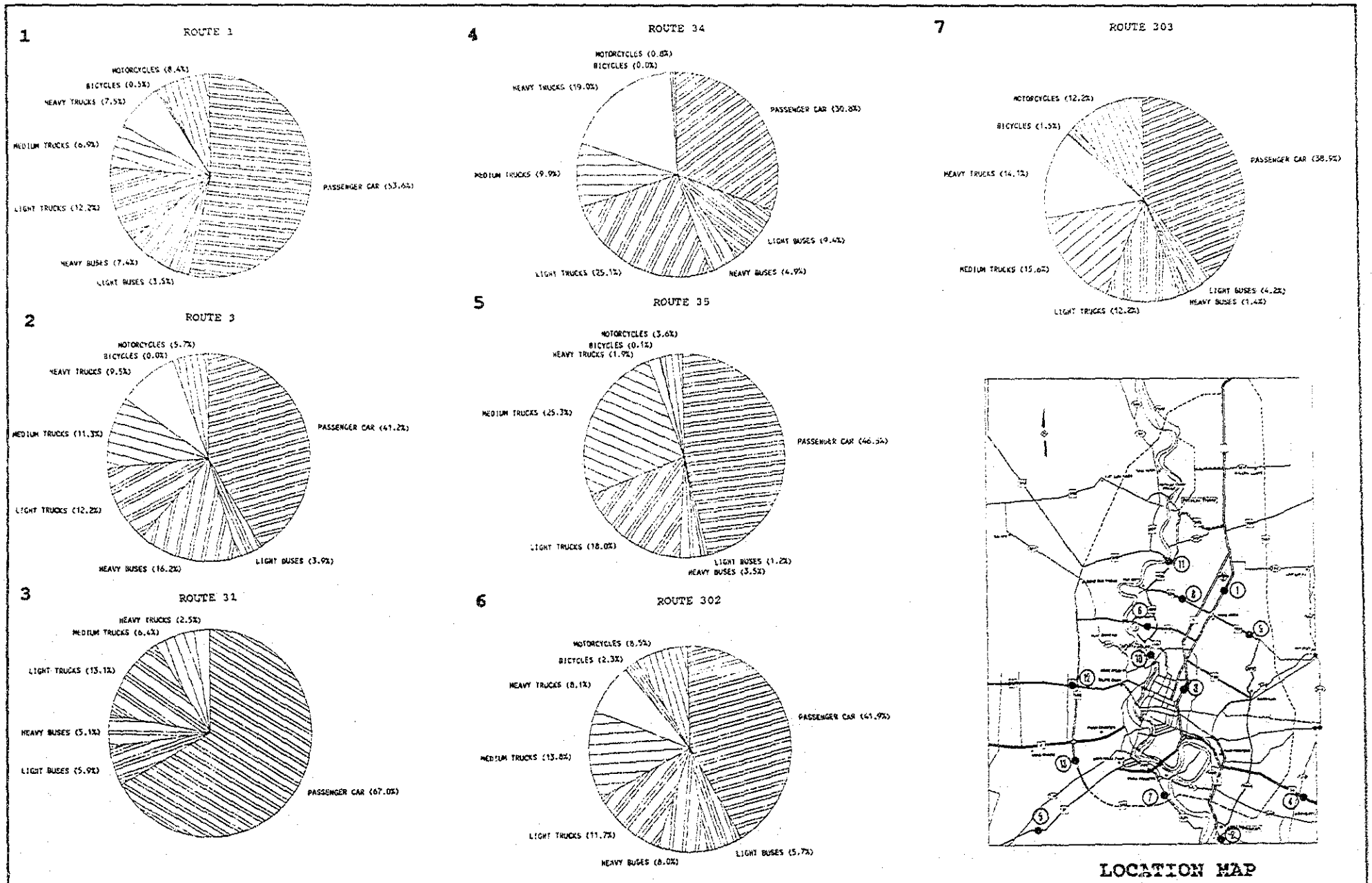
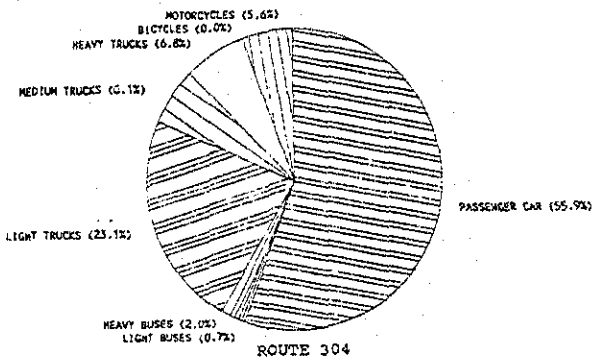
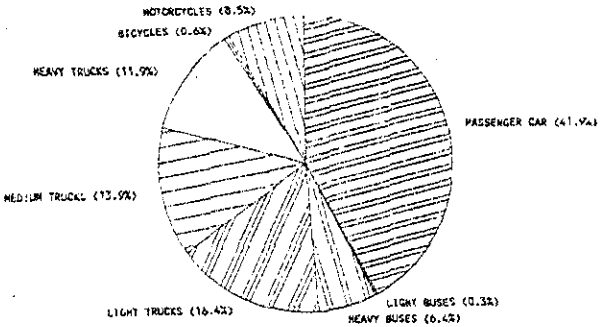


Figure 2.6 VEHICLE TYPE COMPOSITION ON TRUNK ROADS IN 1990 (1)

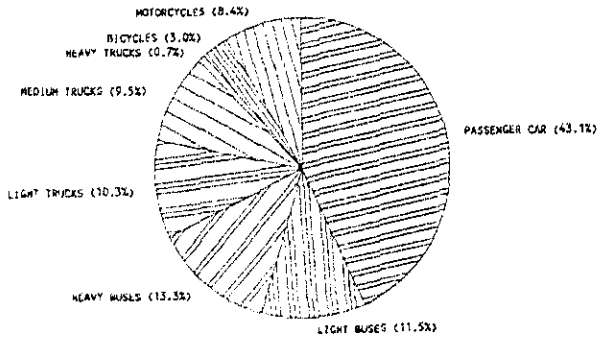
8 ROUTE 304
CONTROL SECTION 101



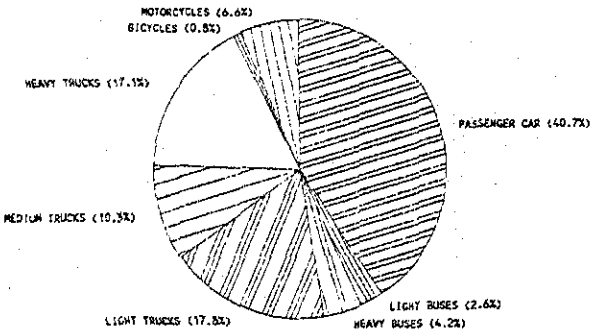
9 ROUTE 304
CONTROL SECTION 102



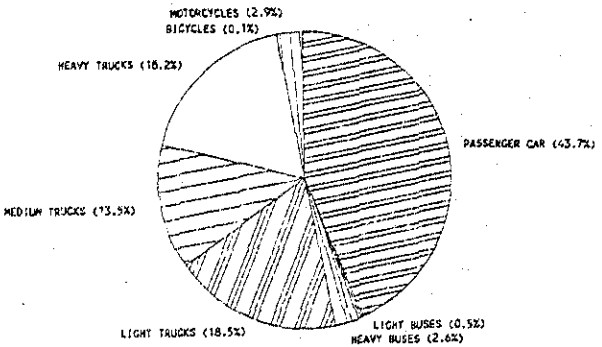
10 ROUTE 306



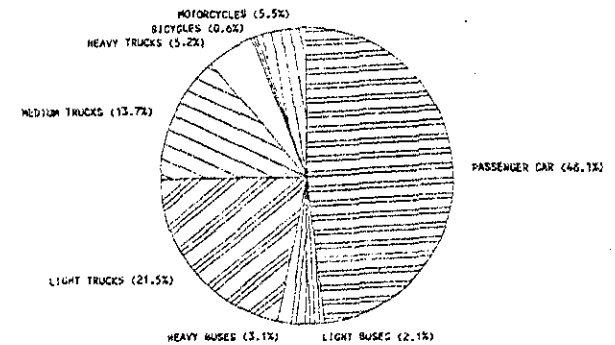
11 ROUTE 307

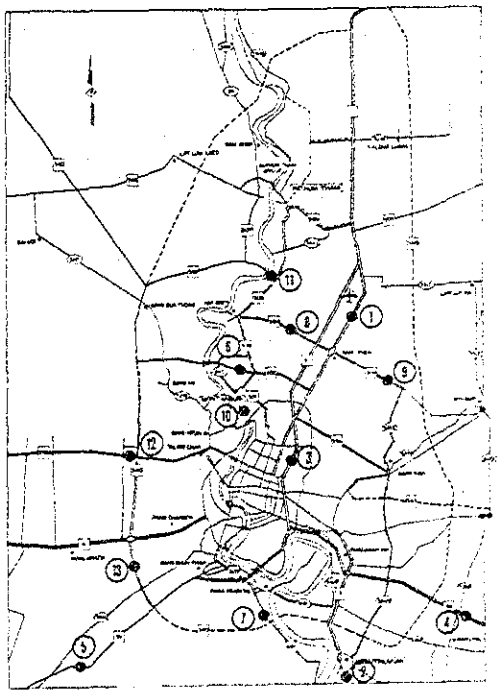


12 ROUTE 338



13 ROUTE 340





LOCATION MAP

Figure 2.6 VEHICLE TYPE COMPOSITION ON TRUNK ROADS IN 1990 (2)

2.3.3 Accident Conditions

Figure 2.7 shows the trend in the annual number of traffic accidents, for Bangkok and the rest of the country, for the 1977 to 1989 period. Figure 2.8 shows the trend in the annual number of casualties for the same period. The two figures indicate the following facts about the accident conditions:

A. The national total figure of accidents recorded in 1989 was approximately 42,500 cases and the national total figure of casualties was approximately 20,000 persons. The Bangkok Metropolis accounted for 85% (approximately 36,000 cases) of all accidents and 62% (approximately 12,500 persons) of all casualties;

B. A closer look into the numbers of accidents and casualties, reveals that the number of accidents increased by 1.84 times for the whole kingdom and by 3 times for Bangkok in the 10-year period from 1979 to 1989. Casualty numbers rose by 1.13 times in the whole kingdom and by 1.40 times in Bangkok Metropolis in the 9-year period from 1980 to 1989 (excluding 1979 when casualties rose sharply). The frequency of accidents increased from 1977 to 1979, leveled off from 1980 to 1987, and began to show a sharp uptrend again in 1988.

Figure 2.9 shows the number of accidents and the accident rate for 1988 in each section of the Study Area. The total number of accidents that occurred in the Study Area in 1988 was 4,925, which caused 2,365 casualties and an accident rate of 28.5 persons/100 million vehicle-kilometers.

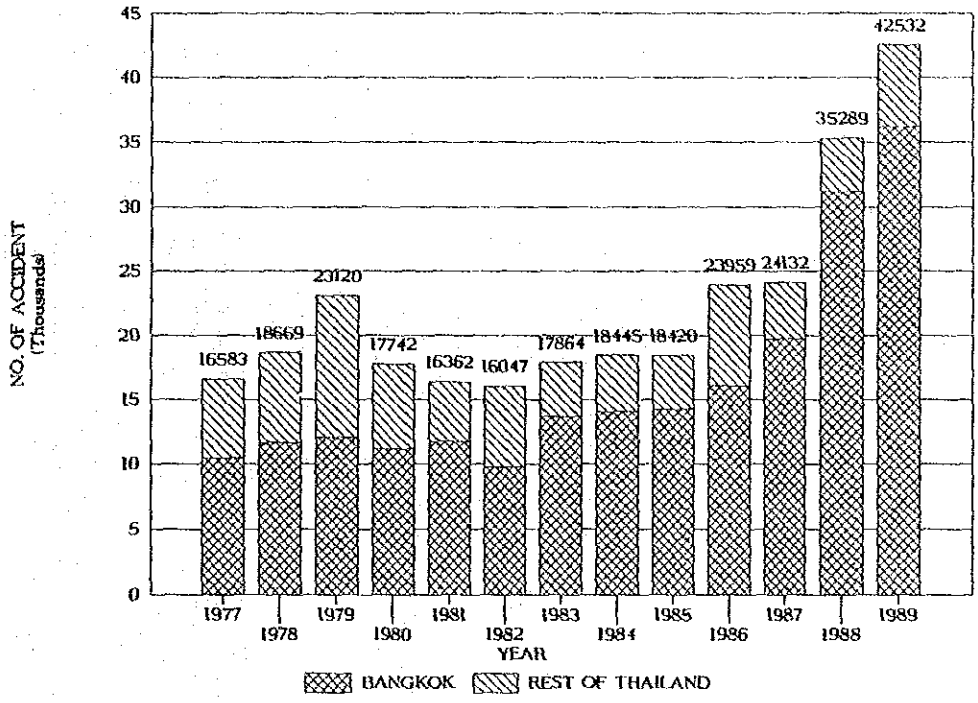


Figure 2.7 TREND IN THE ANNUAL NUMBER OF TRAFFIC ACCIDENTS (1977-1989)

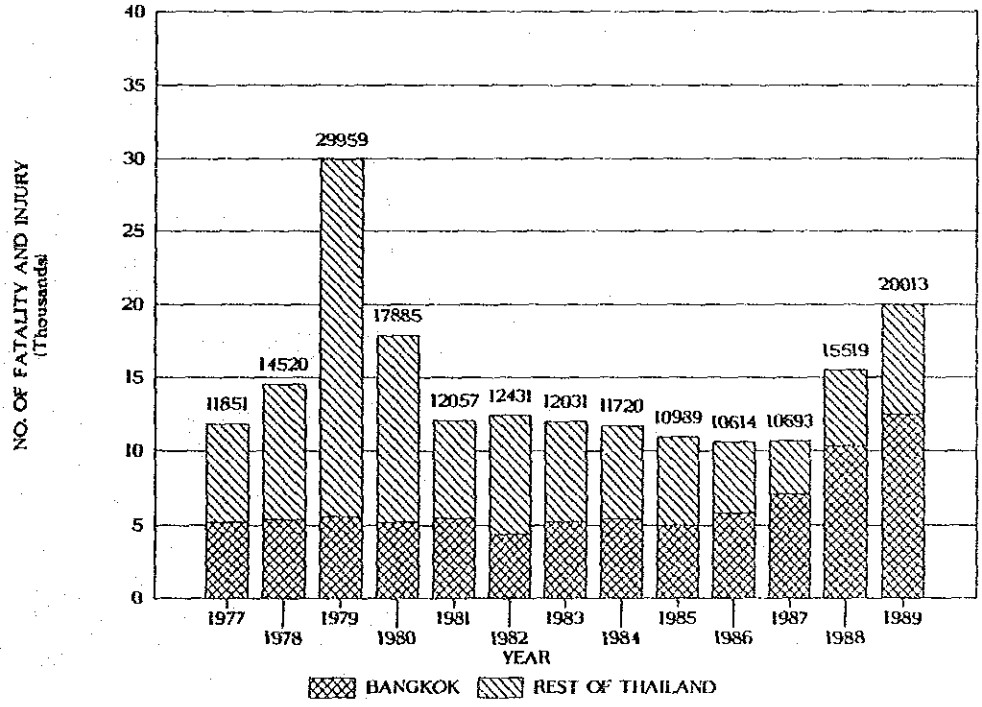


Figure 2.8 TREND IN THE ANNUAL NUMBER OF CASUALTIES (1977-1989)

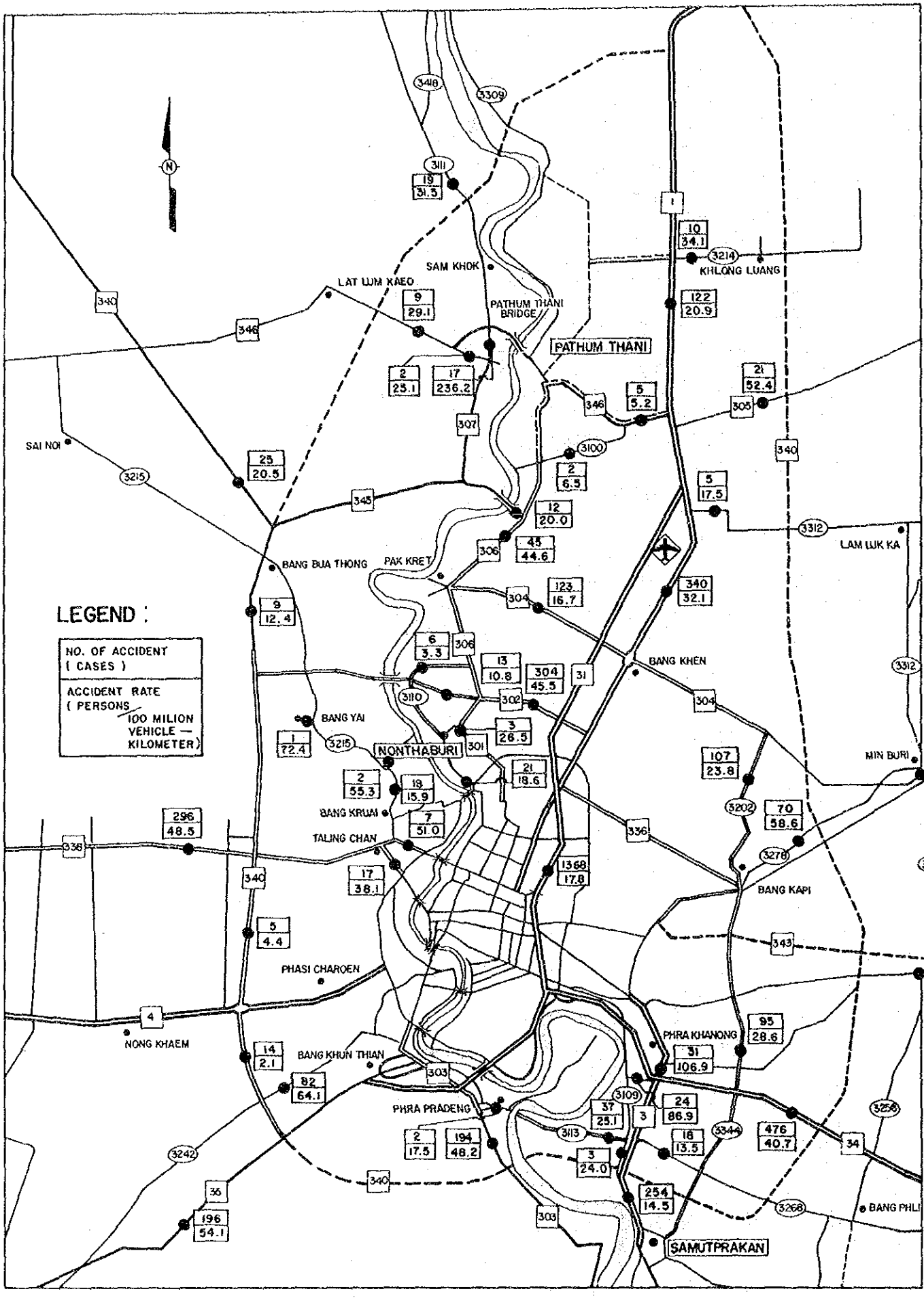


Figure 2.9 NUMBER OF ACCIDENTS AND ACCIDENT RATE (FATALITIES AND INJURIES)-1988)

2.4 REVIEW OF ECONOMIC ACTIVITIES AND LAND-USE IN THE STUDY AREA

2.4.1 Socioeconomic Conditions

(1) Population

Population and population density by region are shown in Table 2.5. The total population of Thailand was 55.9 million and the population density was 109 persons/km² in 1989.

Bangkok Metropolitan Area, which covers the Study Area, has the highest population density (3,727 persons/km²).

Between 1988 and 1989, the population growth rate has increased by 1.7% in the whole kingdom and by 2.0% in Bangkok.

Table 2.5 Population and Population Density by Region: 1987-1989

Region	1987		1988		1989	
	Population (Thousand)	Population Density (person/km²)	Population (Thousand)	Population Density (person/km²)	Population (Thousand)	Population Density (person/km²)
Northern Region	10,585	62	10,732	63	10,873	64
Northeastern Region	18,884	112	19,254	114	19,576	116
Central Region	2,737	165	2,792	168	2,812	169
Bangkok Metropolis	5,609	3,584	5,717	3,653	5,833	3,727
Bangkok Metropolis and vicinity	8,292	1,069	8,509	1,097	8,728	1,125
Eastern Region	3,481	95	3,595	98	3,634	100
Western Region	3,177	74	3,218	75	3,269	76
Southern Region	6,717	95	6,861	97	6,996	100
Whole Kingdom	53,873	105	54,961	107	55,888	109

Source : Local Administration Department, Ministry of Interior, 1989

(2) Gross Domestic Product

The trend in Thailand's gross domestic product (GDP) is shown in Table 2.6.

Table 2.6 Trend in Thailand's GDP

Item	Year	1986	1987	1988	1989
GDP (Current Market Prices)	GDP (Million Baht)	1,095,368	1,253,147	1,506,977	1,790,810
	Per Capita GDP (Baht)	20,679	23,261	27,419	32,043

Source : National Income of Thailand, NESDB, 1989

The per capita gross regional domestic product (GRDP) of selected regions in 1987 is shown in Table 2.7. The Bangkok Metropolitan Area had the highest per capita GRDP of approximately 72,000 Baht.

Table 2.7 Per Capita GRDP by Selected Regions in 1987

Region	Per Capita GRDP (Baht)
Central Region	18,742
Bangkok Metropolitan Area	71,566
Eastern Region	31,094
Western Region	19,795

Source : NESDB, 1987

2.4.2 Land-Use

Figure 2.10 shows land-use in the Bangkok area in 1986, compiled by the Bangkok Metropolitan Administration (BMA), and Figure 2.11 shows the land-use plan based on the general plans prepared by the Department of Town and Country Planning (DTCP).

According to the land-use plans prepared by the DTCP (Figure 2.11), the land-use pattern indicates low-density residential use throughout the eastern area and medium-density residential use and non-residential use along the trunk roads.

Urban areas have developed mainly in the south-eastern and north-eastern directions during the recent rapid economic boom in Thailand. The main urbanized areas in the south-eastern direction are along route 3 and 34. The establishment of factories and residential areas are underway along these roads. On the north-eastern direction along route 1, the development of industrial estates and residential areas have progressed rapidly.

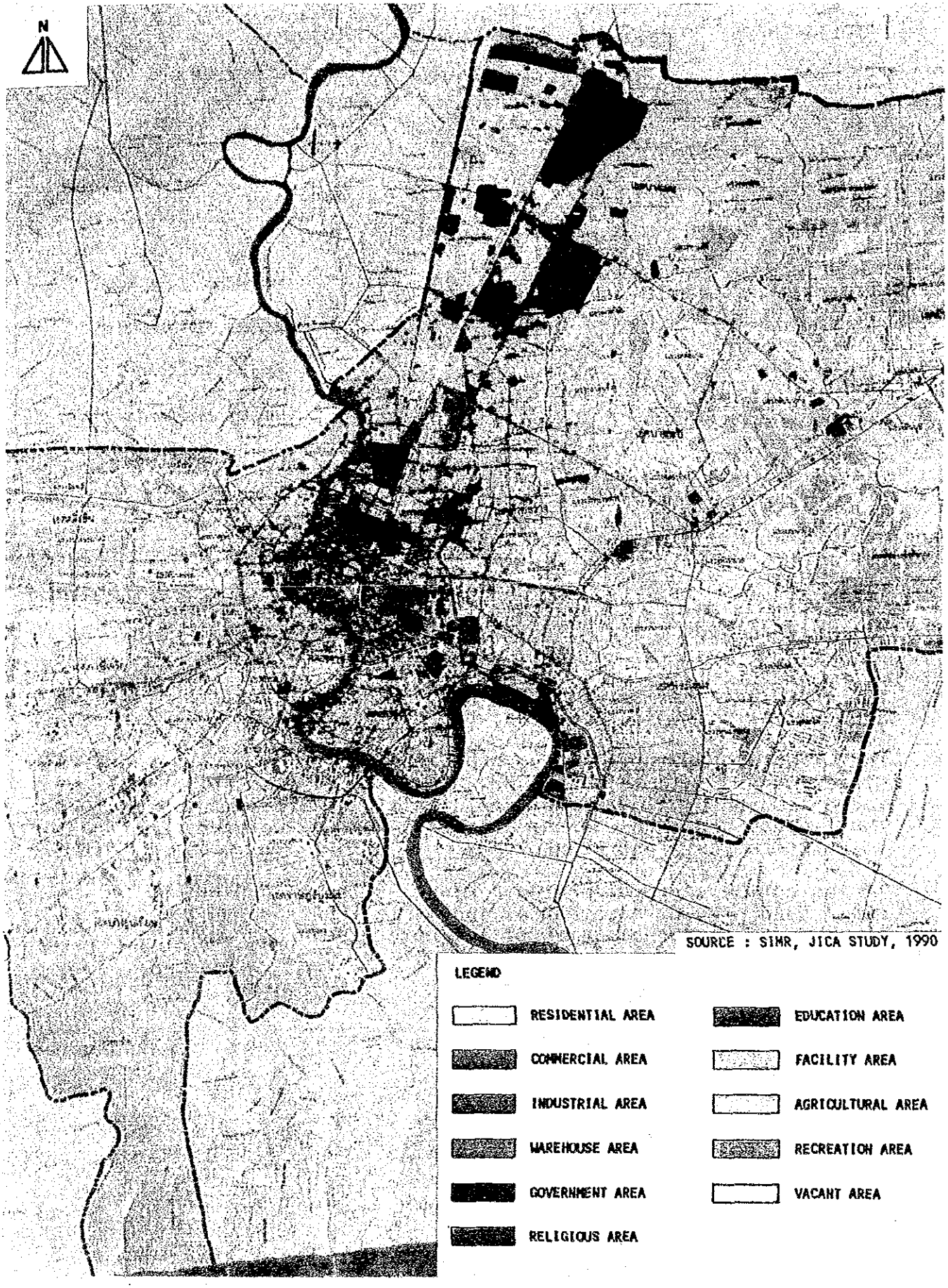
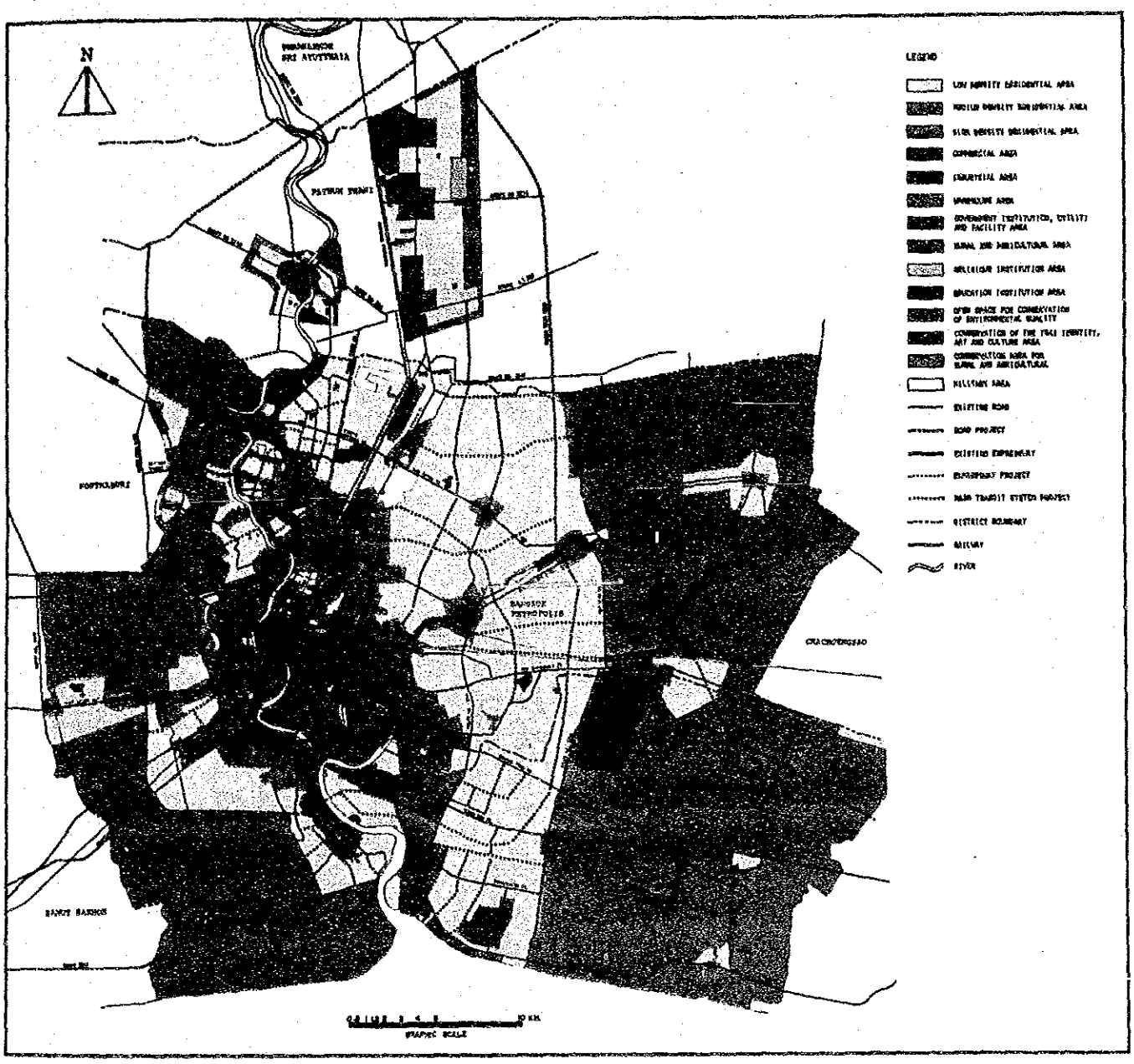


Figure 2.10 LAND-USE IN BANGKOK 1986



SOURCE : SIMR, JICA STUDY, 1990

Figure 2.11 LAND-USE PLAN BASED ON GENERAL PLAN

2.4.3 Motor Vehicle Registration

The trend in motor vehicle registration by vehicle type in Thailand is shown in Table 2.8. The total number of motor vehicle registrations in Thailand increased annually by 14.9% from 2.1 million in 1981 to 6.5 million in 1989. Of these, bus registration has increased annually by 18.9% and motorcycles registration has increased annually by 17.2%.

Table 2.9 shows the trend of motor vehicle registration by vehicle type in the Bangkok Metropolitan Area. The total number of registrations increased annually by 11.5% from 0.72 million in 1981 to 1.72 million in 1989. The percentage growth rate for buses is the highest at 31.1%

Table 2.8 Motor Vehicle Registration in Thailand

Year / Vehicle Type	1981	1982	1983	1984	1985	1986	1987*	1988	1989	Average Annual Increase Rate
Passenger Car	346210	394189	411982	541419	545369	572107	-	816693	656169	8.3%
Motorcycle	1163981	1399470	1716175	1911633	1816286	1958039	-	3894824	4153000	17.2%
Motor Tricycle	8655	8923	11240	11529	13220	12524	-	28017	19905	11.0%
Bus	110213	196719	221015	229979	256213	271753	-	428366	439759	18.9%
Van & Truck	466463	533601	568822	597674	601883	626557	-	994407	1086307	11.1%
Others	42021	47293	47680	49947	50620	76085	-	214868	149880	17.2%
Total	2137543	2580195	2976914	3342181	3283591	3517065	-	6377175	6505020	14.9%

Note * : 1987 data were lost during transference of vehicle registration administration from the Police Dept. to the Land Transport Dept.
Source : Licenses Division, Police Department
Land Transport Department, 1989

Table 2.9 Motor Vehicle Registration in Bangkok Metropolitan Area

Year / Vehicle Type	1981	1982	1983	1984	1985	1986	1987*	1988	1989	Average Annual Increase Rate
Passenger Car	270570	283226	304551	410997	440296	458164	-	590162	486660	7.6%
Motorcycle	289702	338846	390752	435516	485486	589671	-	775538	644597	10.5%
Motor Tricycle	6942	6942	6942	7406	7406	7406	-	7406	7479	0.9%
Bus	29892	122676	139169	140342	158893	171938	-	245560	260367	31.1%
Van & Truck	98139	122268	128341	107537	122593	119903	-	168760	294122	14.7%
Others	25445	28431	27803	27973	30578	33713	-	47743	28361	1.4%
Total	720690	902389	997558	1129771	1245252	1380795	-	1835169	1721586	11.5%

Note * : 1987 data were lost during transference of vehicle registration administration from the Police Dept. to the Land Transport Dept.
Source : Licenses Division, Police Department
Land Transport Department,1989

CHAPTER 3 SELECTION OF TRAFFIC OPERATIONAL MEASURES IN THE STUDY SECTIONS

CHAPTER 3 SELECTION OF TRAFFIC OPERATIONAL MEASURES IN THE STUDY SECTIONS

3.1 METHODOLOGY OF TRAFFIC OPERATION PLANNING

This section describes the general methodology of traffic operation planning.

3.1.1 General Procedure

In order to formulate and enforce an effective traffic operation plan, the following procedures should be observed:

A. Selection of section locations;

B. Identification of traffic problems and problem sections;

C. Selection of traffic operation measures (preparation and comparative evaluation of alternative measures);

D. Implementation of traffic operation plan;

E. Implementation of follow-up survey.

Figure 3.1 shows the standard process of traffic operation planning, with an outline of the studies required for each step. In certain cases the planning process needs to be carried out by feeding back to each step.

In traffic safety planning , attention should be paid to the following points when carrying out the analysis of accident data and when formulating the plan.

(1) Applicability of Accident Data

The accident data provides the most useful and direct information for reviewing the accident prevention plan. However, this data should be used with care since it may not be complete nor fully reliable. This is especially significant when it is used to examine the variation in accident occurrence. The data are useful, however, to clarify the degree of contribution of various casual factors. This is done by statistically processing the accident data, yet this too has its limitations. When formulating an accident prevention plan for each individual problem location, therefore, it is necessary to refer to the accident document and obtain information from those involved in the accident and the traffic policemen in charge.

(2) Need of a Positive Approach

Traffic accidents vary from one location to another. Even if various methods of analysis are devised, it is impossible to identify the problems of each individual accident location. Site investigations are essential to establish the various accident location conditions for each site and to formulate the most effective prevention plan.

(3) Selection of Measures

The accident prevention measures plan to be implemented should focus on certain selected objectives. The plan should not have a variety of objectives.

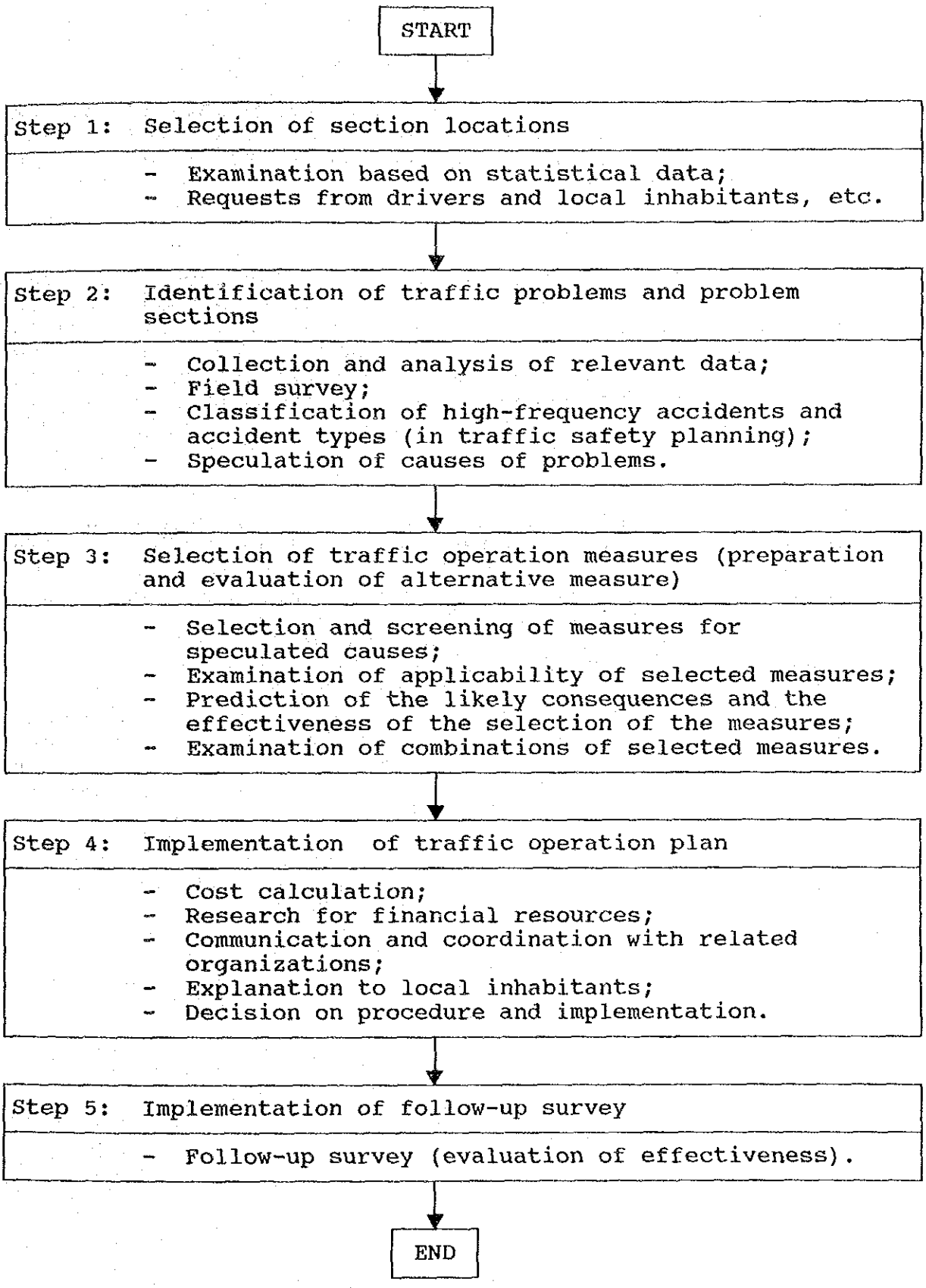


Figure 3.1 STANDARD PROCESS OF TRAFFIC OPERATION PLANNING

3.1.2 Method for Identification of Problems

(1) Method for Identification of Problem Sections

Identification of problem sections was examined on the basis of the method proposed in the TOPR Study. The evaluation of traffic smoothness and traffic safety are outlined below:

a) Smoothness Evaluation

Traffic volume is a basic data item collected through traffic surveys. In the case of evaluating road traffic situations, the traffic volume to traffic capacity ratio for each road section can be a useful indicator. This ratio not only indicates the traffic congestion rate, but it also provides some correlation between traffic volume and travel speed.

b) Safety Evaluation

If traffic accidents are recorded on a road map, a concentration of similar types of accidents at specific points may be revealed. Such a pattern reveals the hazardous locations on the roads. Traffic accident rate is used as an indicator of traffic safety.

(2) Method for Identification of Traffic Problems

The problem locations include special points, intersections and certain road sections. In traffic safety planning, accident data are most frequently used to detect problem points, and they often make it possible to identify locations with a high frequency of accidents.

It is necessary to analyze the following data to identify traffic problems.

a) Road structure data (annually updated road data):

- length ;
- horizontal alignment;
- vertical alignment;
- intersection density;
- sight distance;
- roadside condition;
- traffic safety devices;
- pavement condition;
- others.

b) Traffic data:

- daily traffic volume;
- peak-hour traffic volume;
- turning movement volume at intersection;
- vehicle composition;
- others.

c) Traffic behavior data:

- running speed;
- vehicle headway;
- others.

Field surveys are required in addition to the above data, and video data collected in such surveys are useful in identifying problem locations.

d) Traffic accident data

- number of accidents, casualties, etc.;
- accident characteristics;
- distribution of accident points.

(3) Method for Diagnosis of Problem Sections

The objective of problem location diagnosis is to analyze the conditions where accidents occur at each identified problem point and to determine the problems existing there. The following tasks are indispensable for the purpose of this diagnosis:

- Arrangement of data, including information relating to road conditions, traffic conditions, roadside conditions, etc.;

- On-site observation and investigation of roads and roadsides and traffic conditions;

- Summarizing of accident characteristics, and examination of the causes of accidents (data integration based on above).

The following explains the contents of these tasks.

a) Arrangement of data

The arrangement of data is broadly classified into the following two operations.

A. Arrangement of accident records

The preparation of a collision diagram (Figure 3.2) is the major work. In order to increase the reliability of accident analysis, it is desirable to use the largest possible amount of data. While this calls for an extended period of data collection, it is necessary that no large change take place in the road or traffic conditions during this period.

Figure 3.2 COLLISION DIAGRAM

B. Arrangement of data on road and traffic conditions

The data on road conditions should be summarized and noted down on a single diagram. This is usually coordinated with the collision diagram. In addition to the locations of traffic control devices, the history of their installation should also be written down on the diagram. The traffic survey items should cover directional traffic volume for each approach and pedestrian traffic volume. The data on traffic control measures should include details of signal phasing and timing. These data on traffic conditions should preferably indicate past changes in traffic operation.

b) On-site observations

The following items should be checked at the accident sites:

A. Causal effect of the road structure on the accident, and the possibility of its improvement;

B. Presence of a dead-angle and the possibility of its improvement;

C. Whether the existing traffic signs, markings and signals, etc. are performing the expected functions or producing any reverse effects;

D. Whether or not the traffic-stream is suitably channelized;

E. Possibility of reducing accidents by controlling specific traffic flows (for example, light traffic volumes on a right-turn lane);

F. Possibility of distributing traffic to a direction with less danger of accidents occurring;

G. Whether or not the night-time accident rate is higher than the daytime rate, and the necessity of street lighting, signal controls and delineators for different times of the day;

H. Necessity of reexamining traffic control and regulations;

I. Necessity of a supplementary traffic survey;

J. Influence of parked cars on the accident;

K. Possibility of installing advanced-warning signs enabling drivers to select an adequate lane.

c) Summarizing of accident characteristics

In summarizing the data on the occurrence of accidents, the accident type rate (%) is calculated to determine the types of accidents which are abnormally high in frequency.

The results of problem location diagnosis described above are easier to understand when arranged in the sheet diagnostic shown in Table 3.1.

This table summarizes the results of the traffic data

analyses and it outlines the necessary items for effective traffic safety planning. The diagnostic sheet is a useful tool for the collection and analysis of traffic data needed for traffic safety planning.

3.1.3 Method for Selection of Measures

This section deals with the process of the formulation, examination and enforcement of traffic safety plans to be carried out on the basis of the selection and diagnosis of problem locations described in the foregoing sections.

(1) Individual Accident Prevention Measures and their Effectiveness

Table 3.2 shows the relationships between the present traffic safety planning process and accident types. It should be noted that a traffic safety plan put into action is often a combination of a number of measures, and that its enforcement sometimes produces contrary results or ripple effects. At the moment, however, the generalization of their effectiveness is not quantatively confirmed in Thailand.

(2) Evaluation and Priority Determination of Accident Prevention Measures.

The following steps should be taken for the evaluation and priority determination of accident prevention measures:

A. Estimation of the decrease in the number of accidents and other benefits expected from a proposed measure;

B. Estimation of the cost of a proposed measure;

C. Comparative evaluation of the proposed measures by economic analysis;

D. Determination of priority order.

The availability of basic quantitative data pertaining to the accident reduction rate and accident cost reduction, realizable by each individual measure, is an essential prerequisite for satisfactory performance of these steps. At the moment, however, only fragments of such data are available in Thailand, and hence traffic safety planning will have be based on warrants for some time to come.

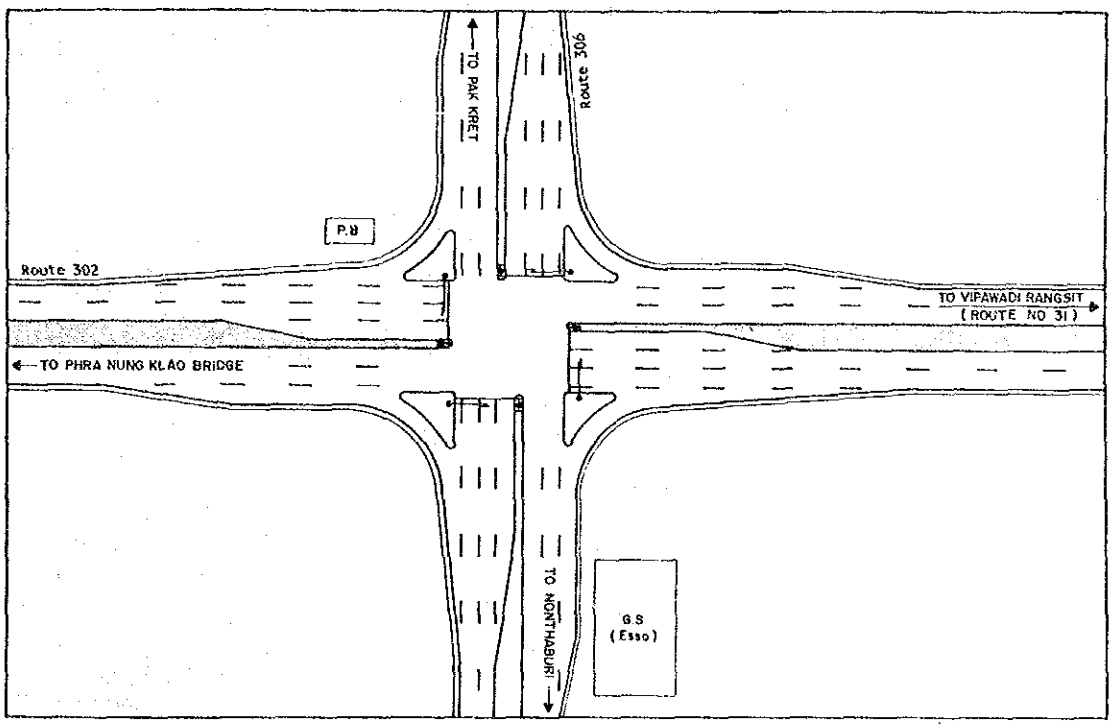
Accordingly, in the study, the measures were selected on the basis of the technical guidelines and engineering specifications in the TOPR study.

Table 3.1 Diagnostic Sheet of Problem Locations

(Form - 1)

LOCATION NO.	OO	LOCATION NAME	OOOOOO			
ROUTE NO.	OOOO	CONTROL SECTION NO. OOO	K.P. OF PROBLEM LOCATION	K.P. OO.O – K.P. OO.O	ROAD CONDITION	inter-section
K.P. OF CONTROL SECT.	K.P. OO.O – K.P. OO.O				DISTRICT CODE	411
DIVISION NAME	Bangkok		DISTRICT NAME	Bangkok	PEDESTRIAN VOLUME (PERSONS/PEAK HOUR)	
TRAFFIC VOLUME (VEHICLES) (P.C.U.)	(WHOLE DAY) MAJOR ROAD 53,299; MINOR ROAD 49,189; (PEAK HOUR) MAJOR ROAD 2,956; MINOR ROAD 3,356		PERCENT OF HEAVY VEHICLES (%)	(WHOLE DAY) MAJOR ROAD 18.5; MINOR ROAD 31.3; (PEAK HOUR) MAJOR ROAD 14.0; MINOR ROAD 32.8	CONGESTION DEGREE	0.85
NO. OF ACCIDENTS(CASES)	(ALL ACCIDENTS) 5; (FATALITIES) 2; (INJURIES) 3		CASUALITIES (PERSONS)	(FATALITIES) 2; (INJURIES) 5	ACCIDENT RATE (PERSONS/100 MIL. VEH. KM.)	78.7
					WHOLE CONTROL SECTION	44.6

EXISTING ROAD CONDITION DIAGRAM



DETAILS OF PROBLEM LOCATION (COMMENTS)

This is an intersection at R.302 and R.306

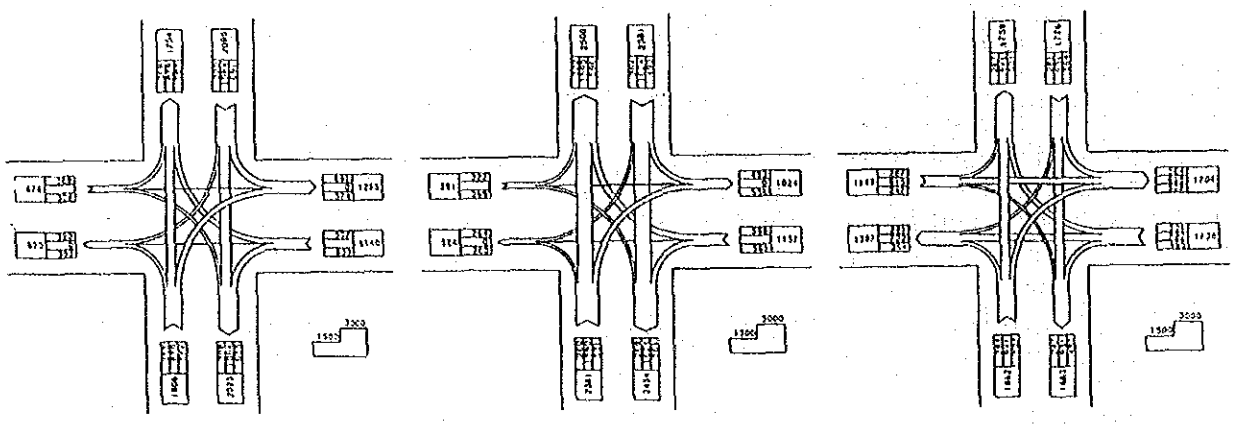
TRAFFIC SAFETY/CONTROL DEVICES INSTALLED

TRAFFIC SIGNAL	O
PEDESTRIAN CROSSING	
PEDESTRIAN OVERPASS	
STREET LIGHTING	O
GUARD FENCE	
CHANELIZATION	O
OTHERS	

TRAFFIC DATA ANALYSIS

TRAFFIC CONDITION DATA

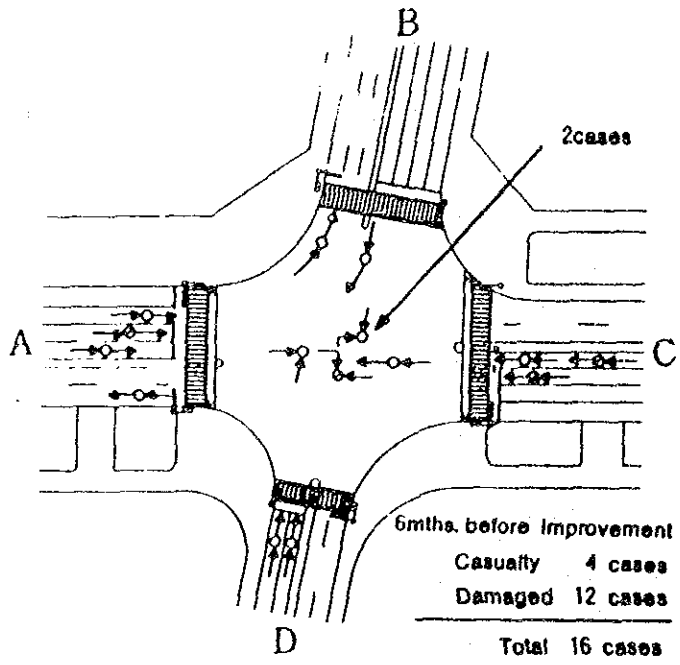
Morning Peak | Evening Peak | Off Peak



Accident Condition Data

STUDY SECTION NO.	ROUTE NO.	CONTROL SECTION NO.	K.P.-K.P.	LENGTH (KM)	TRAFFIC VOLUME		NUMBER OF ACCIDENTS (CASES)	CASUALTIES			ACCIDENT RATE					ACCIDENT RATE OF CONTROL SECTION (CASUALTIES/100 MIL.VEH.KM.)	REMARKS
					ADT (PCU/DAY)	VEHICLE KILOMETER		DEATH (CASES)	INJURY (CASES)	DEATH AND INJURY (CASES)	ACCIDENT DENSITY (CASES/KM)	ALL ACCIDENTS (CASES/100 MIL.VEH.KM.)	DEATH (CASUALTIES/100 MIL.VEH.KM.)	INJURY (CASUALTIES/100 MIL.VEH.KM.)	DEATH AND INJURY (CASUALTIES/100 MIL.VEH.KM.)		
1	1	100	20+500 - 21+500	1.000	46,341	46,341	67	2	17	19	67.0	396.1	11.8	100.5	112.3	32.1	

COLLISION DIAGRAM



LEGEND	
←	VEHICLE EXCLUDING MOTORCYCLE
←	MOTORCYCLE
←	BICYCLE
←	PEDESTRIAN
←	TRAIN
←	PARKING OR STOPPING VEHICLE
●	ACCIDENT WITH FATALITY
⊗	ACCIDENT WITH INJURY
○	ACCIDENT WITH PROPERTY DAMAGES ONLY
←	LOOSING CONTROL
←	OVERTURNING

COMMENTS ON ACCIDENT OCCURRENCE CONDITION

Accident are mostly caused by speeding (10 cases). Accidents caused by overtaking cars are most frequent (14 cases), followed by head-on collisions (3 cases).

CONCEIVABLE MEASURES AND THEIR GROUNDS

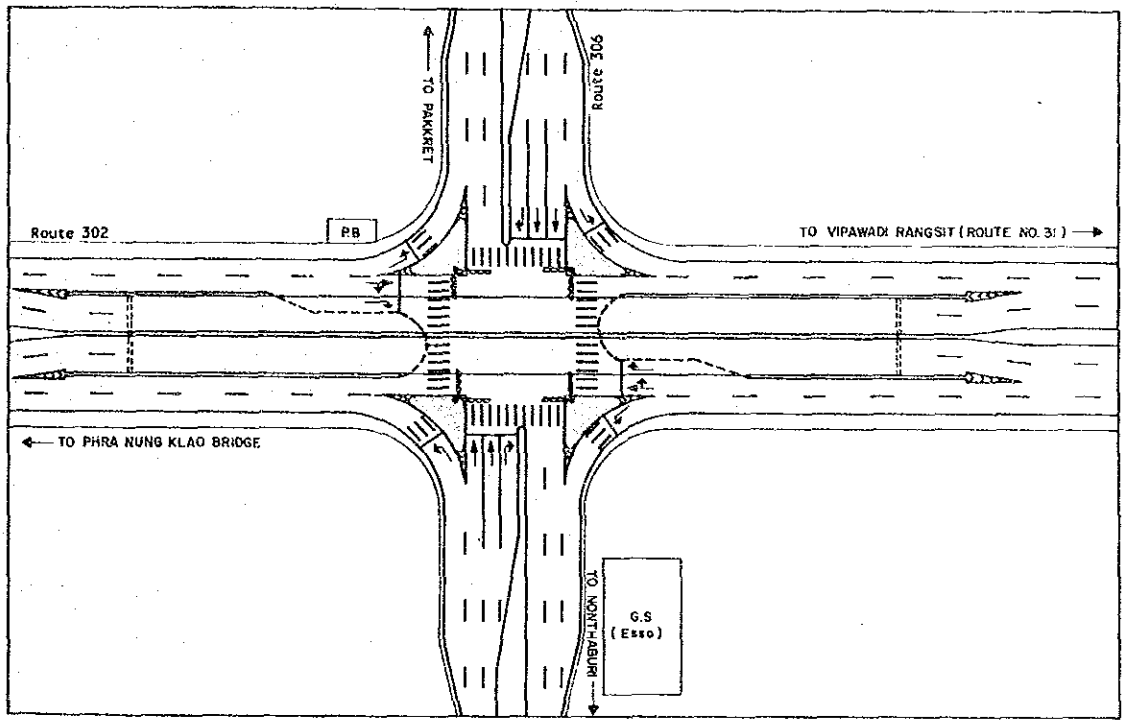
Major Problems

The large amount of entering traffic is causing over-saturation

Possible Countermeasures

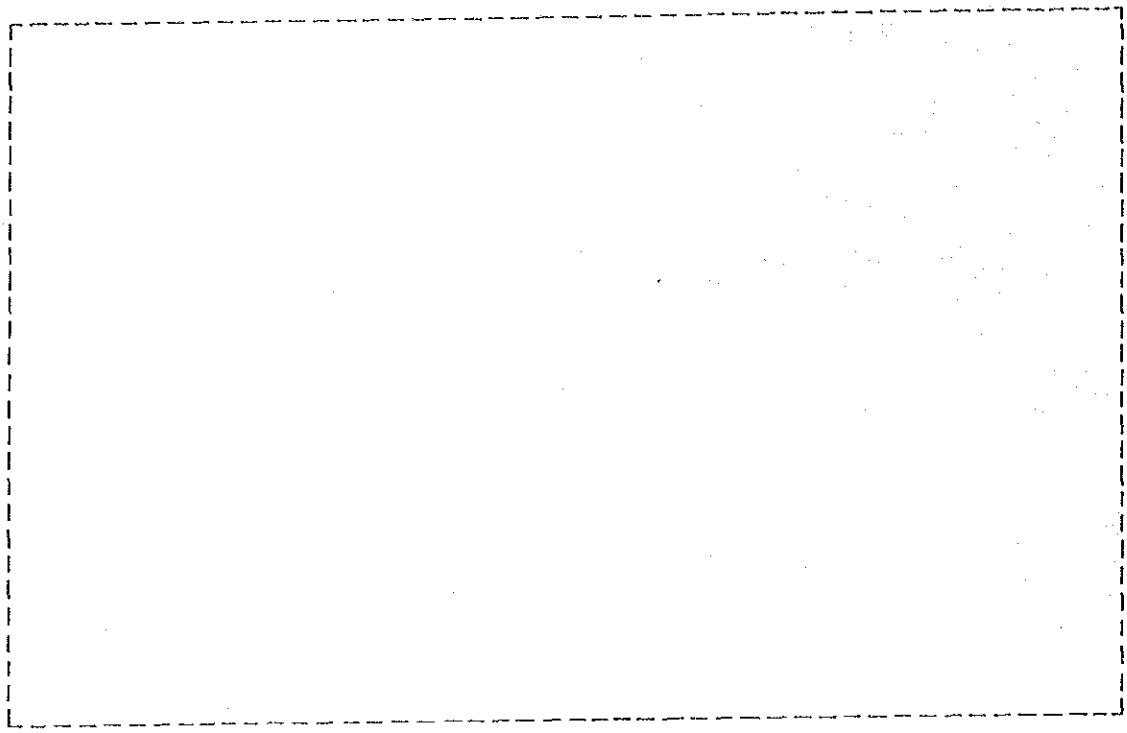
The construction of a grade separation, based on the widening plan of R302, is suggested.

ILLUSTRATION OF TRAFFIC SAFETY / OPERATION PLAN



COMMENTS

SPOT PHOTOGRAPH



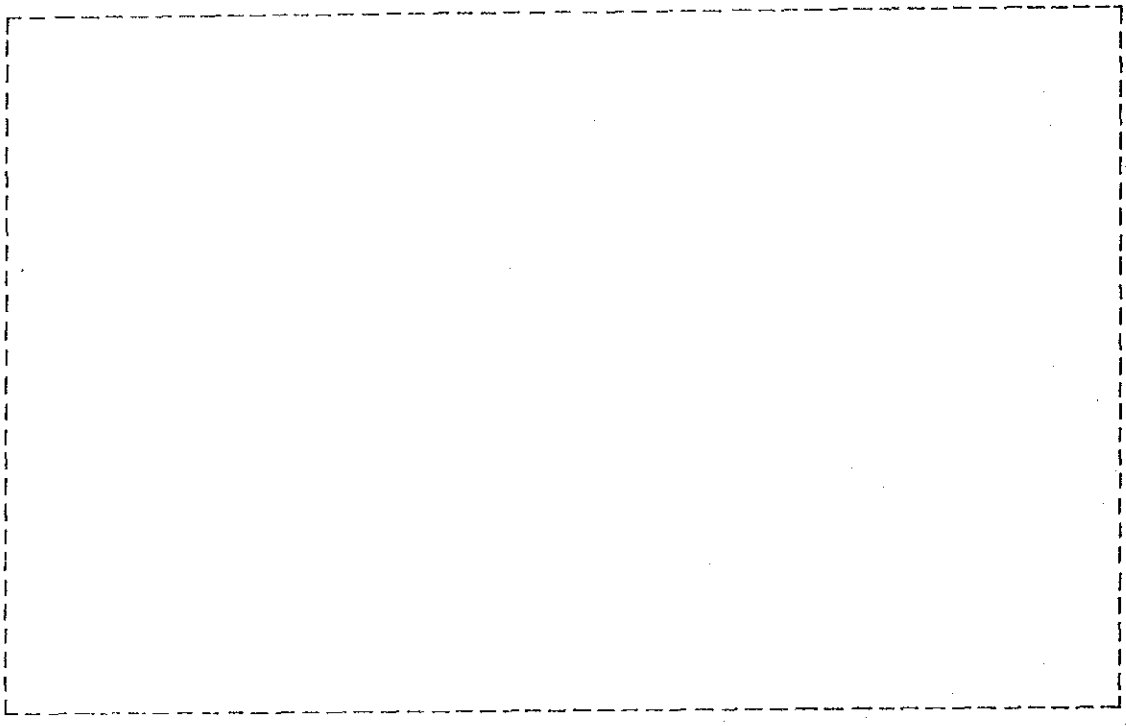


Table 3.2 Relationships between Accident Prevention Measures and Accident Type

TYPES OF ACCIDENTS / MEASURES	VEHICLE VS. PEDESTRIAN					VEHICLE VS. VEHICLE										SINGLE VEHICLE			VEHICLE VS. MOTORCYCLE AND VEHICLE VS. BICYCLE	REMARKS
						HEAD-ON COLLISIONS		REAR-END COLLISIONS												
	PEDESTRIAN WALKING ALONG ROAD	PEDESTRIAN CROSSING ROAD AT INTERSECTION	PEDESTRIAN CROSSING ROAD AT CROSSWALK	PEDESTRIAN CROSSING ROAD AT OTHER SECTIONS	PEDESTRIAN EMERGING ON ROAD	OVER TAKING/PASSING	OTHERS	RUNNING	PARKING AND STOPPING	COLLISION UPON MEETING	COLLISION WHEN OVERTAKING/PASSING	COLLISION WHEN TURNING	COLLISION WHEN TURNING RIGHT	COLLISION WHEN TURNING LEFT	COLLISION WHEN PASSING EACH OTHER	COLLISION WITH STRUCTURE	RUNNING OFF ROADS	COLLISION WITH PARKED VEHICLE		
MEDIAN DIVIDER						●	●					●	●							
FACILITIES FOR CHANNELIZATION												●	●	●					○	
ADDED LAND IN THE NEIGHBORHOOD OF AN INTERSECTION								○				●	●	●						
PASSING LANE (INCLUDE CLIMBING LANE)						●		●			●									
MOTORCYCLE LANE																			●	
TRAFFIC SIGNAL		●	○							●		●	●	●						
TRAFFIC SIGN	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
PAVEMENT MARKING	○	○	○			○	○		○	○	○	○	○	○	○	○	○	○	○	
CROSSING FACILITIES FOR PEDESTRIANS		●	●	●				○												
SIDEWALK AND BICYCLE PATH	●				●			○											●	
STREET LIGHTING	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		SECTIONS WHERE THERE ARE MANY ACCIDENTS, ESPECIALLY AT NIGHT-TIME
DELINEATOR								○								●	●			SECTIONS WHERE THERE ARE MANY ACCIDENTS, ESPECIALLY AT NIGHT-TIME
GUARD FENCE	●			●	●			○								●	●			
PAVEMENT TREATMENT	○					●	●	●			●					●	●			
BUS STOP FACILITIES (INCLUDE PARKING FACILITIES ON ROAD)									●						●			●		

(NOTE) ● MAIN EFFECTS ○ SIDE EFFECTS