Chapter 5
FUTURE ORIGIN-DESTINATION MATRICES

CHAPTER 5 FUTURE ORIGIN-DESTINATION MATRICES

5.1 General

For the establishment of future Origin-Destination (OD) matrices, the procedure used in the determination of the 1982 OD matrices was applied again. The target years of future OD matrices were proposed at 1990, 2000 and 2010 since the service of the Project would cover these years. The types of vehicles of the future OD matrices were determined as passenger cars (including taxi and samlor), motorcycles, private buses, buses with person trips using public transport services and trucks.

5.2 Establishment of 2000 OD Tables

5.2.1 Number of Passenger Cars in Future Years

In this subsection the number of registered passenger cars in future years was estimated, which was used for the forecast of trip generation and attraction together with other indexes. The vehicle fleet estimate was conducted both for the total in the GBA and each zonal registration.

(1) Number of Vehicles in 1982

The number of passenger cars in each Changwat in 1982 is summarized in Table 5–1. The figure was determined by reviewing the statistics in the previous years.

TABLE 5–1 NUMBER OF REGISTERED CARS (1982)

Description		Bangkok	Samut Prakan	Nonthaburi	GBA
Number of Passenger cars	(1982)	359,400 (95)	8,700 (2)	12,200 (3)	380,300 (100)
Population (thousands)	(1982)	5,467 (85)	566 (9)	399 (6)	6,432 (100)
Motorization (cars per 1,000 inh.)	(1982)	66	15	31	59
	(1972)	51	10	18	46

(2) Model for the Estimation of the Number of Cars

For the purpose of establishing the model to determine the number of cars, a linear regression analysis was applied. In this Study, the relationship analysis was applied. The relationship between the number of cars and the gross provincial product (GPP) as an economic index was examined.

The past annual growth rate of per capita GPP in the GBA is shown as follows (Refer to Appendix Table 2–9) :

Bangkok	: 6.0%
Nonthaburi	: 6.1%
Samut Prakan	: 6.5%
GBA TOTAL	: 6.3%

Based on the past records of per capita GPP and the past motorization, the following formulas were established.

Bangkok	: Y = 16.7070 + 0.0020x	(r = 0.954)
Nonthaburi	: Y = −19.0678 + 0.0061x	(r = 0.974)
Samut Prakan	: Y = −4.2238 + 0.0005x	(r = 0.975)
GBA TOTAL	: Y = 13.7754 + 0.0018x	(r = 0.956)

where Y : Motorization (vehicles/1,000 persons)
x : per capita GPP
(r : correlation coefficient)

(3) Estimation of Future per capita GPP

In accordance with the "Fifth 5-year National Development Plan (1982–1986)", GPP for the Bangkok area was estimated at 122,000 million Baht and 174,400 million Baht for the Bangkok Metropolitan Region (in 1972 prices). Based on these target figures, GPP for the GBA was estimated at 163,000 million Baht in 1986.

GPP of the GBA in 1980 was 117,963 million Baht, the annual increase rate in GPP was expected at 5.5% for the years 1982–1986 and per capita GPP during the same period was expected at 3.1%. In this study, considering the above target figures, an increase rate in GPP was assumed by period as follows :

1980–1986 : 3.1%
1986–1990 : 3.0%
1990–2000 : 2.0%

Accordingly, future GPP and per capita GPP were estimated as in Table 5–2.

TABLE 5–2 GPP, PER CAPITA GPP IN THE GBA

Description	1980	1982	1986	1990	2000
GPP (Million ฿)	117,963	132,711	163,000	199,600	280,000
Per Capita GPP (Baht)	19,411	20,633	23,373	26,301	32,060
Population (Thousands)	6,077	6,432	6,974	7,590	8,729

(4) Estimation of the Number of Cars in the Future

Future motorization rate could be estimated by using the model established in (2) above in this subsection. Applying the future per capita GPP to this model, future motorization was estimated. Estimated motorization rate was adjusted to the actual rate in 1980 and 1982, respectively. The actual motorization rate in 1980 was 52 veh/1,000 persons, however, the estimated rate in 1980 was 49 veh/1,000 persons. Similarly, the actual figure in 1982 was 59 veh/1,000 persons compared with the estimated 51 veh/1,000 persons. Considering the source of the determined model using the data up to 1980 and rapid development in the motorization during the recent years, the motorization rate in the future was studied by the following cases:

Case 1 : The estimate was adjusted to the actual figure in 1980 and the same ratio was used to modify the estimates in other years.

Case 2 : Same as above but based in 1982

Based on these two cases, future motorization rate was estimated as in Table 5–3, where future motorization in this study was determined with the average of Case 1 and Case 2.

TABLE 5–3 MOTORIZATION BY YEAR

(Vehicles/1,000 persons)

Description		1980	1982	1986	1990	2000
Estimated		49	51	56	61	71
Adjusted Case 1	(1980)	(52)	54	59	65	75
Case 2	(1982)	(52)	(59)	65	71	82
Applied		52	59	62	68	79

Remarks: The figures in ( ) indicate the statistical data.

The number of passenger cars estimated by using the above motorization is shown in Table 5–4 and Fig. 5–1, respectively.

Number of passenger cars in each Changwat was estimated using the model which was discussed in (2) above and adjusted to the total of the GBA. Table 5–5 shows the estimated cars of the Changwats in 2000.

TABLE 5–4 FUTURE NUMBER OF PASSENGER CARS IN GBA

Year	Vehicles (1,000 veh.)	Motorization (Veh./1,000 inh.)
1980	316.0	52
1982	380.3	59
1986	432.0	62
1990	516.0	68
2000	690.0	79

TABLE 5–5 PASSENGER CARS IN EACH CHANGWAT, 2000

Area	Vehicles
Bangkok	628,000
Nonthaburi	32,000
Samut Prakan	30,000
GBA Total	690,000

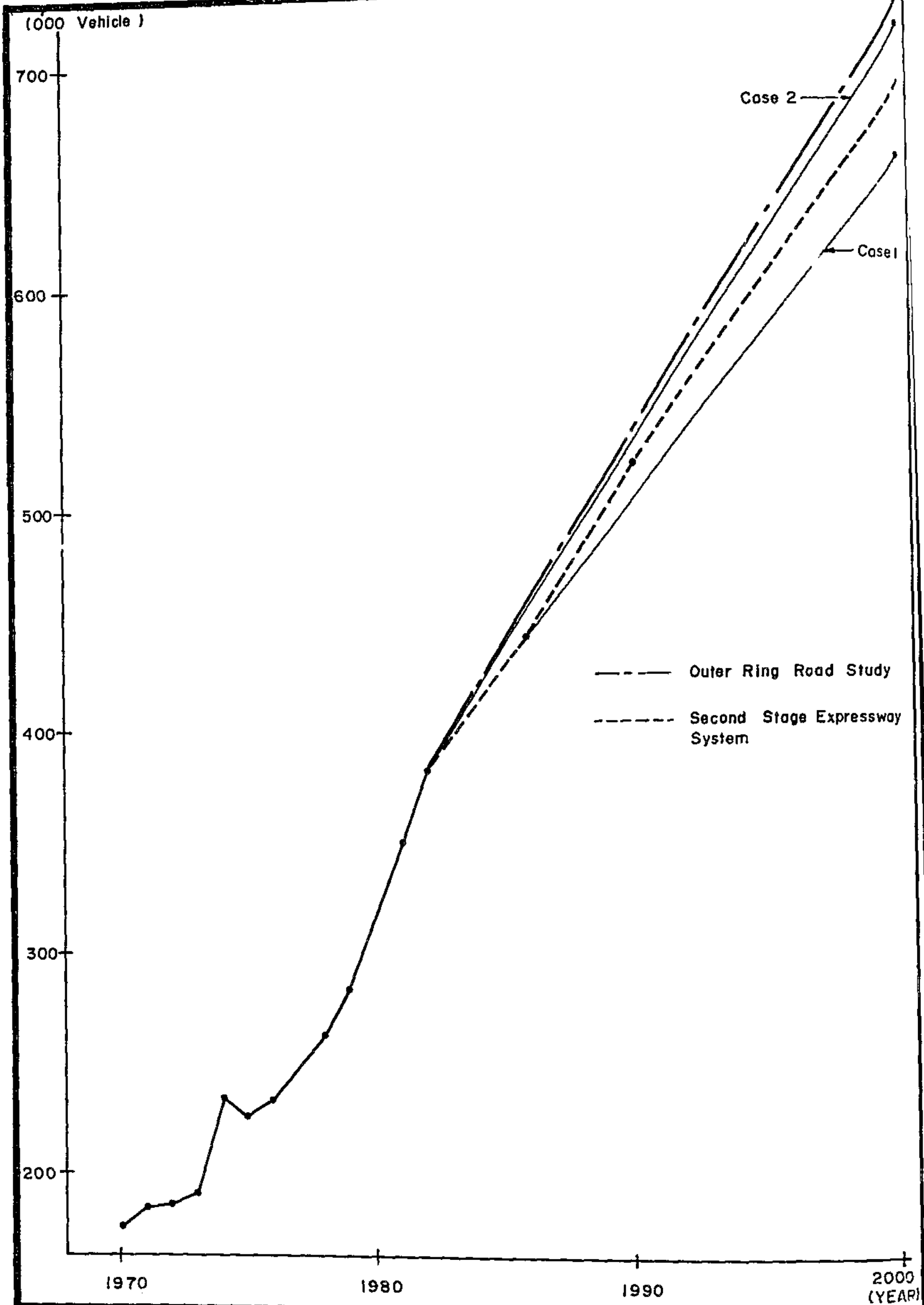

FIG. 5-1 FORECAST OF FUTURE PASSENGER VEHICLE FLEET

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

(5) Number of Cars by Zone

For the estimation of the number of cars by each zone multi-regression analyses were applied with the data of population, workers at work places and the number of cars by zones in the 1972 BTS study data. The model which was established in this study is as follows (Refer to Chapter 4) :

$$Y = -1{,}675 + 0.026x_1 + 0.147x_2 \qquad (r = 0.956)$$

where Y : number of cars

x_1 : population

x_2 : number of workers at work places

Putting the zonal population and workers at work places in 2000 in this formula, the number of cars in each zone for 2000 was estimated. The numbers were aggregated and adjusted to the total of the GBA. Zonal figures are shown in Appendix Table 5–1.

5.2.2 Future Transport Facilities

For the purpose of establishing the future OD matrices, the future transport facilities, such as future road network, construction possibility of Mass Rail Transit System, Deepsea Port project, Bang Sue container freight station project and other transport facilities were discussed. The locations of the planned transport facilities in GBA are shown in Fig. 5–2.

(1) Future Road Network

a) Road Projects by DOH

– Outer Bangkok Ring Road

The Outer Bangkok Ring Road has a U-shaped road in the vicinity of the GBA. Some northwestern portion of it has completed and opened for traffic, however, the construction schedule of the southern and eastern section is not known. In this sense, only the completed section together with the sections with confirmed program were considered as future road network. The detailed condition of the Outer Bangkok Ring Road is described in Appendix 5.1.

– Other Road Projects

DOH plans the following road projects and these roads are adopted to form the future road network in the GBA. Details of these road conditions are described in Appendix 5.2.

- Roads from Bangkok Noi to the intersection of Nakhorn Chaisi Highway ;
- New Airport Road ;
- National Road No. 304 ; and
- National Road No. 306.

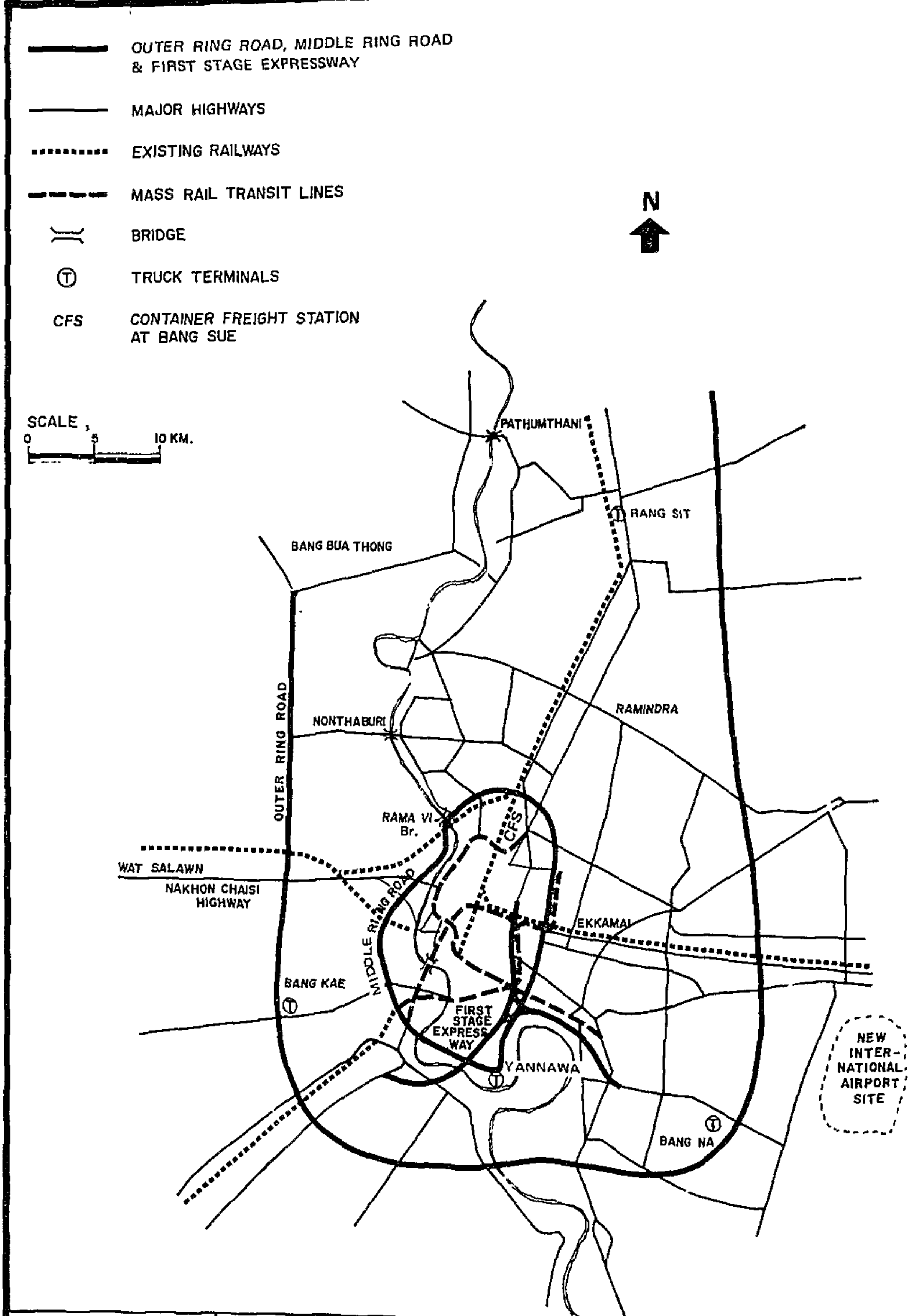

FIG. 5-2

PROPOSED TRANSPORTATION FACILITIES

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

b) Road Projects by DPW

DPW is the government office which has the responsibility to construct the bridges across the Chaophraya River and its access roads. Followings are the list of bridges which will be constructed by DPW across the Chaophraya River and the detail is shown in Appendix 5.3.

- Nonthaburi and Pathumthani Bridges Construction Project ;
- Nonthaburi Road (Access road of the above bridges) ;
- New Memorial Bridge ;
- Western Extension from the Sathon Bridge; and
- New Rama VI Bridge Construction Project.

b) Road Projects by BMA

BMA is the government office under the MOI and it has the responsibility to construct the ordinary road in Bangkok Metropolis. Now, BMA plans the following road projects and the detail is shown in Appendix 5.4.

- North Khlong Sam Sen Line ;
- Ekkamai to Ram Indra Line ;
- Portion of Middle Ring Road ;
- Phathanakarn to On-Nooch Line;
- On-Nooch to Lad Krabang Line ; and
- Lad Krabang to Krungthep Kreeta Line.

(2) Mass Rail Transit System Project

This study was conducted from 1978 to 1980 under the project titled as the First Stage Mass Transit System (MTS) in Bangkok to analyse and assess the priorities of different sections of the MTS network that includes some 50 kilometers of MTS lines plus potential line extensions of some additional 50 kilometers and to recommend an optimum 50 kilometers First Stage System for its implementation schedule.

The study recommended for the implementation of :

- the Rama Line connecting Phra Khanong, Hua Lampong and Bang Sue;
- the Memorial Line connecting Dao Khanong to Makkasan; and
- the Sathon Line connecting Wong Wien Yai, Sathon and Lad Phrao.

The detailed engineering design for the above lines has already been completed, and the Thai Government has completed a shortlist of the private firms which will compete for the project under the condition of 30 years concession to construct and operate the System.

(3) Deep-sea Port

According to the Eastern Seaboard Study[1]) conducted by NESDB in 1982, the Eastern

1) NESDB, Eastern Seaboard Study, Interim Report 5 : Transport and Water Utilities (July 1982)

Seaboard such as Laem Chabang, Sattahip and Rayong will be improved as deepsea ports. In this subsection, only the newly generated trafic volume after the completion of the deepsea ports which will have much relation with Bangkok is discussed.

According to the above study, the following traffic volume is expected between the Eastern Seaboard and the Bangkok area after the completion of the deepsea ports (Refer to Table 5–6).

Among these generated traffic volumes from the Eastern Seaboard, normal traffic on roads was considered to be already included in the interzonal traffic forecast which is discussed in this Chapter 5.

Accordingly, 680 vehicles per day was added to Zone No. 70 in the year 2000 as development traffic by interpolating the figures between 1996 and 2001.

In the case of rail traffic, a plan that the container cargo traffic between the deepsea port and the Bang Sue container freight station was also examined. The daily freight volume of the port traffic from the deepsea port to Bang Sue in the year 2001 was estimated at 8,000 tons in the Eastern Seaboard Study Report. The type and composition of trucks to carry this railway freight from the station were also examined in the Study as follows:

TABLE 5–6 GENERATED (ATTRACTED) TRAFFIC FROM EASTERN SEABOARD TO THE BANGKOK AREA AFTER THE COMPLETION OF DEEP SEA PORT

Description	1986	1991	1996	2001
1. Road Traffic (veh/day)				
1) Port Traffic	–	100	300	700
2) Heavy Industries Traffic	70	70	80	85
3) General Traffic	17,500	22,100	23,900	24,800
TOTAL	18,200	22,270	24,010	25,585
2. Rail Traffic (with Map Ta Phut rail spur) (thousand tons/year)				
1) Port Traffic	680	1,070	1,900	2,950
(Trains per day)	(2)	(3)	(5)	(8)
2) Heavy Industries	500	800	900	1,000
(Trains per day)	(1)	(3)	(3)	(4)
TOTAL	1,180	1,870	2,800	3,950
(Trains per day)	(3)	(6)	(8)	(12)

Source . NESDB, Ibid

10 wheel trucks (Average loading capacity : 12 tons) : 60%
6 wheel trucks (Average loading capacity : 5 tons) : 30%
4 wheel trucks (Average loading capacity : 2 tons) : 10%

Based on these estimations, generated truck volume from Bang Sue Station was estimated at 900 vehicles/day in the year 2001. Furthermore, the freight consumed and produced in heavy industries would be transported to/from Bang Sue station by rail. The freight volume was also estimated at 1,000 thousand tons per year in 2001. It was assumed that 10 wheel trucks handle these freight volumes and 230 trucks generation was estimated from Bang Sue Station in the year 2001.

The total estimated truck volume from Bang Sue Station in 2001 was adjusted to the figure in 2000 using the estimated rate of increase in the cargo traffic during the years from 1996 to 2001. As a result, 1,050 trucks generation per day was added to the Bang Sue Railway Station (in Zone No. 24).

(4) Development Traffic from Samut Sakhon Industrial Estate

Under the 4th National Economic and Social Development Plan, the government will have constructed the Industrial Estate in Samut Sakhon province. Based on the plan, the feasibility study for "Samut Sakhon Industrial Estate Project" was conducted in September 1980. The new development of traffic from the project discussed in this report is summarized in Appendix 5.5.

Accordingly, 2,229 veh/day of passenger cars and 1,726 veh/day of trucks were added to the generated traffic volume of zone No. 72. Total newly generated traffic volume from the Estate was 3,955 veh/day. This additional traffic applies to the years 1990, 2000 and 2010.

(5) Projects by the State Railways of Thailand (SRT)

State Railways of Thailand which is the government enterprise to operate the railways has following four projects to extend its services. The details of these extention of services are described in Appendix 5.6.

- Container Freight Station at Bang Sue ;
- Elevated Lines on the Existing Northern and Eastern Lines ;
- Rail Link between Chachoengsao and Sattahip ; and
- Rail Link between Bangkok and Wong Wian Yai .

In addition SRT is now considering some additional railway car procurement and railway commuter traffic reinforcement projects.

(6) Facilities of Other Sectors of Transportation

The following is the list of other main projects which concern transportation. The detail is shown in Appendix 5.7.

- Don Muang Airport Expansion Project ;
- Second Bangkok International Airport Project ;
- Bangkok Urban Truck Terminals Construction Project ; and
- Bangkok Suburban Transportation Project .

5.2.3 Future OD Matrices

(1) Total Trip Volume of GBA in 2000

The control total of person trip generation from the GBA in the year 2000 was estimated by adopting population forecast and assumed trip rate per person in 2000.

In general, the number of trips per person has a tendency to increase in accordance with the development of the economic activity in the area as discussed in Chapter 4. Trip rate per person in various cities is shown in Fig. 5–3. The trip rate per person in the GBA has increased from 1.15 in 1972 to 1.33 in 1982. The annual average increase rate of trips per person was 1.5% during the past ten years.

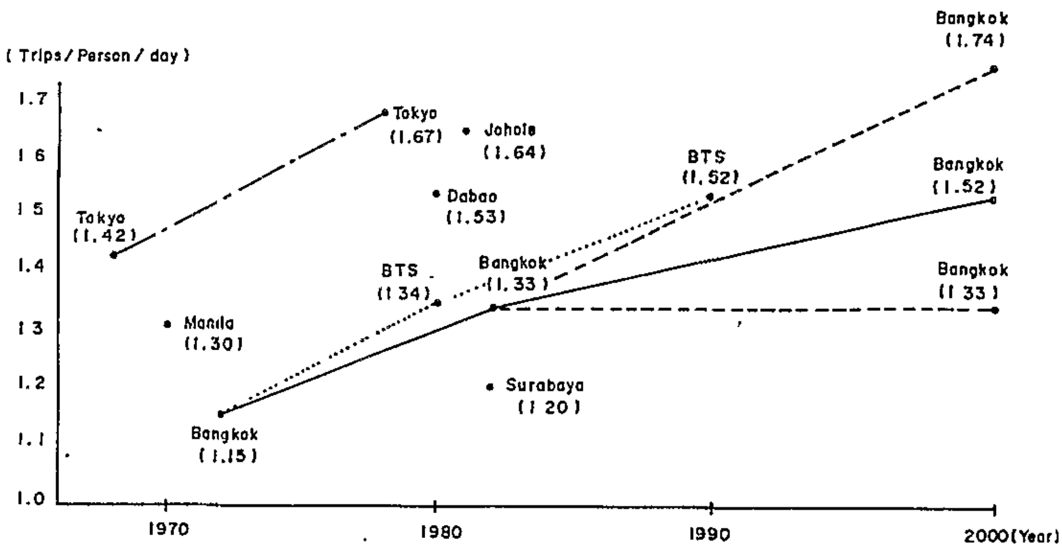

FIG. 5–3 NUMBER OF TRIPS PER PERSON IN VARIOUS CITIES

The annual average change of the trip rate in the Tokyo Metropolitan Area during the past 10 years (1968–1978) was 1.6%. On the other hand, the estimated trip rate in GBA by BTS is shown as follows :

1972–1980 : 1.9% per annum

1980–1990 : 1.3% per annum

Based on this estimation, the trip rates per person in 1980 and 1990 were calculated at 1.34 and 1.52, respectively.

However, the latest GBA master plan prepared by TCP forecasts that the future population growth rate in the GBA will reduce by 40% of the past rate of increase. The average annual growth rate of workers at work places will be also reduced by 20%. It indicates that the trip increase rate in the past cannot be maintained in the future. Incidentally, if the annual increase rate in the past in the GBA is maintained in the future, the trip rate per person in the GBA in the year 2000 will be estimated at 1.74 trips per person (Refer to the previous Fig. 5–3).

The trip rate per person in the GBA increased at 1.5% per annum during the past 10 years, and in the same period the rate of motorization of the passenger cars in the GBA, which would be closely associated with the trip rate per person, increased at 3.2% per annum. The motorization figure in the GBA is estimated to increase at 1.6% per annum from 1982 to 2000. Taking into consideration the trip rate in other large urban areas and the new land use plan of the GBA, 2000, the trip rate per person in the GBA was assumed to increase at 0.75% per annum which was half of 1.5% per annum registered for the period of 1972–1982.

Accordingly, the trip rate per person in the year 2000 was determined at 1.52 and the future person trips generation in the year 2000 in GBA was estimated at 13,260 thousand trips. Compared with the figures in 1982, the increase ratio and the annual increase rate were calculated at 1.55 and 2.5%, respectively.

(2) PT/PVT Rate

If the future motorization figures were applied to the relationship between motorization and PVT rate as discussed in Chapter 4, the PVT rate in the future could be estimated. If the motorization in the year 2000 was estimated at 79 vehicles per 1,000 persons, the future PVT rate was estimated at 30% of total person trips. This percent figure was revised by the following procedure :

$$PVT(A)^{2000} = \frac{PVT(A)^{1982}}{PVT(E)^{1982}} \times PVT(E)^{2000} = 40\%$$

where $PVT(A)^{2000}$: applied PVT rate in 2000
$PVT(A)^{1982}$: actual PVT rate in 1982
$PVT(E)^{1982}$: estimated PVT rate in 1982
$PVT(E)^{2000}$: estimated PVT rate in 2000

Consequently, the percent share of PVT users in the total person trips in 2000 was determined at 40%.

(3) Passenger Car/Motorcycle Rate

It is known that when the income rises above a certain level, the increase in the passenger car ownership will be accompanied with a decrease in the motorcycle ownership. Using the result of the home interview survey which was conducted for this study in July 1982, a relationship between motorization and motorcycle use rate was analyzed. The relationship between the motorization figures and the rate of person trips who use the motorcycle among the total passenger car and motorcycle use person trips is shown in Fig. 5–4. It indicates a tendency of decreases in the percentage of motorcycle use when the car ownership ratio increases.

Using the model in Fig. 5–4, the estimated motorcycle use rate in 1982 was calculated at 25.5%, but the actual rate was 19.0% (Refer to Chapter 4). Therefore, the following formula was prepared to adjust the rate of the motorcycle use for the year 2000.

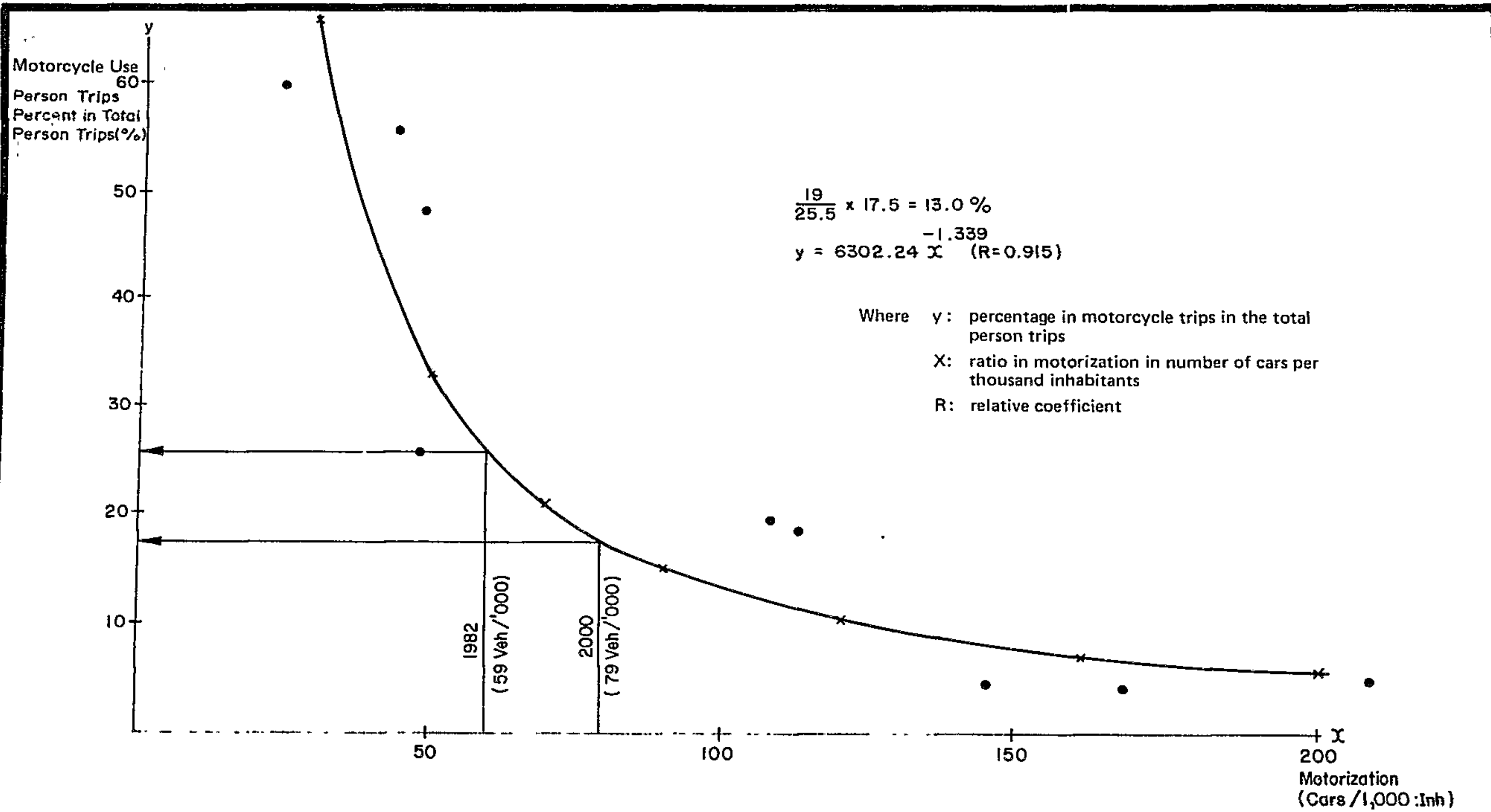

FIG. 5-4

MOTORIZATION VS. MOTORCYCLE USE PERSON TRIPS RELATIONSHIP

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

$$Mc(A)^{2000} = \frac{Mc(A)^{1982}}{Mc(E)^{1982}} \times Mc(E)^{2000}$$

$$= \frac{19}{25.5} \times 17.5 = 13\%$$

where $Mc(A)^{2000}$: applied motorcycle rate in 2000

$Mc(A)^{1982}$: actual motorcycle rate in 1982

$Mc(E)^{2000}$: estimated motorcycle rate in 1982

$Mc(E)^{1982}$: estimated motorcycle rate in 2000

Motorcycle use rate in the year 2000 was thus estimated at 13% of the overall PVT users.

(4) Person Trips Generation by Mode

The estimated future person trips generation results are summarized in Table 5–7 and 5–8. The 1990 figures were estimated by the interpolation on the linear line between 1982 and 2000.

Considering the possible future increase in population, the future urban growth potentiality, and the necessity to maintain the appropriate size of the city, the future person trips generation in the year 2010 was estimated based on the assumption that the annual increase rate of the person trips from the year 2000 will decrease by 50%.

TABLE 5–7 PERSON TRIPS AND VEHICLE TRIPS IN THE GBA

(In Thousand)

Description		1982		1990		2000		2010	
		Person Trips	Vehicle Trips	Person Trips	Vehicle Trips	Person Trips	Vehicle Trips	Person Trips	Vehicle Trips
PVT	Cars	2,382.2 (28)	1,443.8 (71)	3.374 (32)	2,169 (77)	4,614 (35)	3,076 (80)	5,407 (36)	3,677 (81)
	Motor-cycles	558.8 (7)	450.6 (22)	617 (6)	506 (18)	690 (5)	575 (15)	729 (5)	613 (14)
	Sub-Total	2,941.0 (35)	1,894.4 (94)	3,991 (38)	2,675 (95)	5,304 (40)	3,651 (95)	6,136 (41)	4,290 (95)
* PT (Bus)		5,614.0 (65)	119.4 (6)	6,655 (62)	151 (5)	7,956 (60)	199 (5)	8,701 (59)	242 (5)
TOTAL		8,555.0 (100)	2,013.8 (100)	10,646 (100)	2,826 (100)	13,260 (100)	3,850 (100)	14,837 (100)	4,532 (100)

* Number of person trips of PT are converted as bus trips.

TABLE 5–8 INCREASE RATE PER ANNUM OF THE TRIPS IN THE GBA

(Percentage)

Description		1990/1982		2000/1990		2000/1982		2010/1982	
		Person	Vehicle	Person	Vehicle	Person	Vehicle	Person	Vehicle
PVT	Cars	4.4	5.2	3.2	3.6	3.7	4.3	1.6	1.8
	Motor-cycles	1.2	1.5	1.1	1.3	1.2	1.4	0.6	0.7
	Sub-Total	3.9	4.4	2.9	3.2	3.3	3.7	1.5	1.6
PT		2.1	3.0	1.8	2.8	2.0	2.9	0.9	2.6
TOTAL		2.8	4.3	2.2	3.1	2.5	3.7	1.1	2.9

Conversion to the vehicle trips was made by applying the following future passenger occupancy rate :

	1972	1982*	2000
Passenger Car	1.75	1.65	1.50
Motorcycle	1.27	1.24	1.20
Bus	31.50	47.00	40.00

* Passenger Occupancy Survey Result, 1982

The future passenger occupancy rates for passenger car and motorcycle were estimated by the assumption that changes in the occupancy rates in the past, which decreased slightly from 1972 to 1982, would continue until the year 2000. On the other hand, as for the occupancy for buses, expecting improvement to the level of service in the future, the rate of 40 persons per bus was assumed for 2000.

(5) Person Trips Generation by Zone

Future person trips generation by zone was estimated by using the same procedure as determined the 1982 person trips generation by zone. The PT/PVT rate formula of each zone was amended as follows considering the actual rate of PVT in the 1982 survey, and the zonal figure was aggregated and adjusted to the control total (Refer to Fig. 4–11).

$$P = 1.4664\ MOT^{0.62561} + 16.2$$

(6) OD Matrix Tables of Person Trips

As shown in the zonal population and workers at work places estimated in Chapter 3, no zone was forecasted where the population or workers at work places would decrease. Accordingly, person trip OD matrices in the future years were developed by the combination of the existing 1982 matrices plus the net increased person trips over the 1982 volume. The net increased person trips were distributed among the zone pairs by using a gravity model, of which the parameters were determined by the 1982 matrices.

The parameters of the gravity formulas were determined by regression analysis with the model and parameters as follows :

Gravity Model : $T_{ij} = (T_i \times T_j)^{\alpha} \times \frac{k}{D_{ij}^{n}}$

Where T_{ij} : : distributed trip volume between zones i and j

T_i : generated (attracted) trip volume of zone i

T_j : generated (attracted) trip volume of zone j

D_{ij} : distance between the zones i and j in kilometers

α,n,k : coefficients (see the following figures)

Description	k	α	n	Correlation Coefficient
PVT (MC & CAR)	0.0100	0 6099	0.7286	0.94
PT	0.0051	0.6376	0.9595	0.84

The OD matrices shown in the computer output are compiled in the separate files.

(7) OD Matrix Tables of Trucks

In the Nonthaburi Study[2]), the growth of truck traffic was assumed to be equal to that of GRP : i.e. 4.9% per annum from 1980 to 1990 and 4.5% per annum from 1990 to 2000. In the previous truck terminal study, the forecasted growth rate was 5.3% per annum from 1977 to 2000. However, in the 5th National Development Plan (1982–1986) GDP is expected to grow at 6.6% per annum while it registered 7.1% per annum. The registered trucks in GBA for the period of 1978–1981 indicate an average growth rate of 14% per annum and the total trucks in the Kingdom have a rate of 11% per annum for the same period.

It is considered that a high rate of increase in the registration is likely in a short period but would not continue until the year 2000. The growth of truck traffic depends on the development of economy and its sector composition, changes in the location of production and consumption, commodity flows and process of production, as well as changes in the capacity and efficiency of truck loading. It is to be noticed that the government plans to restrain the excessive concentration of population and economic activities in the Metropolis. Under the circumstances, it is determined the growth rate of the total truck traffic is 4% per annum from 1982 to 1990 (1.37 times) and 3% per annum from 1990 to 2000 (1.34 times) in the GBA. These figures are more or less equal to those of private vehicles. The truck OD matrices shown in the computer output are also compiled in the separate files.

2) PWD & Joint Venture of PCI, CHIYODA, TPO Sullivan and AEC, The Nonthaburi and Pathumthani Bridges Construction Project (April 1981)

Chapter 6
EXPRESSWAY NETWORK PLANNING AND TRAFFIC FORECAST

CHAPTER 6 EXPRESSWAY NETWORK PLANNING AND TRAFFIC FORECAST

6.1 Expressway Planning in GBA

6.1.1 Objective

The expressway should serve vehicular traffic moving within the central urbanized area (CUA)[1)] and travelling between the CUA and other areas of the GBA, at a better level than the existing urban roads.

6.1.2 Necessity of Expressway Network

An appropriate expressway network in GBA is necessary to meet the following requirements:

(1) To Maintain Urban Activities in CUA

The CUA, including the core area, should maintain the activities in association with other newly developed core areas which are planned in polycentric type in GBA Plan, 2000. For this purpose an expressway network linking these cores in and around CUA with better service levels should be established.

(2) To Remove Difficulty in Road Construction in CUA

Although it is found necessary to increase the road capacity in CUA, actual construction plans encounter a number of difficulties which discourage the implementation of road improvement plans within CUA. An expressway with higher capacity and efficiency can substitute for several urban roads, ameliorating such difficulties in the CUA.

(3) To Supplement the MTS

Even if the MTS is constructed for a line or two, its service area cannot cover the whole CUA. There are some corridors that have no MTS line on which the expressway should be proposed to cater for the traffic.

(4) To Alleviate Traffic Congestion in CUA

To alleviate the increasing vehicle traffic congestion in CUA, traffic operation and road construction plans should be implemented. The expressway plan can be placed with a high priority in these plans. It is expected to receive a substantial volume of diversion traffic by the provision of expressways, resulting in the reduction of traffic congestion on ordinary roads.

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1) CUA, as discussed in Chapter 4, means the central urbanized area covering the central business district (CBD), certain built-up areas and the area in which mixed land use development with high to medium population densities are expected. Traffic congestion in this area is common. It covers zones 1 to 21 and 47 to 51.

It is to be noted that the expressways in GBA are not to accelerate additional aggregation of population and economy in the inner area, but to support the maintenance of a better road network service in CUA. Accordingly, land use plans and regulations should be effectively associated with the plans of expressways and other transportation systems so as not to accelerate the aggregation.

(5) To Solve the Traffic Problems in CUA

Major roads and intersections catering for the heavy traffic in CUA are shown in Fig. 6–1, and congested roads and areas are enumerated as follows:

1) Phahol Yothin Road upto Kasetsart Area and the parallel northward roads at its western side;

2) Three eastward roads of New Phetchaburi, Sukhumvit and Rama IV Roads;

3) The roads in the Sathon-Silom-Surawong area which is characteristed as a business district;

4) The eastern section of Phet Kasem Road in Thonburi and its adjacent area;

5) The southern side of Sathon Road (the southern part of Yannawa District) where rapid urbanization is seen recently; and

6) Rajchadamri Road and its intersecting roads.

Appropriate location of the expressway should be examined with due consideration to solve the above traffic problems together with probable influence of the future traffic demand.

(6) Required Total Length of Urban Expressways

It is felt that the road network in GBA is insufficient to accommodate the present traffic demand. In order to identify the shortage of the road network and to estimate the total length of expressways required, a crude approach was made by estimating changes in road density[2)], population density and employment density during the years from 1982 to 2000. The result is shown in Appendix Fig. 6–1 and Appendix Fig. 6–2. The following are the findings in the said figures:

1) The four zones (1, 2, 3, and 4) in the city core area are comparatively well provided with major roads even though population and employment are in high densities.

2) The central urbanized area (CUA) is larger in terms of densities in population and employment and the area of major roads, compared with the outside area of CUA.

3) The Thonburi side in CUA which has same population and employment densities has a lower rate in the road density, compared with the Bangkok side.

4) In most of the city core area and CUA, the road density would not increaase with their population growth (The lines linking the points of 1982 and 2000 in Appendix Figs. 6–1 and 6–2 are horizontal, which indicates difficulty in planning new road construction).

2) Road density is calculated by the roads composing the road network for traffic assignment. It neglects some minor roads and does not include "Soi". Road density in percentage = (No. of lanes x lane width x length)/(area of zone).

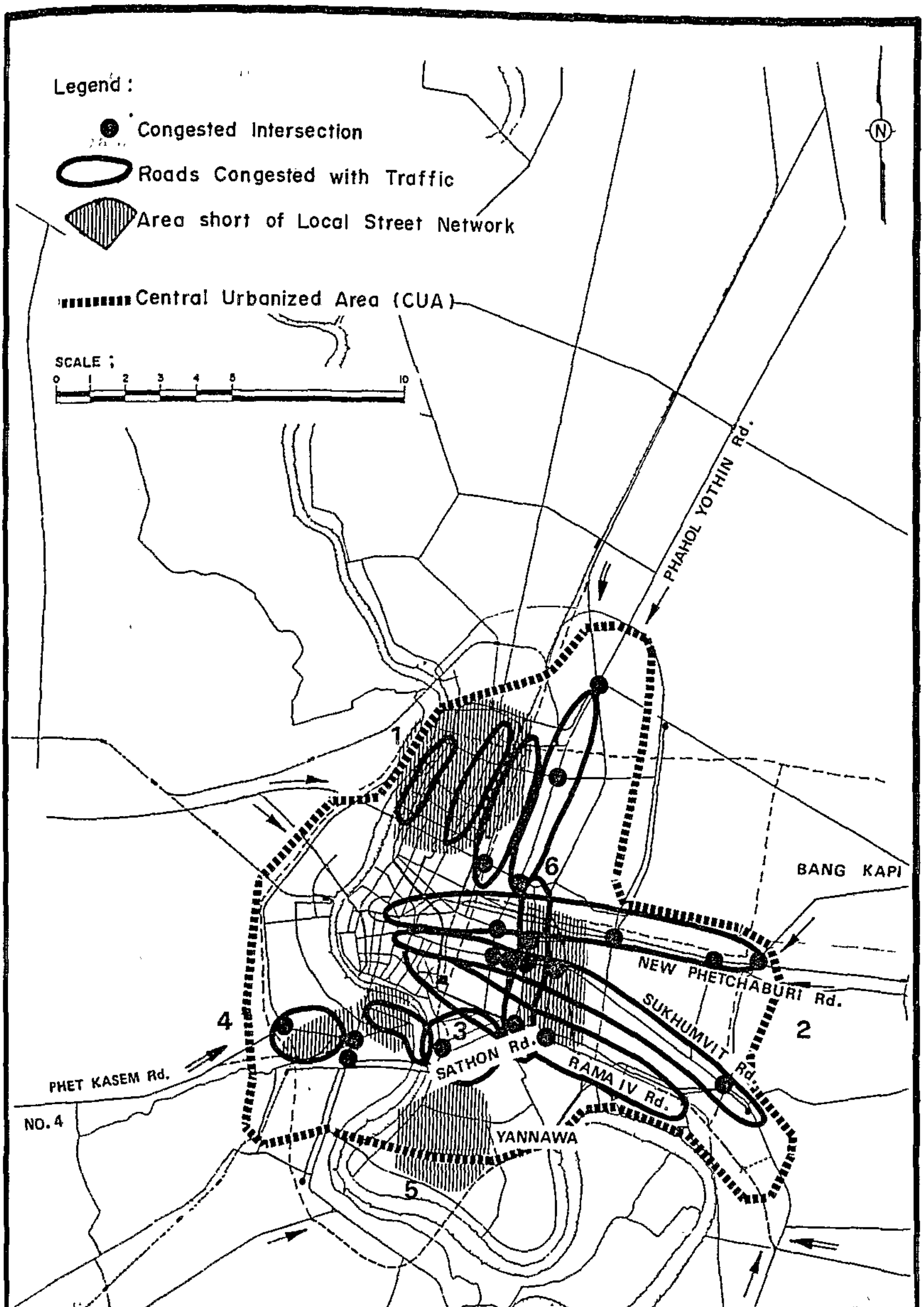
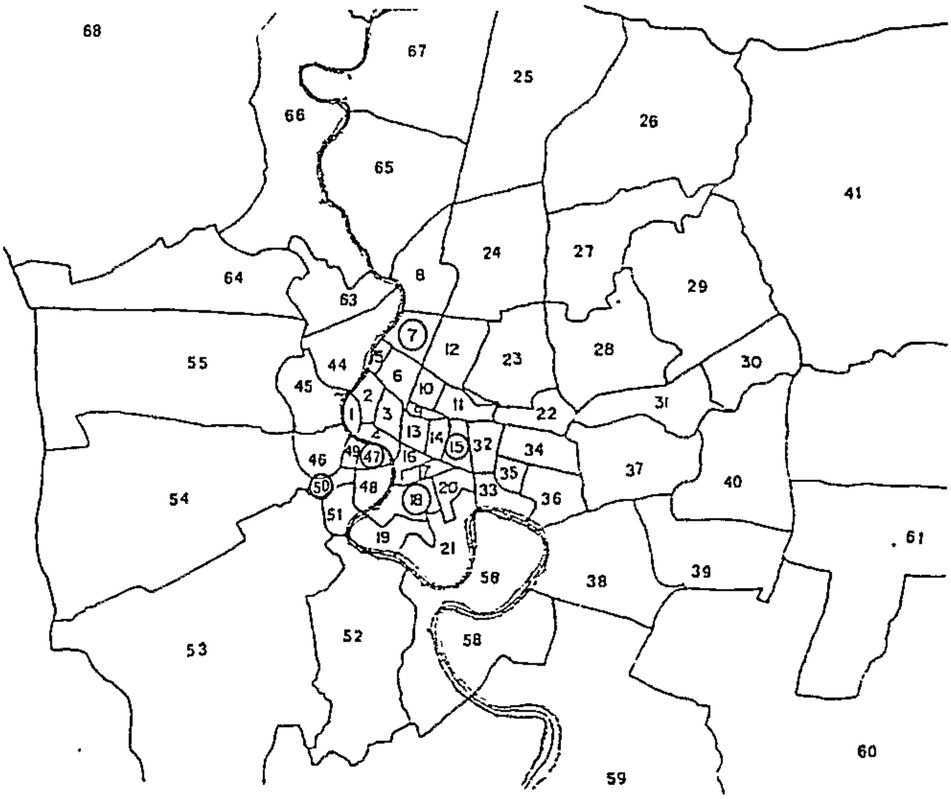


FIG. 6 – I	LOCATION OF TRAFFIC CONGESTED ROADS AND AREAS IN CUA

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

5) The increase in the road density is to be seen in the suburbs (The lines in the figures are right-upwards).

6) There are some zones in CUA that have an extremely low rate in road density as in Zones No. 7, 15, 18, 47 and 50, which can be seen in Fig. 6–2.



Note: Figures in circle indicate zones which are found with lowest density.

FIG. 6–2 ZONES SHORT OF ROAD AREA

The tendency mentioned in 4 and 5 above indicatates difficulty in increasing the road density in CUA, while the current construction and improvement plans are rather for suburban zones. The difficulty would come from extremely high cost in the land acquisition and a number of restraints to the road network expansion.

As in Appendix 6.1, a total length of 90 km of 6-lane arterial roads was calculated as supplementary to the existing major road network. If this shortage is to be filled up with the expressways, the required length is 63 km with the First Stage Expressway System occupying 27 km.

6.1.3 Policies for Expressway Network Planning

The expressway network plan should be developed with a basic understanding that service functions of arterial roads and expressways are different from each other: vehicles with shorter trips, would use major roads and the service by the expressways in the built-up city area would be for the vehicles with relatively longer trips, thus the traffic congestion on the major roads would be substantially reduced. The present situation is such that the construction of two major roads in a built-up area cannot be realized because of a number of constraints. If a single high capacity access controlled expressway is constructed in a limited strip of land it will serve the traffic equivalent to the capacity of the two major roads.

With the above understanding the planning policies for the expressway network were established as follows:

(1) Network of Normal Roads Outside CUA

In the suburban area outside CUA the normal roads should be provided into a grid pattern, since a basic road network is an essential urban infrastructure in the newly developing area.

(2) Network of Expressways in Bangkok

The network of expressways should be in a hybrid pattern (a combination of rings and radials). Details are discussed in section 6.3.

(3) Service Level

High capacity rather than high speed as on the regional expressway should be maintained for the proposed urban expressway.

(4) Approach

Direct approach by the expressway to CUA should be provided for the traffic which moves to and from distant outside areas of CUA. Such traffic with long trips may divert to expressways, reducing traffic congestion on normal roads in CUA.

(5) Position of the First Stage Expressway System

The First Stage Expressway System, being the backbone corridors for the through traffic flowing to and from east, north and west, is considered to constitute one major part of the whole expressway network. For this purpose additional exit/entry ramps should be provided if needs arise.

(6) Relation with the Mass Rapid Transit System

The expressway should be located so as to supplement mutually with the Mass Rapid Transit System in terms of overall transport network in GBA. It is a supplementary from one viewpoint, but may be competitive from other viewpoints.

(7) Bus Operation on the Expressway

Whether or not the expressway should be open to the normal bus traffic, particularly in peak hours, is to be duly considered.

(8) Contribution to Development Projects

The expressway should render service to the new airport, housing and industry development projects and their vicinity as well as projects arising from the Eastern Seaboard.

(9) Accessibility to Cargo Handling Facilities

The expressway should be accessible to such future freight handling facilities as proposed by the Department of Land Transportation and the State Railway of Thailand together with the deep seaport.

(10) Master Plan of Network

A long-range expressway network plan which is called a master plan of expressways in GBA should be proposed. From the master plan the Second Stage Expressway System will be selected.

6.2 Tolled Expressways

The following are basic characteristics of tolled expressways in urban area:

(1) High Cost

There is no open space in CUA, most part of which is covered with built-up areas. Social, institutional and religious locations as well as environmental consideration make it extremely difficult to acquire land for road construction. Under the circumstances, if an urban road or an expressway is constructed in CUA, the construction project should have many frictions as the above mentioned restraints. The construction of an elevated expressway is one of the solutions in improving the road system in CUA. However, it will entail a high cost of construction, probably 3 to 5 times higher than a normal urban road.

(2) Available Funds

It is evident that the Government has limitation in allocating funds to cover the high construction cost of urban expressways, even if the construction project indicates its technical and economic viability.

(3) Charges on Users

Consequently a policy of "Users pay the cost for receiving the service" is applicable to cover part or all of the cost. There are generally two conditions for charging toll fare: the first is that the users should receive substantial amount of benefits for above the payment of toll fare and the second is that there are other roads free of toll charge through which the users can find free alternative routes if they wish so. The new tolled expressway should shorten the travelling time and save the travelling cost. For these savings the users pay a toll fee at a reasonable level. In determining the toll fare level, emphasis should be placed on deprecisiation of the construction and maintenance costs.

In Thailand, the toll system was enacted in 1972 with which the First Stage Expressway System has been under construction. It charges toll fee on the users in order to cover part of the high investment and maintenance costs. It is intended that the Second Stage Expressway System is an extension of the first stage and a unified toll system, although the rate could be revised, is to be applied.

(4) Toll Rate

The toll rate should be determined from two viewpoints: firstly, the toll fee should be less than the perceived benefit of users which is realized by using the expressways, and the other is that the toll revenue should amortize the investment, operation, maintenance and administrative costs during a certain period. With the same viewpoints flat rate, zoning rate and distance-related rate should be studied comparatively. The detail will be studied in the financial analysis in Chapter 13.

6.3 Expressway Network Study for GBA

The urban expressway network plan is established in the following two phases. Phase I study is to determine the basic concept of SES, while Phase II study covers the refinement of the Phase I study and presents the conclusion of the expressway network study.

Phase I Study.

Step 1: Identification of the present urban traffic problems, forecast of the future urbanization and recognization of the functions of expressways.

Step 2: Examination and establishment of the urban expressway network pattern suitable for the Bangkok Metropolis (Master Plan of the Bangkok Metropolitan expressway network).

Step 3: Narrowing down of the network for the Second Stage Expressway System

Phase II Study.

Step 4: Establishment of the Second Stage Expressway System and the refinement study thereof.

6.3.1 Step 1 Study

Based on the present urban traffic conditions and problems and the future traffic problems which the Bangkok Metropolis is deemed to encounter, the service and function of the urban expressways which can cope with the above problems were identified. The service and function should be aimed at the following eight items. The function by expressways is shown in the conceptual diagram in Fig. 6–3.

1) To serve the traffic concentration in the core area (including CBD and densely populated areas);
2) To serve as traffic corridors passing through the CUA;
3) To connect CUA and core areas with primary national roads radial roads which start from Bangkok);
4) To provide a ring road function in dispersing the traffic in the inner urbanized area;
5) To provide well-located access and functional distribution to the traffic coming into CUA from suburban areas;

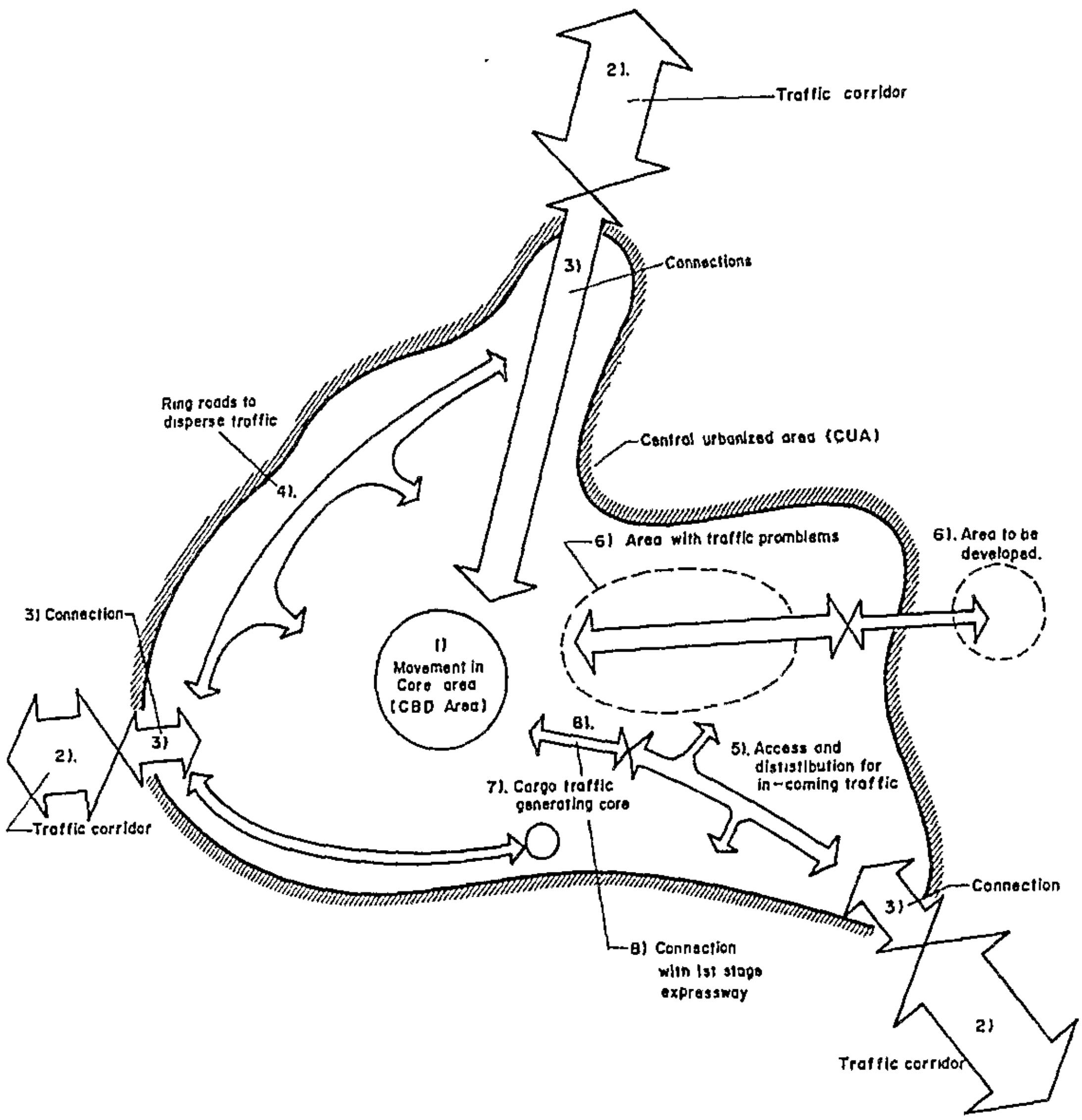


FIG. 6–3 FUNCTION OF EXPRESSWAYS

6) To service effectively the corridors that have present and future traffic problems;

7) To provide connection to the freight handling facilities such as truck terminals, Bang Sue container station and the Port of Bangkok; and

8) To provide effective connection with the First Stage Expressway System.

The traffic corridors mentioned above are enumerated as follows and their relationship with CUA shown in Fig. 6–4:

1) Super Highway (National Road No. 31);
2) Phahol Yothin Road (National Road No. 1);
3) Bang Kapi-Minburi Road (Route No. 3278);
4) New Airport Road;

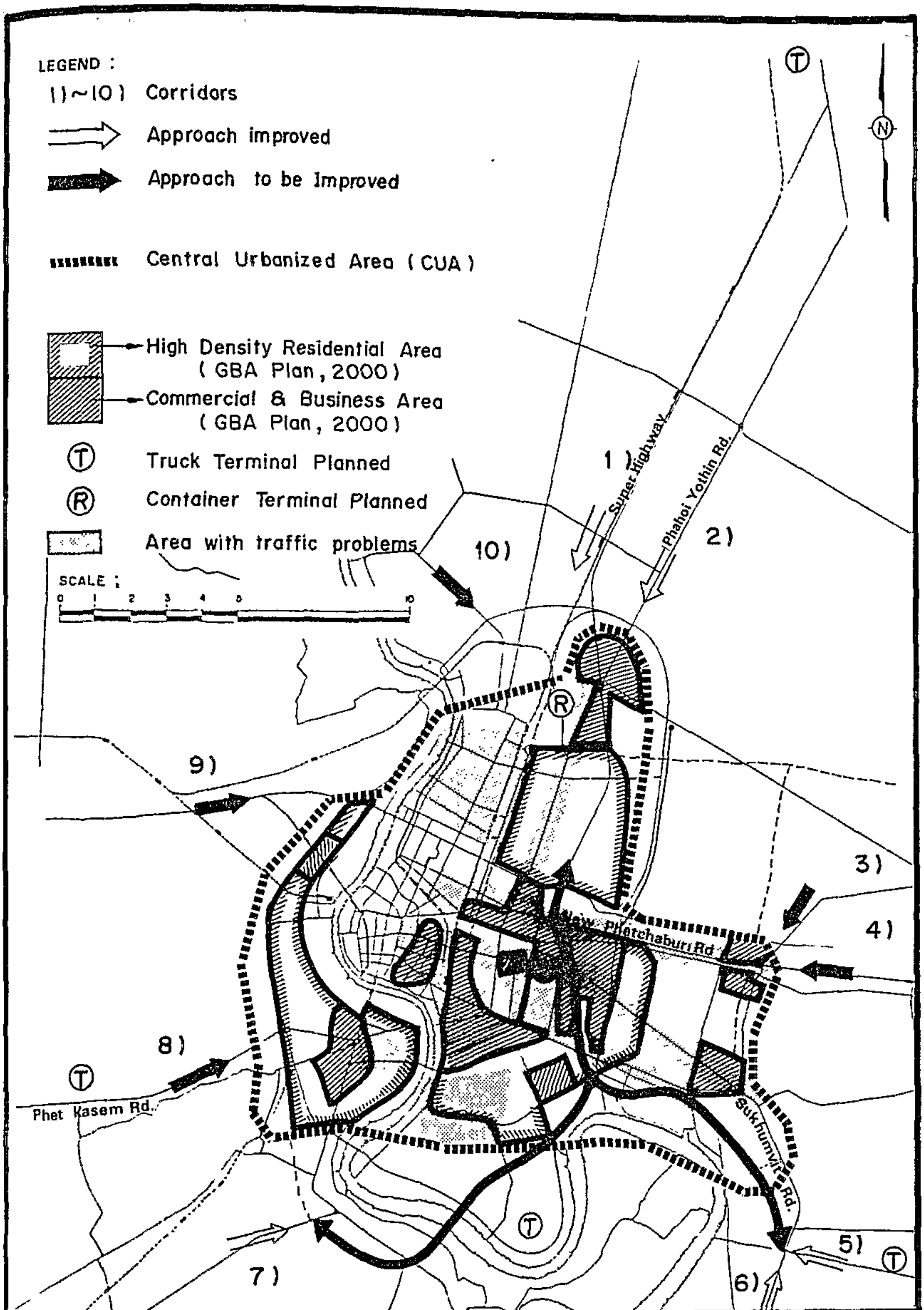


FIG. 6-4

CUA AND TRAFFIC CORRIDORS

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

5) National Road No. 34;

6) National Road No. 3;

7) Thonburi Paktoh Highway (National Road No. 35);

8) Phet Kasem Road (National Road No.4);

9) National Road No. 338; and

10) The road towards Nonthaburi;

The existing conditions of the above traffic corridors and their relations with the First and Second Stage Expressway Systems are tabulated as below:

Traffic Corridors	Present Road Conditions	Substitute Available by High Class Road	Necessity of High Class Road	Measures Required
1)	Good	Super Highway	None	–
2)	Good	Super Highway and Phahol Yothin Road	None	–
3)	Congested Access	Not Available	Required	2nd Stage Expressway
4)	Poor Access	Not Available	Required	2nd Stage Expressway
5)	Good	1st Stage Expressway	None	–
6)	Good	1st Stage Expressway	None	–
7)	Good	1st Stage Expressway	None	–
8)	Congested Access	Not Available	Required	2nd Stage Expressway
9)	Poor Access	Not Available	Required	Middle Ring Road or 2nd Stage Expressway
10)	Poor Access	Not Available	Required	2nd Stage Expressway

6.3.2 Step 2 Study

In order to establish the pattern of urban expressway network for the Bangkok area, the most appropriate pattern is to be selected from the view points of future traffic demand and the futute land use. The selection methodology is shown in Fig. 6–5 and described below:

1) Future traffic demand is estimated based on the Bankok land use plan, 2000. (Refer to Chapter 5);

2) Then, for clarifying future traffic problems, the future traffic demand is assigned to the road network which does not include the Second Stage Expressway System; that is, the network of ordinary roads and the First Stage Expressway System (As for the step for traffic assignment, refer to section 6.4);

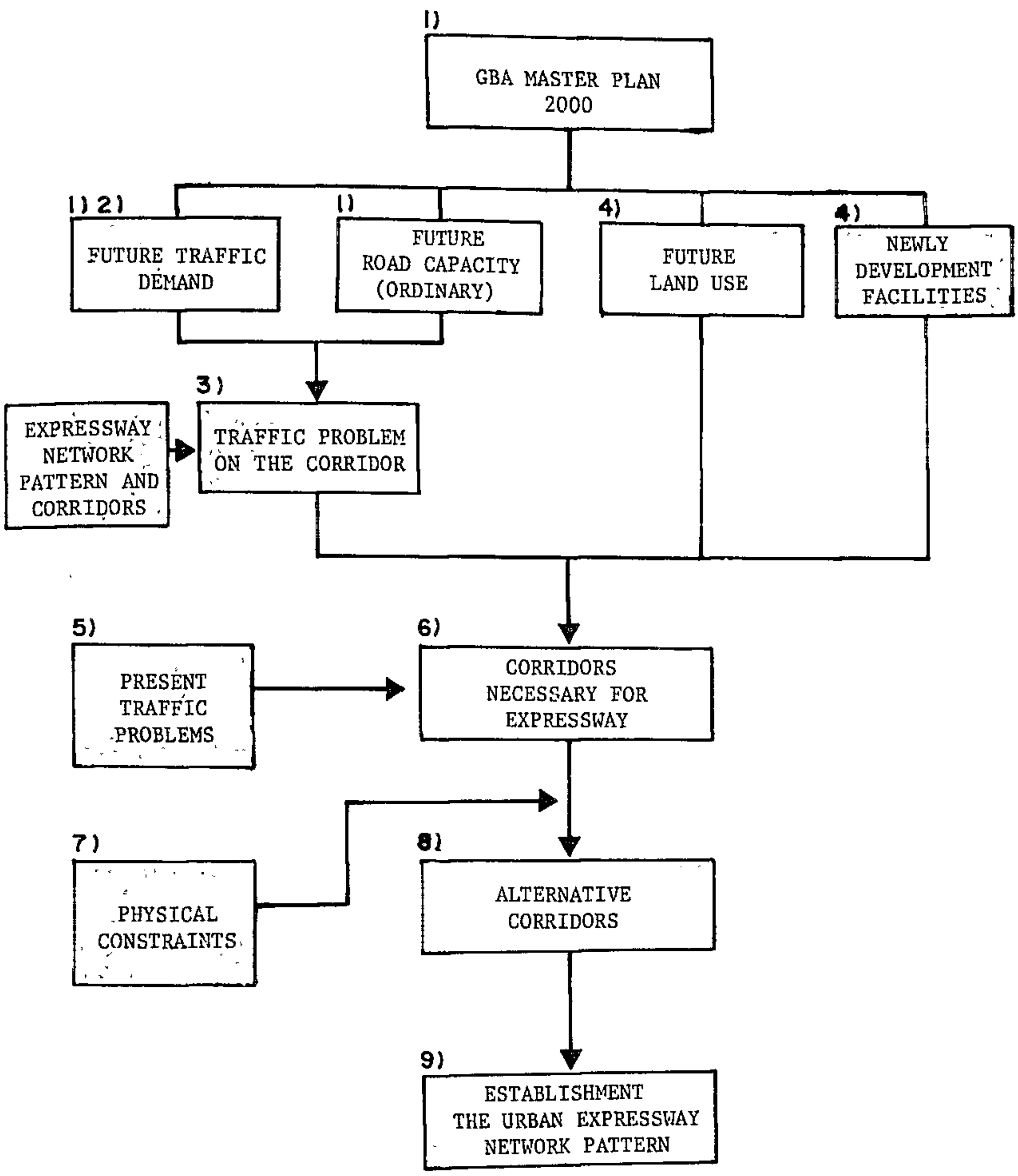


FIG. 6 – 5 WORKING FLOW OF SELECTION OF THE MOST APPROPRIATE EXPRESSWAY PATTERN IN THE GBA

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

3) Comparison is made of the assigned traffic demand with the future road capacity to verify the necessity of the proposed corridors of each expressway network patttern examined in Fig. 6–7, in terms of traffic congestion ratio;

4) Examine the relationship of the proposed corridors with the future land use and the location of new development facilities;

5) Examine the relationship of the proposed corridors with the present traffic problems;

6) Select the corridors necessary for expressways;

7) Check the engineering constraints to the corridors selected by the above procedure;

8) Consider the alternative corridors if necessary; and

9) Establish the pattern of urban expressway networks.

Based on the OD tables for the year 2000 estimated in Chapter 5, the future traffic was assigned to the case where the First Stage Expressway System and ordinary roads exist but without the Second Stage Expressway System. The result is shown in Fig. 6–6 (As for the estimating method, refer to section 6.4). In this figure, future land use pattern and location of the future development projects are also shown. Then an asssessment was made of the condition of each corridor that was already examined in the expressway network pattern. Fig. 6–7 indicates both the capacity by the corridors and the demand by the future traffic and ratio between the two in terms of traffic congestion. In the same figure the sections of corridors that have a congestion ratio of more than 1.5 (including 1.45) are marked. From the above result, the followings are cleared:

1) Even though the urbanization would be in a polycentric land use pattern, CBD will form the monocentric pattern especially inside the Middle Ring Road.

2) Coinciding with the future land use pattern, heavy traffic demand is expected on Phahol Yothin Road and Super Highway at the northern side of CBD; New Phetchaburi, Sukhumvit and Rama IV Roads at the eastern side of CBD; and Silom and Sathon Roads at the southern side of CBD. In addition the northwestern portion of the Middle Ring Road will also have a heavy traffic in the future.

3) Almost all corridors have a congestion ratio of more than 1.0 unless the urban expressways are provided (where the designed service level = 1 : volume/capacity = 0.8).

4) Construction of radial roads between the boundary of CUA and the city center is required in the future, but no extension beyond the periphery is required.

5) Since the congestion in the city center is remarkable, construction of the expressway with such type that would absorb the traffic as much as possible in and around the center is preferable.

6) The network of existing ordinary roads will not be sufficient for the above purpose. The construction of the expressway that passes closely by the city center is required.

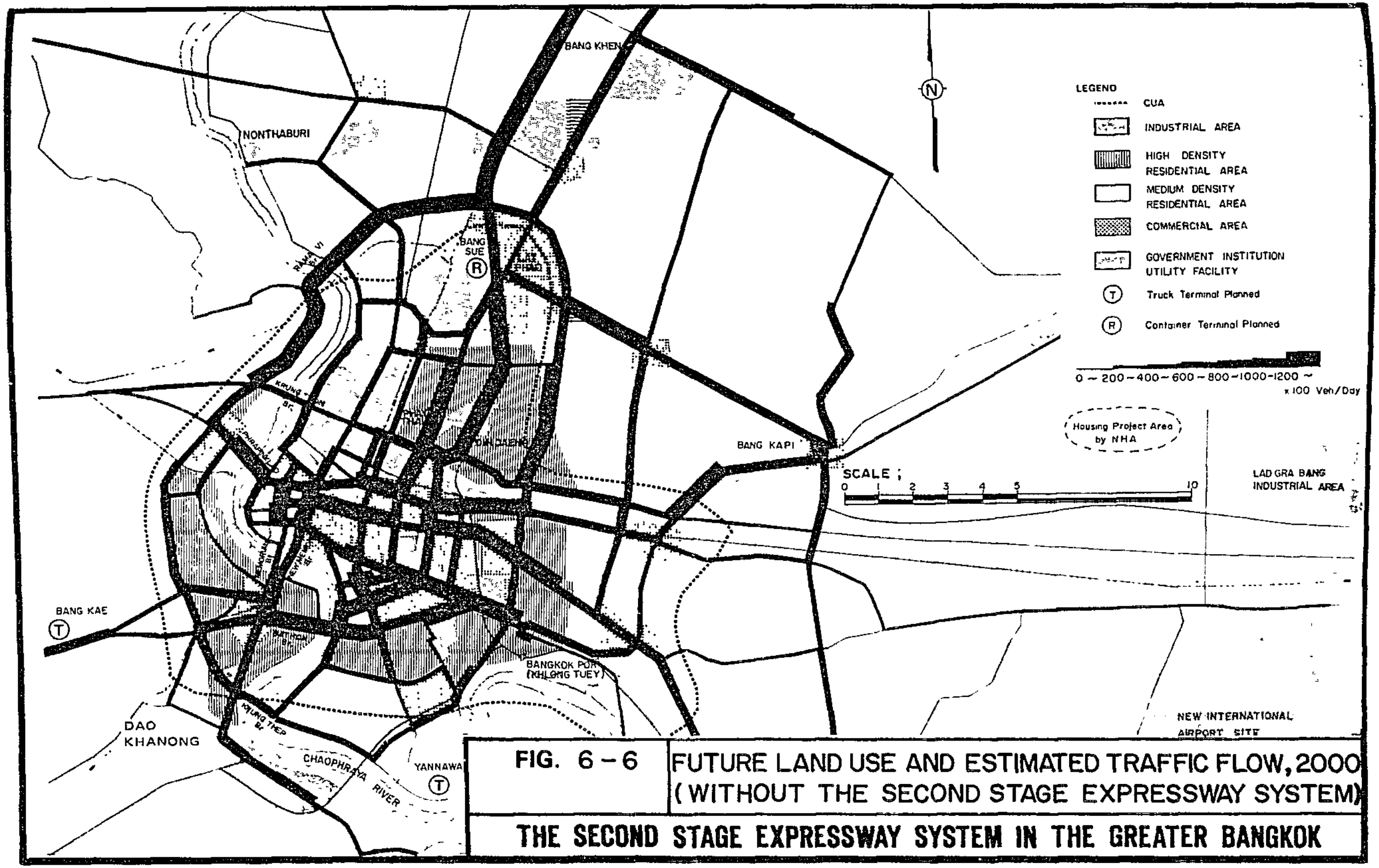


FIG. 6 - 6 FUTURE LAND USE AND ESTIMATED TRAFFIC FLOW, 2000 (WITHOUT THE SECOND STAGE EXPRESSWAY SYSTEM)

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

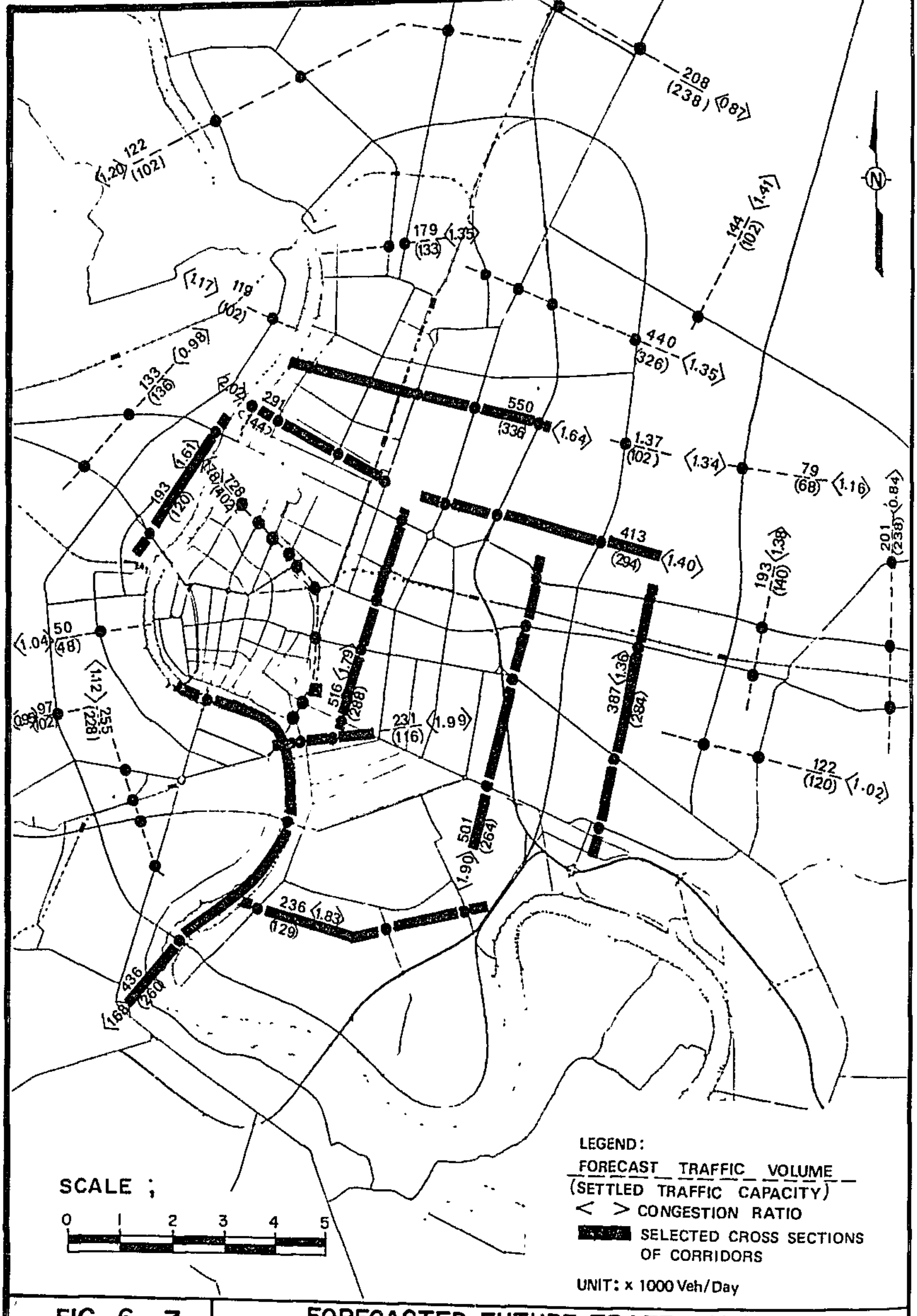


FIG. 6-7 FORECASTED FUTURE TRAFFIC VOLUME, CAPACITY AND CONGESTION RATIO ON TRAFFIC CORRIDORS, 2000

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

Among the corridors, the ones in a radial pattern have the following respective necessities by direction (Refer to Fig. 6–8):

Northern Direction (A Corridor)

A radial corridor is necessary for the traffic towards the Super Highway, but with an extension as far as the Middle Ring Road.

Eastern Direction (B Corridor)

A radial corridor linking the city center with the eastern areas to which New Phetchaburi, Sukhumvit and Rama IV Roads run parallel is required, but its extension should be examined from the aspect of the future development such as housing estate and the new international airport.

Western Direction (C and D Corridors)

Necessity of continuous provision of roads in the direction from Phet Kasem Road toward the city center is recognized. An additional bridge will be necessary between Memorial Bridge and Krung Thep Bridge, besides the existing Sathon Bridge. Port-Dao Khanong section of the FES will be constructed at the southern side. There might be less necessity in the direction connecting from National Road 338 toward the inside of the city. However, the traffic using Krung Thon Bridge and Phrapin Klao Bridge would have a great volume, and one bridge for the traffic from the Middle Ring Road toward the city center would be required.

Southern Direction (E Corridor)

A radial approach from Yannawa where housing development is under way toward the city center is required.

They (A-E Corridors) from a radial pattern originating from the core area.

Another corridor of traffic can be recognized on the north-western part of the Middle Ring Road based on the future traffic demand (F Corridor).

Then the location of these corridors and the construction constraints related to them in the Bangkok city were examined as below. Previous Fig. 6–8 shows the location of the corridors and major constraints.

The areas where the construction is difficult are such as Rattanakosin Island which was once CBD, being a historical conservation area nowadays and where new structures are prohibited; the Royal Palace; the Parliament Building; the land such as Rama IV Road that is reserved for the MTS project with no space to provide the expressway and the areas which have been too densely developed to spare the land for the expressway construction.

From the above physical conditions, the corridors at issue are the ones denoted by B, C and D in the figure.

B Corridor: This corridor runs through the densely urbanized area. Shift of its location can be considered.

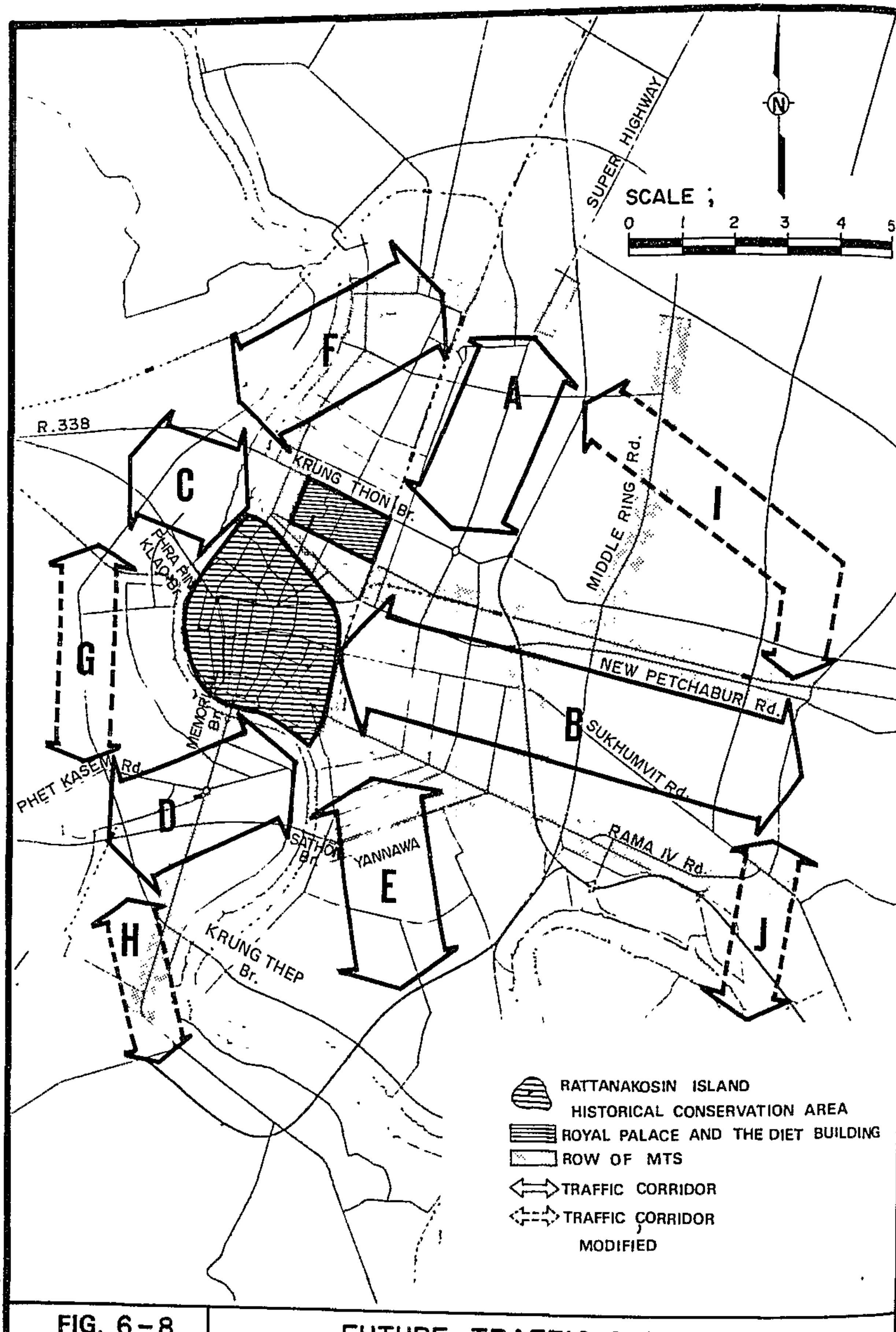


FIG. 6-8	FUTURE TRAFFIC CORRIDORS AND MAJOR CONTROL POINTS

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

C Corridor: The direction of this corridor toward the city center will be subjected to many constraints such as Rattanakosin Island, the Parliament Building, etc. The substitutes by F and G corridors can be examined.

D Corridor: Partly because the cost of a bridge to cross the Chao Phraya River is expensive and partly because the location of the third section, Dao Khanong-Port of the First Stage Expressway System, is competitive with this corridor, H Corridor can be examined.

Other Corridors: I and J Corridors which constitute the eastern part of the master plan would not be subject to serious problems but according to the traffic assignment result they will be required as spine corridors to serve for the enhancement of polycentric urbanization considering the long-term development.

Based on the above discussion the necessity of a radial type expressway was recognized. However, with the physical constraints and the long-term regional development in the metropolis, some additional ring shaped expressways were also considered to connect the radial expressways. Consequently, "Hybrid Pattern" has been selected as a basic expressway pattern of the GBA.

In this context the expressway system which is mentioned in the Terms of Reference of this study, will also be examined for its viability from the viewpoints of traffic and economy. The provisional traffic assignment result in the year 2000 is illustrated in Appendix Fig. 6–3.

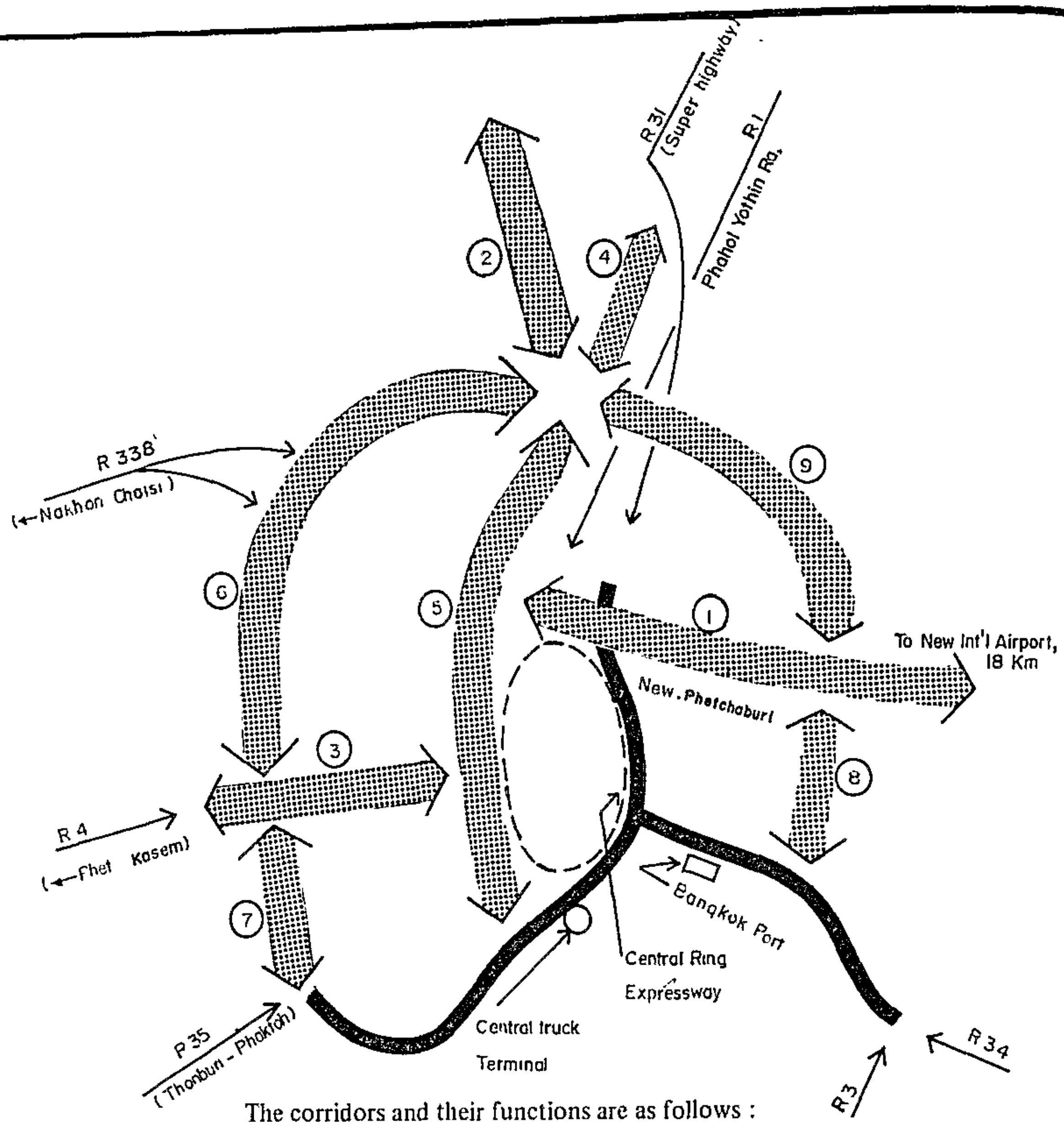
Fig. 6–9 illustrates a pattern of the hybrid type expressway network necessary for the Bangkok Metropolis, which would lessen the problems in the present traffic and the future urbanization. Based on this figure urban expressway network was roughly established as shown in Fig. 6–10, with the total length of about 75 km. With the First Stage Expressway System, the pattern forms an inner ring road about 20 km long in the center and an outer ring about 50 km long along the outskirts with three radial expressways to the north, the east and the west.

6.3.3 Step 3 Study

The expressway routes comprising the Second Stage Expressway System is selected from the network master plan as studied above. The target year of the completion of the SES is around 1995, with a length in the range of 20-40 km. The detail will be discussed in section 6.4.

6.3.4 Step 4 Study

The Second Stage Expressway System that has been examined by the studies in the above steps is forwarded to refine its feasibility in Phase II. The study standards involve the following items: economic and financial viability, engineering study, environmental consideration, etc.



The corridors and their functions are as follows :

Corridor No.	Functions	Corridor No.	Functions	Corridor No.	Functions
1	1) Serves the eastern housing development district (Bang Kapi & Minburi) 2) Mitigates traffic congestion on New Petchburi Road 3) Approach to New Airport 4) Arterial corridor in east-west direction	4	1) Mitigate traffic congestion on Pahon Yothin Road 2) Connects the Sriyan area to its north	8	1) Serves Akkamai, Khlong Tan and Asoke from National Roads No. 3 and 34 2) Connects Phrakbanong with Akamai, Khlong Tan and Asoke 3) Serves the traffic from Akkamai and Khlong Tan 4) Functions as Outer Ring Expressway
2	1) area and its north	5	1) Approach to CBD 2) Forms a part of Middle Ring Expressway 3) Arterial corridor in north-south direction	9	1) Disperses the traffic from Lad Krabang to the city centre 2) Functions as outer Ring Expressway
3	1) Serves the Nonthaburi area 2) Serves the area along National Road No. 4	6 & 7	1) Serves the trucks coming from National Road No. 338 (to central terminal and Bangkok Airport) 2) Disperses the traffic coming from National Roads No.4, 35 & 338 3) Functions as Outer Ring Expressway		

FIG. 6 – 9

CONCEPTUAL LINKAGES OF EXPRESSWAY AND TRUNK ROAD : (IN HYBRID PATTERN)

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

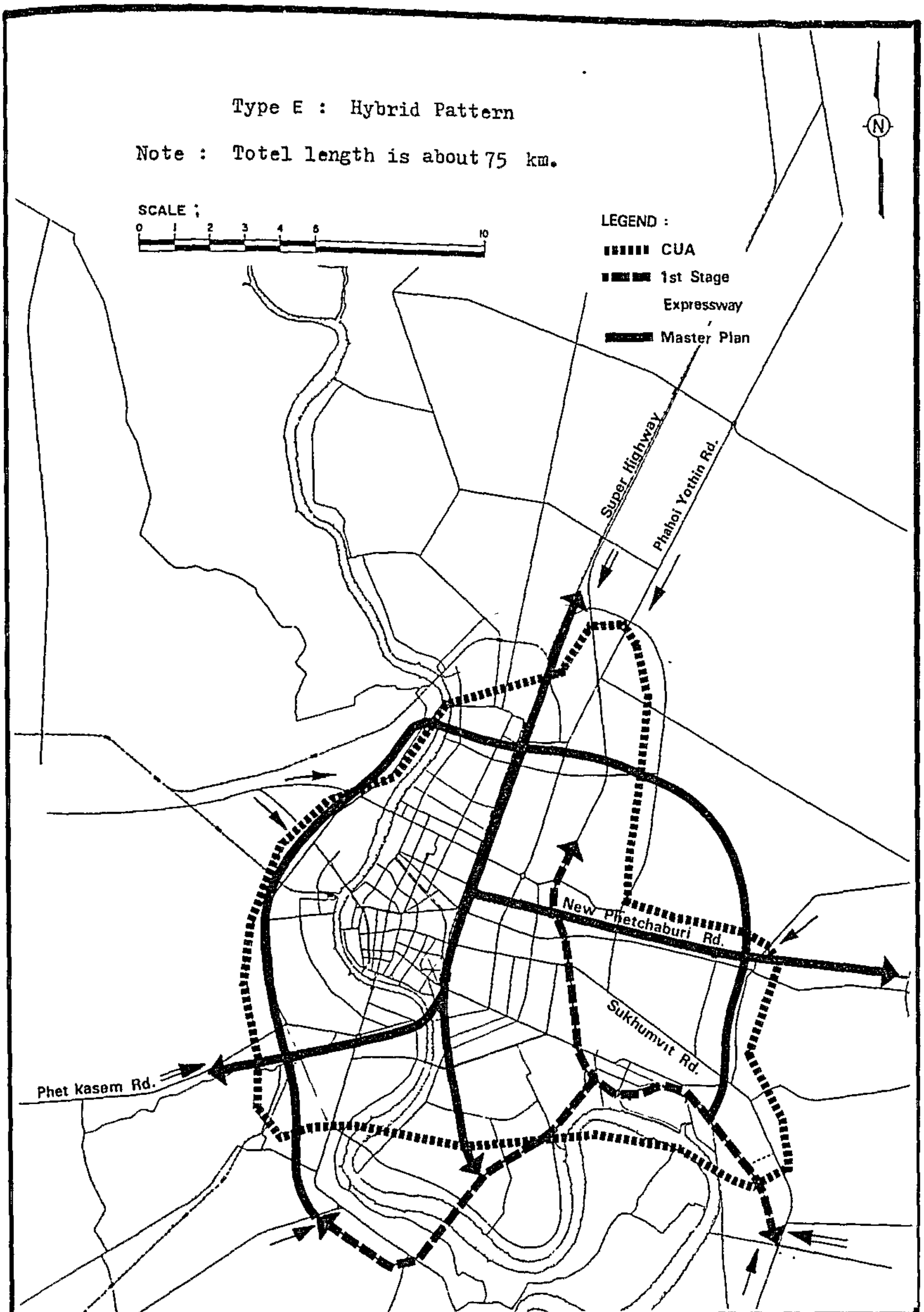


FIG. 6-10 1

PROPOSED MASTER PLAN OF EXPRESSWAY NETWORK

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

6.4 Traffic Assignment

6.4.1 Methodology

Conceptual work flow for the traffic assignment is shown in Fig. 6-11 and itemized as follows:

1) Minimum time-route search and motor cycle traffic assignment are examined only on the ordinary road network.

2) Minimum time-route search is examined both on the ordinary roads and First and Second Stage Expressways.

3) Minimum time-route search is conducted both on the ordinary roads and Mass Rapid Transit lines (MTS).

4) Estimation of the diversion rate to the expressways comparing the travelling time in 1) and 2) above.

5) 30% of total passenger car trip assignmnet (Total OD matrices are divided into the following 5 lots to make the phasing assignment of the traffic: 1st 30%, 2nd 20%, 3rd 20%, 4th 20%, and 5th 10%).

6) Modal split between bus and MTS is examined by travel time difference between 1) and 3) above.

7) 30% of the total PT OD traffic assignment is conducted using the result of 6) above.

8) Division between bus person OD and MTS person OD is identified.

9) Division between public bus passengers and private bus passengers is identified. The latter includes those on tourist bus and private bus. Due consideration is given to the diversion of private bus passengers to the expressway.

10) Store the 1st lot of traffic assignment result, then proceed with the succeeding step-wise traffic assignment as mentioned in 5) above. For the truck trips the steps of 1), 2), 4) and 5) are applied in the same process as the passenger car trips.

11) Repetition of the steps in 1) - 10) above through the 2nd to the 5th lots.

6.4.2 Assignment Conditions

(1) Future Road Network

The future road network has been discussed in subsection 5.2.2, and the road sections that are likely to be implemented by 1990 were examined for network for traffic assignment. These road sections are illustrated in Fig. 6–12. The future road network which was coded with link and node numbers is filed separately from this Report.

(2) Q-V Model

The concept of Q-V is illustrated in Fig. 6–13, where the travel speed is determined according to the volume of road traffic and the road user will select a route which

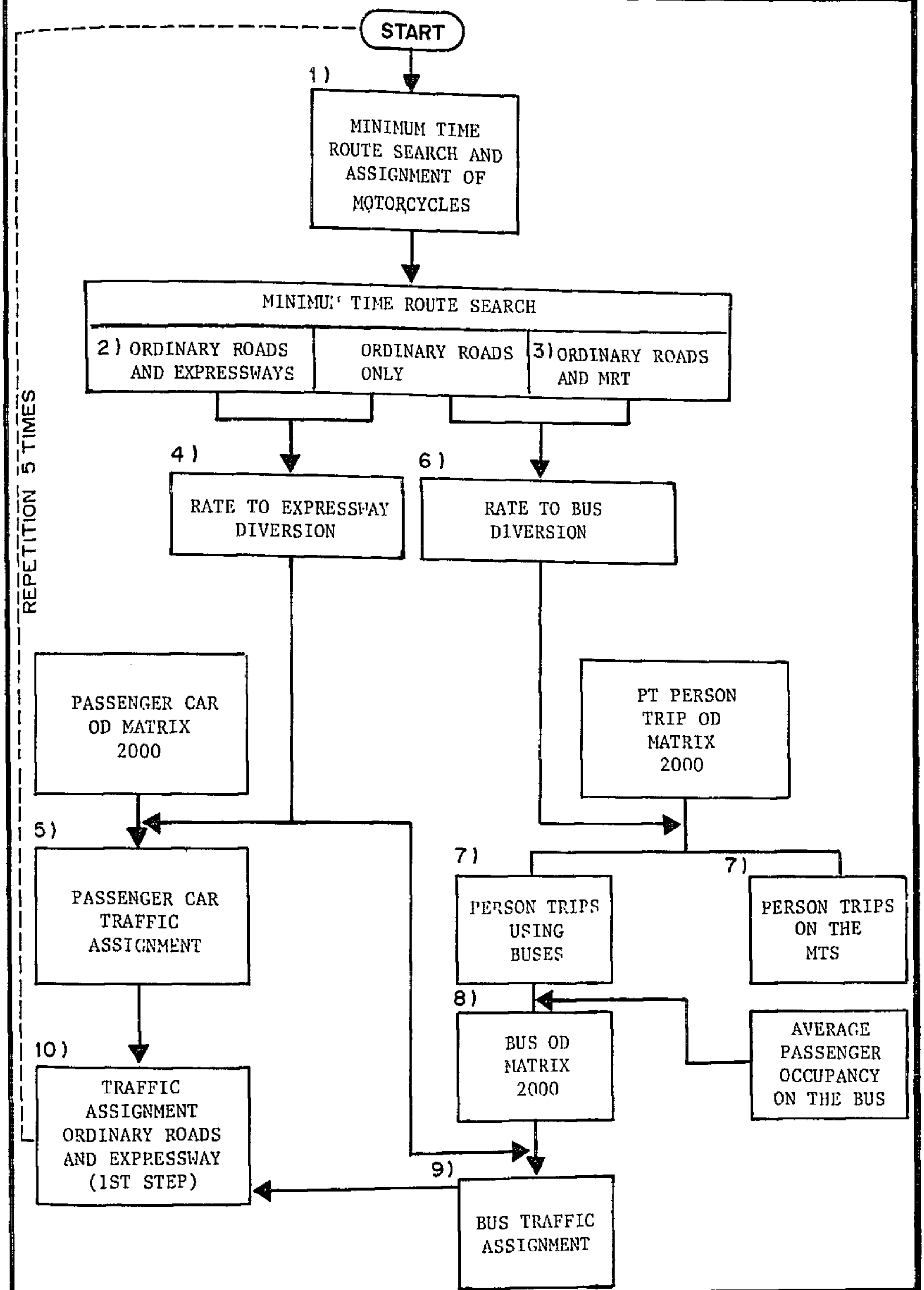


FIG. 6 - 11 CONCEPTUAL WORKING FLOW FOR TRAFFIC ASSIGNMENT (Person Trips)

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

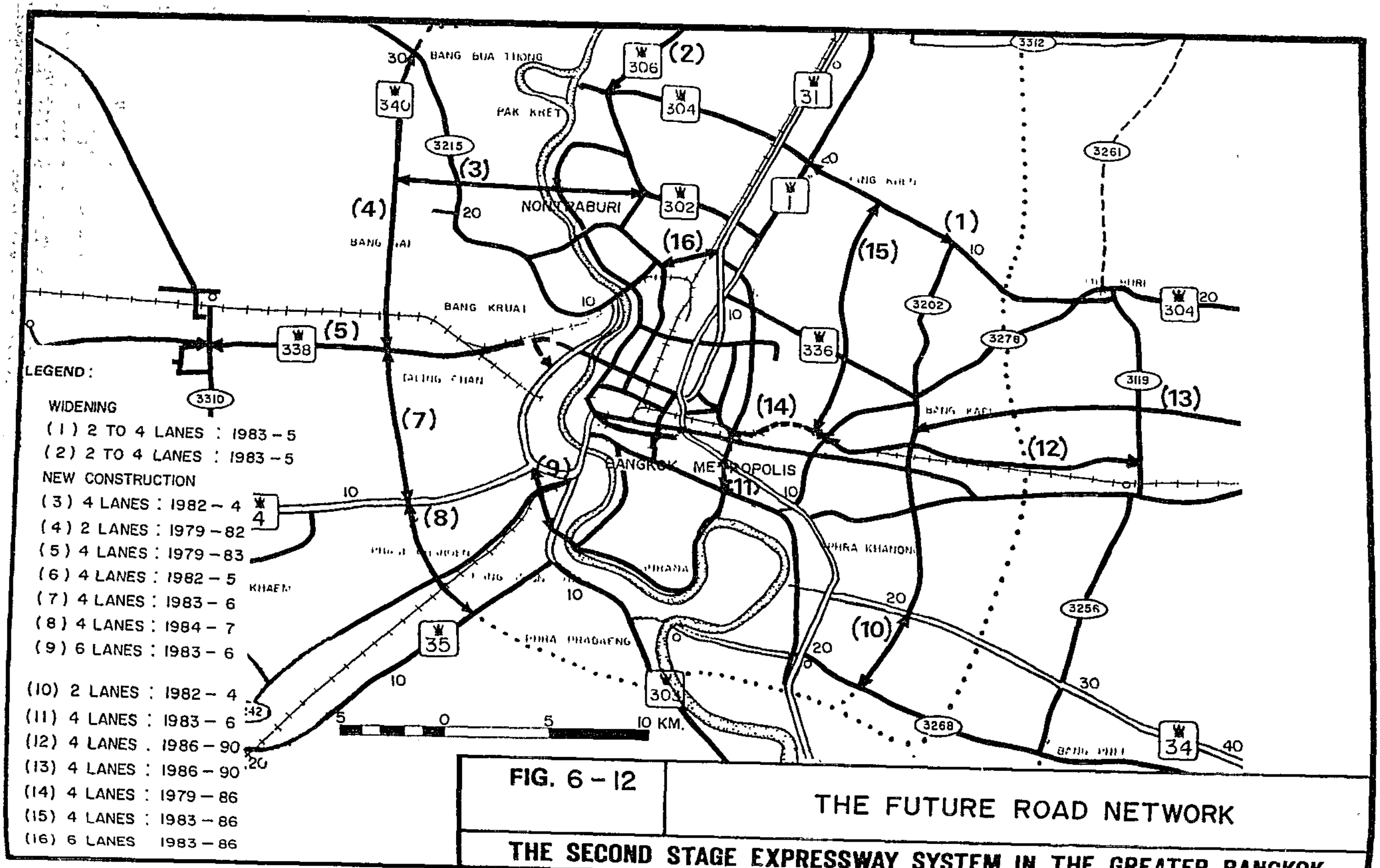


FIG. 6 – 12

THE FUTURE ROAD NETWORK

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

minimizes his travelling time from the origin to the destination.

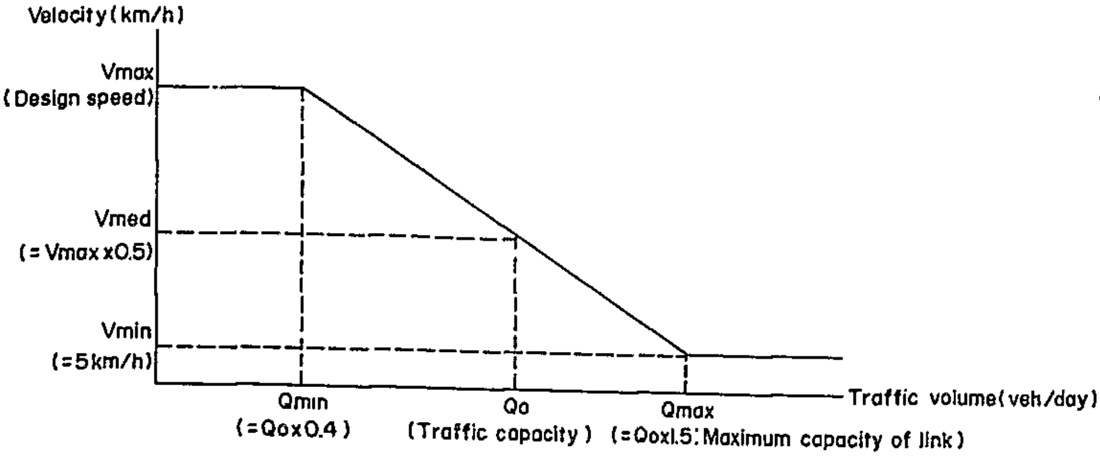


FIG. 6–13 LINK SPEED/FLOW CURVE

When the traffic volume is below Q min, the vehicle may be able to travel at the maximum speed (V max), while when the traffic volume exceeds Q min the travel speed decreases.

According to the results of the travel speed survey as mentioned in Chapter 4 and the speed flow curve previously established to the recognized standard (such as AASHTO), the traffic capacity limit conditions of the road network were divided into 10 different categories according to the nature of the road. The Q-V curves by each type of road were tabled in Appendix Table 6–1.

To make closer simulation with the actual traffic flow pattern (namely, the traveller selecting his route so as to minimize his travel time and avoid the road congestion), the assignment was broken down into five lots as mentioned in the previous subsection so that the degree of congestion could be reassessed at each separate step.

(3) Mass Rapid Transit System (MTS)

According to the progress of the Mass Rapid Transit System. The exprected opening year of MTS is 1989 as in the earliest case. In this sense, the possibility of completion of all of the proposed lines by the year 2000 seems very low. Therefore, only two high priority lines were chosen as a base of traffic assignment. They are the whole Rama-line and some section of Sathon-line (the latter ranges only between Rama IV Road and the workshop). In addition to the above assumption, a case of no MTS was also examined for reference.

The modal split between MTS and buses was assumed with a proposition that the passengers who will use the MTS would come from PT (Public transport) users and no PVT (Private Transport) users were considered. This diversion would come out in reality but the volume would be modest. It can also be said that the diversion from PVT to PT was already considered when the PT/PVT rate was examined. Fig. 6–14 illustrates the lines of MTS which were assumed to be constructed before 1990 in this study.

(4) A Modal Split Model: MTS and Buses

In June 1982, passengers using the existing railways and buses were interviewed to find a split pattern between the two modes. Using these interview results a linear regression analysis was conducted, being shown in Fig. 6–15. The established formula for MRT/Buses modal split are described as:

$$Y = a - b\,(B\text{-}R)$$

where Y : in percent of (bus users)/(bus and rail users)

(B-R) : in minutes; B is the travel time through buses and R is that through railways

$$Y = 77.805 - 2.722\,(B\text{-}R),\ (r=0.882) \qquad (1)$$

(3.384), (0.387) ....standard deviations

$\overline{Y} = 74.063,\ \overline{X} = 1.375$ .... mean values

Basic understandings of the above model are stated as:

A. Waiting time ....Rail : 15 min. Bus : 5 min.
B. Walking time to the facilities..........Rail : 10 min. Bus : 5 min.
C. Comfort ....no significant difference
D. Fare rate.................no significant difference

If a mass rail transit line is constructed with the services (fare, frequency, comfort, easy access to on and off, etc.) quite similar to those of buses, the percent share would be around 50% for buses and 50% of rail transit. Accordingly, the modal split line is assumed to shift in parallel downwards to (x, y) at (0, 50) as in Fig. 6–15 (2).

$$Y = 50 - 2.722\,(B\text{-}R)$$

The shifted modal split line indicates that 77% of the passengers will use the new rail service if the use would result in 10 minutes less travelling time than buses. On the other hand, if the use of railways takes 10 minutes more than buses, approximately 77% of the passengers will remain the bus routes. If the time is same, 50% for buses and 50% for MTS, ceteris paribus.

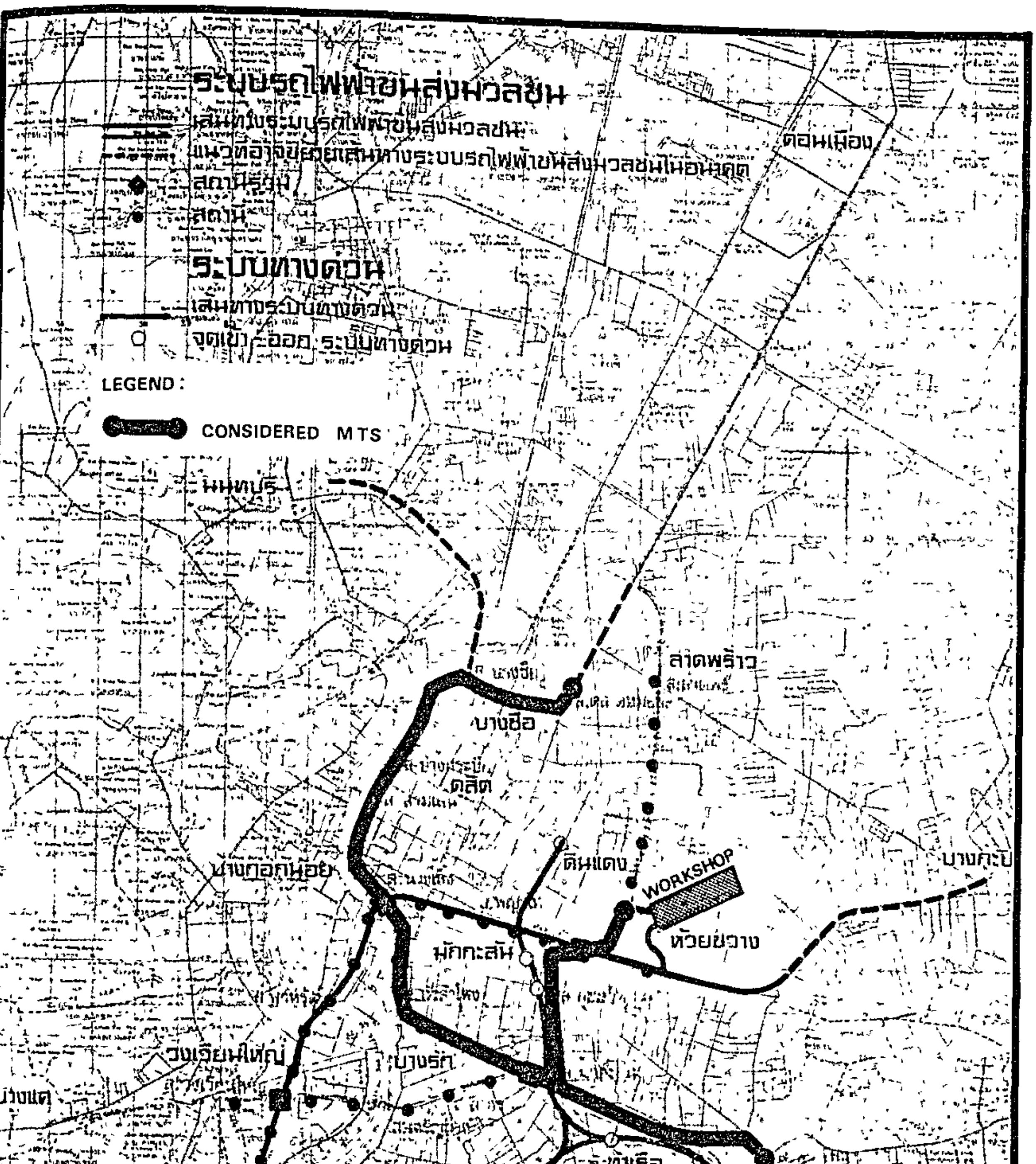


FIG. 6 – 14	MASS RAPID TRANSIT SYSTEM CONSIDERED FOR THIS TRAFFIC ASSIGNMENT

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

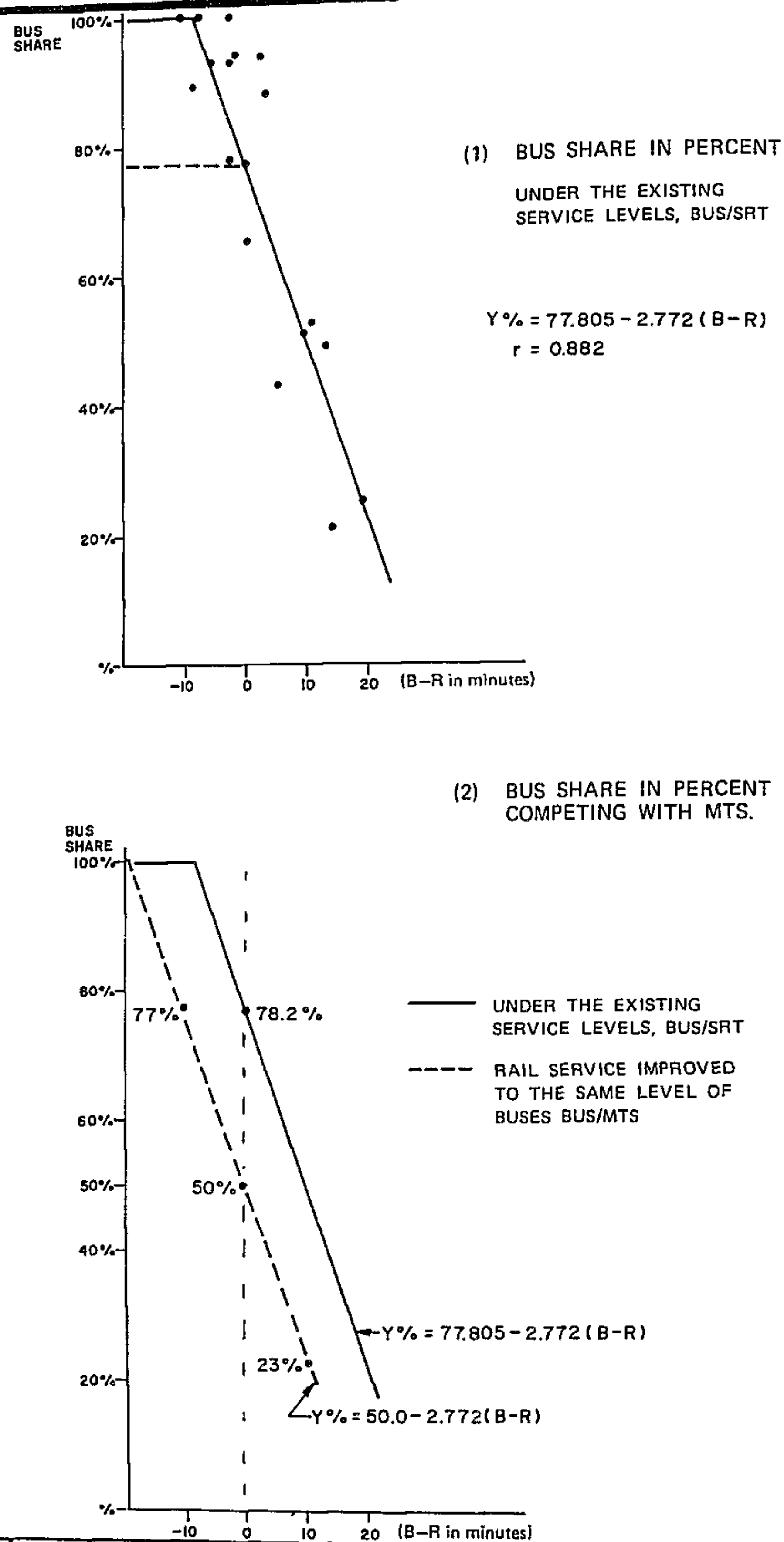


FIG. 6-15	MODAL SPLIT : BUSES VS EXISTING RAILWAYS, AND MTS.

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

6.4.3 Expressway Traffic Diversion Model

(1) General

In order to forecast the volume of traffic diversion on the tolled expressways, a diversion model should be determined based on the study of the trend of drivers' preference for the expressways in travel time, comfort, route conditions and toll payment. For this purpose origin destination interviewing survey at roadside was conducted in February 1983. The detailed results of the survey are shown in Appendix 6.2. In this subsection only the main results are duscussed.

(2) Methodology

The conceptual working flow for establishment of traffic diversion model to the Expressway is shown in Fig. 6–16.

(3) Model Formula

From the various tolled expressway traffic diversion studies, it is known that the traffic diverted volume on the tolled expressway has some relationship between its travel time through the expressway, toll rate and travel time through the ordinary road. In this study, the basic traffic diversion formula was selected as follows:

$$P = \frac{K}{1 + \alpha (T/S)^{\beta}}$$

where
- P : Traffic diversion ratio to the expressways
- T : Factors by using the expressway
- S : Shifting coefficient which was assumed to increase with the growth of GPP
- α, β : Parameters
- K ; Upper limit of diversion

Based on the above formula, following two types of models were examined:

a) Travel Time Difference Model

$$P = \frac{K}{1 + \alpha (T/S)^{\beta}}$$

$$T = F/(TG\text{-}TH) \qquad =$$

where
- P : Traffic diversion ratio to the expressways
- TH : Travel time via expressway (min.)
- TG : Travel time via ordinary roads (min.)
- F : Toll fare (Baht)

b) Travel Time Ratio Model

$$P = \frac{K}{1 + \alpha (T/S)^{\beta}}$$

$$T = (TH + F/V)/TG$$

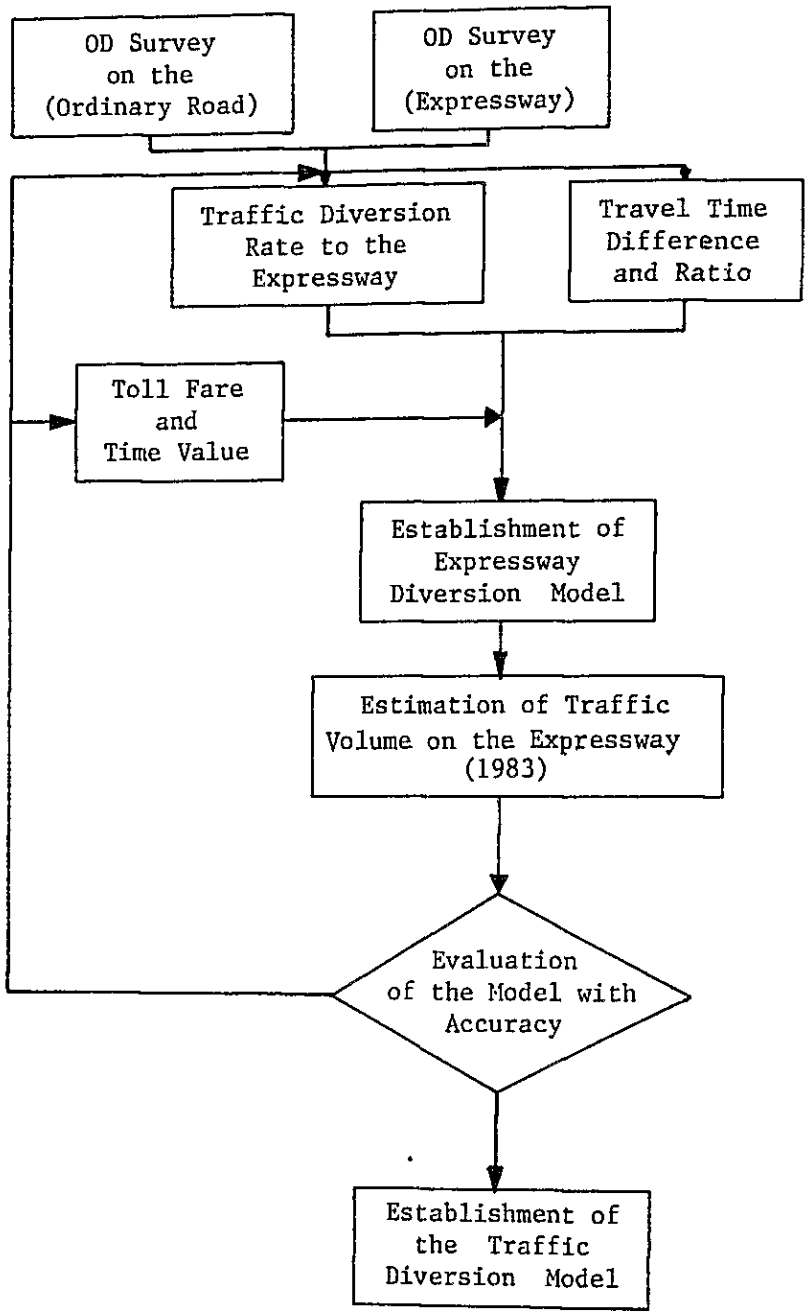


FIG. 6 – 16 CONCEPTUAL WORKING FLOW FOR ESTABLISHMENT OF TRAFFIC DIVERSION MODEL TO THE EXPRESSWAY

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where P : Traffic diversion ratio to the expressways
TH : Travel time via expressway (min.)
F ; Toll fare (Baht)
V : Time value (Baht/min.)
TG : Travel time via ordinary roads (min.)

c) Regression Analyses Results

Regression analyses results are shown in the following Table 6–1.

TABLE 6–1 PARAMETERS OF THE DIVERSION MODEL

Model Formula	Type of Vehicle	Parameters			Correlation Coefficient	Number of Sampled Data
		K	α	β		
Time Balance Model	Car	1.0	0.43617	1.73492	0.943	80
	L.T	1.0	0.31962	2.42538	0.947	59
	H.T	1.0	0.77752	2.25915	0.605	57
Time Ratio Model	Car	1.0	1.38891	4.61396	0.836	83
	L.T	1.0	1.05694	7.90495	0.818	59
	H.T	1.0	1.34179	4.09833	0.707	56

(4) Evaluation of the Models

For the purpose of verifying the accuracy of the established two types of model, traffic assignment was conducted on the FES route network in the year 1982. The assigned traffic volume was compared with an actual traffic volume counted in 1983. It was concluded that the "time balance model" proved more accurate than the "time ratio model".

Furthermore, actual traffic flow and the estimated traffic volume in terms of traffic flow between Bang Na toll gate and other ramps, and on ramp traffic volume were also studied. These results are shown in Appendix Tables 6–13, 6–14 respectively.

(5) Conclusions of the Models

Based on the above evaluation, furture traffic forecast was conducted using the time-balance model. Adopted traffic diversion model to the Expressway is shown in Fig. 6–17. Examined time ratio model is shown Appendix Fig. 6–7.

For the purpose of applying the model to the futute traffic assignment, shifting coefficient was determined based on the future growth of economic index. In this study, the coefficient was assumed to increase with the growth of GPP and determined as following Table 6–2. The concept of the shifting coefficient is illustrated in Fig. 6–18.

TABLE 6-2 COEFFICIENTS OF THE TIME-BALANCE MODEL

	Parameter			Shifting Coefficient	
	K	α	β	1982-1990	1990-2000
Car	1	0.43167	1.73492	1.5046	1.4022
L.T	0.9	0.31962	2.42538	1.5046	1.4022
H.T	0.8	0.77752	2.25915	1.5046	1.4022

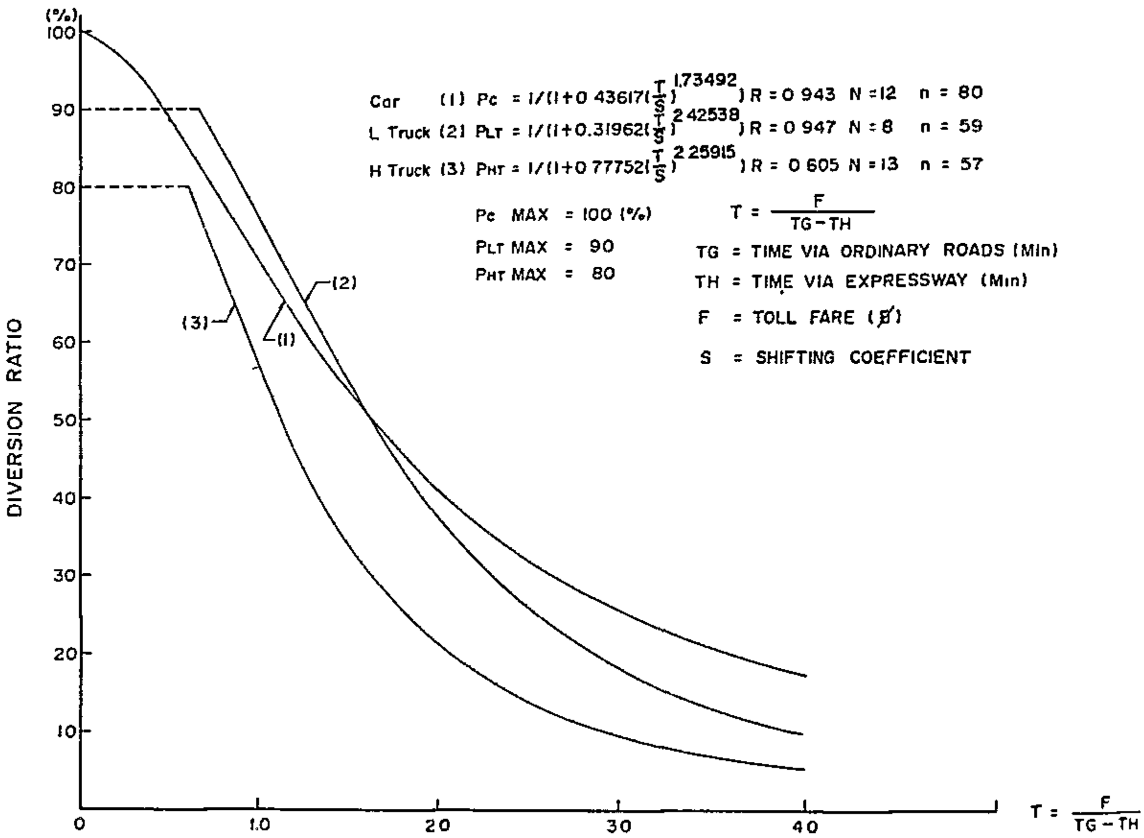


FIG. 6-17 EXPRESSWAY DIVERSION FORMULA TIME-BALANCE APPROACH

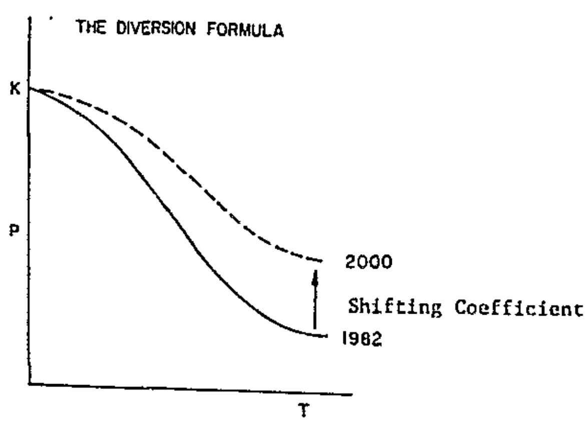


FIG. 6-18 CONCEPT OF SHIFTING COEFFICIENT

6.4.4 Traffic Assignment Cases

In this study two types of traffic assignment were conducted, namely Phase I and Phase II traffic assignments. The purposes of these traffic assignments are:

Phase I — To determine the approximate magnitude of the SES by comparing alternative network plans of the expressway.

Phase II — To clarify the viability of SES from the view points of traffic, economic and financial aspects.

Traffic assignment cases in Phase I study are summarized in Table 6–3, in which 23 cases were examined by dividing into three target years as 1990, 2000 and 2010 and two basic categories, i.e., a case in which some lines of MTS were completed and the other case in which no MTS was completed. In Fig. 6-19 four typical cases: 0, 2, 3, and 4 are illustrated. Traffic assignment cases in Phase II study are summarized in Table 6-4, in which 21 cases were examined with the object to determining the appropriate tariff system and the length of SES (In Fig. 6–20 six typical cases: FT, W, ST, R-1, R-2, and R-4 are illustrated). In the following subsection, screening procedure to determine the SES route network which was conducted in Phase I together with the provisional traffic assignment is discussed. In addition, final traffic assignment results which were conducted in Phase II on the selected SES route network are also discussed.

TABLE 6–3 TRAFFIC ASSIGNMENT CASES IN PHASE I STUDY

Case No.		Expressway			MTS
		First Stage	Second Stage	Total length of SES	
With MTS	0	With	Without	0 km	Rama Line & a part of Sathorn Line
	2	- do -	TOR	95	- do -
	3	- do -	Master Plan	80	- do -
	4-1	- do -	Second Stage	36	- do -
	4-2	- do -	Second Stage (Reduced)	28	- do -
Without MTS	00	- do -	Without	0	Not Constructed
	33	- do -	Master Plan	80	- do -
	44-1	- do -	Second Stage	36	- do -
	44-2	- do -	Sécond Stage (Reduced)	28	- do -

TABLE 6–4 TRAFFIC ASSIGNMENT CASES IN PHASE II STUDY

Case No.	Description	Expressway					Tariff		year				Typical Traffic Assignment Cases
		FES Route		SES Route		Total length of SES	Exist (10-20฿)	New Tariff	1982	1990	2000	2010	
		Exist	3rd Sect.	North Connection	East Connection								
	Determination of T.Diversion Model												
FT-1	(Time Difference)	O	–	–	–	16.8km	O		O				FT
2	(Time Ratio)	O	–	–	–	16.8	O		O				
W-1(a)	Without SES	O	O	–	–	27.1		15-30฿		O			W
1(b)	Without SES	O	O	–	–	27.1		20-30฿		O			
2	Without SES	O	O	–	–	27.1		20-30฿			O		
3	Without SES	O	O	–	–	27.1		20-30฿				O	
	Determination of SES												
ST-1	Tariff System	O	O	O	O	32.8	O				O		ST
2(a)	" "	O	O	O	O	32.8		20-30฿			O		
2(b)	" " *	O	O	O	O	32.8		20-30฿			O		
3(a)	" "	O	O	O	O	32.8		25-35฿			O		
3(b)	" "	O	O	O	O	32.8		30-40฿			O		
3(c)	" "	O	O	O	O	32.8		35-45฿			O		
3(d)	" "	O	O	O	O	32.8		40-50฿			O		
3(e)	" "	O	O	O	O	32.8		40-60฿			O		
	Determination of SES												
R-1	Route Length	O	O	O	x	27.9		20-30฿			O		R-1
2	" "	O	O	x	O	30.7		20-30฿			O		R-2
4	" "	O	O	x	x	25.8		20-30฿			O		R-4
5	" "	O	O	O	x	27.9		20-30฿		O			R-1
6	" "	O	O	O	x	27.9		20-30฿				O	R-1
B-1	SES Bus Study	O	O	O	O	32.8		20-30฿			O		ST
2	SES Bus Study	O	O	O	O	32.8		20-30฿		O			

Note : * V min. = 10 km/h

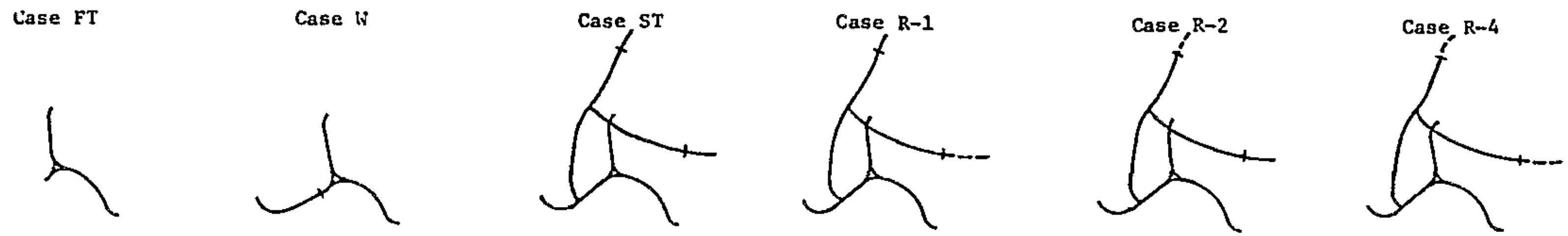


FIG. 6–20 TYPICAL TRAFFIC ASSIGNMENT CASES (2)

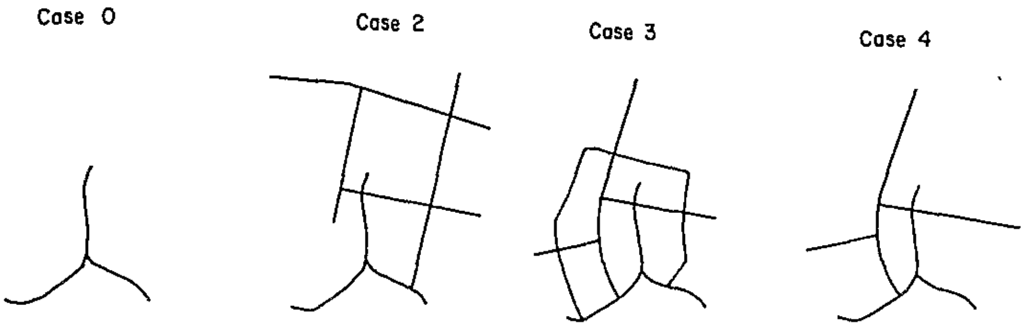


FIG. 6–19 TYPICAL TRAFFIC ASSIGNMENT CASES (1)

6.4.5 Screening Procedure by Traffic Assignment to Establish the SES

The screening process to establish the SES is illustrated in Fig. 6–21 and described below. The screening steps include the analysis of the results of provisional traffic assignment and subsequent provisional economic viability. The economic viability was studied in Chapter 12 in detail. The overall methodology of the screening in which due consideration was also given to the economic aspect is discussed in the following paragraphs:

Screening Process (Refer to Fig. 6–21)

1) Provisional traffic assignment including the First Stage Expressway System (FES) only as a "without project" case;

2) Provisional traffic assignment to the master plan network;

3) Provisional benefit-cost ratio analysis of the master plan network;

4) Examination of alternative SES's among the master plan network by traffic volume, total length of expressway, necessity, and cost required;

5) Provisional traffic assignment to the selected alternative SES;

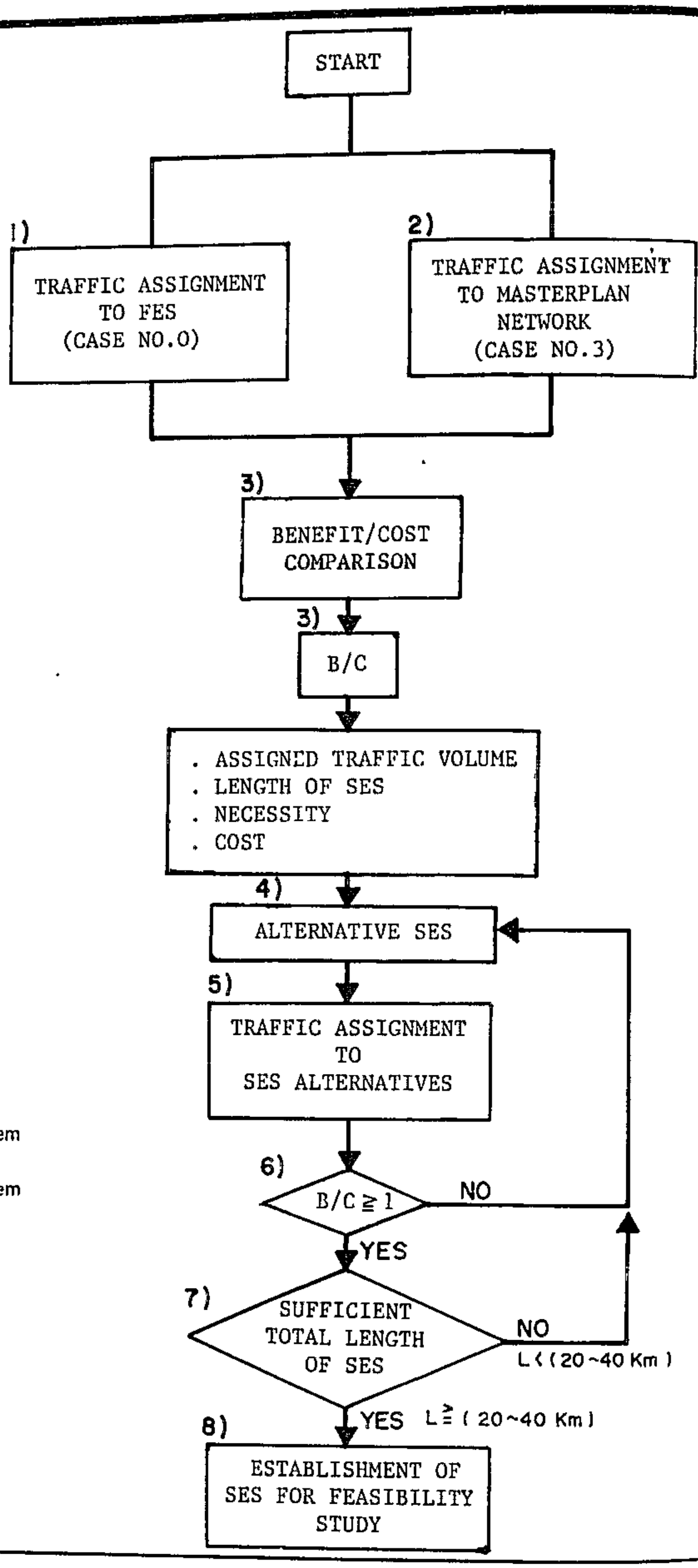
6) Check the provisional B/C ratio (if the B/C $\leqq 1$, traffic assignment to the other combinations of SES will be executed);

7) Check the total length of SES (if the total SES length is less than 20 kms, another SES alternative will be verified); and

8) Establishment of SES within the limit of the total length between 20 kms and 40 kms.

6.4.6 Determination of SES Route Network

In this subsection SES route network was determined by the provisional traffic assignment result and the preliminary economic analysis result.



Note: FES : First Stage Expressway System
SES : Second Stage Expressway System

FIG. 6 - 21 THE FLOW CHART OF THE WHOLE OF SCREENING PROCESS

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

The future traffic volume was assigned on the expressway master plan as summarized in Fig. 6–22. From the figure the following can be recognized:

- Radial expressway rather than ring expressway has a higher traffic volume as shown below. Average traffic volume per kilometer in 2000 is shown as:

Radial route	733.9	(100 veh/day)
Ring route	537.9	(100 veh/day)

- Particularly, the North-South route (Super Highway-Yannawa) and the East route have a high traffic volume.
- The traffic on the West route has a high volume on the crossing section of the Chao phraya River from the Middle Ring Road. But the construction cost of a bridge across the river is expensive. Therefore, the West route should be considered as one of the alternatives, even though the estimated traffic volume is high.
- A high traffic volume is expected on the north-western part of the outer ring expressway. As discussed in subsection 6.3.2, however, traffic problems would occur mainly in the center of Bangkok in the future. High priority in the construction of the expressways should be put on the radial route rather than the ring route.
- From the viewpoint of provisional economic viability discussed in Chapter 12, the benefit-cost ratio for the master plan network is under 1.0. Therefore, reduction in the length of the expressways should be considered.

Based on the above considerations, the Provisional Second Stage Expressway Network was established as shown in Fig. 6–23.

It is noticed that a reduced SES was proposed as an alternative case, which excluded the West route. Total length of provisional SES and the reduced SES was determined at 38.7 km and 33.6 km, respectively. (In the course of Phase II study, reduced SES was refined at 32.8 km)

From now on, in this study report, "SES" will be used to mean the reduced length expressway.

6.4.7 Estimated Traffic Assignment Results

Based on the selected SES route network, a full scale traffic assignment was conducted in Phase II. Before the assignment in Phase II, a review of the traffic assignment of Phase I was conducted. The following are items modified in the course of the Phase II traffic assignment. The details of these modifications are discussed in Appendix 6.3.

- Traffic volumes to and from the external zones;
- Traffic volumes on rampways;
- Zoning and OD matrix; and
- Road network.

In addition to the avove, traffic assignment was conducted to clarify the following two items from the view point of traffic engineering:

- Recommendation of most appropriate SES route length; and
- Recommendation of most adequate tariff rate on the Expressway.

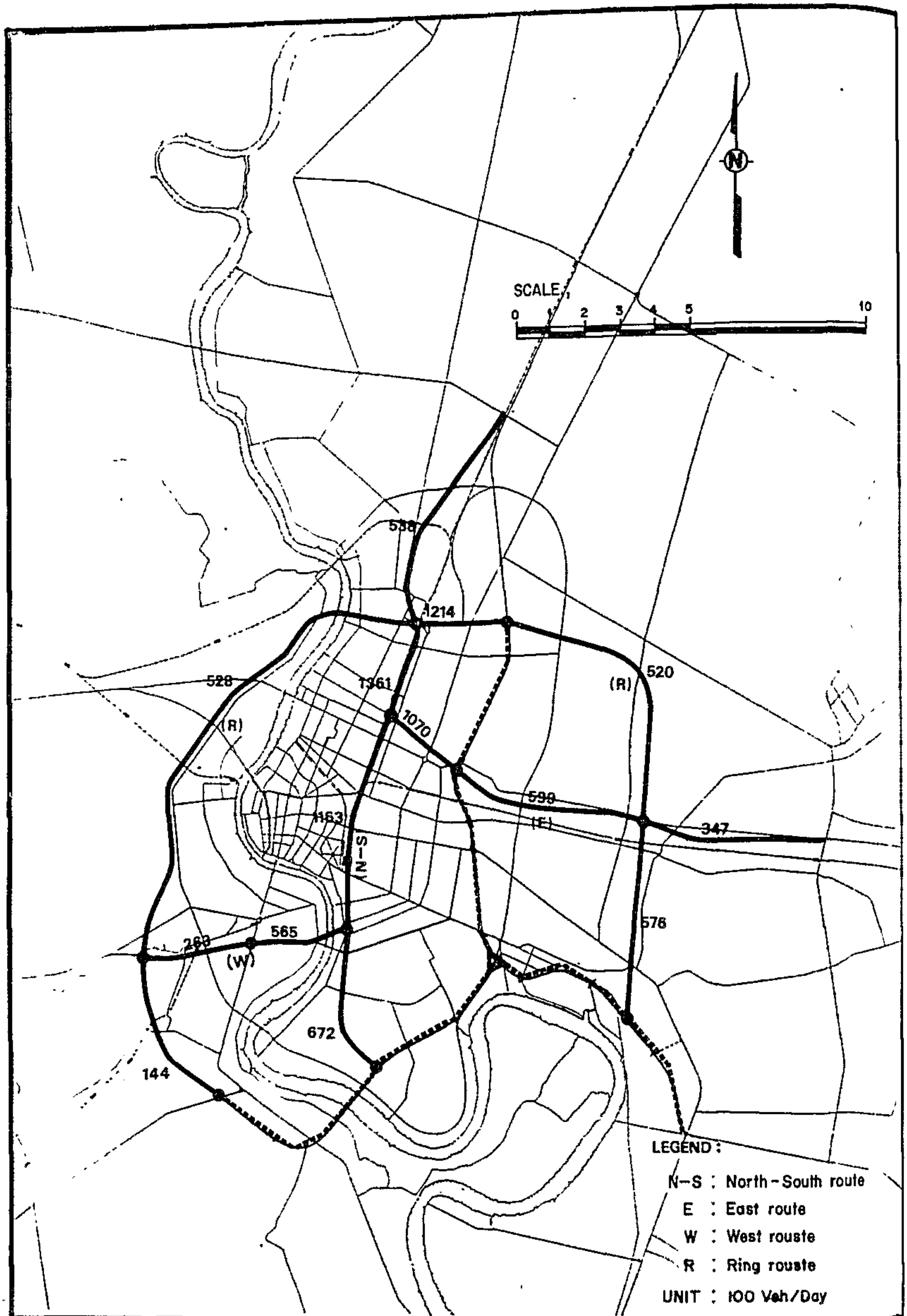


FIG. 6-22	ESTIMATED AVERAGE TRAFFIC VOLUME PER KILOMETER ON EACH ROUTE SECTION, 2000

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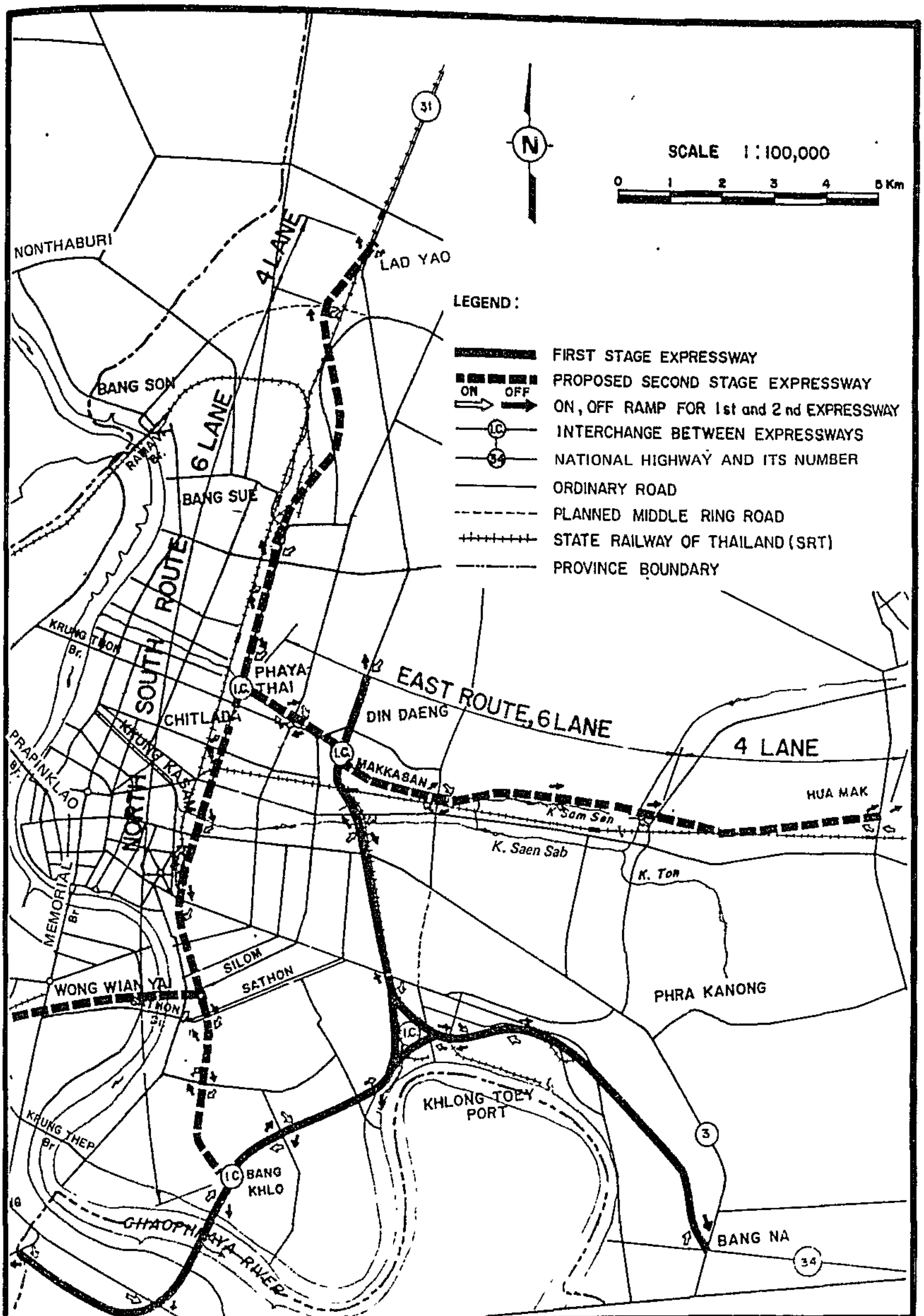

FIG. 6 – 23 THE PROVISIONAL SECOND STAGE EXPRESSWAY NETWORK

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

Traffic assignment results are summarized in Tables 6–5 and Fig. 6–24 respectively. The traffic assignment results were examined in the following subsections.

(1) Assigned Traffic Volume on the Expressway

The following are the main result of the traffic assignment in Phase II study.

- Traffic volume on the expressway in case ST-2 (year 2000) was estimated as 594 thousand vehicles per day under the condition that 20 Baht per small vehicle and 30 Baht per large vehicle would be the toll.
- Traffic rate increase on the Expressway during 1990 to 2000 was estimated at approximately 9.8% p.a., as against, 2000 to 2010 estimated at 2.9% p.a. (Case R-1, R-5 and R-6).
- During the same period total traffic volume in the GBA will increase by 3.5% p.a. and 2.1% p.a., respectively.
- These facts indicate that up to the year 2000 traffic volume on the expressway will increase tremendously, however, after 2000, due to the reduced travel speed on the Expressway, the rate of increase in the number of vehicles will reduce. Still, the rate of increase on the Expressway will be more than that of an ordinary road.
- In the case "Without SES" (FES only), traffic volume was estimated as 269 thousand vehicles in the year 2000 under the condition of toll rate 15 Baht per small vehicle and 25 Baht per large vehicle. The traffic volume would be increased approximately 3.4 times, 7.4% p.a. compared with 1983 figures (80 thousand vehicles per day).
- With increases in the toll fare of the Expressway, the estimated traffic volume decreases. After the toll fare has increased about twice from 20 Baht for small vehicle and 30 Baht for large vehicle to 40 and 50 Baht, respectively, the total number of trips on the Expressway reduces from 594,000 veh/day to 499,000 veh/day (only 16% decrease). This underlines the fact that traffic congestion on the ordinary roads inevitably leads to a large traffic demand on the Expressway.

(2) Reduction in Traffic Volume on the Ordinary Roads through Completion of the SES

Assigned traffic volume on the ordinary road network under the condition that the SES is completed is shown in Fig. 6–25. Assigned traffic volume differences in terms of traffic congestion ratio between "With" and "Without SES" cases is shown in Fig. 6–26. Reduction in traffic volume on the selected cross sections of SES corridors is shown in Table 6–6. The following classifications can be educed from these presentations:

- Compared with Fig. 6–25 (With SES) and previous Fig. 6–6 (Without SES), reduction in traffic volume on the radial roads in CUA is remarkable, especially Phahol Yothin Road in its southern section, and Phetchaburi, Sukhumvit and Rama IV Roads in their westward. These roads are already heavily congested and have characteristics as trunk radial roads in each direction. Therefore, reduction in the traffic volume on these roads in the future will contribute to one of the solutions to the traffic problems in CUA.

TABLE 6–5 TRAFFIC ASSIGNMENT RESULT – 1

Case No.	Description	Year	Number of Trips ('000 trips/day)		Average Trip Length (km)			Ave. Traffic Volume per kilometer on Expwy (veh/day)	Ave. Traffic Congestion Rate on Expwy (%)	Ave. Travel Speed on Expwy (km/h)
			On Expwy	% of Expwy	Expwy Users On Expwy	Expwy Users Total	All of the Vehicles			
	Traffic Div. M.									
FT-1	Difference	1982	76	3.4	7.5	25.5	12.6	30,699	17.1	71.4
2	Ratio	1982	113	5.1	6.4	23.9	12.7	39,140	21.7	72.8
	Without SES									
W-1(a)	15-30 ฿	1990	135		10.5	24.8		43,735	24.3	70.9
(b)	20-30 ฿	1990	119		10.6	24.9		38,765	21.5	69.8
2	20-30 ฿	2000	269	6.1	10.8	27.0	14.8	89,414	49.7	54.7
3	20-30 ฿	2010	362		9.4	27.1		104,630	58.1	48.4
	SES Tariff									
ST-1	10-20 ฿	2000	650	14.7	11.6	23.1	14.9	104,944	58.3	48.0
2(a)	20-30 ฿	2000	594	13.4	12.5	23.7	15.0	103,231	57.4	48.8
2(b)	20-30 ฿ *	2000	520	11.8	12.7	23.7	14.5	92,033	51.1	55.1
3(a)	25-35 ฿	2000	574	13.0	12.8	23.8	15.0	102,354	56.9	49.3
3(b)	30-40 ฿	2000	548	12.4	13.0	23.9	15.1	99,331	55.2	50.6
3(c)	35-45 ฿	2000	517	11.7	13.3	24.3	15.1	96,086	53.4	51.9
3(d)	40-50 ฿	2000	499	11.3	12.9	23.8	15.1	89,861	49.9	55.6
	SES Route									
R-1	20-30 ฿	2000	594	13.4	12.1	23.6	15.0	108,054	60.0	48.4
2	20-30 ฿	2000	591	13.4	12.1	23.8	14.4	101,983	56.7	49.0
4	20-30 ฿	2000	589	13.3	11.7	23.7	15.0	106,858	59.4	48.6
5	20-30 ฿	1990	233		11.7	21.8		41,176	22.8	71.8
6	20-30 ฿	2010	793		11.7	24.2		139,955	77.8	38.2
	SES Bus Study									
B-1(a)	20-30 ฿	2000	592	13.4	12.5	23.7	15.0	111,719	62.1	48.4
(b)	20-30 ฿	2000	591	13.4	12.7	23.8	15.0	112,926	62.7	48.3
	SES Bus Study									
B-2(a)	20-30 ฿	1990	234	7.4	12.1	21.8	12.9	42,564	23.6	74.3
(b)	20-30 ฿	1990	233	7.4	12.1	21.7	12.9	42,594	23.7	70.6

Note : * V min. = 10 km/h

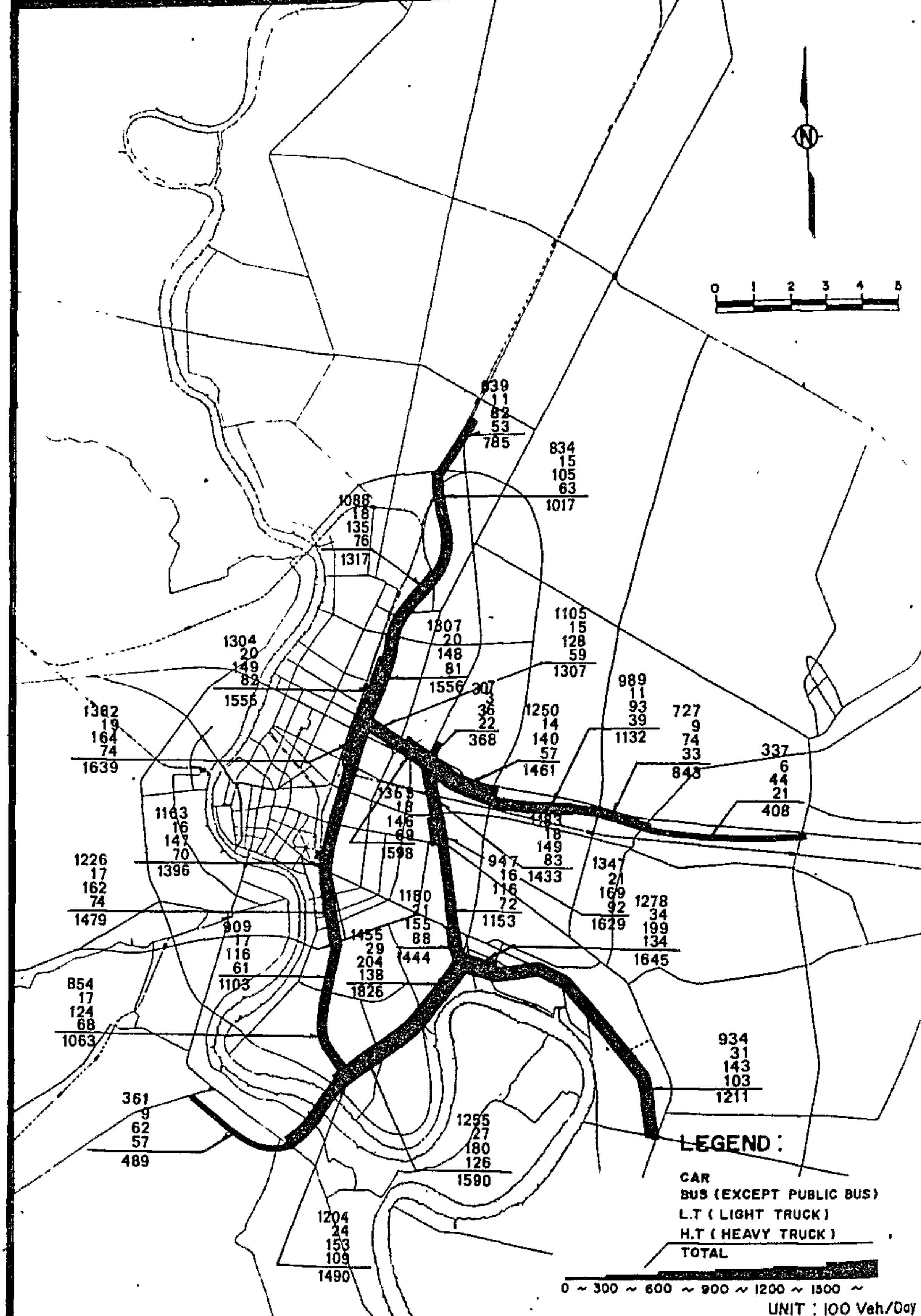

FIG. 6-24

ESTIMATED TRAFFIC VOLUME, 2000
CASE NO. ST-2(a)

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FIG. 6 – 25	ESTIMATED TRAFFIC VOLUME ON THE ORDINARY ROADS, 2000 CASE NO. 4 – 1
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TABLE 6–6 COMPARISON OF ASSIGNED TRAFFIC VOLUME ON THE ORDINARY ROADS, 2000

Traffic Corridors		Estimated Traffic Volume:000Veh/day (Capacity) 1) With (SES)	Without (SES)	With / Without (%)	Congestion Ratio With (SES)	Without (SES)	Without (1982)
SES	N-S Route	1894 (1478)	2340 (1478)	80.9	1.28	1.58	0.77
	E Route	1281 (976)	1597 (976)	80.2	1.31	1.64	0.91
	Sub Total	3175 (2454)	3937 (2454)	80.6	1.29	1.60	0.81
	E Route (East Connection)	173 (238)	201 (238)	86.1	0.73	0.84	0.47
	Total	3348 (2692)	4138 (2692)	80.9	1.24	1.54	0.79
Others		2603 (2102)	2823 (2102)	92.2	1.24	1.34	0.75
TOTAL		5951 (4794)	6961 (4794)	85.5	1.24	1.45	0.77

Note: 1) Estimated traffic volume and capacity is calculated by accumulating the total cross-sectional traffic volume on the screen-line illustrated on Fig 6–26.

- Traffic volume on the ordinary roads in the core and its vicinity will reduce by 14% by the completion of SES. Especially, along the SES corridor, the volume will reduce by about 20%.
- Number of trips on the Expressway exceeds 10% of total trips in the GBA. By the completion of SES, trip rate percentage of the Expressway indicates 13.4% compared with 6.1% of "FES only" case. It can be said that by an absorption of such traffic by the Expressway from the ordinary roads, it will contribute to the mitigation of traffic congestion on the ordinary roads.
- In the case of "Without SES", daily average traffic congestion ratio on the ordinary roads in CUA in the year 2000 was estimated as 1.45. In this case, the congestion ratio on the ordinary roads along the SES corridor and other area was estimated as 1.54 and 1.34, respectively. However, by the completion of SES, the congestion ratio on the ordinary roads along the SES corridor will reduce by 1.24 the same as the other area.
- Even after the completion of SES, average traffic congestion ratio on the ordinary roads in CUA exceeds 1.00. This fact indicates that a continuous traffic improvement program will still be required in CUA in the future.
- Congestion ratio of the roads along the Easternmost section of SES will not exceed 1.00 even in the future (both "With" and "Without SES" cases). The need for this section of SES will be discussed in (10) of this subsection in more detail.

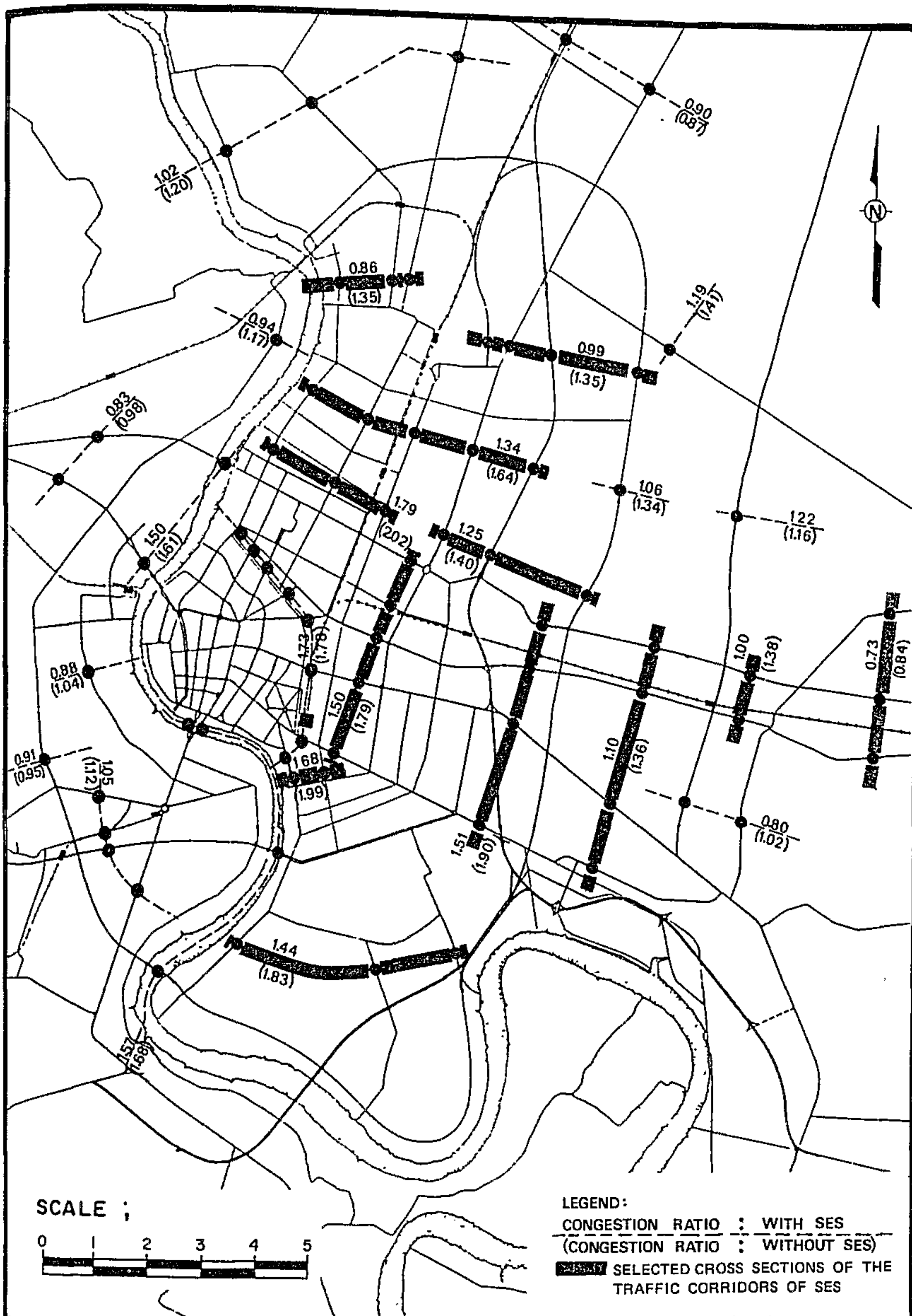


FIG. 6 – 26	CONGESTION RATIO ON TRAFFIC CORRIDORS, 2000

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

(3) Traffic Volume by Year

The estimated traffic volumes on the SES for main sections of the expressway by year are shown in Fig. 6–27. The estimated traffic volumes on the master plan are shown in Appendix Fig. 6–9. Total average traffic volumes per kilometer on the expressway are summarized in Table 6–7 together with its increasing rate.

Estimated traffic volume increase on the radial expressways is remarkable, compared with that on the expressway in the core area.

Annual traffic rate increase of "With" case is always higher than that of "Without" case during the whole project period.

TABLE 6–7 TOTAL AVERAGE TRAFFIC VOLUME PER KILOMETER

Description		Without (FES only)	With (FES+SES) ST-2(a)	(FES+SES)/ (FES)	Congestion Rate (FES+SES)
		(veh/day)	(veh/day)		(%)
Year	1990	38,765	41,176	1.06	22.8
	2000	89,414	103,705	1.16	57.6
	2010	104,630	139,955	1.34	77.8
		(%)	(%)		
Annual	2000–1990	8.7	9.7	–	–
Increasing	2010–2000	1.6	3.0	–	–
Rate	2010–1990	5.1	6.3	–	–

(4) Vehicle-kilometers and Vehicle-Hours

By the accumulation of the results of multiplying the traffic volume assigned onto each link by its length and travel time, total vehicle-kms and vehicle-hours in each case are calculated as shown in Table 6–8.

From this table the following could be clarified:

1) By the completion of SES, total vehicle-kms in the GBA will increase a little (increasing rate = 0.2% : W-2/ST-2 (a)), however, total vehicle-hours will decrease significantly.

2) Above fact indicates that the completion of SES will contribute significantly to mitigate the traffic congestion of the GBA.

3) By the completion of SES, vehicle-kms and vehicle-hours rate on the Expressway will increase by year as can be seen in Table 6–9.

4) Estimated travel speed by type of road and years are shown in Table 6–10 as calculated by the relationship between vehicle-kms and vehicle-hours.

By the completion of SES, total average travel speed on the Expressway will decrease, however, travel speed both on the ordinary roads and GBA total area will increase. In the year 2010, average travel speed on FES and SES will decrease to 38.2 km/hr. This fact indicates that some additional expressway construction such as a Third Stage Expressway System will be required by that time.

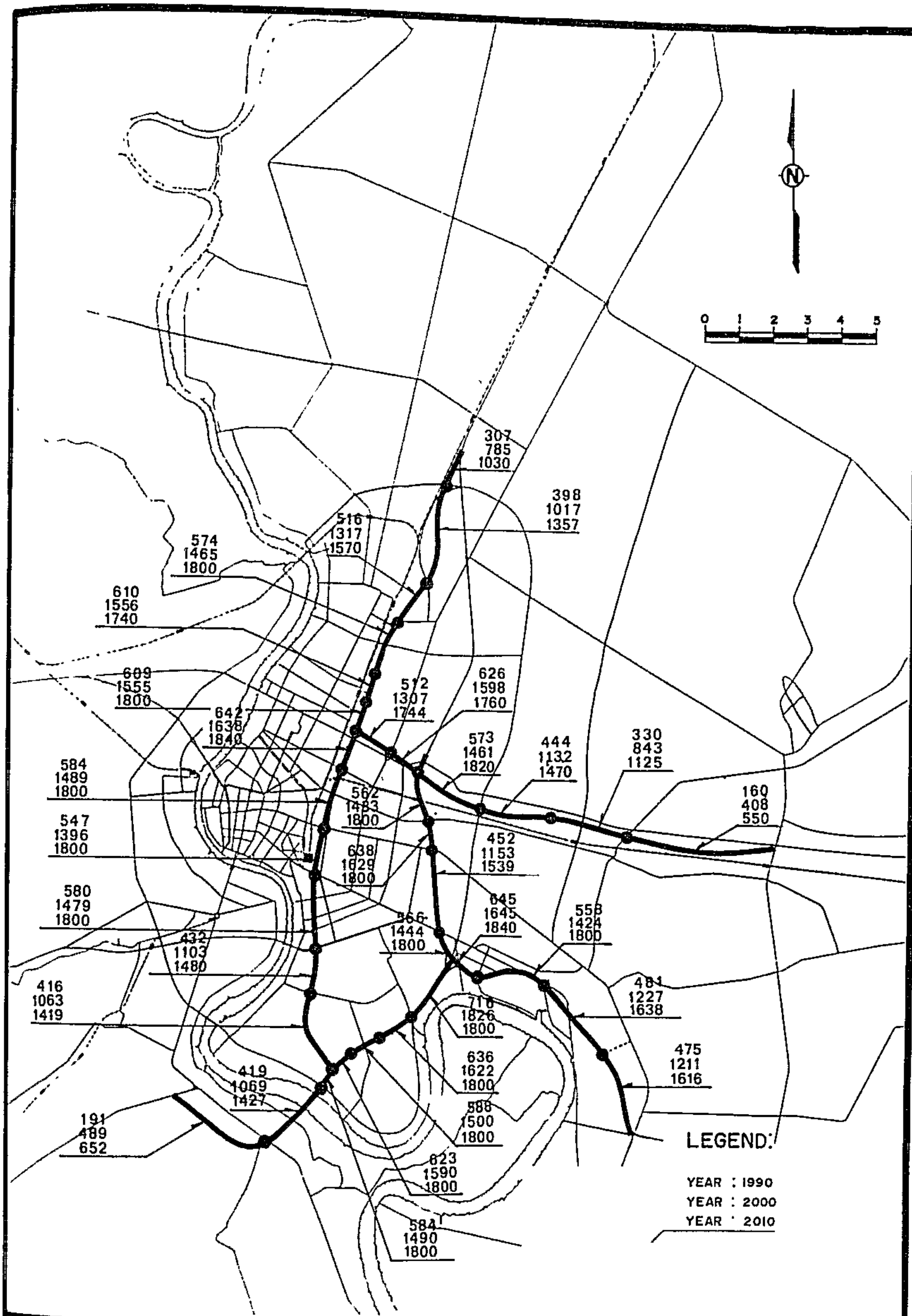


FIG. 6 -27

ESTIMATED TRAFFIC VOLUME (ST-2(a))

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

TABLE 6–8 TRAFFIC ASSIGNMENT RESULT – 2

Case No.	Description	Year	Vehicle-Kms ('000 kms)			Vehicle-Hours ('000 Hrs)			Remark
			On Expwy	On Ord.Rd.	Total	On Expwy	On Ord.Rd.	TOTAL	
FT-1[1]	Traffic Div. M. Difference	1982	571	21,307	21,878	8	563	571	
2	Ratio	1982	728	21,200	21,928	10	556	566	
W-1(a)	Without SES 15-30 ฿	1990	1,417	30,193	31,610	20	892	912	
1(b)	20-30 ฿	1990	1,256	30,371	31,627	18	901	919	
2	20-30 ฿	2000	2,897	48,277	51,174	53	2,233	2,286	
3	20-30 ฿	2010	3,390	64,546	67,936	70	4,001	4,071	
ST-1	SES Tariff 10-20 ฿	2000	7,535	43,814	51,349	157	1,640	1,797	
2(a)	20-30 ฿	2000	7,412	44,374	51,786	152	1,713	1,865	
2(b)	20-30 ฿ *	2000	6,608	43,531	50,139	120	1,678	1,798	
3(a)	25-35 ฿	2000	7,349	44,500	51,849	149	1,742	1,891	
3(b)	30-40 ฿	2000	7,132	44,877	52,009	141	1,786	1,927	
3(c)	35-45 ฿	2000	6,899	45,214	52,113	133	1,822	1,955	
3(d)	40-50 ฿	2000	6,452	45,500	51,952	116	1,860	1,976	
R-1	SES Route 20-30 ฿	2000	7,164	44,656	51,820	148	1,723	1,871	
2	20-30 ฿	2000	7,149	42,566	49,715	146	1,745	1,891	
4	20-30 ฿	2000	6,903	44,901	51,804	142	1,751	1,893	
5	20-30 ฿	1990	2,730	28,893	31,713	38	788	826	
6	20-30 ฿	2010	9,279	59,393	68,672	243	3.141	3.384	
B-1(a)	SES Bus Study 20-30 ฿	2000	7,407	44,440	51,847	153	1,719	1,872	
(b)	20-30 ฿	2000	7,487	44,348	51,835	155	1,707	1,862	
B-2(a)	SES Bus Study 20-30 ฿	1990	2,822	28,904	31,726	38	786	824	
(b)	20-30 ฿	1990	2,824	28,899	31,723	40	784	824	

Note: * V min. = 10 km/h

TABLE 6–9 PERCENTAGE OF VEHICLE-KMS AND VEHICLE-HOURS ON THE EXPRESSWAY

(%)

Year	FES only		FES + SES (ST-2(a))	
	Vehicle-kms	Vehicle-hours	Vehicle-kms	Vehicle-hours
1990	4.0	2.0	8.6	4.6
2000	5.7	2.3	14.4	8.3
2010	5.0	1.7	13.5	7.2

Note: The vehicle-kms and vehicle-hours on the Expressway are expressed above as a percentage of the totals.

TABLE 6–10 ESTIMATED TRAVEL SPEED

(Km/hr)

Year	FES Only			FES + SES (ST-2(a))		
	Expressway	Ordinary Road	GBA	Expressway	Ordinary Road	GBA
1990	69.8	33.7	34.4	71.8	36.7	38.4
2000	54.7	21.6	22.4	48.0	25.8	27.7
2010	48.4	16.1	16.7	38.2	18.9	20.3

(5) Average Trip Length on the Expressways

The average trip lengths of vehicles are shown in Table 6–5. This trip length is the average expressway distance travelled by the vehicles and is obtained from the ramp OD matrices of the expressways. According to these results, as a general tendency, the trip length on the expressways increases with the extension of the sections in service and year. Average trip length on the Expressway was estimated as approximately 12 kms (ST-2(a): Year 2000). On the other hand, total average trip length in GBA was 15 kms. 12 kms of average travel length occupied 22% of operating length of the Expressway (approx. 55 kms) in the year 2000. Considering the future expansion of the GBA and the flat toll tariff system, 12 kms of average travel length on the Expressway seems reasonable.

(6) Traffic Volume on Interchanges

The estimated traffic flows on the interchanges of the expressways are shown in Fig. 6–28. The detailed discussion about the interchange traffic flows is made in Chapter 9 together with peak-hour traffic volume.

(7) Traffic Volume at On/Off Ramp : 2000

Traffic volume on each ramp was estimated. For the purpose of designing the number of toll booths and the intersection planning, these results are discussed in Chapter 9.

(8) Ramp-Zone Relationship

The relationship between a rampway and zones (origin and destination) in terms of traffic volume is shown in Fig. 6–29. Reflecting a tendency that the Expressway users have long distance trips, they have substantial length on the ordinary roads approaching the Expressway. An excessive traffic concentration at on/off ramps will be reduced by increasing the number of ramps on the SES. The Expressway users generated (attracted) from the inside zones of CUA will be distributed to these additional on/off ramps on the SES.

(9) Traffic Volume on Expressways between Ramps (OD Matrices between Ramps)

Traffic volume between the on-ramp and off-ramp is shown in Appendix Table 6–17 where the ramps are grouped to identify macro-scopic tendencies. The groups are shown in Appendix Fig. 6–10. The volumes among the ramp blocks are shown as desired lines in Fig. 6–30 for SES, 2000. Among the block pair trips, the largest generated traffic flow is recognized in block No. 6 (Sathon-Bangkok Station area) and the second one is in block No. 3 (Bang Na area).

(10) SES Route Length

For the purrpose of determining the most appropriate SES route length from the traffic view point, the following four possible cases were compared:

ST-2 (a) – Full scale construction of SES

R-1 – Deletion of East connection from Phra Khanong-Bang Kapi road to the ending point of East Route of the SES (approx. 5 kms.)

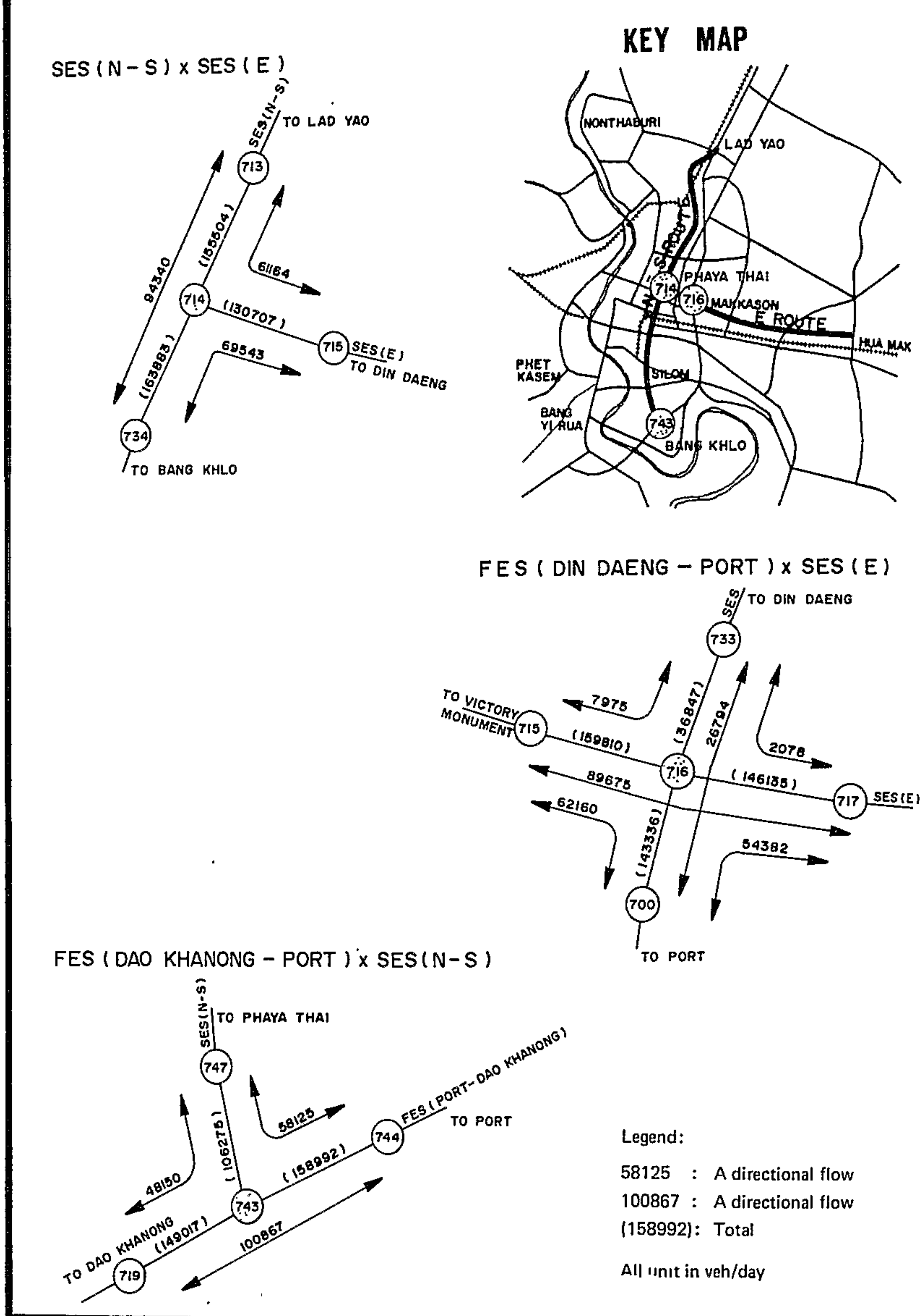


FIG. 6-28 ESTIMATED TRAFFIC FLOW AT INTERCHANGE , 2000
CASE NO. ST - 2(a)

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

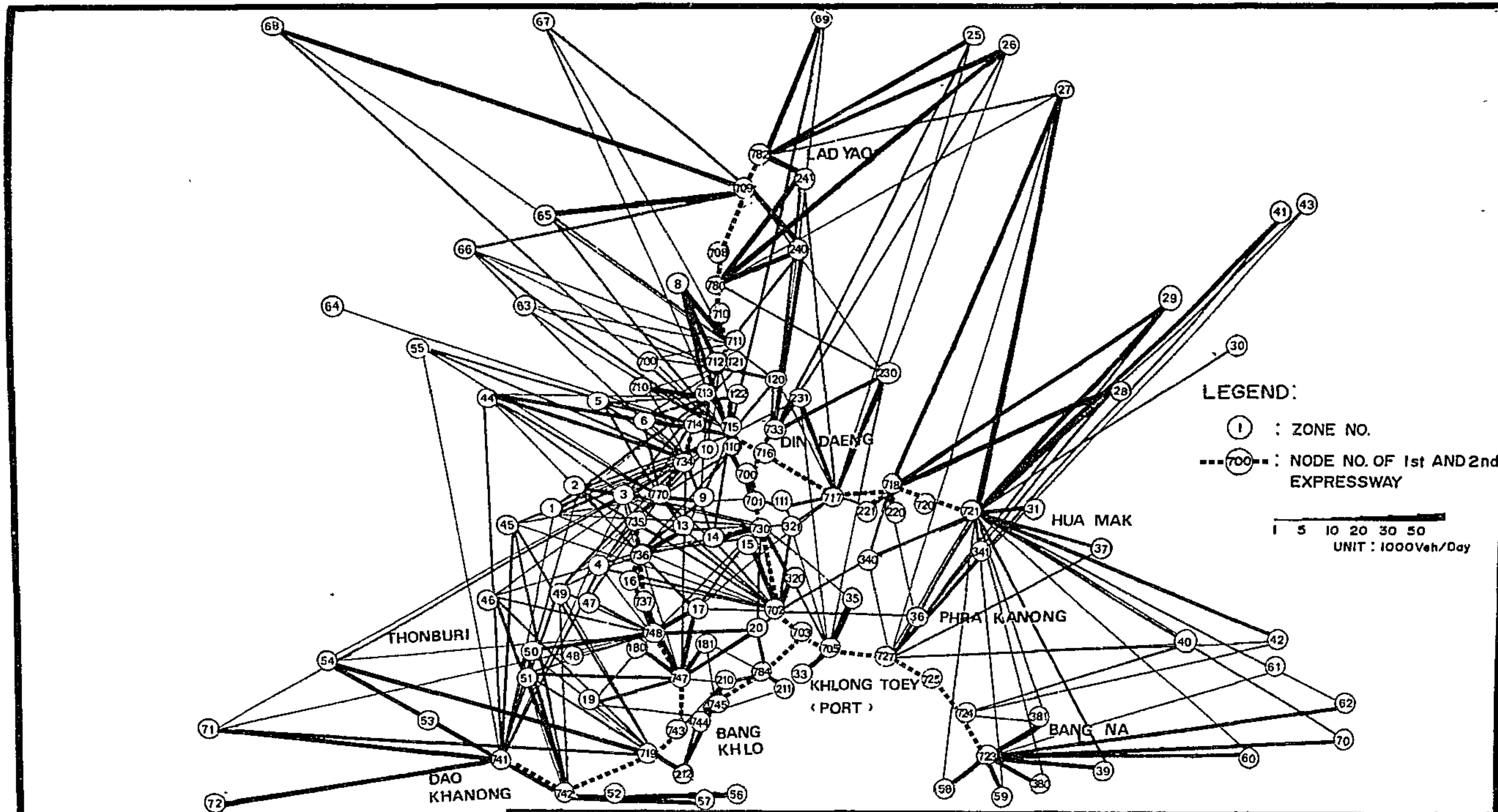


FIG. 6-29 RAMP - ZONE DESIRED LINES, 2000 CASE NO. R-1

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

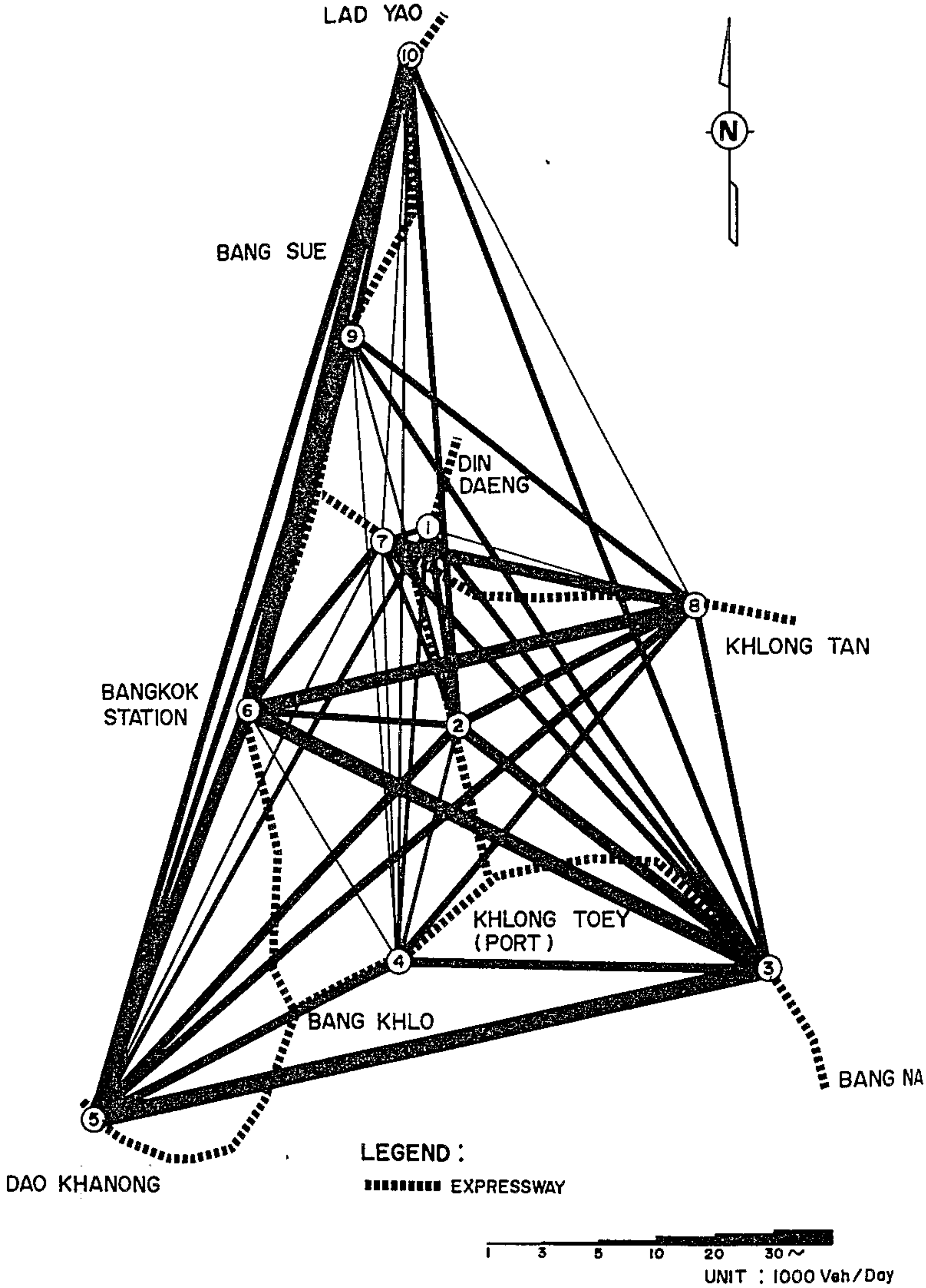


FIG. 6-30	RAMP BLOCK DESIRED LINES, 2000 CASE NO. R-1

THE SECOND STAGE EXPRESSWAY SYSTEM IN THE GREATER BANGKOK

R-2 – Deletion of North connection of the SES from Middle Ring Road to the connecting point with Super Highway (Approx. 2 kms.)

R-4 – Deleted both North and East connections of the SES

Number of trips and other results for the above alternatives area shown in the following Table 6–11.

TABLE 6–11 TRAFFIC ASSIGNMENT RESULT BY SES DEVELOPMENT ALTERNATIVES

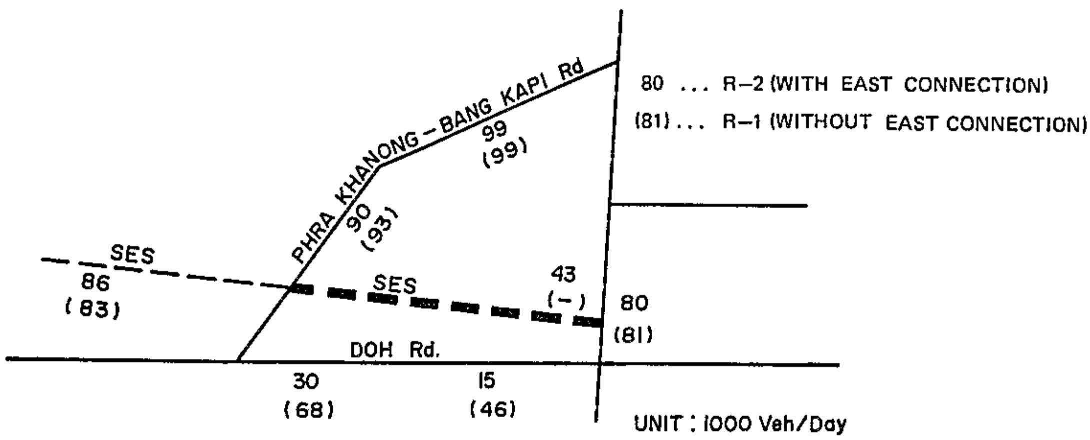
(Year: 2000)

Case No.	SES Route Network		Total Length of SES (km)	Number of Trips on the Expwy ('000 trips/day)	Trips on the Expwy (%)	Ave. Traffic Volume per Kilometer on the Expwy (veh/day)
	North Connection	East Connection				
ST-2(a)	O	O	33	594	13.4	103,231
R-1	O	X	28	594	13.4	108,054
R-2	X	O	31	591	13.4	101,983
R-4	X	X	26	589	13 3	106,858

(11) Traffic Volume at the Eastern End and the Northern End of the SES

Estimated traffic volume on the ordinary roads which run parallel with the SES North/East connection is as follows:

a) East Connection, 2000



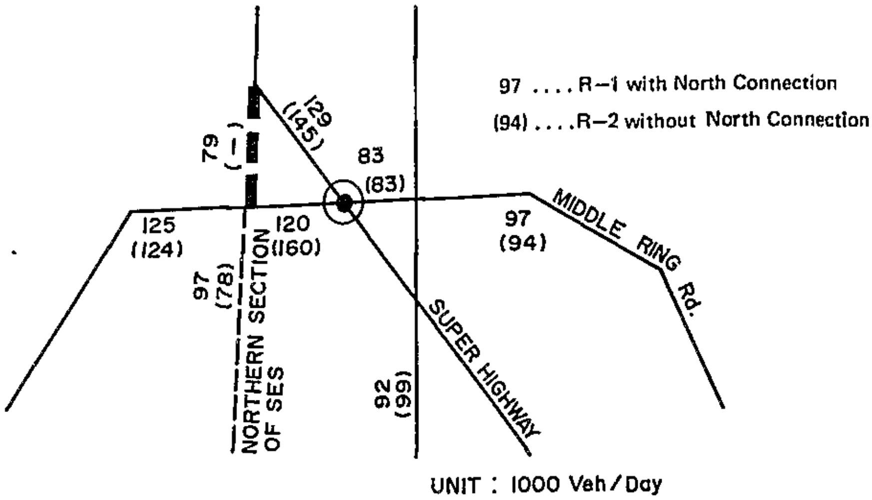
– Estimated traffic volume on the East connection was 43,000 veh/day.

– Comparing with the without East connection, estimated traffic volume on paralleled DOH road increases two to three times, however, this road has four lanes and the capacity estimates as 68,000 veh/day, therefore, it can possibly handle the estimated traffic volume.

– Estimated traffic volume on the Phra Khanong-Bang Kapi road has not increased even though the East connection is not yet constructed.

– Total estimated traffic volume on this cross section of the corridor in the year 2000 will not exceeded the capacity of the total roads in the corridor even without the easternmost section.

b) North Connection, 2000



– Estimated traffic volume on the North connection was 79,000 veh/day. If the section of SES is not constructed, the estimated traffic volume on Super Highway and the Middle Ring Road section between Super Highway and SES will have increased significantly.

– Due to the expectedly heavy traffic flow between Super Highway and the Middle Ring Road, it would be difficult to treat the traffic flow at the intersection of Super Highway and Middle Ring Road (◉ mark).

Accordingly, it is concluded that the North connection should be constructed during SES stage and the East connection should be determined by the result of the economic viability study in Chapter 12.

(12) Overall Traffic Evaluation of the Expressways

Based on the several results mentioned above the following conclusions can be made.

1) By the estimated traffic volume on the SES, the necessity of the SES, both N-S and East Routes, are identified from the traffic engineering view point.

2) Even when the SES is constructed, traffic problems in the CUA would still remain. Therefore, ordinary road construction effort by BMA should be continued both in CUA and its periphery. In addition to this, especially on the periphery of CUA, the establishment of an arterial road network is required to avoid similar traffic problems in the area in very near future.

3) It was confirmed that the completion of SES would result increases in traffic volume of FES. Indeed, as a result of completion of the SES, traffic volume on the FES would be increased by about 20%. With good cooperation between FES and SES, both Expressways can function as a single system of the "Hybrid" expressway network pattern.

4) In planning the SES, the direct linkage of the expressway with trunk radial roads was studied and proposed. Accordingly, if this planning principle is applied to the FES, an extension of the third leg (Port-Dao Khanong section) to connect with Phet Kasem Highway may be suggested. It is approximated if this extension is constructed, the traffic volume on the third leg of FES will increase by 30 percent reaching 63,000 veh/day on the westernmost section.

5) Vehicle composition by type on the expressways together with road network of GBA in 2000 is summarized as follows:

Vehicle Type	Expressway Systems	GBA Road Network
Passenger Car	82.1%	75.8%
Bus *	1.5%*	1.4%
Light Truck	10.4%	12.9%
Heavy Truck	6.0%	9.9%
	100%	100%

Note: * Private Bus only

It is foreseen that the expressways would be mainly used by passenger cars rather than by trucks and buses.

6) From the forecast traffic demand on SES in the year 2000, an additional expressway construction will be required just after the completion of the SES to form a Third Stage Expressway System.

7) Regarding the timing of construction, first priority should be given to form the Ring shaped expressway combined together with FES. Conceptual idea of this construction priority of SES is illustrated in Fig. 6–31. Basic idea of each priority section is described below together with an estimated average traffic volume per kilometer in the year 2000 by each section which is shown in the parenthesis.

Section 1:
- Heavy traffic volumes (155.8 thousand veh/day)
- Early stage realization of the difficult section to acquire the ROW
- Early stage connection with SES and FES
- Early stage construction of Makkasan Interchange

Section 2:
- Heavy traffic volume (144.9 thousand veh/day)
- Early stage realization of the difficult section to acquire the ROW
- Early stage realization of the Ring Shaped Expressway

Section 3:
- Early stage realization of the Ring Shaped Expressway
- Average traffic volume (106.6 thousand veh/day)

Section 4:
- Heavy traffic volume (147.0 thousand veh/day)
- Connection with Middle Ring Road

Section 5:
- Early stage amelioration of traffic congestion on Phahol Yothin Road and the intersection at the end on Super Highway
- Contribution to the generation of traffic volume from the Nonthaburi area
- Average traffic volume (103.7 thousand veh/day)

Section 6: – Meet the traffic demand from the East of Bangkok (Traffic will be using the DOH road for a while which runs parallel with SES)

– Average traffic volume (94.3 thousand veh/day)

Section 7: – Completion of East Route of SES

– Average traffic volume (43.0 thousand veh/day)

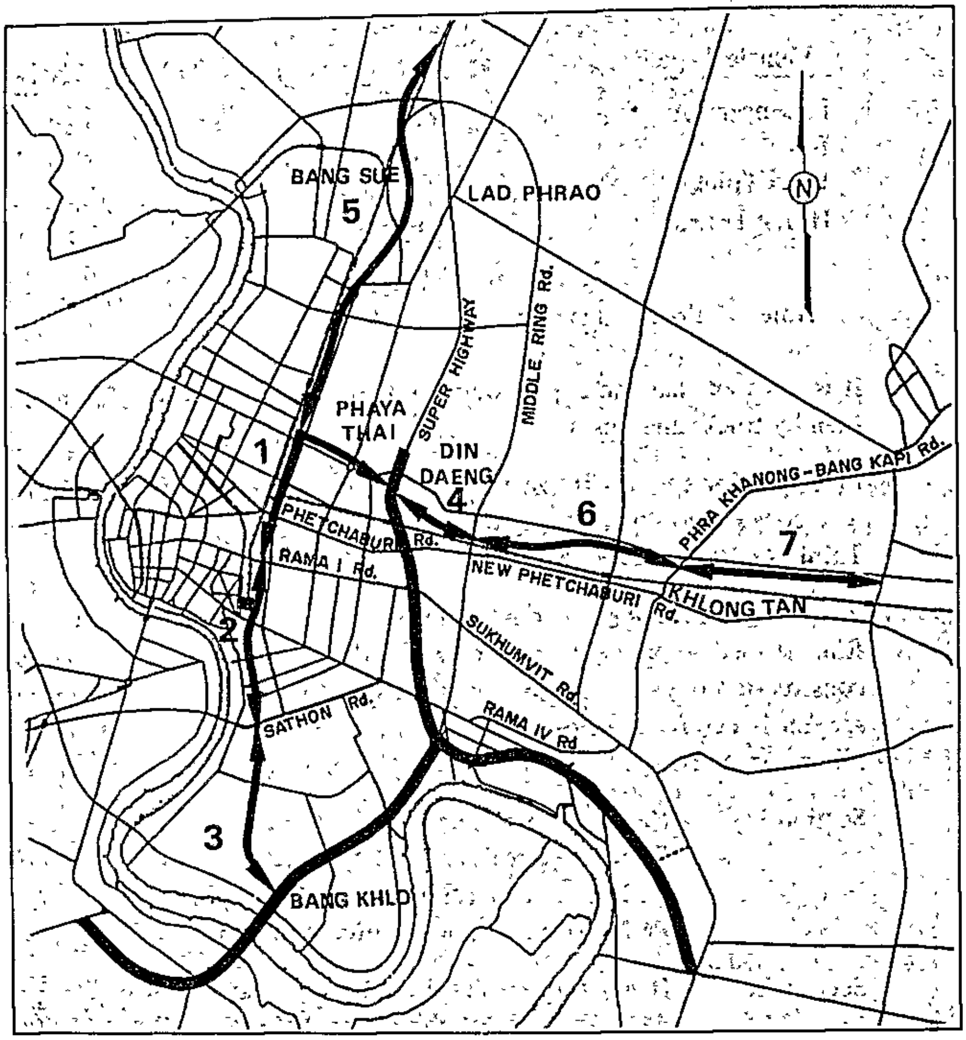


FIG. 6–31 CONSTRUCTION PRIORITY OF SES

8) To provide smooth traffic flow at on/off ramps, intersection improvement on the ordinary roads should be considered where the Expressway on/off ramps connect.

9) Final network of the SES should be determined in accordance with the economic viability which will be reflected by the future traffic demand, savings in traffic cost, and the investment efficiency.