with road and railway transports. However, it still performs some role in freight transports, especially for agricultural products and construction materials.

5) Air Transport

Thai Airways International, owned by the Government, operates scheduled services radiating from Bangkok to all over the country. Total number of commercial airports reaches 22, including 3 international airports which are Bangkok, Chiang Mai and Phuket.

3.3 HIGHWAY CONDITIONS

(1) Highway Network

Among various types of roads in Thailand, DOH has responsibility for national and provincial highways which form a frame of nationwide road network.

The total length of the existing national and provincial highways reaches 49,868 km in 1988, of which national highways are 16,698 km and provincial highways 33,170 km, as shown in Table 3.14. Among them there are 2 existing toll highways of 243 km in total which are being operated by DOH.

Table 3.14 LENGTH OF HIGHWAYS UNDER DOH RESPONSIBILITY – 1988 (Km)

Region	Special/National Highways					Provincial Highways					Total				
	Under Maintenance			Under construction	Total	Under Maintenance			Under construction	Total	Under Maintenance			Under construction	Grand Total
	Paved	Unpaved	Total			Paved	Unpaved	Total			Paved	Unpaved	Total		
North	3,366	16	3,382	360	3,742	6,117	1,424	7,541	3,592	11,133	9,483	1,440	10,923	3,952	14,875
North-East	4,597	34	4,631	90	4,721	5,538	2,056	7,594	1,548	9,142	10,135	2,090	12,225	1,638	13,863
Central	4,754	20	4,774	310	5,084	4,893	1,390	6,283	1,396	7,679	9,647	1,410	11,057	1,706	12,763
South	3,105	7	3,112	39	3,151	3,504	973	4,477	739	5,216	6,609	980	7,589	778	8,367
Total	15,822	77	15,899	799	16,698	20,052	5,843	25,895	7,275	33,170	35,874	5,920	41,794	8,074	49,868

Source : DOH

Existing national highway network including toll highways is identified based on the DOH road map and road inventory data. This is shown in Figure 3.5.

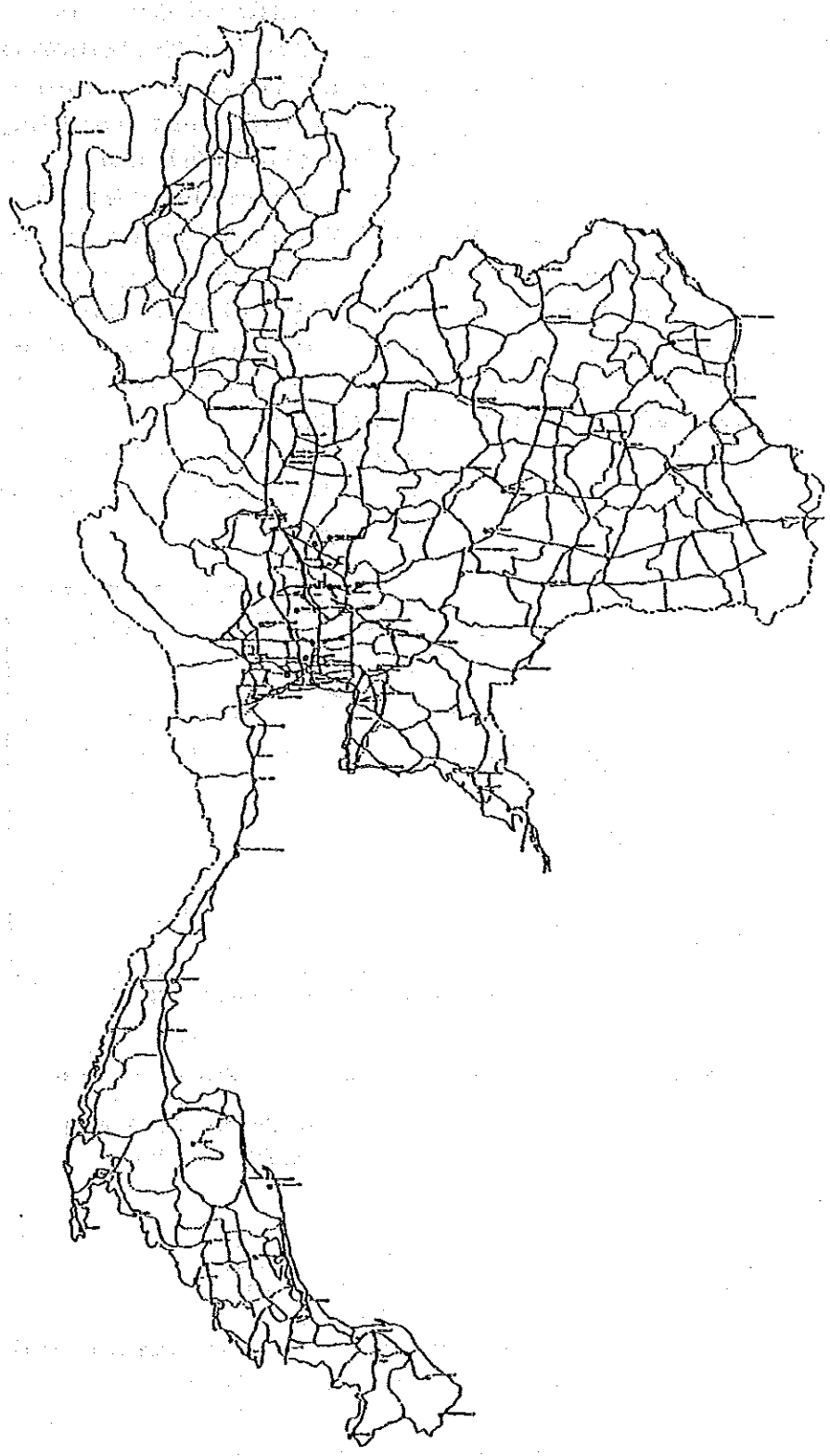


Figure 3.5 NATIONAL HIGHWAY NETWORK

2) Traffic Condition

As a general analysis, Figure 3.6 gives the cumulative frequency distribution, which prepared based on traffic counting data conducted by DOH, for the number of traffic volume counting sections on the national highways and different ranking values of ADT in the year 1989. According to the DOH policy, the limit of ADT for two-lane highways is 8,000 vehicles. The percentage of sections with more than ADT of 8,000 vehicles in the whole national highway network is only 17% at present. Assuming an approximate growth factor of 4.0 up to the target year 2010, sections with more than ADT of 2,000 at present will exceed ADT of 8,000 in 2010. This means that 67% of national highways must be improved to divided highways in 2010.

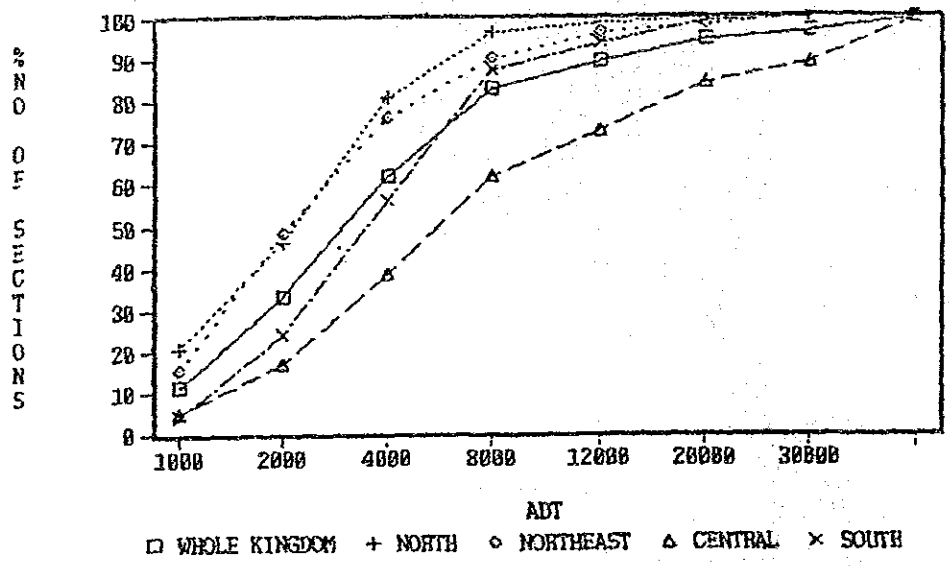


Figure 3.6 CUMULATIVE NO. OF SECTIONS AND ADT OF ALL NATIONAL HIGHWAYS — 1989

3) Budget of DOH

The amount of DOH's budget in 1988 is 10,007 million Baht which is about 4% of the government national budget.

The breakdown of this amount is 1,983 million Baht for administration, 5,208 million Baht for construction and 2,816 million Baht for maintenance.

4) Management for Toll Highways

In order to cope with the management of toll highways, DOH has set up Toll Highway Office under the Chief Engineer for maintenance.

Toll Highway Office has 5 sections in DOH's head office in Bangkok, which are; Administration, Planning, Toll Income, Account and Finance, and Concession Highway, and 3 toll collection offices in the sites of Ban Pa In and Inn Buri (Route No. 32), and Bang Na (Route No. 34) under the jurisdiction of Toll Income Section.

The open system is adopted by DOH at present as a toll collection system for all toll highways. Existing toll rates by type of vehicles are 1 Baht for motorcycle, 3 Baht for 4-wheel car, 8 Baht for 6-wheel truck and 10 Baht for 10-wheel truck.

The toll revenue of DOH is steadily increasing year by year in proportion to the increasing number of vehicles passed as shown in Figure 3.7.

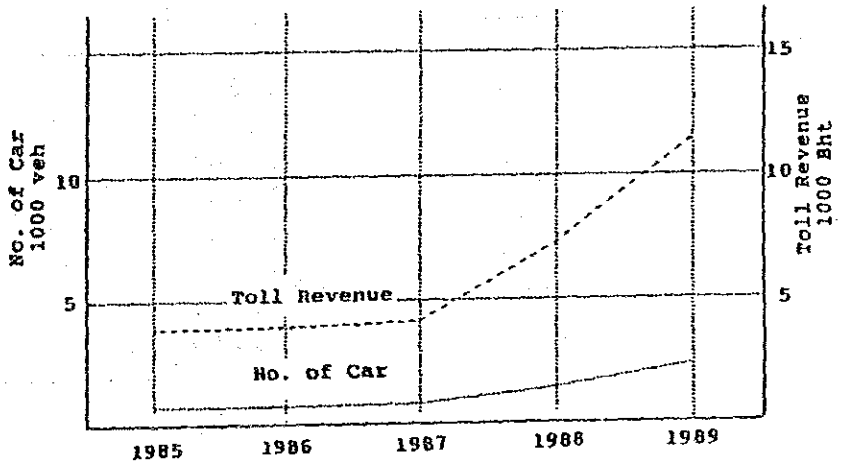


Figure 3.7 TOLL REVENUE AND NUMBER OF CARS

5) Design Standards

The average daily traffic (ADT) dictates the design of a highway in regard to its width, number of lanes, lane width and the surface type. Based on this criteria, the DOH has established the following design standards:

Highway Classification	No. of standards
Primary Highways	4 standards (P_D, P_1, P_2, P_3)
Secondary Highways	5 standards (S_D, S_1, S_2, S_3, S_4)
Provincial Highways	7 standards (F_D, F_1, F_2, F_3, F_4, F_5, F_6)

6) Traffic Accidents on Highways

Table 3.15 shows the number of traffic accidents and casualties on the highways under DOH.

Table 3.15 NUMBER OF TRAFFIC ACCIDENTS AND CASUALTIES ON DOH HIGHWAYS — 1988

Year	Accident	Killed	Injured
1981	3,211	1,652	4,749
1982	3,264	1,952	6,202
1983	2,875	1,661	5,286
1984	2,061	1,063	3,437
1985	3,178	1,629	5,681
1986	2,614	1,466	4,859
1987	2,782	1,564	4,569
1988	3,173	2,115	5,563

7) Expressways in Bangkok

In Bangkok, there are three routes of toll expressways, with 27.1 km in total, operated by ETA(The Expressway and Rapid Transit Authority of Thailand)under the jurisdiction of the Ministry of Interior.

The First Stage Expressway System of ETA is funded by the Goverment's budget and partially by foreign loan, and the loan amortization is covered by the ETA's operating revenue.

Toll rates have been classified at three categories:

Four-wheel vehicles	—10 Baht
Six or ten-wheel vehicles	—20 Baht
More than ten-wheel vehicles	—30 Baht

The toll revenue in 1988 is 858.47 million Baht against 76.6 million vehicles which used the expressways. This indicates that average toll rate per vehicle is 11.2 Baht.

On the other hand, the expenses in 1988 is 1,633.53 million Baht. Out of the total, 703.6 million Baht, which is 43% is expenses for general administration.

CHAPTER FOUR

DEVELOPMENT PLAN AND SOCIO-ECONOMIC FRAMEWORK

CHAPTER 4

DEVELOPMENT PLAN AND SOCIO-ECONOMIC FRAMEWORK

4.1 THE NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLAN

1) Regional Development Plan

The Sixth Plan sets a strategy to decentralize socio-economic activities concentrated in Bangkok to designated regional urban growth centers. These centers are classified as follows:

- Regional urban growth centers:
  Chiang Mai, Khon Kaen, Nakhon Ratchasima, Songkhla-Hat Yai and Chon Buri.

- Second-generation urban growth centers:
  Phitsanulok, Nakhon Sawan, Udon Thani, Ratchaburi, Surat Thani and Phuket.

- Other regional urban growth centers:
  Lampang, Chiang Rai, Ubon Ratchathani, Roi Et, Surin, Sakon Nakhon, Rayong, Chachoengsao, Saraburi, Kanchanaburi, Phetchaburi, Pattani and Nakhon Si Thammarat.

They are shown in Figure 4.1.

2) Eastern and Southern Seaboard Development Programs

The Eastern Seaboard Development Program which the high priority is given over the Fifth and Sixth Plans is based on new infrastructure and industrial activities that will boost Thai economy, external trade and regional balanced growth in the country.

The Eastern Seaboard area consists of three Changwats: Chon Buri, Chachoengsao and Rayong which have Laem Chabang and Map Ta Phut as industrial development areas, with a total area of about 13,215 square kilometers and a total population of about 2 million people.

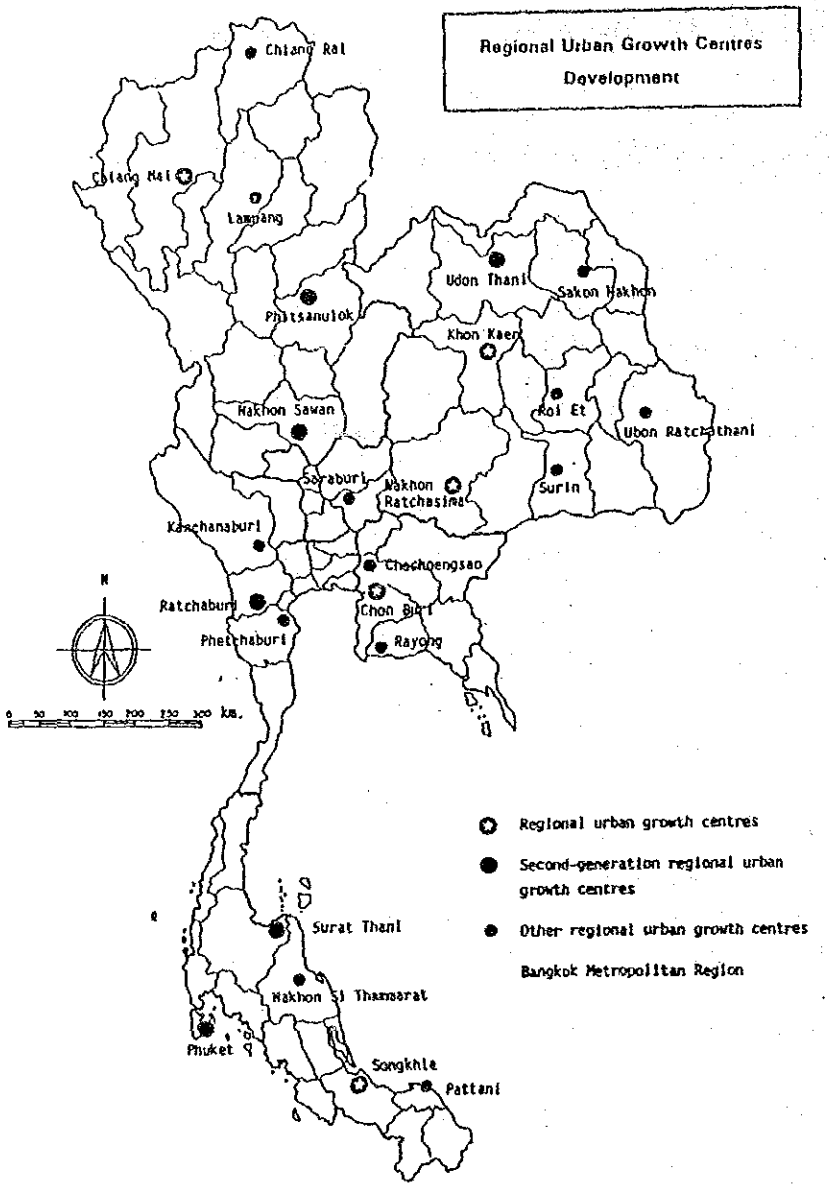


Figure 4.1 REGIONAL URBAN GROWTH CENTERS

— Laem Chabang Area

The Laem Chabang complex is located 125 km southeast of Bangkok and 10 km north of the international resort of Pattaya. It is planned to have a commercial deep-sea port, an industrial estate and an export processing zone backed up by a complete urban center and essential infrastructure.

— Map Ta Phut Area

Map Ta Phut Complex is located to the west of Rayong and 180 km southeast of Bangkok. The complex is becoming a large gas-related and heavy industry with deep-sea port.

3) Southern Seaboard Development Program

The Southern Seaboard development program is planned aiming at alleviation of the urban concentration around Bangkok by strengthening productive capacities and investing in infra-structure of the area. The basic components of the program are:

— Krabi Terminal: Offshore loading-unloading crude terminal/ deep-sea port/ industrial estate/ new town

— Khanom Terminal: Offshore loading-unloading crude terminal/ deep-sea port/ industrial estate/ new town

— Landbridge: High speed road/ rail/liquid (crude/natural gas/petrochemical/water) pipeline

4.2 ESTABLISHMENT OF SOCIO-ECONOMIC FRAMEWORK

Population and GPP are selected as the major items of the framework to forecast the future traffic volume, because they are closely related to traffic generation and attraction.

1) Population

The growth rate of population is assumed based on NESDB's medium fertility assumption which is recommended for policy and plan formation and the past trend of population growth, as shown in Table 4.1.

Table 4.1 ESTIMATED POPULATION GROWTH RATE (%)

	1985-1990	1990-1995	1995-2000	2000-2005	2005-2010
Annual Growth Rate (%)	2.0	1.8	1.4	1.1	0.9

On the basis of above growth rates, the total population of the whole kingdom is forecasted and then the regional population is estimated by means of the total population as the control total. The results of estimation are presented in Figure 4.2.

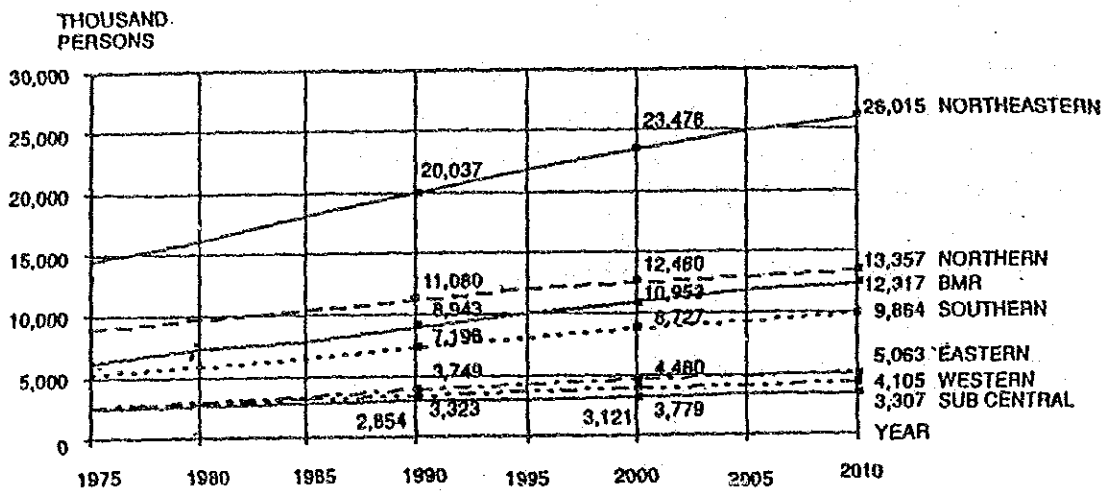


Figure 4.2 FUTURE POPULATION BY REGION

The population by Changwat is calculated based on the trend during the period of 1975 — 1988. Changwat population thus predicted is modified in the same way by means of the population in the region as the control total.

2) Economic Indicators

Based on the trend of economic growth of Thailand and various reports presented by many agencies, the annual growth rate of GDP is estimated to be 6.4% from 1990 to 2000 and 5.1% from 2000 to 2010.

By applying these growth rates, GDP is estimated as shown in Figure 4.3.

The GRP is calculated based on the past trend by using the results of regression analyses and then modified by means of GDP as the control total as shown in Figure 4.4.

The GPP is estimated on the same manner as the GRP estimation.

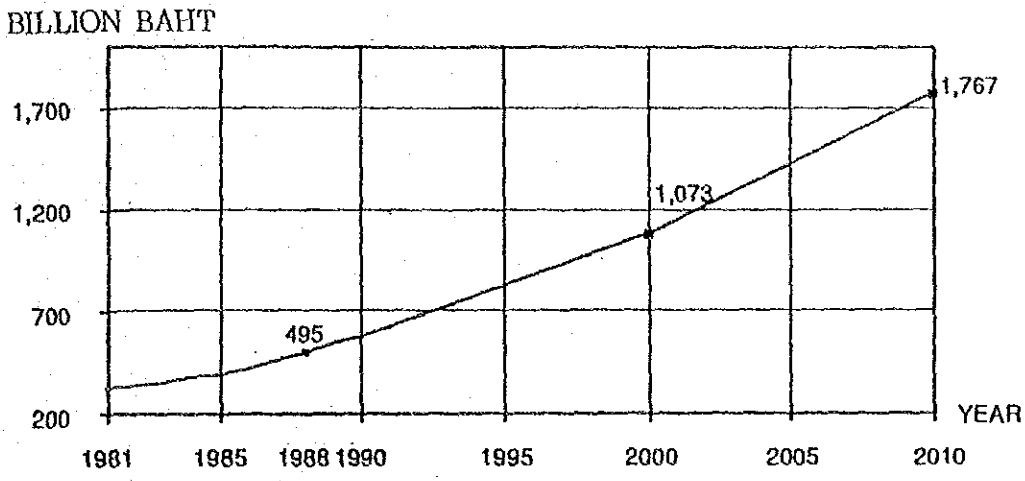


Figure 4.3 FUTURE GDP AT 1972 CONSTANT PRICES

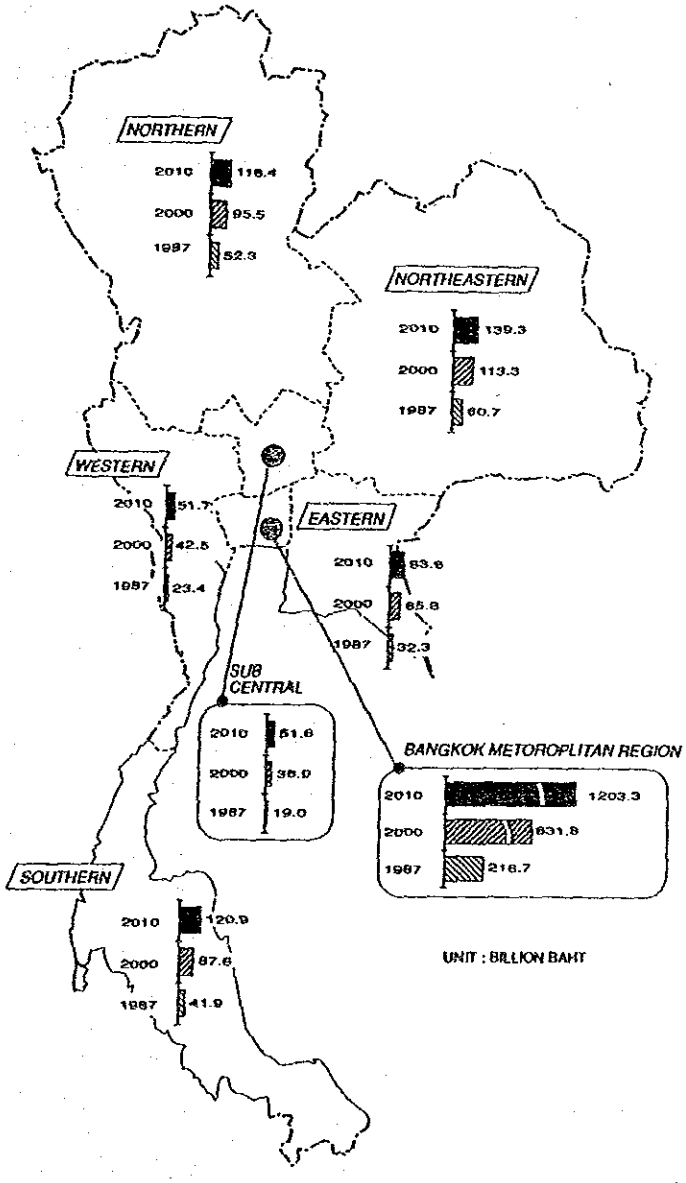


Figure 4.4 FUTURE GRP AT 1972 CONSTANT PRICES

CHAPTER FIVE

TRANSPORTATION DEVELOPMENT PLAN

CHAPTER 5

TRANSPORTATION DEVELOPMENT PLAN

5.1 FUTURE PLAN OF TRANSPORTATION SECTORS

The Government of Thailand is preparing the Seventh National Economic and Social Development Plan (the Seventh Plan) to establish basic national policies for the next 5 years from 1992 to 1996. Guidelines for transport development to instruct the development strategies for transportation are to be included in the Seventh Plan as one of the important national policies.

Outline of the guidelines for the land transport under examination is as follows:

Roles

- Land transport will continue to be the major mode.
- Land transport must support air and water transport to provide efficient inter-modal transport.

Objectives

- To develop land transport as to support the growth of all sectors of the economy.
- To emphasize land transport as a mean of distributing development to people in rural areas, improving living standards and protecting the environment.
- To attempt to solve the problem of congestion and to reduce environmental damage in towns, especially in seriously affected areas, i.e. Bangkok Metropolitan Region.

Strategies

- Developing land transport in line with growth in the na-

tional economy.
. To develop land transport for special economic areas.
. To develop land transport links with neighbouring countries.
. To provide land transport links with other modes.

— Distributing the development of land transport to the regions and to rural areas.
. To expand the road network in the regions.
. To increase the efficiency of rail transport.
. To construct passenger and freight terminals.
. To promote the efficient use of roads.

— Alleviating the problem of traffic congestion and the deterioration of the environment in towns.
. To adopt a long term plan (15 years) to solve the problem.
. To encourage private sector participation in solving the problem.
. To adopt overhead mass rapid transit system.
. To adopt transport system management to increase efficiency.
. To construct urban expressways.
. To amend rules and regulations.

5.2 CONCEPT OF THE SEVENTH HIGHWAY DEVELOPMENT PLAN

According to the concept for the land transportation development plan in the Seventh Plan, DOH is now preparing the Seventh Highway Development Plan.

The main targets of the Highway Development Plan are:

— To develop the Special Highways System or the Inter-city Motorway System and upgrade highway standards, especially the increase of the traffic lanes for the important road network.
— To emphasize on the rehabilitation of the existing roads.
— To construct the bypass road in the major cities which have serious traffic problems.
— To develop and expand the provincial highway network.
— To emphasize on traffic road safety programme.
— To introduce toll motorway system.

CHAPTER SIX

TRAFFIC SURVEY, ANALYSIS AND FORECAST

CHAPTER 6

TRAFFIC SURVEY, ANALYSIS AND FORECAST

6.1 INTRODUCTION

For the estimation of traffic volumes on planned motorways, three traffic surveys on the national highway network are carried out. Collected data from the surveys are used to analyze the present traffic characteristics and to establish OD tables for inter-Changwat trips per vehicle category. Then, a trip generation model is developed on the basis of the estimated future socio-economic indicators to forecast the future trip generation of each Changwat. The forecasted trips are applied to trip distribution process to establish the future OD tables for the target years of 2000 and 2010.

Traffic volumes are assigned first on the existing and future national highway networks without considering the proposed motorway network, which is the case of "Without Project". Next, volumes of traffic which will have to be handled in the future on both of the motorway network and the national highway network are determined, which is the case of "With Project".

6.2 TRAFFIC SURVEYS

The following three surveys are carried out in this study:

- OD survey
- Classified traffic counting survey
- Traffic speed survey

1) Origin-Destination Roadside Interview Survey

a. Purpose

The purposes of this survey are as follows:

i. To prepare the present OD tables
ii. To forecast the future OD tables
iii. To estimate the future traffic volumes on the motorway network

b. Zoning

The zoning is carried out on the administrative base in which each Changwat is considered as one zone. Survey locations are located on the national highway network at the Changwat boundaries. There are 73 Changwats in the whole kingdom which will produce OD matrices with the size of 73 × 73.

c. Location of Survey Stations

A total number of 123 survey stations is set up through reviewing and analyzing geographical and socio-economic data. They are classified into three types according to their locations as follows, so they can be used as regional and divisional screen lines in the analysis procedure.

Region Stations	11
Division Stations	33
Changwat Stations	79
Total Number of Survey Stations	123

d. Survey Items

The survey are carried out on the following nine types of vehicles.

- Passenger car and taxi
- Light bus
- Medium bus
- Heavy bus
- Pick-up (passengers)
- Pick-up (commodity)
- 4-Wheel truck
- 6-Wheel truck
- 10-Wheel truck

Collected data of the survey are:

i. Vehicle data
  - Type
  - Capacity

ii. Trip data
- Origin (Changwat and Amphoe)
- Destination (Changwat and Amphoe)
- Purpose
- Number of passengers
- For trucks: Number of assistants
  commodity volume
  commodity type

e. Procedure

The survey is made on sampling base in the two directions of traffic for twelve hours (06:00-18:00) on weekdays.

2) Classified Traffic Counting Survey

a. Purpose

The purpose of this survey is to get expansion factors to expand the OD data collected for twelve hours.

b. Procedure

The survey is made for twenty-four hours (06:00-06:00) at the same stations and on the same days of the OD survey. Categories of vehicles are as follows:

- Tricycle (with engine)
- Motorcycles
- Passenger Car and Taxi
- Light Bus
- Medium Bus
- Heavy Bus
- Pickup Truck
- 4-Wheel Truck
- 6-Wheel Truck
- 10-Wheel Truck
- Other Vehicles (with engine)

3) Traffic Speed Survey

a. Purpose

The purpose of this survey is to get basic data to estimate the travel time for each designated link in the national highway network.

b. Procedure

Survey locations are selected for this survey according to the different highway classifications and levels of service. The total selected number of sections is 35 sections which represent all the DOH classes for the national highway network.

The survey is carried out by one team for about three weeks using the floating car method which consists of a minimum of three runs for each traffic direction. Collected data are:

- Road and section identification
- Day, date, direction and weather
- Start and finish time
- Traffic volume for 15 minutes
- Time and speed for each run
- Average speed for each direction.

6.3 ESTABLISHMENT OF PRESENT AND FUTURE OD TABLES

Present and future OD tables are prepared based on procedures shown in Figure 6.1.

Surveyed OD data are expanded based on expansion factors derived from the classified traffic counting survey and daily and monthly fluctuation factors prepared by analyzing DOH permanent counting data.

In order to avoid the adoption of double counted data, trips are screened as follows:

- Only inter-region trips are selected at survey stations on region boundaries.

- Only inter-division trips in the same region are selected at survey stations on division boundaries.

- Remaining trips, i.e., inter-Changwat trips in the same division are selected at survey stations on Changwat boundaries.

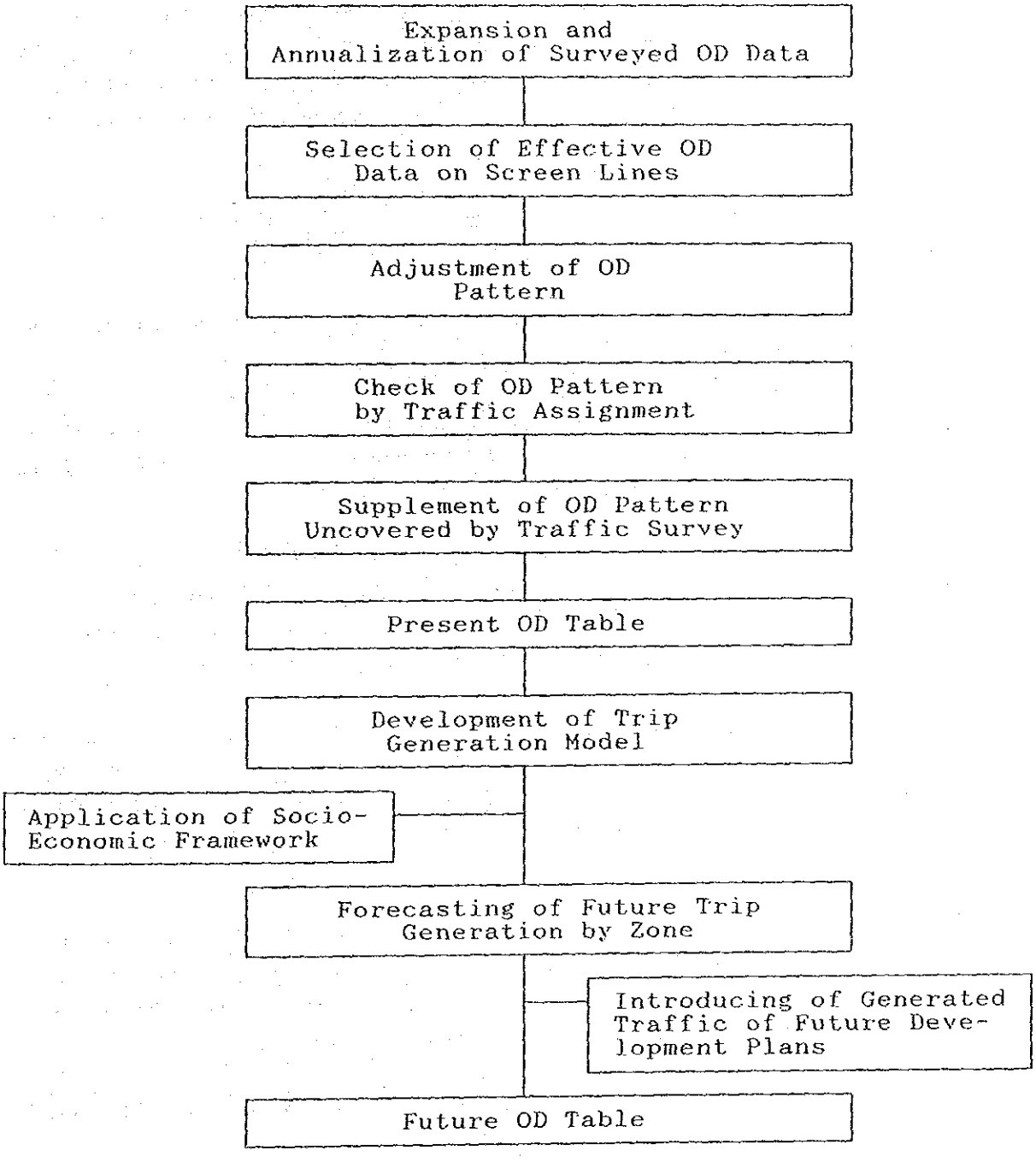


Figure 6.1 FLOW CHART TO ESTABLISH PRESENT AND FUTURE OD TABLES

Trips which can not be recorded during 12 hours between 06:00 and 18:00 hrs. are adjusted by a scanning procedure for all surveyed OD data.

Trip matrices of the OD table thus prepared are allocated on the existing national highway network in the form of assigned traffic volumes. Validity of the prepared OD table is checked by comparing this assigned traffic volumes with actual traffic volumes.

OD pattern on links uncovered by the OD survey is supplemented with ADT data of DOH.

Through procedures mentioned above, the present OD table of the year 1990 is prepared.

Trip generation model is developed by analyzing the relationship between attracted and generated trips in the present OD table and socio-economic indexes for each zone.

Applying the estimated socio-economic indexes of the future framework to the generation model, future trip generation by zone is calculated. The trip generation by zone is converted to the form of the OD table by applying Frater Method.

Trips generated by future development plans, i.e., the Eastern Seaboard Development Plan and Southern Seaboard Development Plan, are estimated through reviewing the size and the schedule of the plans. These estimated trips are added to the above future OD table.

Through procedures mentioned above, future OD table for the years 2000 and 2010 are prepared. Based on these tables, the number of trip-ends on the division level in 1990, 2000 and 2010 are illustrated as shown in Figure 6.2.

As shown in this figure, the number of trip-ends in 2010 will reach 4.3 times of that in 1990.

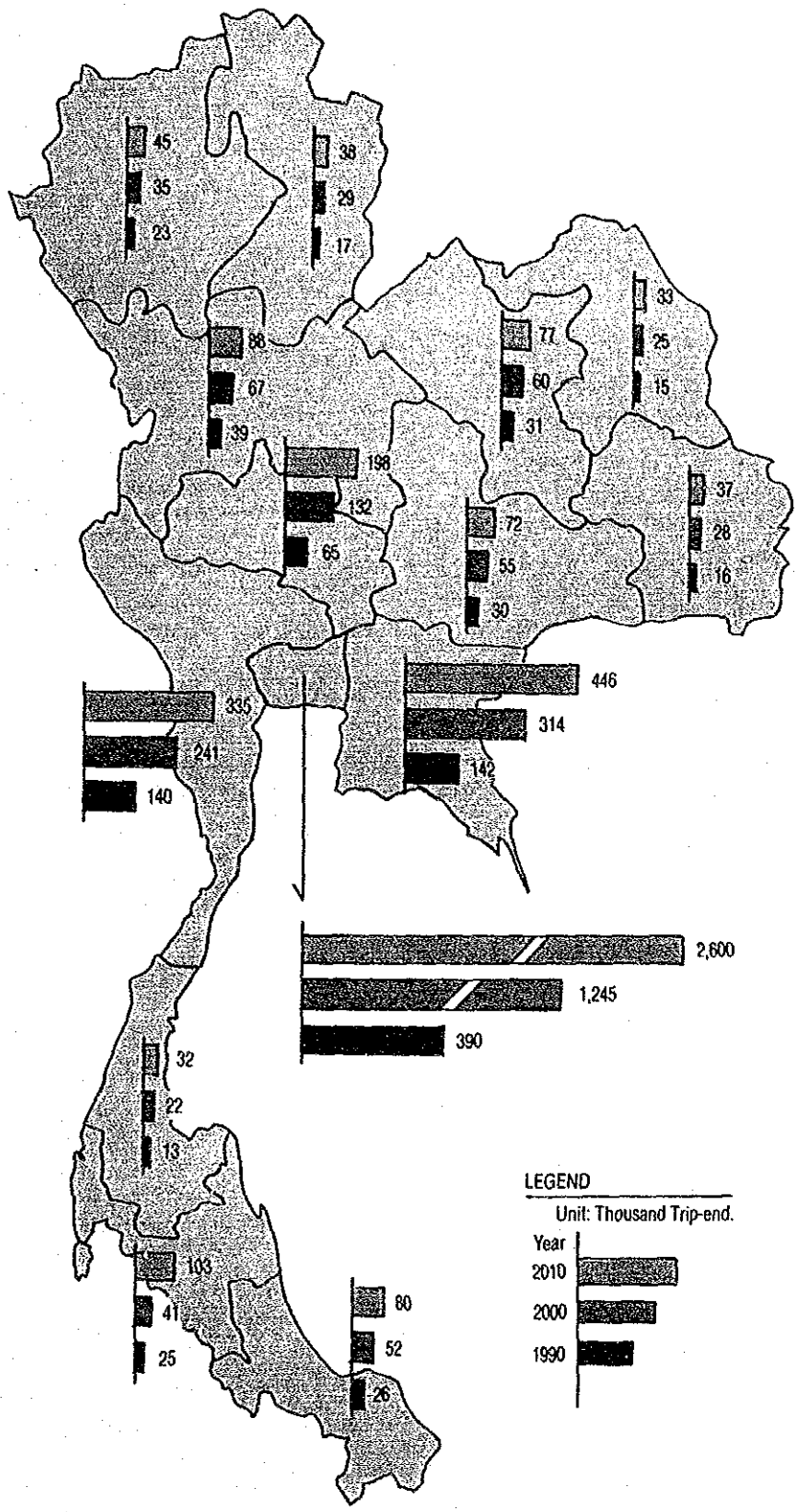


Figure 6.2 PRESENT AND FUTRE TRIP GENERATION AND ATTRACTION BY DIVISION

6.4 TRAFFIC ASSIGNMENT

Trip matrices of the OD tables are assigned as follows:

- Present trip matrices are assigned on the existing national highway network in 1990.

- Future trip matrices are assigned on the future national highway network in 2000 and 2010; "Without Project" case.

- Future trip matrices are assigned on the future national highway and proposed motorway networks in 2000 and 2010; "With Project" case.

The assignment procedures are shown in Figure 6.3.

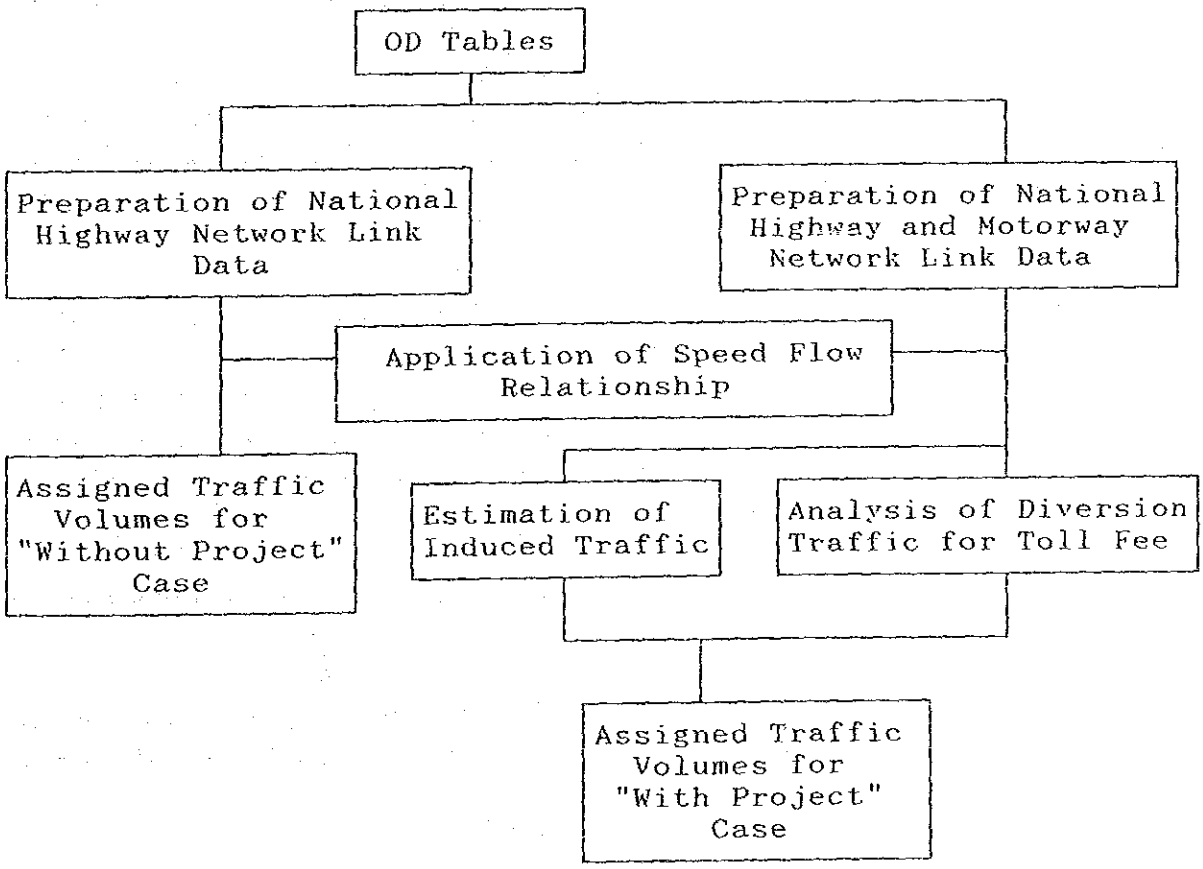


Figure 6.3 FLOW CHART FOR TRAFFIC ASSIGNMENT OF FUTURE TRIPS

Required travel time is calculated for each link according to its link data of travel speed and road conditions, and trips matrices are assigned to the shortest route connecting concerned OD pair in terms of travel time.

When traffic assigned on the shortest route increased till a certain level of congestion, alternative routes are selected to handle remaining trips.

The speed flow relationship applied for selection of the shortest route is derived from the traffic speed survey.

Through the above procedures, traffic volumes on national highway networks in "Without Project" case are estimated.

For the estimation of traffic volumes in "With Project" case, two procedures; the estimation of induced traffic and the analysis of diversion traffic for toll fee, are applied in addition to the same assignment technique applied for "Without Project" case.

The induced traffic is estimated through developed induced traffic model which is structured based on the saving in travel time between "Without Project" and "With Project" cases for each OD pair.

The diverted traffic from the national highways to the motorways is estimated considering constraint of toll fee. Toll fees are assumed to be 1 Baht/km for light vehicles and 2 Baht/km for medium and heavy vehicles. The formula used by Nihon Doro Kodan is applied after conversion and comparison with the formula of AASHTO.

Assigned traffic volumes on the national highway network in 1990 are shown in Figure 6.4.

Assigned traffic volumes on the national highway network without motorways and on the toll motorway network are shown in Figure 6.5 and 6.6, respectively.

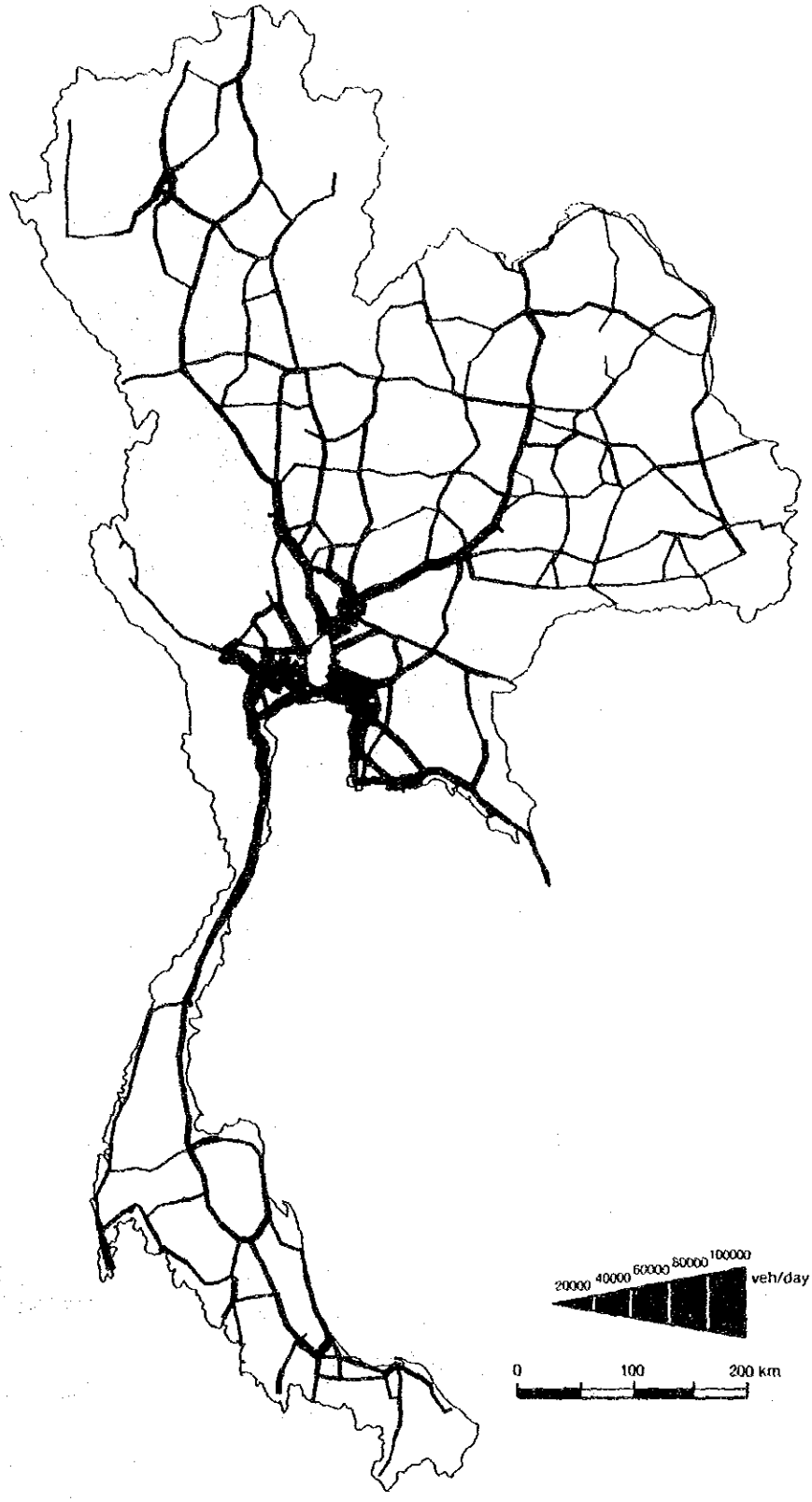


Figure 6.4 ASSIGNED TRAFFIC VOLUMES ON NATIONAL HIGHWAY NETWORK – 1990

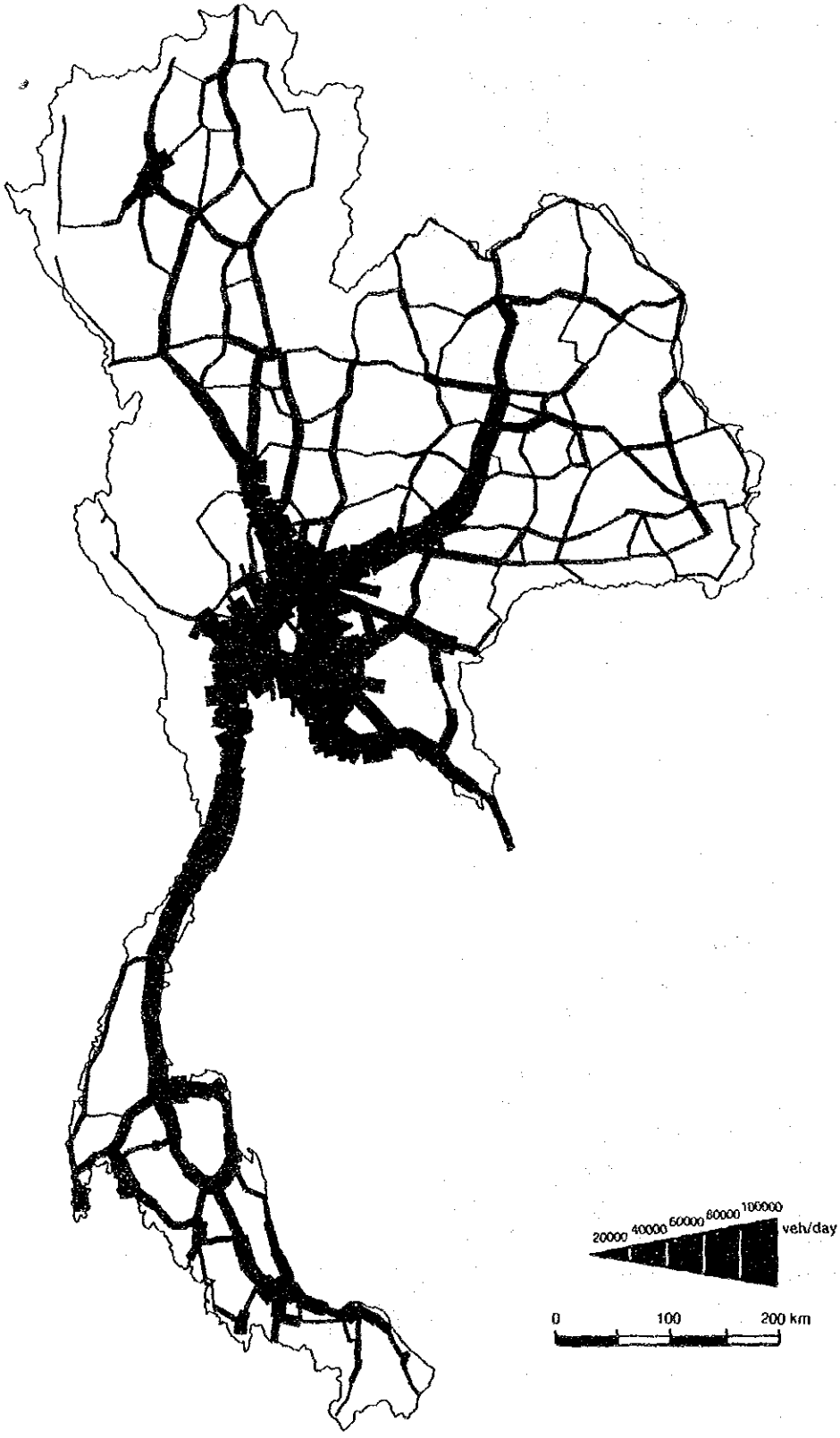


Figure 6.5 ASSIGNED TRAFFIC VOLUMES ON NATIONAL HIGHWAY NETWORK ("Without Project" Case) – 2010

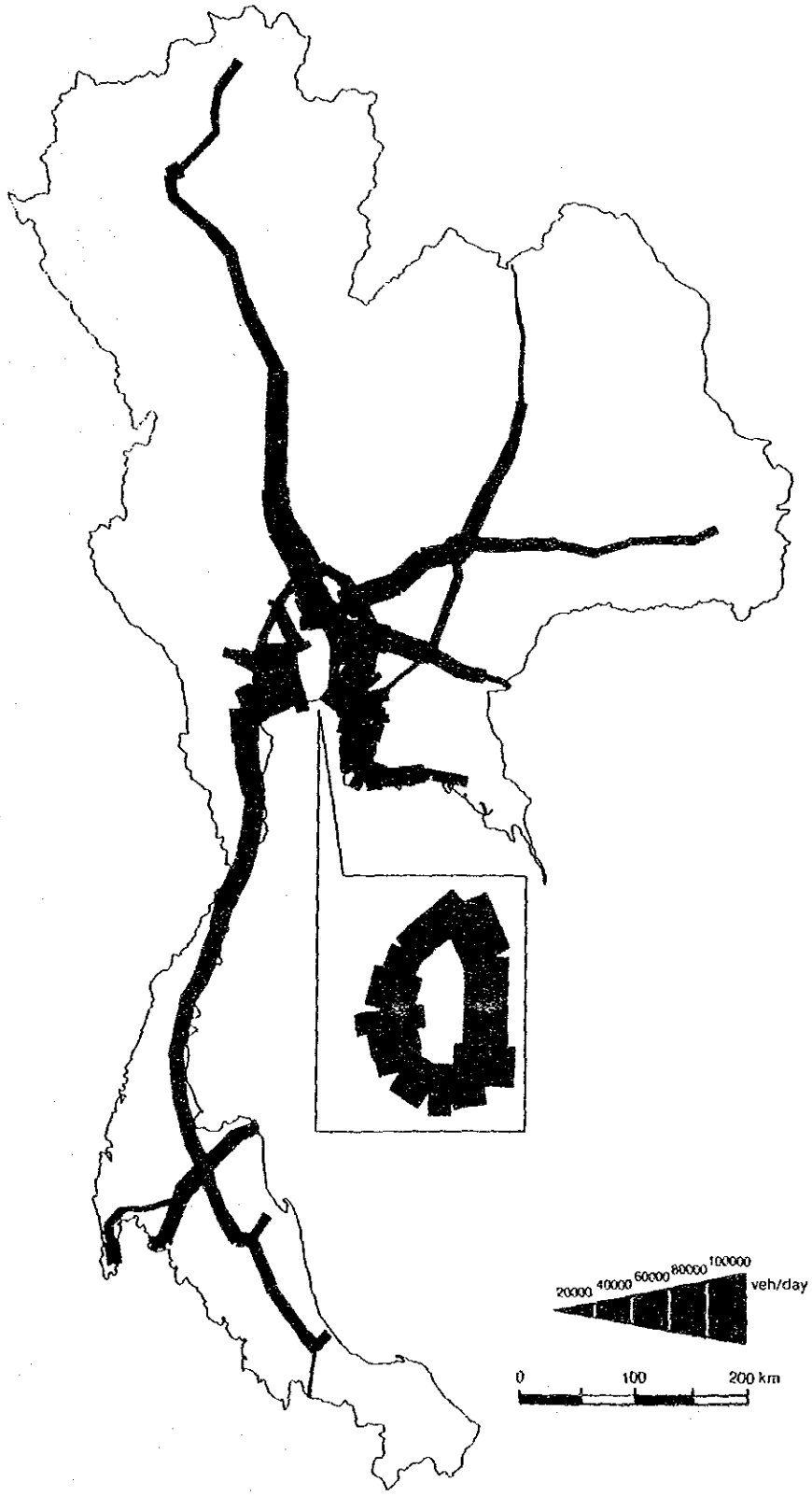


Figure 6.6 ASSIGNED TRAFFIC VOLUMES ON PROPOSED TOLL MOTORWAY NETWORK

CHAPTER SEVEN

MOTORWAY NETWORK MASTER PLAN

CHAPTER 7

MOTORWAY NETWORK MASTER PLAN

7.1 MOTORWAYS DEVELOPMENT POLICY

The nationwide motorway network should be established in order to realize the following development policies of the Government of Thailand.

- To sustain the current remarkable economic growth by dealing effectively with increasing transport needs.
- To plan universal development of the whole nation by speedy and effective transportation system between regions.
- To promote decentralization of socio-economic activities from Bangkok and its surrounding areas by improving transportation conditions in regional areas.
- To promote development of industrial developing areas and growth pole cities designated in the National Plan by tightly connecting them.
- To alleviate regional disparities in socio-economic level by promoting development in regions, especially by generating or attracting industrial activities.
- To form a part of international highway network, particularly the Pan Asian Highway, to promote exchanges and trades to neighbouring countries.
- To ensure on-time and safe driving by alleviating traffic congestion and baring mixed traffic which is a main cause of traffic accidents.
- To create job opportunities in regional areas through investments for motorway construction.

The development of motorways requires a huge amount of cost. In order to raise this huge amount of the road investment with less government burden, introduction of "Special Funds System" and "Toll Road System" should be considered.

7.2 PROCEDURE FOR ESTABLISHMENT OF MASTER PLAN

Figure 7.1 shows the practical procedures for establishment of the master plan of the motorway network.

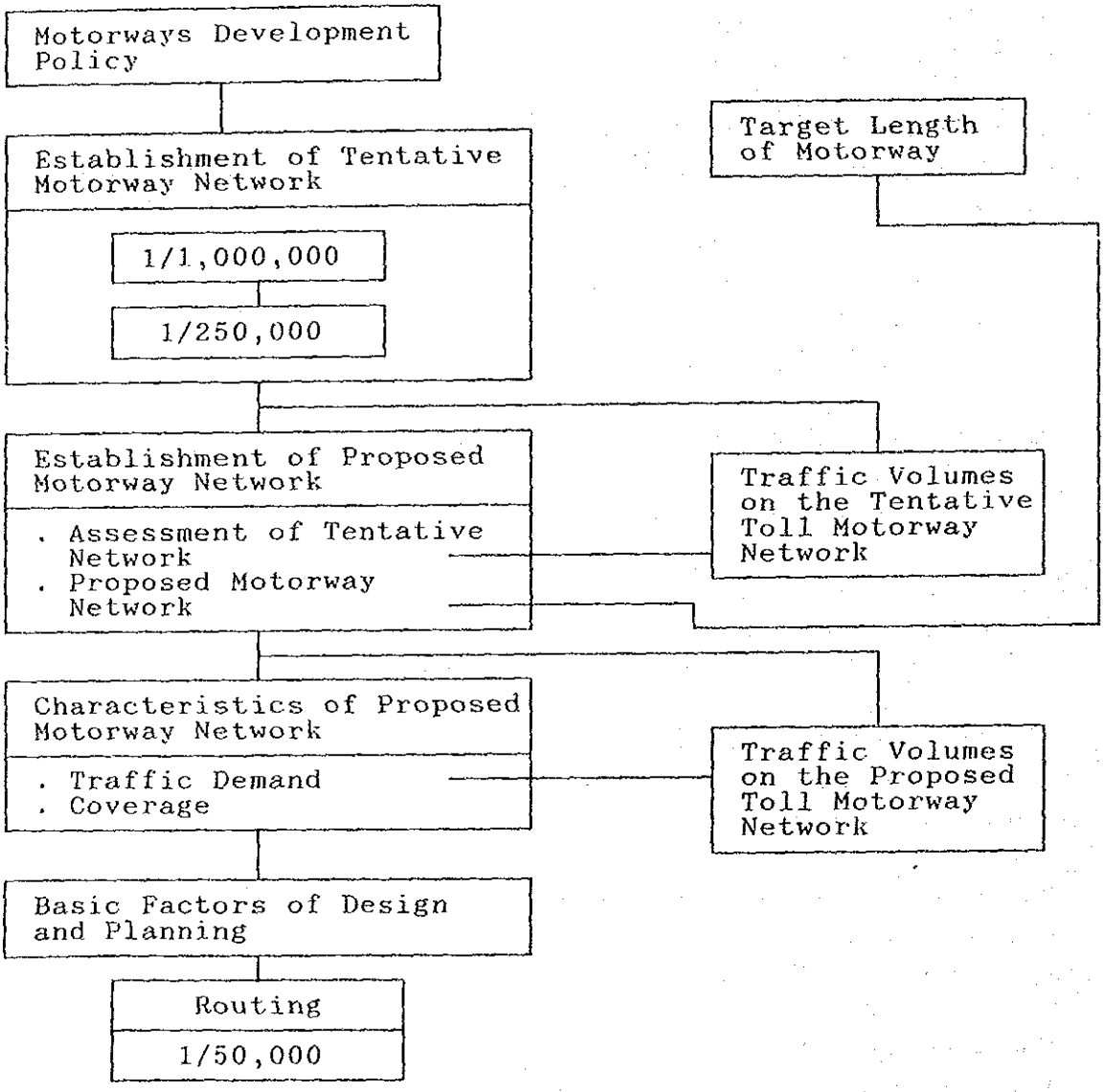


Figure 7.1 PROCEDURES FOR ESTABLISHMENT OF MASTER PLAN OF THE MOTORWAY NETWORK

7.3 TARGET LENGTH OF MOTORWAYS

Generally, the target length of roads required for a country or region is related to the indices of the area, population and per capita GNP, and can be estimated by the following equation:

$$L = K\sqrt{A \times P}$$

where,
- L : Target road length
- K : Function of per capita GNP (G)
- A : Area
- P : Population

The relationship between K and per capita GNP (G) is obtained based on K values of 12 selected countries as follows.

$$K = 0.000686056 + 0.000000087 \times G$$

Applying the following indices of Thailand, the target length of motorways in Thailand is calculated to be 4,124 km, as shown in Table 7.1.

Table 7.1 TARGET LENGTH OF MOTORWAYS IN THAILAND

	in 1988
GNP Per Capita Income (US$)	1,062
Area (Km^2)	514,000
Population (1,000)	54,560
Target Length (Km)	4,124

7.4 ESTABLISHMENT OF TENTATIVE MOTORWAY NETWORK

7.4.1 Basic Idea for Planning

The motorway network is established through the following basic ideas:

— To connect Bangkok metropolitan area with all other regions as the arteries of the network aiming for drastic improvement in nationwide land transportation.

— To directly connect the industrial developing areas with the cities designated in the National Development Plan as cultural and industrial regional centers aiming for their development.

— To connect most of Changwat centers, large industrial developing estates, important airports, sea/inland ports and famous places of interest so that these major points can be connected through the motorway within reasonable time aiming for the universal development of national land, the effective utilization of cultural facilities and the promotion of tourism.

— To connect major points accessing to neighboring countries aiming for the formation of a part of the international highway network and encouragement of exchange and trades with them.

— To construct Outer Bangkok Ring Motorway which will redistribute the traffic pattern.

In areas with high potential but not covered by the basic ideas mentioned above, supplementary motorways are planned considering the population, economic and social importance in these areas so as to enjoy the benefits of the motorway network.

The major points such as designated developing areas and cities, Changwat centres, important transport centres, etc., considered in the formation of the motorway network are shown in Figure 7.2.

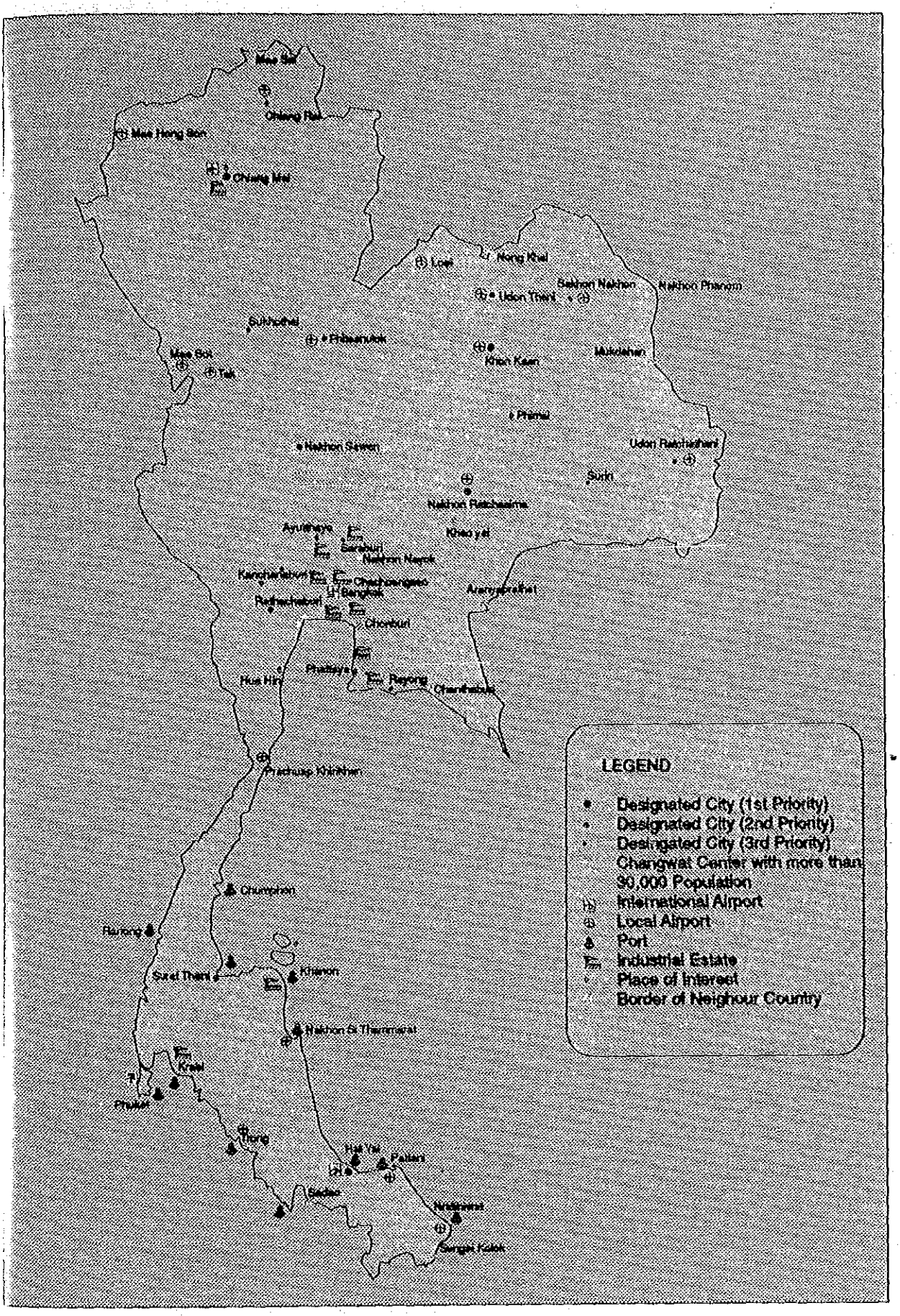


Figure 7.2 LOCATIONAL MAP OF MAJOR POINTS

7.4.2 Tentative Motorway Network

The tentative motorway network is established based on the basic ideas for planning.

Practical routing for the tentative motorway network is carried out on 1/250,000 map considering the control points after rough trials on 1/1,000,000 map.

The total length of the established tentative motorway network is 5,851 Km. It is shown in Table 7.2.

Table 7.2 TENTATIVE MOTORWAY NETWORK

ROUTE NO.	ORIGIN	DESTINATION	LENGTH (km)
TR-1	OBRR	CHIANG MAI	578
TR-2	OBRR	NONG KHAI	534
TR-3	OBRR	RAYONG	196
TR-4	OBRR	KLONG PRAUN (SONG KHLA)	941
TR-5	OBRR	OBRR	170
TR-6	KRABI	KHANOM	184
TR-11	UTTARADIT	MAE SAI (CHIANG RAI)	363
TR-12	MAE SOT (TAK)	MUKDAHAN	696
TR-31	OBRR	KANCHANABURI	101
TR-32	OBRR	ARANYAPRATHET (PRACHIN BURI)	222
TR-33	CHON BURI	NAKHON RATCHASIMA	230
TR-41	PHRASAENG (SURAT THANI)	PHUKET	143
TR-42	HAT YAI (SONG KHLA)	SUNGAI KOLOK (NARATHIWAT)	208
TR-101	CHIANG MAI	MAE SUAI (CHIANG RAI)	146
TR-201	UDON THANI	SAKHOL NAKHON	146
TR-202	NAKHON RATCHASIMA	UBON RATCHATHANI	299
TR-301	RATCHABURI	THA WUNG (LOP BURI)	168
TR-302	THA WUNG (LOP BURI)	BANG PAKONG (CHACHOENGSAO)	187
TR-303	ORR	SUPHAN BURI	62
TR-401	RON PHIBUN (NAKHON SI THAMMARAT)	NAKHON SI THAMMARAT	36
TR-2001	SAKHOL NAKHON	NAKHON PRANOM	78
TR-3001	RAYONG	CHANTHABURI	98
TR-4001	TUNG SONG (NAKHON SI THAMMARAT)	TRANG	65
		TOTAL	5,851

7.5 ESTABLISHMENT OF PROPOSED MOTORWAY NETWORK

7.5.1 Assessment of the Tentative Motorway Network

In order to establish a proposed motorway network, each route of the tentative motorway network is evaluated according to the covered major points and population as well as handled traffic volumes.

Criteria adopted in the assessment are as follows:

1. Major point-coverage value:
   is the numbers of the major points from where a traveler can arrive to the nearest interchange within 60 minutes.

Major points/100 kilometer	Marks
less than 5	**
5 - 10	*
more than 10	no

2. Population-coverage value:
   is the total population who can arrive to the nearest interchange within 1 hour.

Population/kilometer	Marks
less than 10,000	**
10,000 - 20,000	*
more than 20,000	no

3. Traffic Volume:
   is the average daily traffic volume (ADT) without induced traffic.

ADT	Marks
less than 8,000	**
8,000 - 12,000	*
more than 12,000	no

As seen above, routes to which many marks are attached are assessed as low priority routes.

Results assessed based on the above criteria of each route in the tentative motorway network are shown in Table 7.3.

Table 7.3 ASSESSMENT OF TENTATIVE NETWORK BY ROUTE

TR No.	Length (km)	Major Points: No. of Covered Points	Major Points: Coverage (points/100 km)	Major Points: Evaluation	Population: Covered (1,000 persons)	Population: Coverage (person/km)	Population: Evaluation	Traffic Volume: Traffic Volume (ADT)	Traffic Volume: Evaluation	Total Evaluation	
1	578	74	13		15,951	27,597		29,533			
2	534	61	11		15,631	29,272		23,621			
3	196	49	25		9,725	49,617		49,871			
4	941	78	8	*	13,994	14,871	*	24,366		**	
5	170	50	29		10,624	62,494		50,907			
6	184	11	6	*	983	5,342	**	21,440		***	
11	363	9	2	**	2,369	6,526	**	9,400	*	*****	D
12	696	26	4	**	7,559	10,861	*	8,526	*	****	D
31	101	39	39		9,856	97,584		33,511			
32	222	36	16		9,614	43,306		32,312			
33	230	28	12		3,745	16,283	*	9,834	*	**	
41	143	10	7	*	760	5,315	**	9,957	*	****	
42	208	21	10		2,294	11,029	*	9,003	*	**	D
101	146	12	8	*	2,103	14,404	*	9,949	*	***	
201	146	8	5	*	2,348	16,082	*	7,255	**	****	D
202	299	19	6	*	6,333	21,181		12,743		*	
301	168	58	35		11,543	68,708		21,615			
302	187	45	24		10,676	57,091		20,778			
303	62	34	55		9,787	157,885		35,351			
401	36	6	17		1,564	43,444		14,704			
2001	78	5	6	*	1,079	13,833	*	3,850	**	****	D
3001	98	10	10		1,342	13,694	*	18,733		*	
4001	65	5	8	*	1,536	23,631		10,563	*	**	D
TOTAL	5,851	694		* < 10 ** < 5			* < 20,000 ** < 10,000		* < 12,000 ** < 8,000		

Note: D: Deleted Routes

Routes with two or more marks in total are TR-4, TR-6, TR-11, TR-12, TR-33, TR-41, TR-42, TR-101, TR-201, TR-2001 and TR-

4001. They are assessed as low priority routes. However, the routes TR-4, TR-6, TR-33, TR-41 and TR-101 are reevaluated and remained as component routes of the proposed motorway network by considering their vital roles.

In conclusion, 17 routes, combined later into 14 routes, with a total length of 4,345.4 km are selected among 23 routes with a total length of 5,851 km of the tentative motorway network as the Proposed Motorway.

7.5.2 Proposed Motorway Network – 4,300 km –

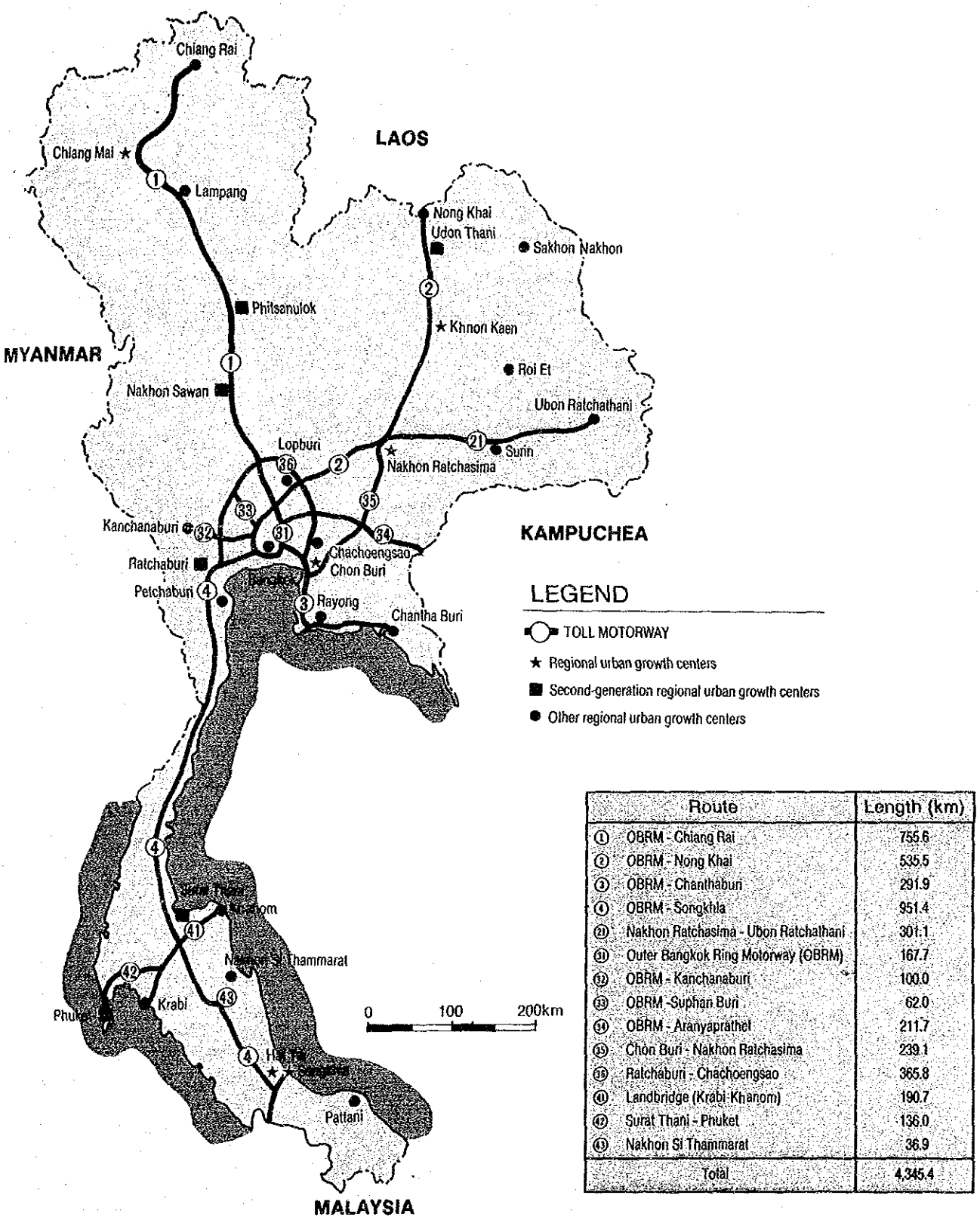
In Section 7.3, the target length of motorways required in Thailand is estimated to be 4,124 km based on the international comparison. This length of 4,124 km is not so different than the length of 4,345.4 km determined through the procedures mentioned above.

Therefore, the motorway network of 4,345.4 km in total length which is composed of 14 routes shown in Table 7.4 is presented as a proposed motorway network and this is called "4,300 Km Network Plan". Routes of the proposed motorway network are illustrated in Figure 7.3.

Table 7.4 4,300 KM MOTORWAY NETWORK

PROPOSED ROUTE NO.	ORIGIN	DESTINATION	LENGTH (KM)	SELECTED ROUTE NO.
TM-1	Bang Pa-In	Chiang Rai	755.6	TR-1,11,101
TM-2	Bang Pa-In	Nong Khai	535.5	TR-2
TM-3	Phra Khanong	Chanthaburi	291.9	TR-3, 3001
TM-4	Phasi Charoen	Malaysia Border	951.4	TR-4
TM-21	Nakhon Ratchasima	Ubon Ratchathani	301.1	TR-202
TM-31	Bang Pa-In	Bang Pa-In	167.7	TR-5
TM-32	Bang Yai	Kanchanaburi	100.0	TR-31
TM-33	Bang Bua Thong	Suphan Buri	62.0	TR-303
TM-34	Thanyaburi	Aranya Prathet	211.7	TR-32
TM-35	Chonburi	Nakhon Ratchasima	239.1	TR-33
TM-36	Wat Phleng	Bang Pakong	365.8	TR-31, 302
TM-41	Krabi	Khanom	190.7	TR-6
TM-42	Phrasaeng	Phuket	136.0	TR-41
TM-43	Ron Phibun	Nakhon Si Thammarat	36.9	TR-401
	Total		4,345.4	

Note : Lengths of the routes are subject to the more accurate results of routing in Section 7.8.



Route	Length (km)
① OBRM - Chiang Rai	755.6
② OBRM - Nong Khai	535.5
③ OBRM - Chanthaburi	291.9
④ OBRM - Songkhla	951.4
㉑ Nakhon Ratchasima - Ubon Ratchathani	301.1
㉟ Outer Bangkok Ring Motorway (OBRM)	167.7
㉜ OBRM - Kanchanaburi	100.0
㉝ OBRM -Suphan Buri	62.0
㉞ OBRM - Aranyaprathet	211.7
㉟ Chon Buri - Nakhon Ratchasima	239.1
㊱ Ratchaburi - Chachoengsao	365.8
㊶ Landbridge (Krabi-Khanom)	190.7
㊷ Surat Thani - Phuket	136.0
㊸ Nakhon Si Thammarat	36.9
Total	4,345.4

Figure 7.3 PROPOSED MOTORWAY NETWORK

7.6 CHARACTERISTICS OF 4,300 KM MOTORWAY NETWORK

The proposed motorway network is characterized on the basis of two main factors, which are traffic and coverage.

7.6.1 Traffic

Traffic is sub-characterized as vehicle-hour and trip length. They are extracted as shown in Table 7.5.

Table7.5 TRAFFIC CHARACTERISTICS OF TOLL MOTORWAY AND NATIONAL HIGHWAY NETWORKS – 2010

		Toll Motorway Network	National Highway Network	Total
Vehicle-Hour (1000 Veh-hr)	W/O-MTW	-	9,411	9,411
	W-MTW (4300)	826	6,184	7,010
Average Trip Length (Km)	W/O-MTW	-	65.0	65.0
	W-MTW (4300)	159.5	53.0	70.5

Note : - W/O-MTW : without-motorway
- W-MTW (4300) : with-motorway of 4300 Km (proposed)

The total vehicle-hour in case of "With Project" is 7,010,000, while in case of "Without Project", it is 9,411,000. The ratio between this two cases, i.e. 0.745, indicates that time savings of 25.5% in terms of vehicle-hour is expected by introducting the 4,300 km motorway network.

As seen in Table 7.5, the average trip length on the motorway is 159.5 km, while on the national highway is 53.0 km. The difference is over 100 km.

Figure 7.4 shows the share of trip length distribution of motorway and national highway networks. The share of the motorways occupies 50% for trips longer than 200 km, while that of the national highways have more than 95% share in the short trips in the range between 0 – 40 Km.

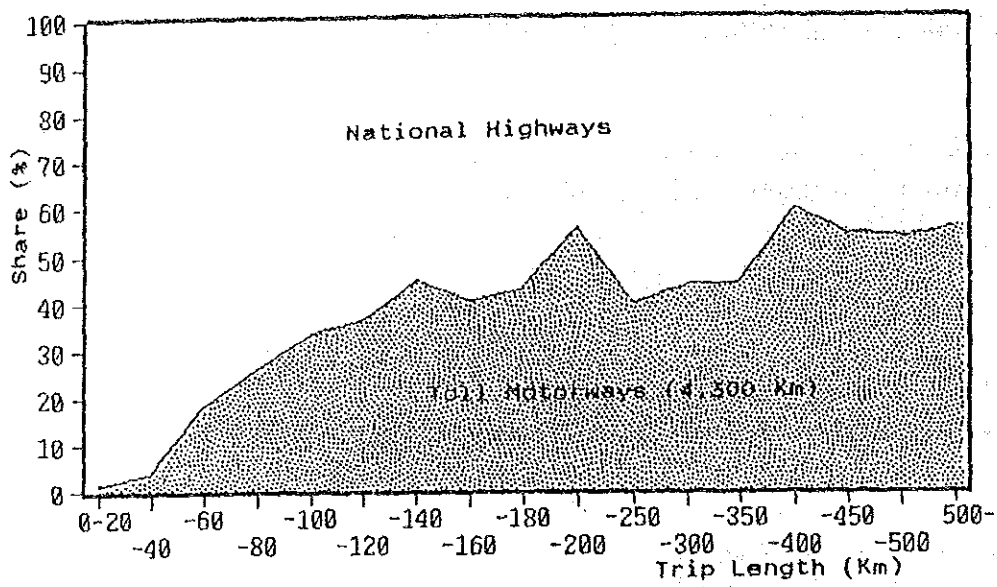


Figure 7.4 SHARE IN TRIPS BETWEEN NATIONAL HIGHWAY AND TOLL MOTORWAY NETWORKS — 2010

7.6.2 Coverage

The coverage rates of 4,300 km network are presented on the viewpoints of: 1) population and area, and 2) major points.

1) Population and Area - coverage Rates

The characteristics of population - and area - coverage defined in Section 7.5.1, are shown in Table 7.6.

Table 7.6 POPULATION AND AREA COVERAGE RATES — 2010

	0 - 30 min.	0 - 60 min.
Population	54.7 %	72.1 %
Area	32.8 %	53.5 %

As shown in the above table, 72.1% of people in the whole nation will be able to gain access to motorways within 60 minutes by car.

On the other hand, the area covered within 60 minutes by car is at a lower rate of 53.5%. Figure 7.5 illustrate the boundaries of the area - covered within 60 minutes.

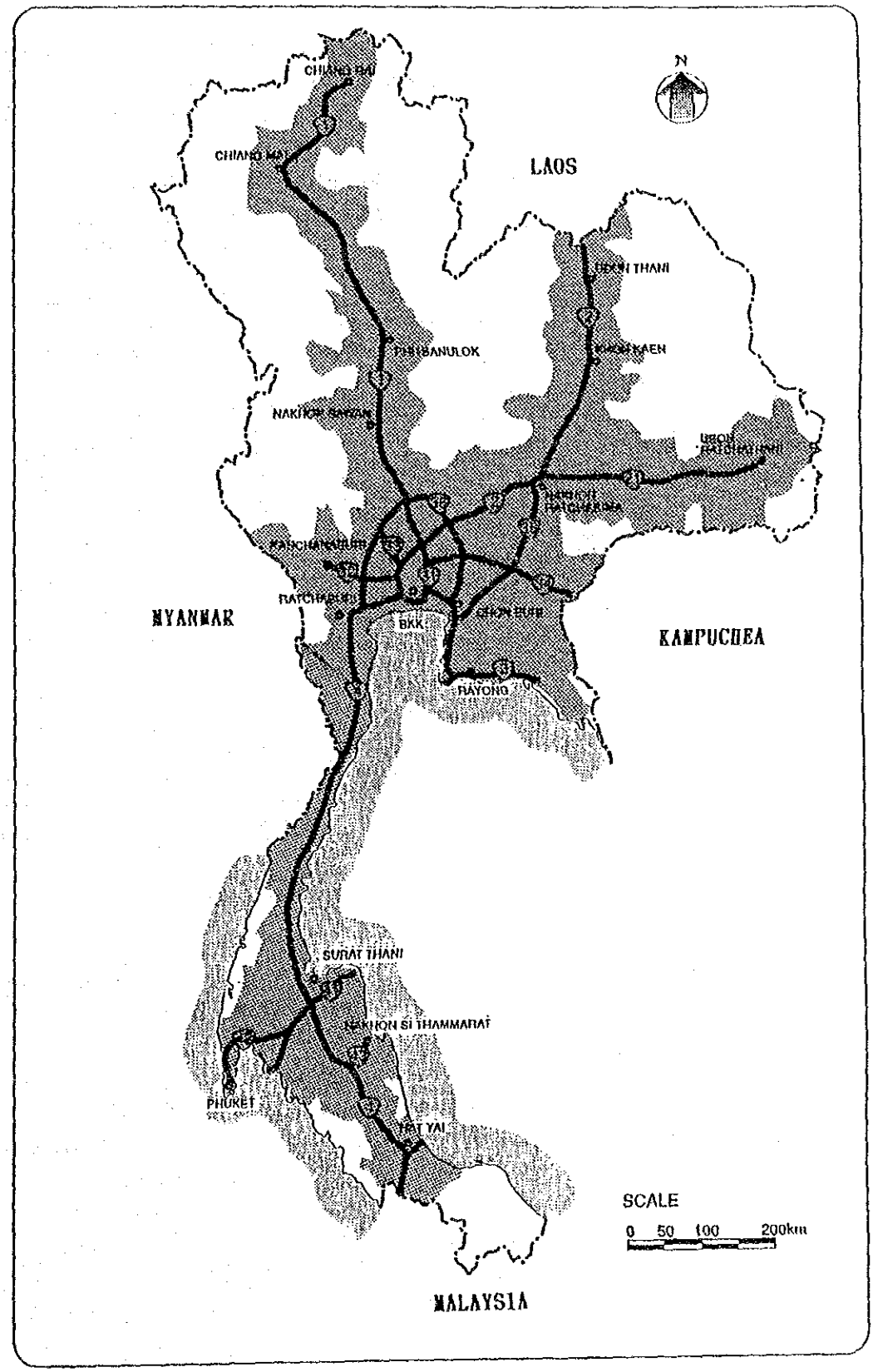


Figure 7.5 BOUNDARIES OF AREA - COVERED WITHIN 60 MINUTES

2) Major Point - coverage

Table 7.7 gives the number of major points of each category which is covered by the 4,300 km network.

Table 7.7 COVERED MAJOR POINTS BY 24,3002 KM NETWORKS

Category		Total	4,300 Km Network			
			0-30 min		0-60 min	
		Number	Number	%	Number	%
Designated City	1st	5	5	100.0	5	100.0
	2nd	6	6	100.0	6	100.0
	3rd	13	10	76.9	10	76.9
Large City	>100,000	8	8	100.0	8	100.0
	> 50,000	10	9	90.0	9	90.0
	> 30,000	30	22	73.3	25	83.3
Industrial Area	Nation Plan	5	5	100.0	5	100.0
	Other	36	35	97.2	35	97.2
Airport	International	5	5	100.0	5	100.0
	Local	20	10	50.0	11	55.0
Seaport	Deep Seaport	8	8	100.0	8	100.0
	Other Port	12	6	50.0	7	58.3
Inland-water port		14	14	100.0	14	100.0
Interest Place		13	10	76.9	11	84.6
Changwat center		73	48	65.8	55	75.3
Total		258	201	77.9	214	82.9

The network covers 83% of the total major points in number, which are connected to the motorways within 60 minutes by car.

In particular, the network covers 100% of the designated cities of 1st and 2nd priority, large cities with more than 100,000 in population, national plan industrial areas, international airports, deep - seaports and inland - water ports.

On the other hand, points covered at the rate of less than 60% are local airports which have not the ability to operate jet airplanes, and coastal ports with small capacities located in the Southern Region.

7.7 BASIC FACTORS OF DESIGN AND PLANNING

A motorway should offer high traffic mobility service by providing the following characteristics:

- to control access
- to handle heavy traffic volumes
- to provide safety, speedy and comfortable driving conditions.

The basic design standards to satisfy the above requirements which include the road classification, design speed, cross section, etc., are proposed. Also, basic concepts of planning the facilities, such as interchanges, rest facilities and bus stops, are proposed.

7.7.1 Basic Factors of Design

Proposed basic factors of design classifications, design speeds and design traffic volumes of motorways are summarized in Table 7.8.

Table 7.8 BASIC FACTORS OF DESIGN

Class	Design Speed (Km/h)	Design Traffic Volume (Veh/day)		
		Over 24,000	24,000-16,000	16,000-8,000
M-1	120 - 100	Flat and Hilly	Flat	
M-2	100 - 80	Mountainous	Hilly and Mountainous	Flat and Mountainous

Width of cross section elements of motorways are defined in Table 7.9.

Table 7.9 WIDTH OF CROSS SECTION ELEMENTS

Class	Lane Width (m)					Shoulder Width (m)		Median (m)
	4-Lane		6-Lane					
	Left	Right	Left	Middle	Right	Left	Right	
M-1	3.50	3.75	3.50	3.75	3.50	3.00	1.50	variable
M-2	3.50	3.50	3.50	3.75	3.50	3.00	1.50	@ 10.0

A cross section of the motorway consisting of traffic lanes, shoulders and median, is illustrated in Figure 7.6.

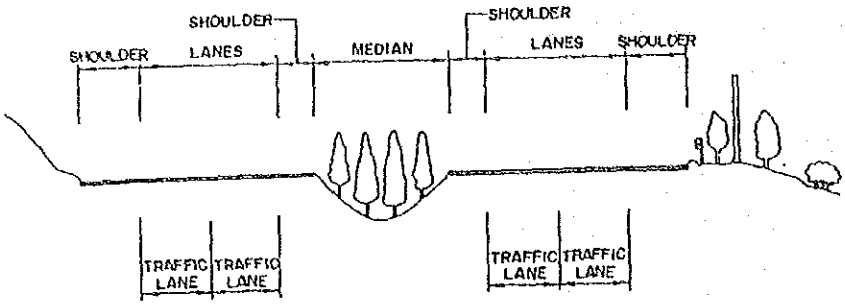


Figure 7.6 CROSS SECTION ELEMENTS

7.7.2 Planning of Motorway Facilities

1) Interchanges and Junctions

Interchanges and junctions are defined as follows:

- Junction: is to connect two or more motorways through the ramps having the functions of diverging and merging the traffic flow.

- Interchange: is to connect the motorway and other roads through the ramps having the functions of the entrance and exit to and from the motorway.

The locational planning of interchanges is carried out in the following manner through integrated considerations of traffic, social, environmental conditions, etc.:

a. To be located at or near intersections crossing important trunk roads, i.e. national highways.

b. To be located at areas in the suburbs of cities having more than 30,000 of population, or where a population of 50,000—100,000 will be served by that interchange.

c. To be located at or near intersections crossing roads connected to the important sea ports, air ports, places of interest, transportation facilities and other major

points.

d. To be located at intervals whereas on-off traffic volumes handled by one interchange is less than 30,000 veh./day.

e. To be located at intervals of 5 km to 50 km.

2) Rest Facilities

Rest facilities are classified into the following two categories:

a. Service Area
To include: Restaurant, Parking Area, Public Lavatory, Gas Station, Free Rest Place, Route Information, Repair Shop, Garden.

b. Parking Area
To include: Vending Machines, Parking Area, Public Lavatory, Garden.

They are located in appropriate combinations at intervals of 50 km to 100 km for service areas and 15 km to 20 km for parking areas.

3) Bus stops

In order to promote maximum utilization of motorways, bus stops are installed at interchanges and at intermediate points along the route.

7.8 ROUTING

Table 7.10 lists the control points which are considered in the routing of the 4,300 km proposed motorway network.

Main considerations for routing of each route are described in Main Test and the results are illustrated in Appendix 7.14 as route planning charts.

Table 7.10 CONTROL POINTS

Category	Control Point
1. Natural conditions i. Topographical conditions	- Mountain range - Valley - Wide river - Large lake and marsh
ii. Geographical conditions	- Large soft ground area
2. Traffic facilities	- Rough location of interchange
3. Environmental conditions i. Life-environmental conditions	- City, town and industrial area - Wat and other religious facility - School, and other social facility - Power transmission line - Irrigation facility
ii. Natural-environmental conditions	- National park and other restricted area
4. Public works and public facilities	- City plan and land use plan - Royal irrigation area - Road, Railway, Port, Airport - Army base - Dam - Mining
5. Cultural properties	- Historic site - Scenic spot

7.9 ROUTES INSIDE OBRR TO CONNECT WITH PROPOSED MOTORWAYS

For effective utilization of proposed motorways outside OBRR, optimum connection with main roads inside OBRR is indispensable.

The study is limited to the area outside OBRR. Therefore, only

routes directly connected with main roads inside OBRR close to the end points of proposed motorways are roughly examined.

As a result, 5 routes are temporarily selected as the routes to be newly constructed for connecting with proposed motorways. They are shown in Table 7.11 and Figure 7.7. However, for final determination of these routes, more detailed study in cooperation with ETA, BMA and other concerned agencies is required.

Table 7.11 CONNECTED ROUTES INSIDE OBRR

No.	Origin	Destination
1	Thanyaburi (TM-34)	Dan Muang
2	Phra Khanong (TM-3)	Ban Kapi
3	Phasi Charoen (TM-4)	Dao Kanong
4	Bang Yai (TM-32)	Nonthaburi
5	Bang Bua Thong (TM-33)	Nonthaburi

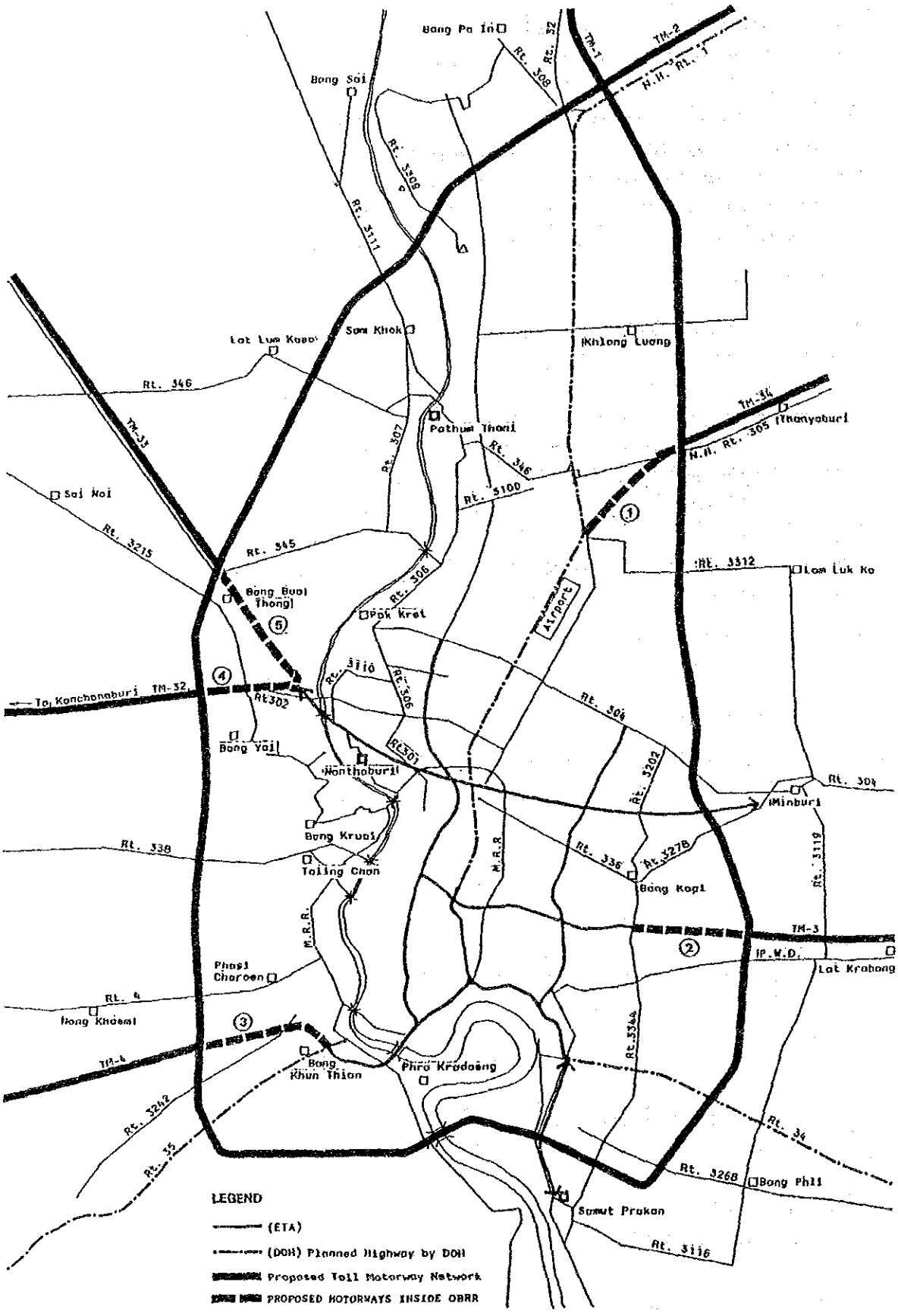


Figure 7.7 PROPOSED URBAN MOTORWAY NETWORK INSIDE OBRR

CHAPTER EIGHT

ENVIRONMENTAL CONSIDERATIONS

CHAPTER 8

ENVIRONMENTAL CONSIDERATIONS

For the motorways, some environmental problems may occurred, which are almost the same as for ordinary roads. However, it is confident that the newly constructed motorways have better environmental conditions than ordinary roads, since environmental considerations are taken in the designing and planning stages of motorways and their facilities. In addition, the traffic volumes diverted from ordinary roads to motorways have a favorable influence upon the environmental conditions in surrounding areas of both roads and motorways.

This chapter include the outline of motorway environmental problems, impact assessment, protection measures and the improvement of motorway environment through introducing the practice and examples in Japan. Main environmental considerations are also included in the main text for each route of the motorway network.

8.1 OUTLINE OF MOTORWAY ENVIRONMENTAL PROBLEMS

The environmental problems of motorways can be generally categorized into 3 groups depending on their causes, i.e. problems caused by traffic, problems caused by construction activities and problems caused by constructed structures.

1) Air Pollution

Vehicle exhaust gases contain water vapor, carbon dioxide and nitrogen oxides as principal components, along with carbon monoxide, hydrocarbons and particles produced by incomplete combustion.

2) Water Pollution

Source substances of water pollution include road surface drainage water, waste water from rest facilities, and tunnel washing water.

3) Noise

The problem of noise is a particularly important factor in the environmental pollution caused by traffic and is one of the principal causes of the movements by residents against road construction and repair.

4) Vibration

Although some surface roads through urban districts produce vibration problems, motorways with a reasonable slope area for a frontage road between the roadway and the residential zone produce very little vibration which rarely becomes a problem.

5) Obstructed Sunlight and TV Reception

The obstruction of sunlight and TV reception is produced by the construction of elevated motorways, embanked roads and in many cases motorways in urban areas.

6) Natural Environment

Destruction of the natural environment occurs for plants through the destruction of the forest by changes in the supply of underground water, direct sunlight and ventilation and the introduction of dust and exhaust gases emitted from vehicles, and for animals in extinction, degeneration, movement and dispersion caused by the division of their territories.

7) Others

8.2 ENVIRONMENTAL IMPACT ASSESSMENT AND FORECAST

8.2.1 Environmental Impact Assessment

Environmental impact assessment procedures are as shown in Figure 8.1, and the environmental phenomena to be assessed are as follows.

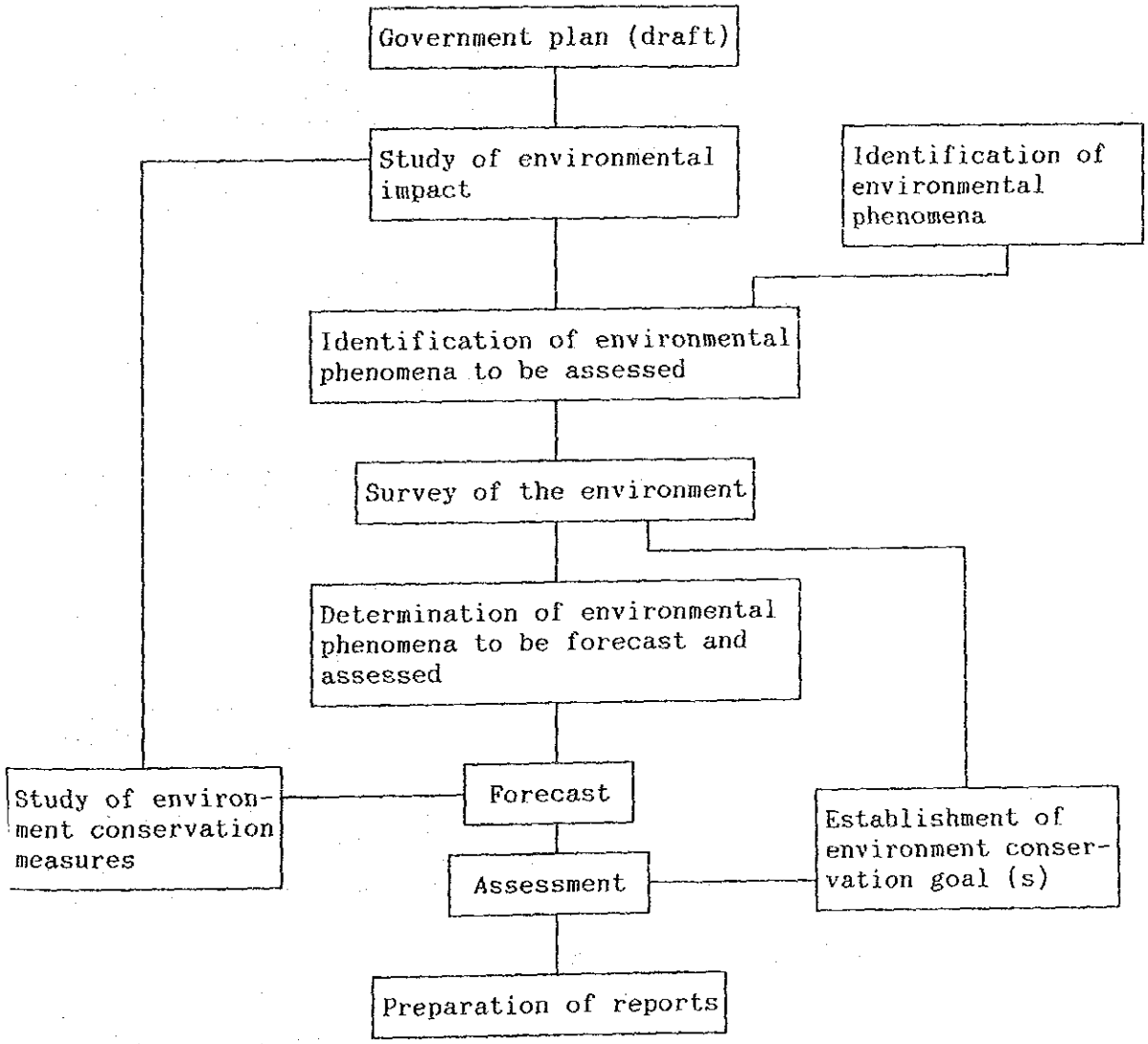


Figure 8.1 ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURE

1) Environmental phenomena which affect human health and living environment
   a. Air pollution
   b. Water pollution
   c. Noise
   d. Vibration
   e. Ground subsidence

2) Environmental phenomena which affect the natural environment
   a. Configuration of ground and geological features
   b. Plants
   c. Animals

3) Environmental phenomena which affect the natural landscape

Environmental assessment is also applied as necessary to historic spots, beauty spots, natural monuments, traditional architecture and historic landscapes.

8.2.2 Forecasting Methodology

As shown Figure 8.1, forecast of environmental related values such as dB for noise and vibration, subsidence etc., is required for environmental impact assessment. Forecast procedure used by Nihon Doro Kodan are briefly explained in this chapter for the following items.

- Air Quality
- Water Quality
- Noise
- Road Traffic Vibration
- Land Subsidence
- Natural Environment
- Natural Landscape

8.3 ENVIRONMENTAL PROTECTION MEASURES

Measures for vehicles, major sources of environmental pollution, and improvement of the vehicle structure are very important and effective in the environment conservation of roadside areas. However, improvement of the environmental condition

through the technological improvement of the vehicles is effective only to a limited extent; therefore, comprehensive measures should be taken. These include highway planning, improved highway structures, appropriate traffic control, optimum use of the roadside land and urban renewal plans. Environmental protection measures possible for road administrators are also limited to certain areas and may be classified as follows.

1) Environmental Protection Goals

Environmental protection measures should be measured against the targeted environmental quality levels established for the various environmental components. In this section, as an example, environmental quality standards for noise approved in Japan by Cabinet Decision of May 25, 1971, as presented in Table 8.1 are introduced.

Table 8.1 ENVIRONMENTAL QUALITY STANDARDS FOR NOISE

Category of area		Time blocks			Remarks
		Daytime	Morning and evening	Nighttime	
AA		Not more than 45 dB (A)	Not more than 40 dB (A)	Not more than 35 dB (A)	(Pertinent area) The area conforming to the divisions designated by the prefectural governors in Paragraph 2 of the "Government ordinance authorizing the designation of the locations and water areas relating to the environmental quality standards." (Attainment period) For areas facing roads the required standards shall be attained within five years following the establishment of the standards. For areas facing trunk roads with heavy traffic, when attainment within five years is very difficult, an effort shall be made to reach the goal as soon as possible after the five years.
A		Not more than 50 dB (A)	Not more than 45 dB (A)	Not more than 40 dB (A)	
Special standards for "areas facing roads"	Two lanes	Not more than 55 dB (A)	Not more than 50 dB (A)	Not more than 45 dB (A)	
	More than two lanes	Not more than 60 dB (A)	Not more than 55 dB (A)	Not more than 50 dB (A)	
B		Not more than 60 dB (A)	Not more than 55 dB (A)	Not more than 50 dB (A)	
Special standards for "areas facing roads"	Two lanes	Not more than 65 dB (A)	Not more than 60 dB (A)	Not more than 55 dB (A)	
	More than two lanes	Not more than 65 dB (A)	Not more than 65 dB (A)	Not more than 60 dB (A)	

(Note) AA : Areas requiring extraordinary quiet.
A : Areas primarily residential.
B : Areas used for commerce and industry containing also a fair number of residences.
Lane: A roadway wide enough for safe and smooth transit by automobiles in single file.

2) Measures Incorporated in Highway Planning

When the basic highway plan is designed, surveys of the affected areas are conducted for possible influence by the road.

The survey covers weather, land use, urban planning, industries, cultural properties, wildlife, vegetation, living conditions, population, public facilities, recreation facilities and other aspects. Based on the survey results, a comprehensive study is made on alternative routings. The degree of possible environmental impact, technical feasibility, cost, road function and social and economical aspects are considered before the highway plan is made final.

3) Measures Embodied in Highway Construction

Road traffic pollution includes a variety of environmental problems such as noise, air pollution and vibration. Because the predominant problem is noise and since protective measures built into the highway against other forms of pollution are technically difficult, the environment protection measures taken in the highway structure are aimed at noise attenuation and landscape preservation. Measures to attenuate traffic noise are shown in Figure 8.2.

4) Measures Taken for Roadside Areas and Vicinity

Some of the road environmental problems can be solved by comprehensive means to improve the motorway structure. However, as it is difficult to solve the existing problems in a short time, the governmental monetary assistance will be needed.

Considering the motorway environment, it is needed not only to measure the environmental problems but also to improve the surrounding environment of the motorways and to more positively create higher environmental conditions, which are expected to be achieved at the designing stage.

For example, Landscaping which is aimed to achieve the harmony between surrounding environmental conditions and the motorway structure and facilities has such functions of aesthetic improvement, conservation of life and natural - environment, road safety, disasters prevention and creation of green shade.

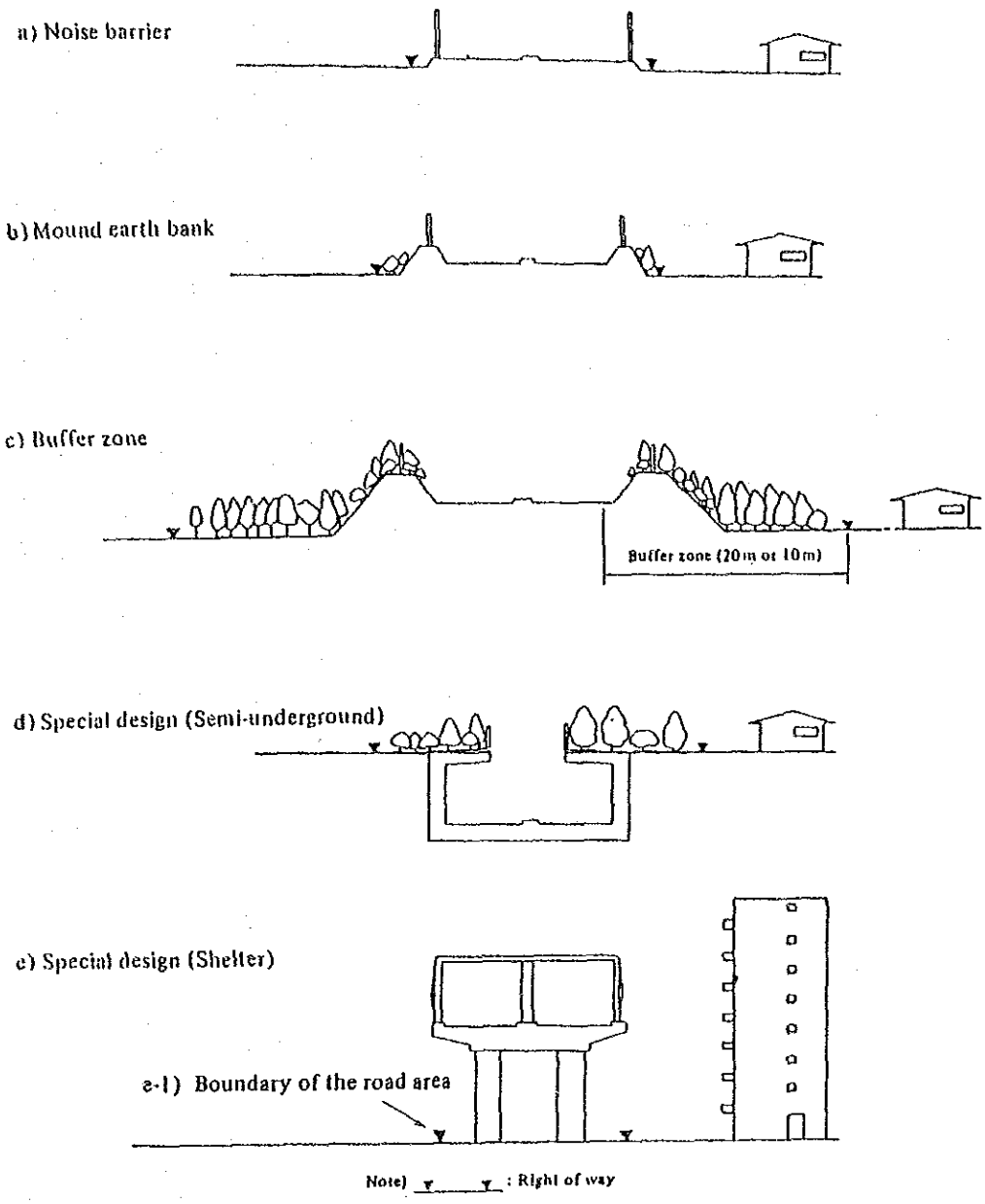


Figure 8.2 MEASURES FOR NOISE IN HIGHWAY STRUCTURE

CHAPTER NINE

SYSTEM AND ORGANIZATION

CHAPTER 9

SYSTEM AND ORGANIZATION

9.1 FINANCIAL SYSTEM

The development of motorways requires a huge amount of cost. In order to raise this huge amount of the road investment with less government burden, it is necessary to introduce the following financial systems beside appropriation of the general tax revenue.

1) Introduction of the "Special Funds" ("Earmarked Tax Revenues") raised from the road user taxes.

2) Introduction of the "Toll Road System" for early construction with loaned funds from international financial institutions and private sector, and payback later by the toll revenue.

9.1.1 Special Fund System (Earmarked Tax Revenue System)

In general, the "Special Fund" is defined as the specific tax revenue to be appropriated for the specific purpose. The earmarked tax has the same meaning.

The "Special Fund" for road improvement/construction should reflect the "Beneficiaries Pay Principle" i.e. road users have to pay for road improvements through the road users taxes such as gasoline tax, oil tax, vehicle tax, etc., because the road users enjoy the benefits by using roads. The toll charge on the motorways is one of the applications of this principle.

Many countries, such as Japan, U.S.A., F. R. Germany, France, Korea, etc., have special fund system for road works. The reasons why the special fund system for road development has been adopted in many countries are as follows: