URBAN TRANSPORT STUDY

IN

GREATER METROPOLITAN AREAS

OF

GEORGETOWN, BUTTERWORTH AND BUKIT MERTAJAM

MALAYSIA

ANALYSIS AND FORCASTS OF TRAFFIC MOVEMENT

TECHNICAL REPORT - 11

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1 Outline of the method of estimating traffic volume.

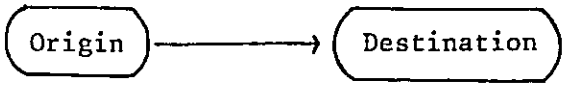
1-1 Explanation of traffic terms.

Generally the Origin and Destination Table called O-D table is used when forecasting future traffic demand because this table can show the movements of vehicles among the zones. The movements of vehicles are called trips.

The concept of 'trip' and 'O-D table' are explained by using the following simple example.

1-1-1 Trip

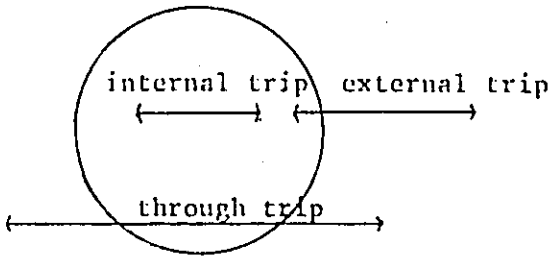
The term 'trip' means the route taken by a vehicle from the origin to the destination.



A single trip has 2 trip ends. One trip end, the origin, is called the "trip generation" and the other, the destination, is the "trip attraction".

1-1-2 Division of the trip

The total number of trips in the study area is divided into the following 3 groups.



These 3 groups are shown in the following O-D table.

Table 1-1 O-D Table by the internal, external and through trip.

destination / origin	internal area	external area
internal area	internal trip	outgoing trip
external area	incoming trip	through trip

internal trip external trip through trip

1-1-3 O-D table.

The following O-D table shows an example where there are only 4 traffic zones.

Table 1-2 O-D table by 4 traffic zones.

origin \ destination		traffic zones 1	2	3	4	trip generation
traffic zones	1	t11	t12	t13	t14	g^1
	2	t21	t22	t23	t24	g^2
	3	t31	t32	t33	t34	g^3
	4	t41	t42	t43	t44	g^4
trip attraction		a1	a2	a3	a4	T

In this example t12 is the number of trips that start from zone 1 and arrive at zone 2.

g^1 (tij = t11 + t12 + t13 + t14) is the total number of trip ends that arrive at zone 1.

tij is called 'trip distibution', gi 'trip generation' and ai 'trip attraction'.

Thus, it is evident that the total number of trip generation is the same as the total number of trip attraction.

$$T = g^1 + g^2 + g^3 + g^4$$
$$= a1 + a2 + a3 + a4$$

This total number of trip distibution is called 'trip production'. Eventually, the O-D table will show the volume of 'trip production', 'trip generation', 'trip attraction' and 'trip distribution'.

1-1-4 Traffic zone.

Zone codes are made up of the following 3 figures.

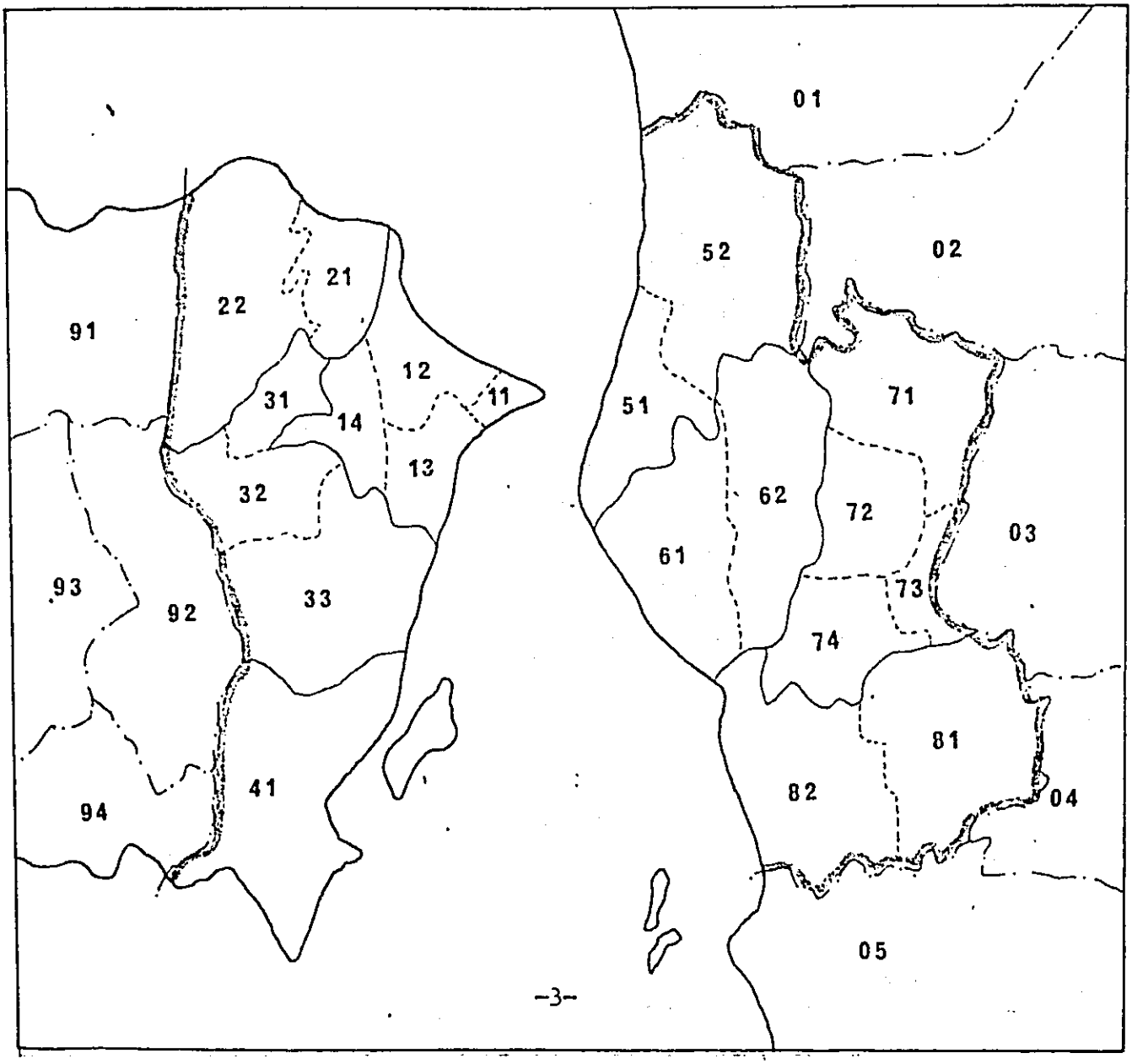
| 2 | | | --- large zone (for the purpose of grasping the outline of traffic movement)

| 2 | 1 | | --- middle zone (the zone which is for practical use)

| 2 | 1 | 2 | --- small zone (most detailed zone in this survey)

According to these zones, the internal area is divided into 8 large zones, 20 middle zones and 57 small zones.

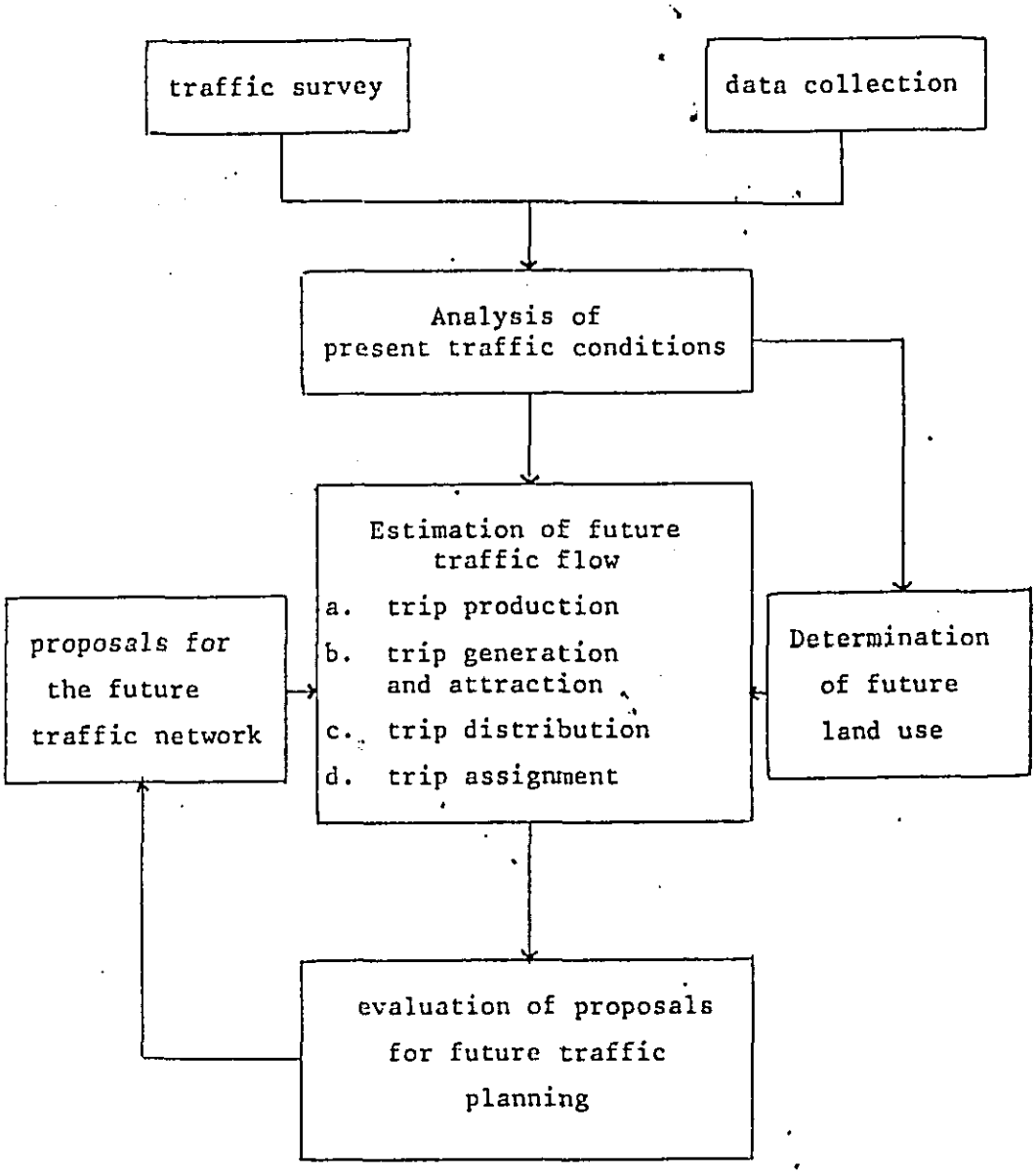
Fig 1-1 Zone Map (middle zone)



1-2 General methodology of estimating the traffic flow.

Fig 1-2 shows the main steps in the methodology of traffic planning most commonly used.

Fig 1-2 The methodology of traffic planning



The procedure starts with the collection of data and conducting traffic surveys which constitute the basis for the analysis of statistical relationships. Then the future traffic network which could best serve the expected land-use is outlined. There after the future flow in the alternative traffic network can be estimated through four steps, that is, trip production, trip generation and attraction, trip distribution and traffic and assignment. Sometimes modal split step is required between trip distribution and traffic assignment.

Finally the results are evaluated and any possible alterations of the traffic network are introduced. Usually the land-use pattern is considered fixed while the traffic network is considered a flexible variable. Here, the future traffic network is outlined and the land-use pattern which is likely to appear under the triffic network is estimate.

As such the traffic network has an impact far beyond the traffic conditions because, if the expected interaction between traffic network and land-use does exist, then we can control the urban development through traffic planning.

The following section discusses the main items in the previous flow-chart. (Fig. 1-2)

1-2-1 Data collection

The collection of data is mainly concerned with:-

a. present land-use and land utilization rates.

b. existing traffic facilities.

Data for the land-use and the land utilization rates are used as explanatory variables when relating to the number of trips to and from different zones. At the same time these data are important when the estimates of the future land-use are worked out.

Data for existing traffic facilites are used for the inventory of the corresponding supply of the facilites, the proposal for new transportation systems and to help to explain the observed trip patterns.

1-2-2 Traffic Surveys

The core of the traffic surveys is the home-interview survey which provides the survey area with the information mentioned below with regards to particular information on the households and the trips made by owners on the previous day.

1-2-3 Analysis of present conditions.

The data collected are analysed in order to find relationships and trends which may form the basis for forecasts.

Usually the relationship are expressed in the use of some traffic models which apply to present traffic situations.

The traffic model is used for estimating traffic demand. Commonly, the types of traffic models are divided into the following 4 methods.

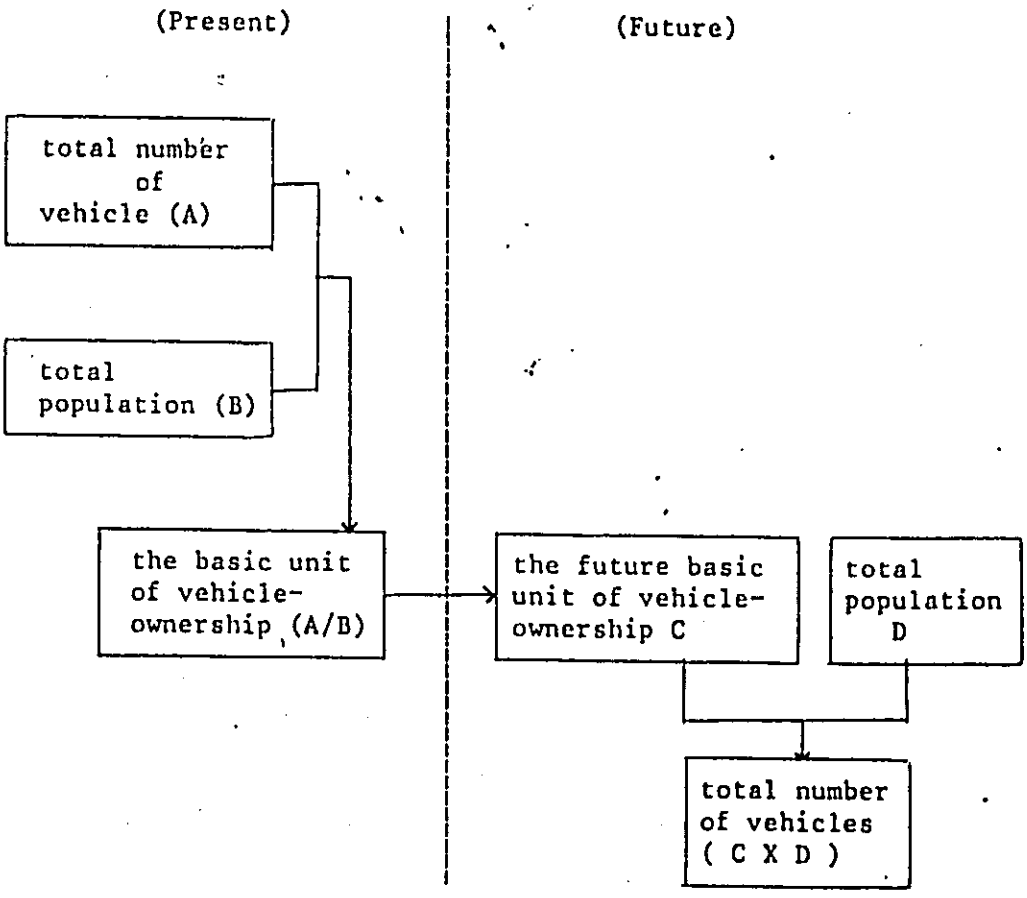
(1) the basic unit method.
(2) the growth rate method.
(3) the regression method.
(4) the simulation method.

(1) The basic unit method.

The basic unit is obtained by means of dividing the objective quantity by a certain unit. For example, the basic unit of vehicle-ownership is obtained by dividing the total number of vehicles by the total number of population or the total number of households.

In estimation work, we use this basic unit to estimate future objective quantity.

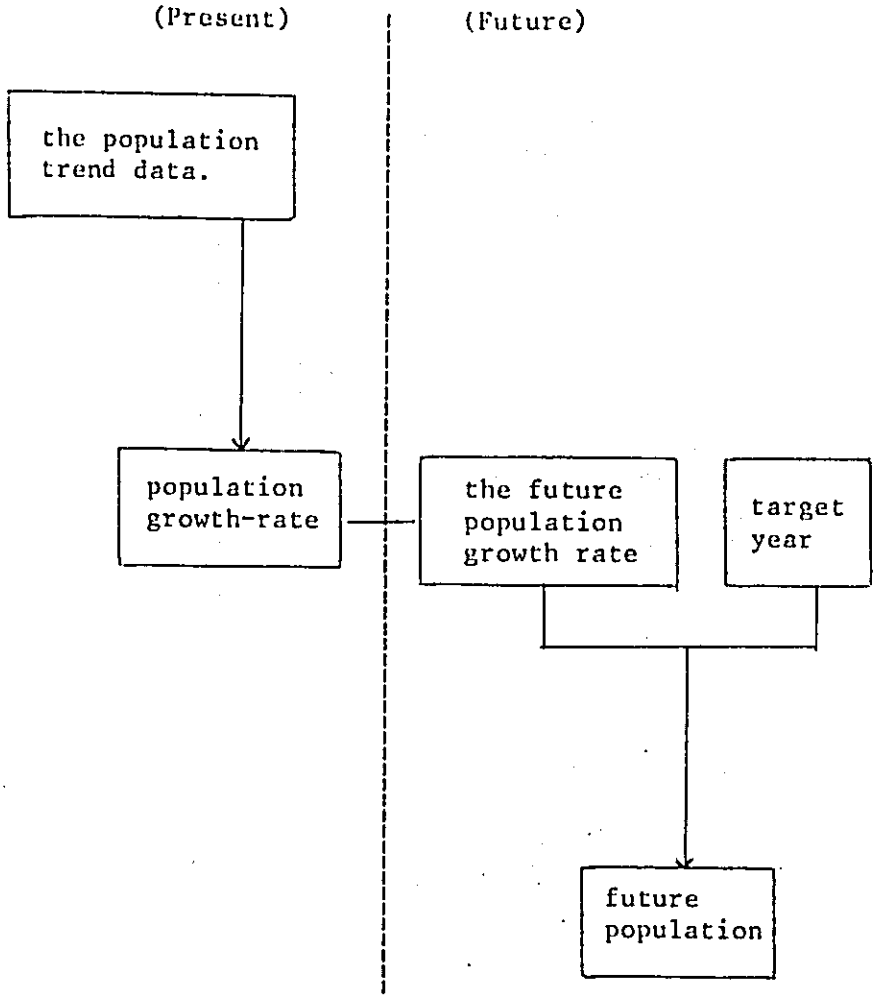
Example:



(2) The growth rate method.

The growth rate is obtained from various trend data, for example, the population projection data together with the data on the rate of population growth is very much used.

Example:

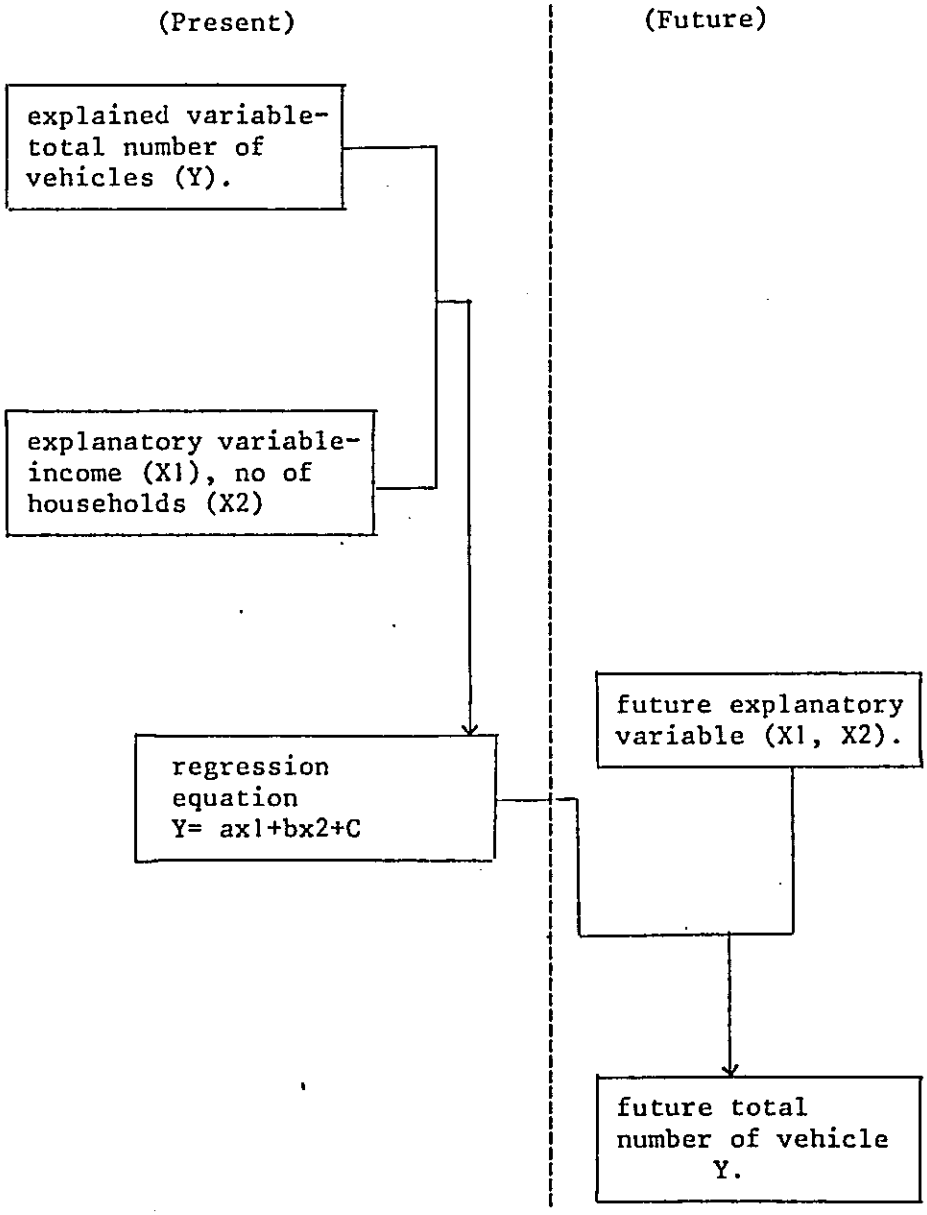


(3) The regression method.

This method makes use of the least square method to obtain the regression equation.

The explained variable is the unknown factor and the explanatory variables are the known factors, ie. the population figure and the area by land-use.

Example:



(4) The simulation method.

By using this method, we can obtain information on traffic phenomena, that is, the traffic flow at the roundabouts, the traffic flow on the roads and the traffic flow in the road network.

Some hypotheses of the actual flow is made and then the traffic flow is artificially created by using the computer.

(5) General.

Generally speaking, the following models are usually used in line with each step of the traffic estimation.

Table 1-3 Models used in the line with each step of the traffic estimation.

stage of estimation \ type of model	basic unit model	growth rate model	regression model	simulation model
trip production	0	0		
trip generation and trip attraction	0	0	0	
trip distribution			0	
traffic assignment				0

1-2-4 Determination of future land-use.

It is important to determine the future land-use because a knowledge of the future land-use pattern is a prerequisite in the estimation of traffic demand. It is a fact that the future population density is strongly related to the number of trip generations in the future. Therefore, it may rightly be said that the future land-use pattern will determine the future traffic demand.

1-2-5 Proposals for the future traffic network.

In order to obtain some guidelines in the preparation of the proposals for the future traffic network, an estimate of the existing capacity of the network when exposed to both the observed and the forecasted traffic is first made. A comparison between the "demand" and the "supply" on each link can be carried out.

The proposals for the traffic network usually emerge from the comparison, from policy objectives and from engineering experience and judgement.

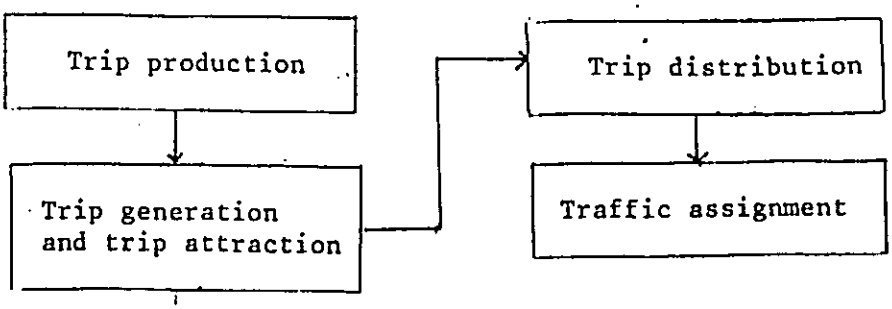
1-2-6 Estimation of future traffic demand.

The next step in the planning process is the estimation of the future traffic flow.

The data used are the proposed land-use figures and related figures (population, employment, etc.), the different proposals for the traffic network and the relationships and trends which have been developed from the traffic surveys.

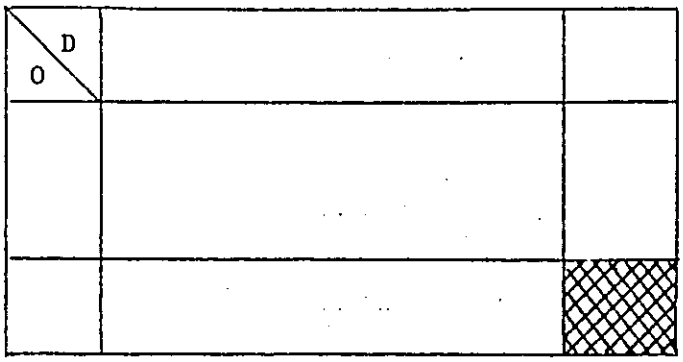
The estimation consist of four steps.

The flow-chart is as follows:-



(1) Trip production.

This is the first step in the estimating of O-D tables. The purpose of this is to estimate the total number of trips in the study area. This is shown by the shaded portion in the following table.

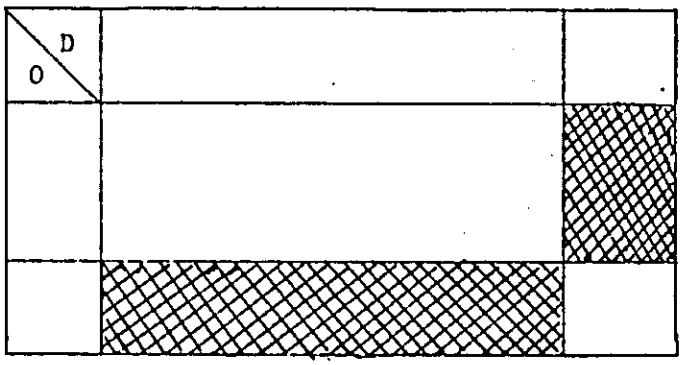


As is usually done, trip production is estimated by multiplying the total number of vehicles by the unit trip production of each vehicle. The unit trip production used is obtained from the actual survey, that is the car O-D survey.

Another method which is used occasionally is the correlation formula which is calculated from the population figure, the number of vehicles, etc.

(2) Trip generation and trip attraction.

This is the estimation of the number of trips that start from and arrive at each traffic zone.

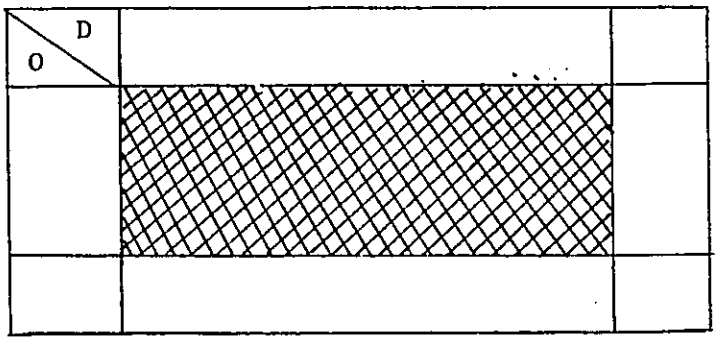


It is easy to understand this concept if we consider the purpose of each trip. For example, when the purpose of the trip is to get to the working place, a single commuter usually produce one trip. Therefore, the trip generation for this purpose is

related to the number of residents, number of employees, land-use area by utilization etc.

(3) Trip distribution.

This is the most complicated step in the estimation of future traffic demand because if there are 50 traffic zones, we must estimate for 2500 (50 x 50) pairs of trip distributions.



Many empirical formulae were formulated by many of our predecessors for the purpose of estimating the trip distributions. Among them, the gravity model is the most general method. Therefore, the concept of gravity model is introduced.

The fundamental formula of gravity model is shown as follows:-

$$Tij = R \frac{gi \times aj}{tij\ r}$$

Tij : trip distribution from zone i to zone j.
gi : trip generation from zone i.
aj : trip attraction to zone j.
tij : time taken from zone i to zone j.
r : coefficient of distance resistance.
R : coefficient.

This is common sense, that is, the more gi or aj increases, the more the traffic volume between i and j will increase and, the shorter the distance from i to j become, the more the increase in volume of traffic.

This formula is applied to the "law of terrestrial gravitation"' (Newton's Law).

These coefficients are estimated from the least square method applied to the relationship between the present O-D table (which is obtained from the car O-D survey) and the present time taken for each zone pairs.

(4) Completion of the O-D table.

Data on trip production, trip generation, trip attraction and trip distribution are required for completing the O-D table.

(5) Traffic assignment.

After the O-D table has been estimated, it is necessary to estimate the traffic volume on each road. This process involves some amount of simulation. First, we make a model of the road network, and then to the traffic volume of each zone pairs (as already forecasted in the O-D table) are assigned the road network according to the travel time between origin and destination.

It is commonly accepted that the travel time also includes the time spent whenever there is traffic congestion. For the purpose of actualizing the above-mentioned situation, the O-D table is sub-divided and the traffic assignment on each O-D table is sub-divided and the traffic assignment on each O-D table is executed repeatedly.

1-2-7 Evaluation of the proposals for future traffic planning.

When the future traffic flow in a network has been computed, overloaded parts or poorly utilized parts will be indicated. The necessary alterations are introduced and a new capacity for the the network will be carried out. This procedure is applied to each of the alternative proposals.

When the distribution of traffic on the network is obtained the total trip length and travel time is also computed. These figures, together with the construction costs constitute the basis for the economic assesment of the different proposals.

2 The procedure for completing the present O-D table.

For the purpose of grasping the traffic movements, various kinds of traffic surveys were carried out.

The present O-D table according to each vehicle type was completed using that data.

In this section, the main results of each traffic survey is explained firstly, and then the procedure for completing the present O-D table is explained.

2-1 Some of the main results from the traffic surveys.

Some traffic surveys were carried out in June 1979. They were the owner-interview survey, ferry survey, cordon-line survey and screen-line survey,.

First, some of the results of each traffic survey will be explained, then the method of completing the present O-D table will be shown.

2-1-1 Owner-interview Survey.

From the results of the owner-interview survey, information on vehicle owners and traffic movements can be obtained.

(1) The vehicle-ownership situation.

The number of vehicles and motorcycles registered with the R.I.M.V. in the state of Penang up to the end of May 1979 is shown in the following table.

Table 2-1 Number of vehicles and motorcycle.

Type of vehicle	Number
Car	61674
Van	3709
Medium Lorry	4461
Heavy lorry	7043
Taxi	474
Bus	1073
Total for vehicle	78434
Motorcycle	124984
Grand total	203418

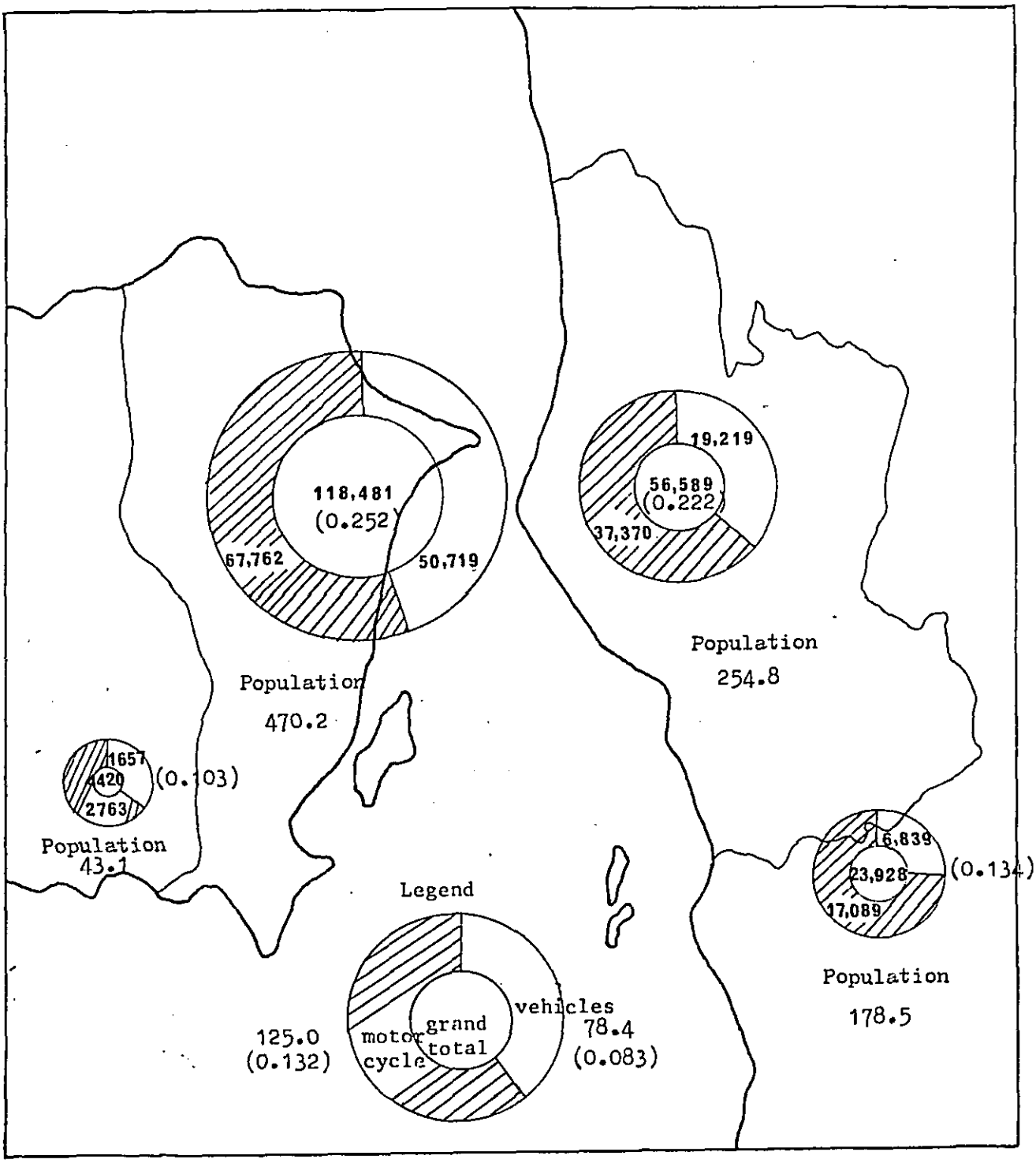
Population: 946580 persons.

The registration of vehicles/motorcycles at the R.I.M.V. did not take into consideration the classification by area. Therefore the number of vehicles in the internal area was estimated by using the results of out owner-interview survey.

Table 2-2 The number of vehicles in the internal area.

Vehicles / Car	Car	Van	Medium Lorry	Heavy Lorry	Taxi	Bus	Total	Motor cycle
Internal area	55956	3294	3671	5744	350	923	69938	105132
External area	5718	415	790	1299	124	150	8496	19852
Penang State	61674	3709	4461	7043	474	1073	78434	124984

Figure 2-1 The number of vehicle by area.



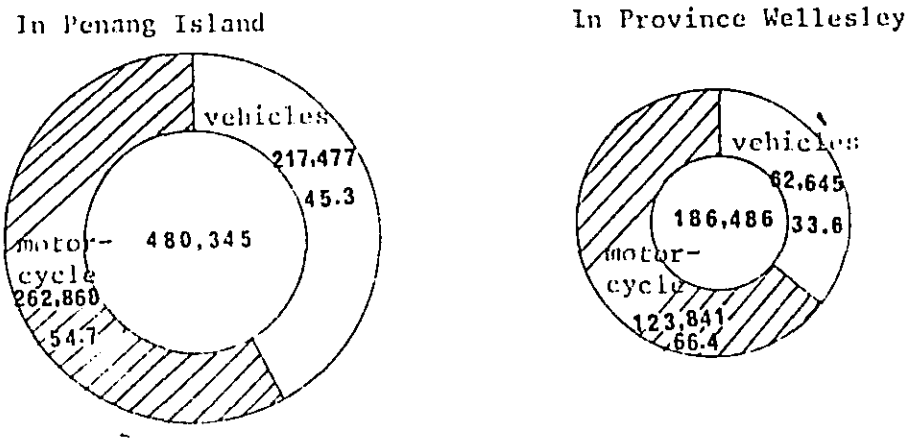
( ) : number of vehicle / population

(2) The number of trips recorded in the internal areas of Penang Island and Province Wellesley.

This survey traces the movements of vehicles in the internal areas of Penang Island and Province Wellesley.

The results are as follows:-

Figure 2-2 The number of trips in the internal areas
(unit: trip per day)



The above figure shows that in Province Wellesley, trips made by motorcycles contribute to a large proportion of the trips generated, amounting to 66% of total number of trips. In Penang Island, on the other hand, trips by motorcycles contribute to 55% of the total number of trips generated. Thus, proportion of trips between vehicles and motorcycles is roughly one to one.

2-1-2 Ferry Survey.

The results of this survey provide information on the movements of vehicles and passengers between Penang Island and Province Wellesley.

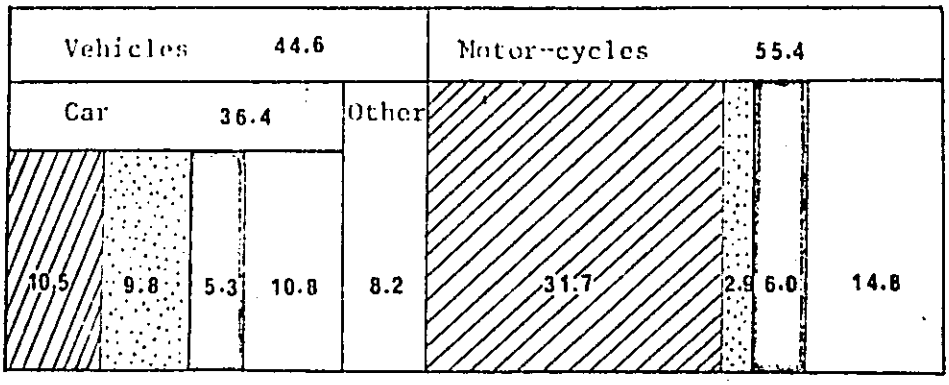
The types of vehicles and the trip purpose of the drivers are as follows.

Table 2-3 The types of vehicles using Ferry.

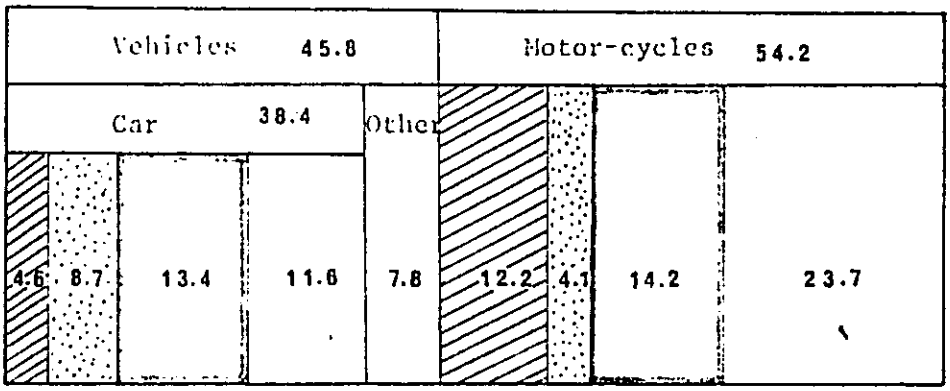
Vehicles \ Origin destination / trip purpose		From P.I. to P.W.	From P.W. to P.I.	Total	(Percentage)
CAR	going to work	1,235	553	1,788	(7.5)
	business trip	1,159	1,050	2,209	(9.2)
	private trip	634	1,618	2,252	(9.4)
	going home	1,282	1,398	2,680	(11.2)
	sub-total	4,306	4,642	8,948	37.4
	lorry	848	843	1,691	7.1
	taxi	39	40	79	0.3
	bus	83	61	114	0.5
	sub total of vehicles	5,272	5,546	10,818	45.2
MOTORCYCLE	going to work	3,732	1,472	5,204	(21.8)
	business trip	348	493	841	(3.5)
	private trip	706	1,711	2,417	(10.1)
	going home	1,756	2,875	4,631	(19.4)
	sub-total	6,545	6,551	13,096	54.8
	Grand total	11,817	12,097	23,914	100.0

Figure 2-3 The types of vehicles using Ferry

From Penang Island to Province Wellesley



From Province Wellesley to Penang Island



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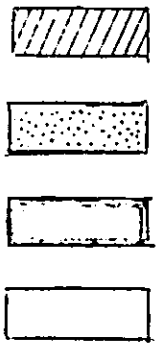


The distribution of vehicles and motorcycles which makes use of the ferry is as follows:-

Figure 2-4 : eration and attractio
of vehicles which made use of the ferry.

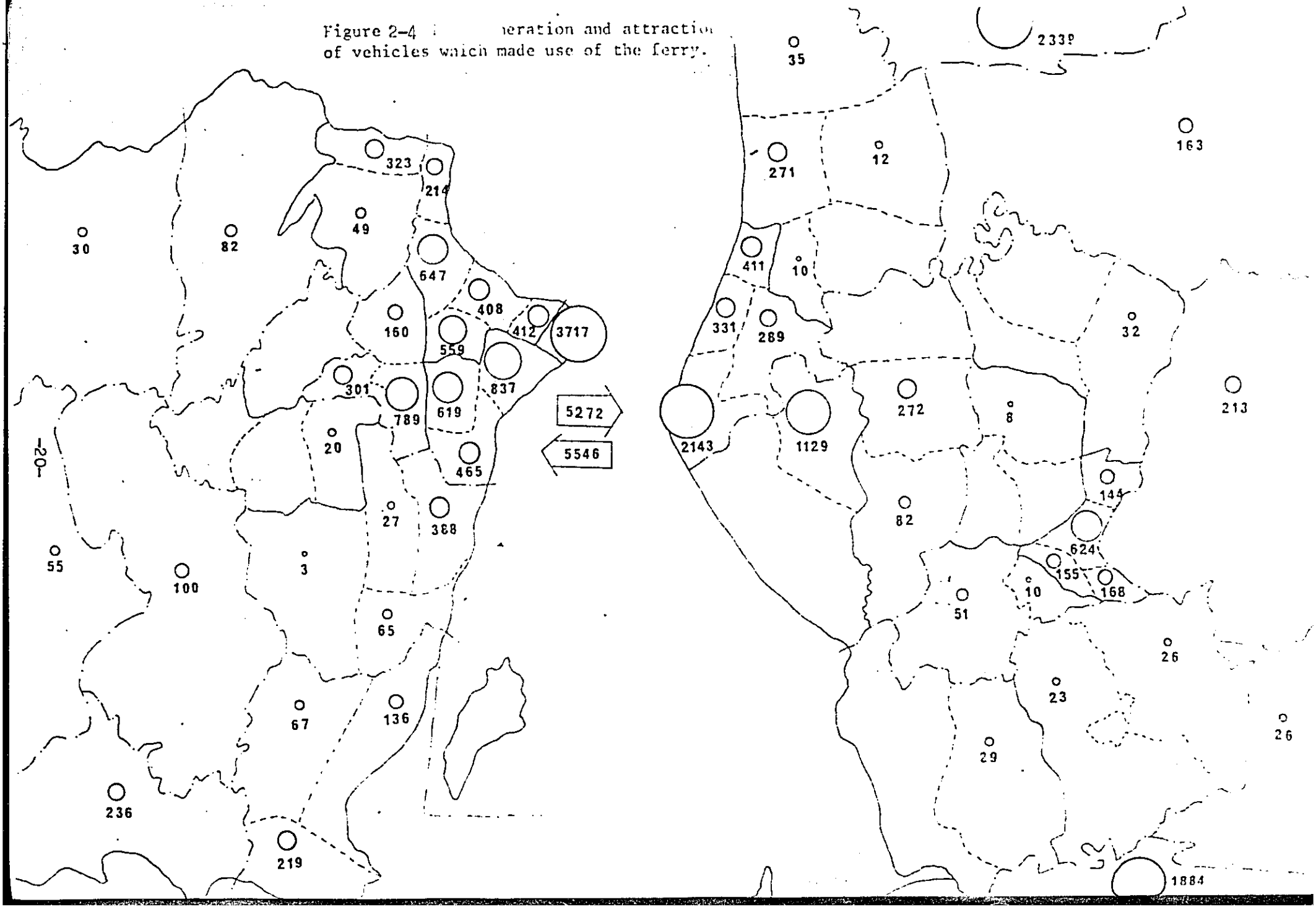
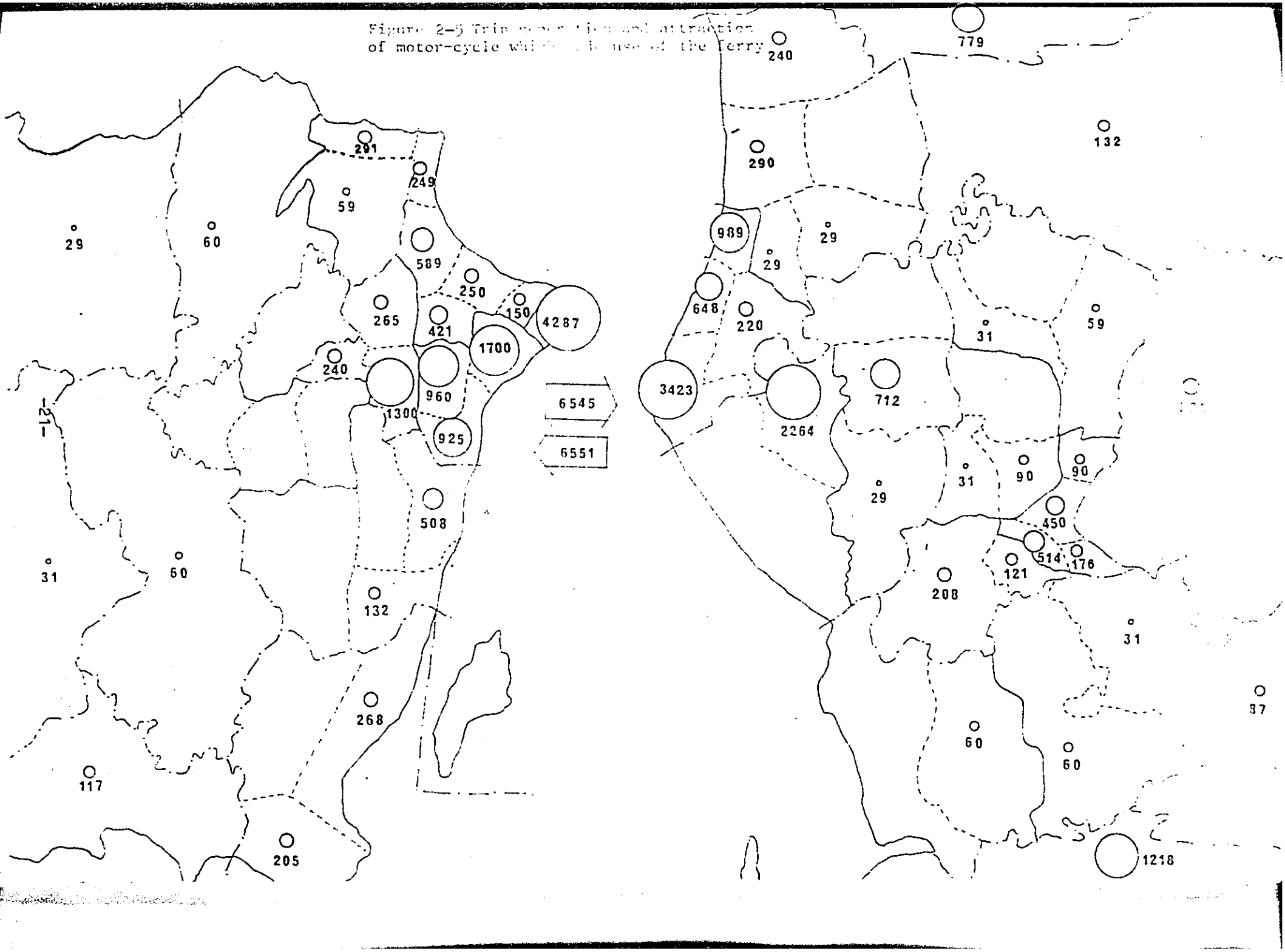


Figure 2-5 Trip generation and attraction of motor-cycle whi[illegible] the use of the ferry

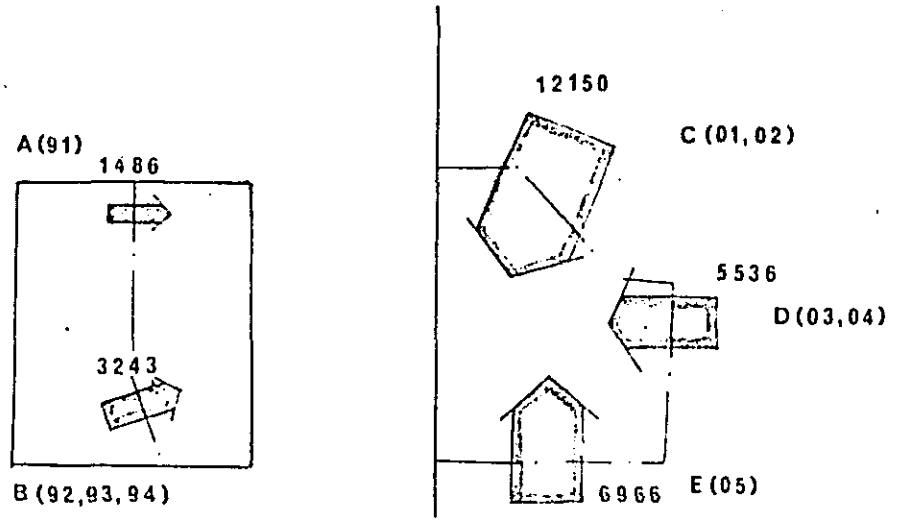


2-1-3 Cordon-line Survey.

From this survey, the present situation of external trips and through trips was obtained.

This results for each direction of external trips (incoming) are as follows.

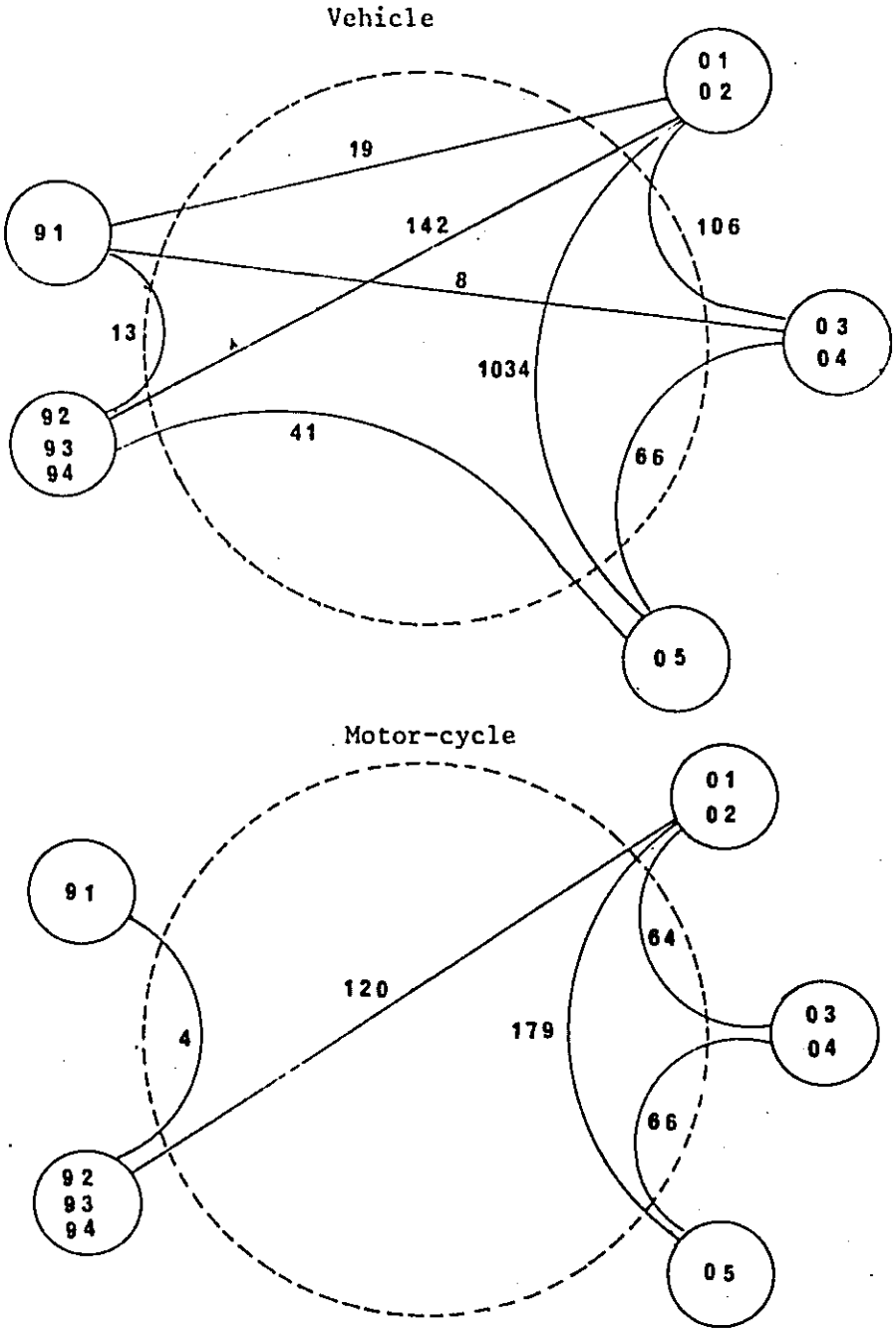
Figure 2-6 Number of external trips (in coming)



Direction / Vehicles and trip purpose		From A	From B	From C	From D	From E	Total
CAR	going to work	121	324	911	273	386	2015
	trip business	74	165	964	437	631	2271
	trip private	155	249	1521	628	817	3370
	going home	210	327	1333	619	998	2487
		564	1074	4738	1955	2838	11169
lorry		172	278	2027	693	1409	4579
taxi		82	85	475	50	323	1015
bus		30	5	102	35	14	186
Vehicle		847	1443	7340	2733	4585	16948
	going to work	187	700	1783	690	420	3780
	trip business	62	352	565	348	222	1549
	trip private	162	305	1103	752	672	2994
	going home	226	453	1356	1009	1076	4120
motor-cycles		639	1800	4810	2803	2381	12433
grand total		1486	3243	12150	5536	6966	29381

The result of traffic flow for through trip is as follows.

Figure 2-7 Traffic flow of through trip



2-1-4 Soreen-line Survey.

The results from this survey were used for the verification of the other traffic surveys. The traffic movements which were recorded by each traffic survey must correspond to the actual traffic volume on the screen line.

On checking the degree of accuracy, it was found that the results of those traffic surveys were very accurate and therefore can be used purpose of analyzing data from now on.

2-2 The procedure for completing the present O-D table

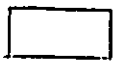
The present O-D table is completed from the following elements which are completed from the results of the following surveys.

Table 2-4 The O-D table and the elements.

O \ D		internal area		external area	
		P.I.	P.W.	P.I.	P.W.
internal area	P.I.	internal trip	internal trip which makes use of ferry	external trip	external trip which makes use of ferry
	P.W.	internal trip which makes use of ferry	internal trip	external trip which makes use of ferry	external trip
external area	P.I.	external trip	external trip which makes use of ferry	through trip	through trip which makes use of ferry
	P.W.	external trip which makes use of ferry	external trip	through trip which makes use of ferry	through trip

LEGEND

owner-interview survey



ferry survey

cordon-line survey.

In the case of an overlap in the data collection, the following priority for the different surveys was used:-

1st priority data from the ferry survey
2nd priority data from the cordon line survey
3rd priority data from the owner-interview survey.

For example, the trips which made use of the ferry may have been interviewed at the ferry survey, cordon line survey and owner-interview survey. In this case, the data from the ferry survey was used to complete the O-D table. The basis for the above choice was based on the accuracy of each traffic survey.

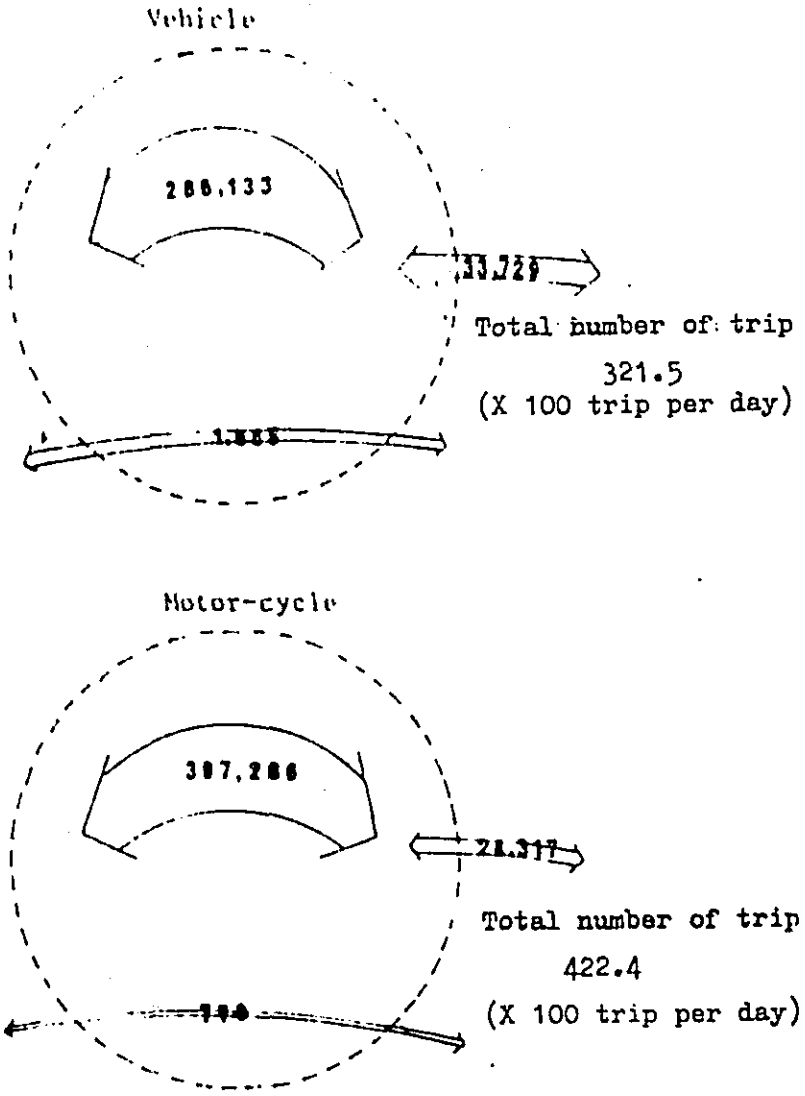
3. Present traffic situation

3-1 Some situation from the Present O-D table.

3-1-1 An out-line of the traffic movements.

An out-line of the traffic movements is as follows :-

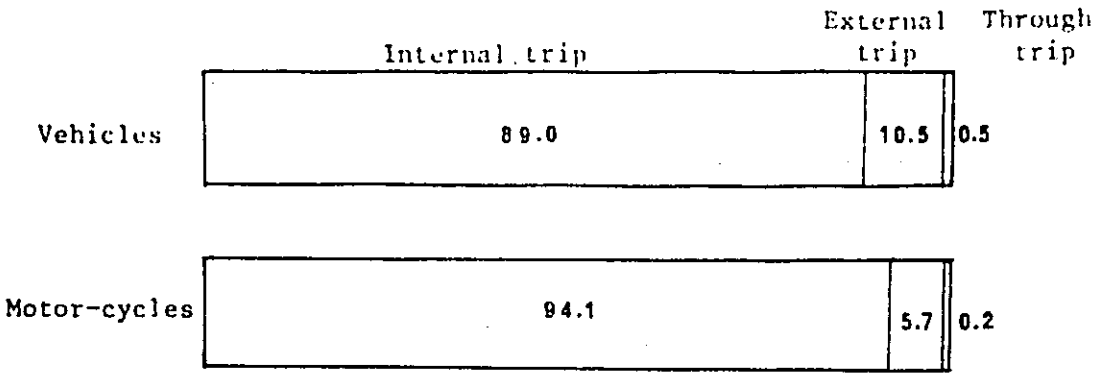
Figure 3-1 Number of trips for each travelling type.



The percentage for the different types of trips are shown in the following figure. From this, it can be seen that for internal trips, the ratio is higher for motor-cycles than for vehicles.

This means that the trip length of motor-cycles are shorter than those of vehicles, that is, motor-cycles are used more for short distance travelling.

Figure 3-2 The percentage for the each types of trips



3-1-2 A break down of trip purpose.
The type of trip and the trip purpose are as follows.

Table 3-1 Type of trip and trip purpose

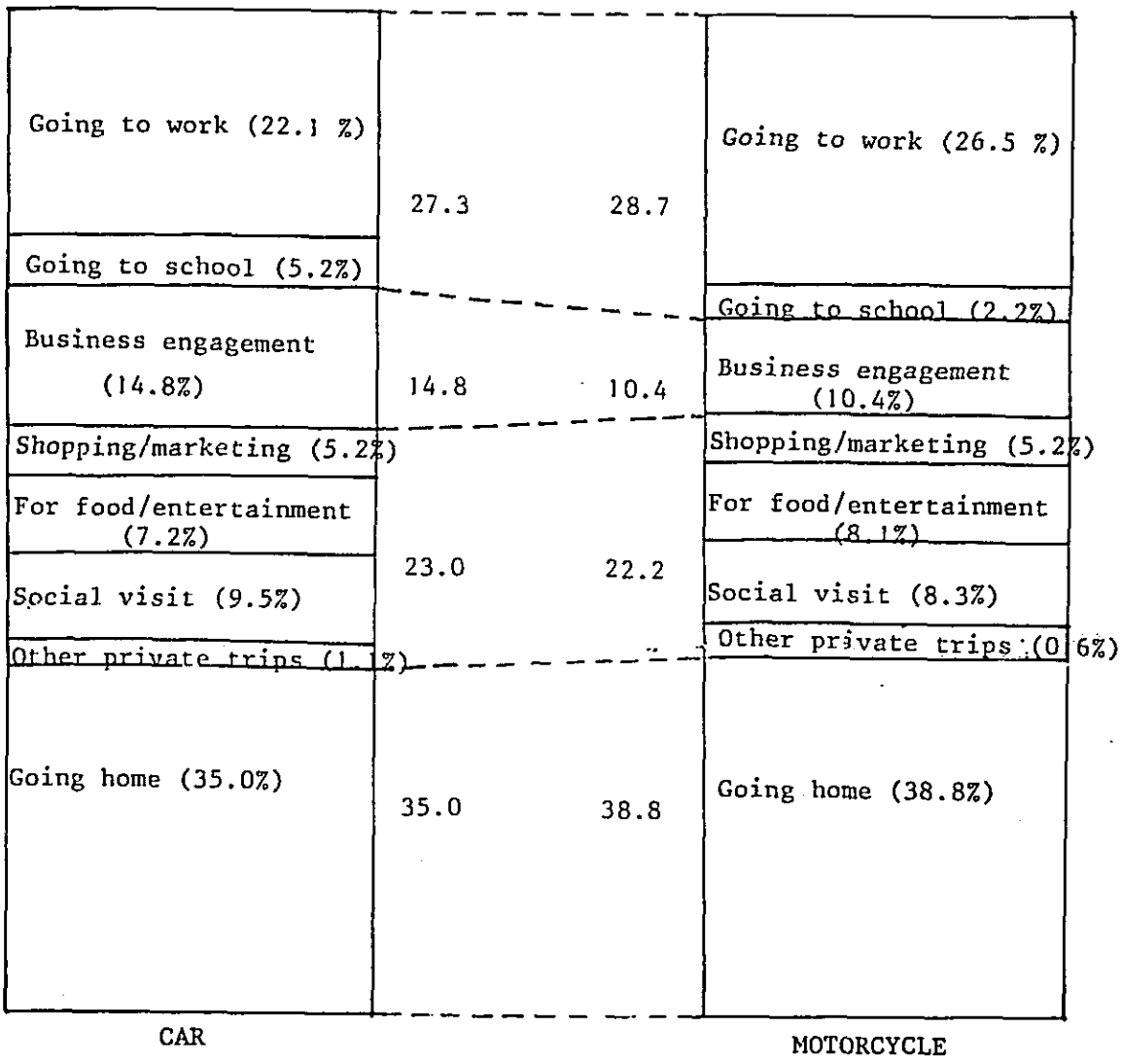
Type of trip / vehicle and trip purpose			number of internal trip	number of external trip	number of through trip	Total
vehicle	CAR	going to work	66378	4127	186	70691
		trip business	33428	4601	215	38239
		trip private	53060	6220	257	59537
		going home	83171	7006	511	90688
			236038	21992	1169	259199
		lorry	28381	9339	464	38184
		taxi	2723	1991	42	4756
		Bus	18987	411	11	19409
			286133	33729	1685	321547
motor-cycle		going to work	113412	7816	172	121400
		trip business	40907	3095	51	44053
		trip private	87810	5406	108	93324
		going home	155286	8020	442	163748
			397286	24317	770	422373
grand total			683419	58046	2455	743920

The trip purpose in detail is as follows:-

Table 3-2 The trip purpose in detail (unit: 1000 trip per day)

Broad Purpose		Car	Motor-cycle
Classification	Detailed classification		
Going to work	Going to work	57.2 (22.1)	111.9 (26.5)
	Going to school	13.6 (5.2)	9.5 (5.2)
Business trip	Business engagement	38.3 (14.8)	44.1 (10.4)
Private trip	Shopping/Marketing	13.5 (5.2)	21.8 (5.2)
	For food/Entertainment	18.6 (7.2)	34.1 (7.2)
	Social visit	24.5 (9.5)	35.0 (9.5)
	Other private trips	2.8 (1.1)	2.5 (1.1)
Going home	Going home	90.7 (35.0)	163.8 (38.8)
T O T A L		259.2 (100.0)	422.4 (100.0)

The Comparison between the trip purpose of cars and motorcycles is as follows:-

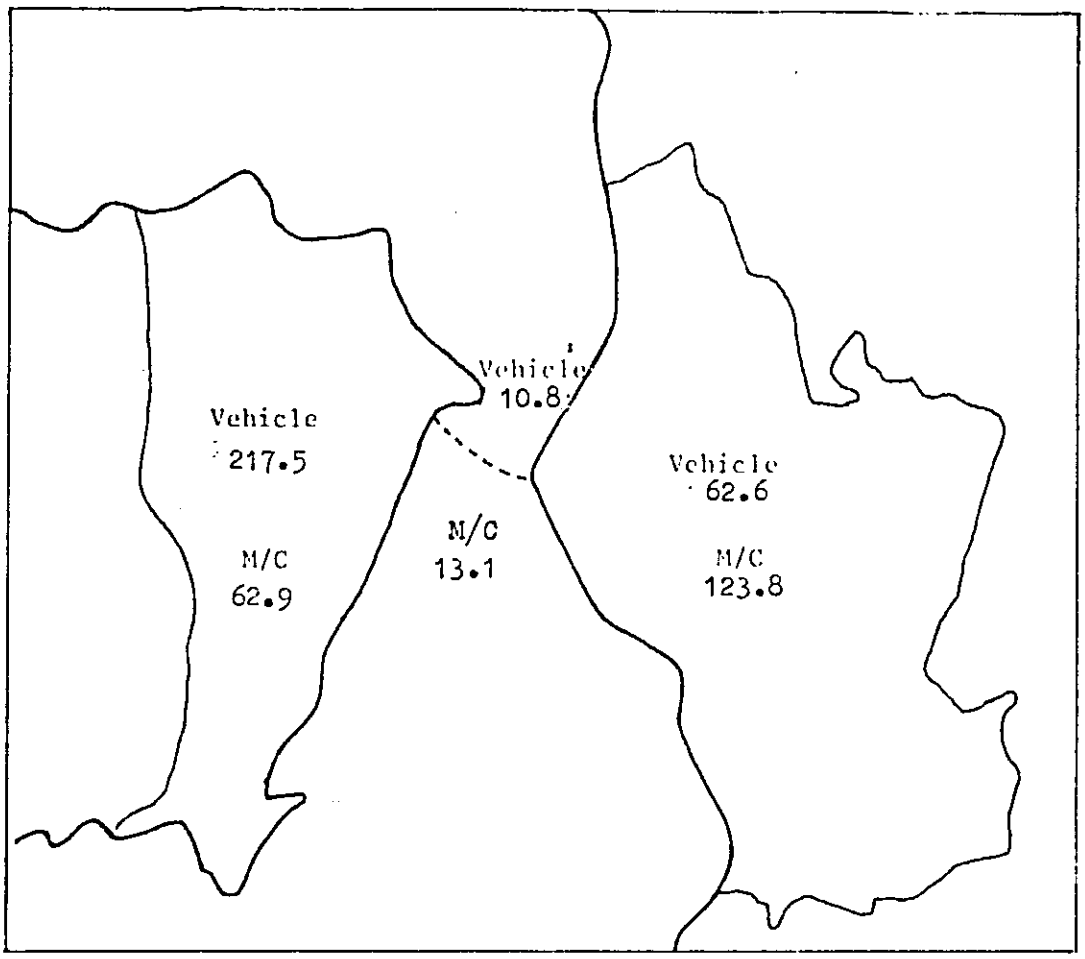


There is no conspicuous difference between the trip purpose of cars and motorcycles except in the case of business trips where the figures for cars are slightly higher than those for motorcycles.

Internal trips are divided into 3 types i.e. the trips which move into the internal areas of Penang Island, the trips which move into the internal areas of Province Wellesley and the trips which make use of the ferry.

Figure 3-3 Trip by Area.

(unit: 1000 trip per day)

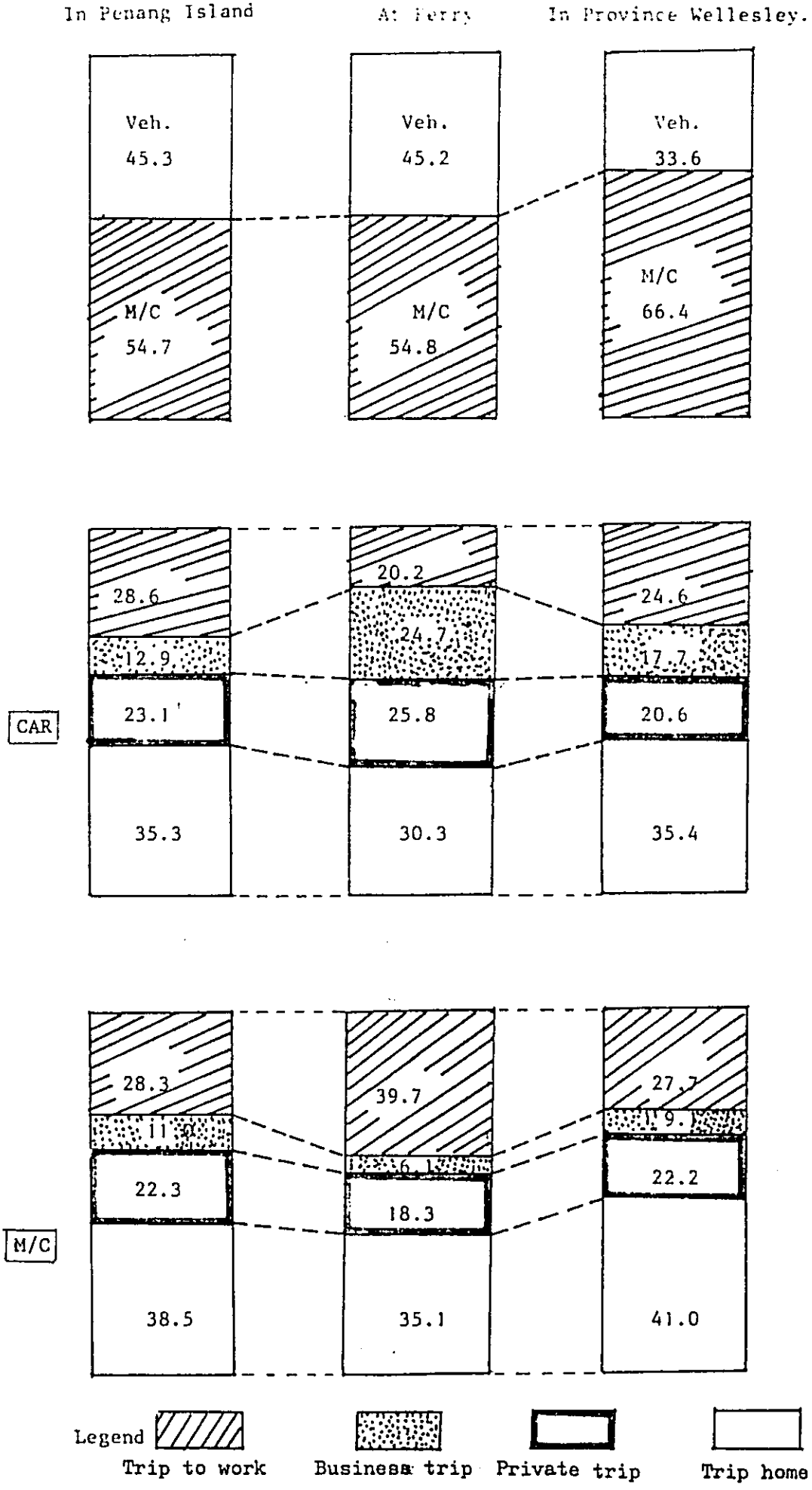


The composition of the trip purpose for the 3 types of trips are compared in the following table.

Table 3-3 The composition of the trip purpose by area.

(unit: 1000 trip per day)

Vehicles and trip purpose \ Area		In Penang Island	At the ferry	In Province Wellesley
CAR	Going to work	51.5 (10.7)	1.8 (7.5)	12.5 (6.7)
	Business trip	23.2 (4.8)	2.2 (9.2)	9.0 (4.8)
	Private trip	41.6 (8.7)	2.3 (9.4)	10.5 (5.6)
	Going home	63.6 (13.2)	2.7 (11.2)	18.0 (9.7)
	Sub-total	180.1 (37.5)	8.9 (37.4)	50.9 (27.3)
Lorry		19.3 (4.0)	1.7 (7.1)	8.2 (4.4)
Taxi		2.3 (0.5)	0.1 (0.3)	0.4 (0.2)
Bus		15.8 (3.3)	0.1 (0.5)	3.1 (1.7)
Sub total of vehicles		217.5 (45.3)	10.8 (45.2)	62.6 (33.6)
MOTORCYCLE	Going to work	74.3 (15.5)	5.2 (21.8)	34.3 (18.4)
	Business trip	28.9 (6.0)	0.8 (3.5)	11.3 (6.1)
	Private trip	58.6 (12.2)	2.4 (10.1)	27.5 (14.8)
	Going home	101.1 (21.0)	4.6 (19.4)	50.8 (27.3)
	Sub-total	262.9 (54.7)	13.1 (54.8)	123.8 (66.4)
Grand total		480.3 (100.0)	23.9 (100.0)	186.4 (100.0)


In Penang Island
At Ferry
In Province Wellesley.
Veh.
45.3
M/C
54.7
Veh.
45.2
M/C
54.8
Veh.
33.6
M/C
66.4
CAR
28.6
12.9
23.1
35.3
20.2
24.7
25.8
30.3
24.6
17.7
20.6
35.4
M/C
28.3
11.0
22.3
38.5
39.7
6.1
18.3
35.1
27.7
11.9
22.2
41.0
Legend
Trip to work
Business trip
Private trip
Trip home

3-1-3 Average number of trips per day.

From the owner-interview survey, the average number of trips per day can be obtained. Using the technical term in traffic studies, these figures are called "unit trip production". There are two types of unit trip production. One is the gross unit trip production while the other is the net unit trip production.

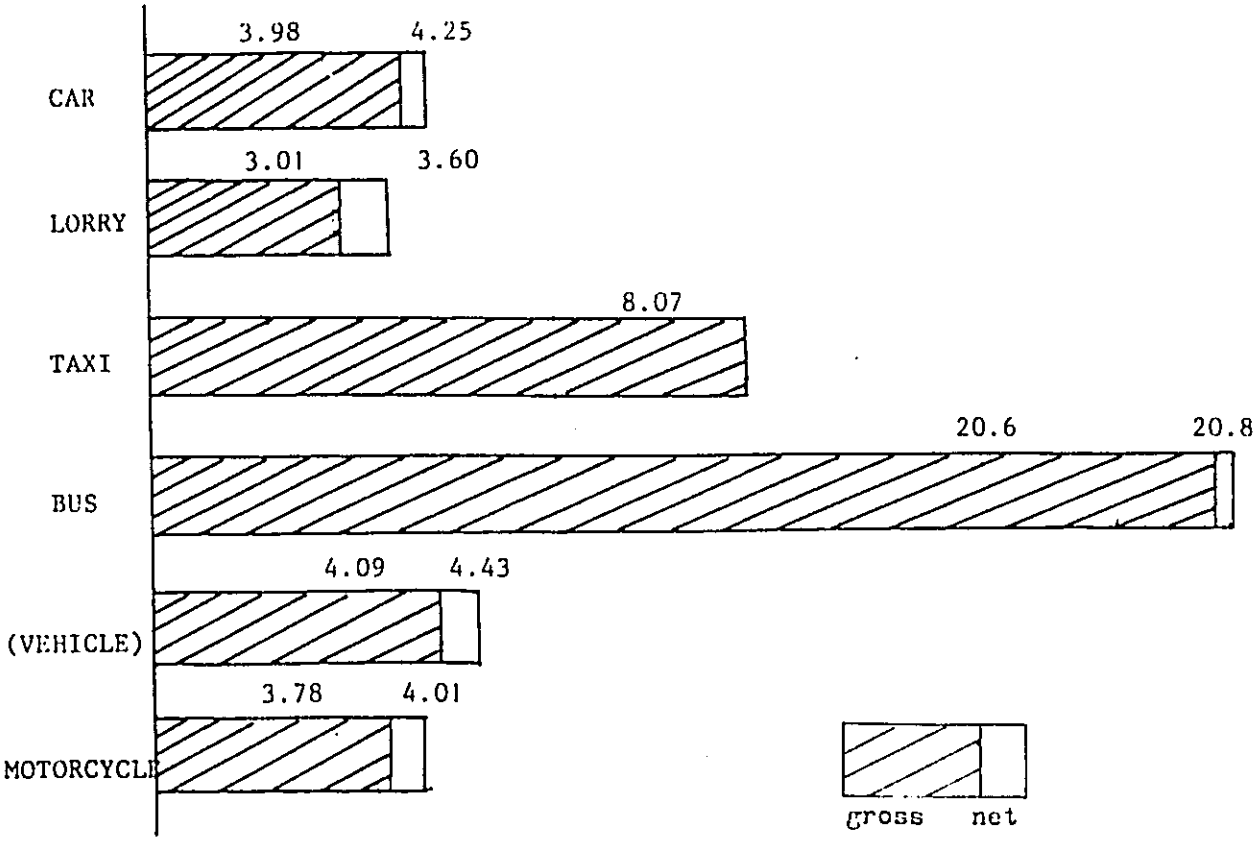
Some vehicles did not make any trips on the day of the interview. Therefore the former the gross unit trip production is the average trip per day of one vehicle which also includes zero (0) and the latter is the actual average number of trips per day of one vehicle.

These figures are as follows;

Table 3-4 Average number of trips per day (unit: trip per vehicle per day)

	The unit trip production (gross)	The unit trip production (net)	The % of zero number of trips
Car	3.98	4.25	6.3 %
Lorry	3.01	3.60	16.4 %
Taxi	8.07	8.07	0 %
Bus	20.6	20.8	0.9 %
(Vehicles)	4.09	4.43	7.7 %
Motor-cycle	3.78	4.01	5.7 %
All vehicles	3.90	4.17	6.5 %

Figure 3-4 The unit trip production. (unit: trip per vehicle per day)



3-1-4 Departure time and arrival time.

The departure time and arrival time of all vehicles with regard to trip purpose is shown in the following figure.

Figures for all trip purpose show that there are three peak hours in a day, that is, 8am - 9 am, 1pm - 2 pm and 5pm - 6 pm. These peak hours are caused by commuting trips, lunch hour trips and going home trips.

Figure 3-5 Departure time and arrival time

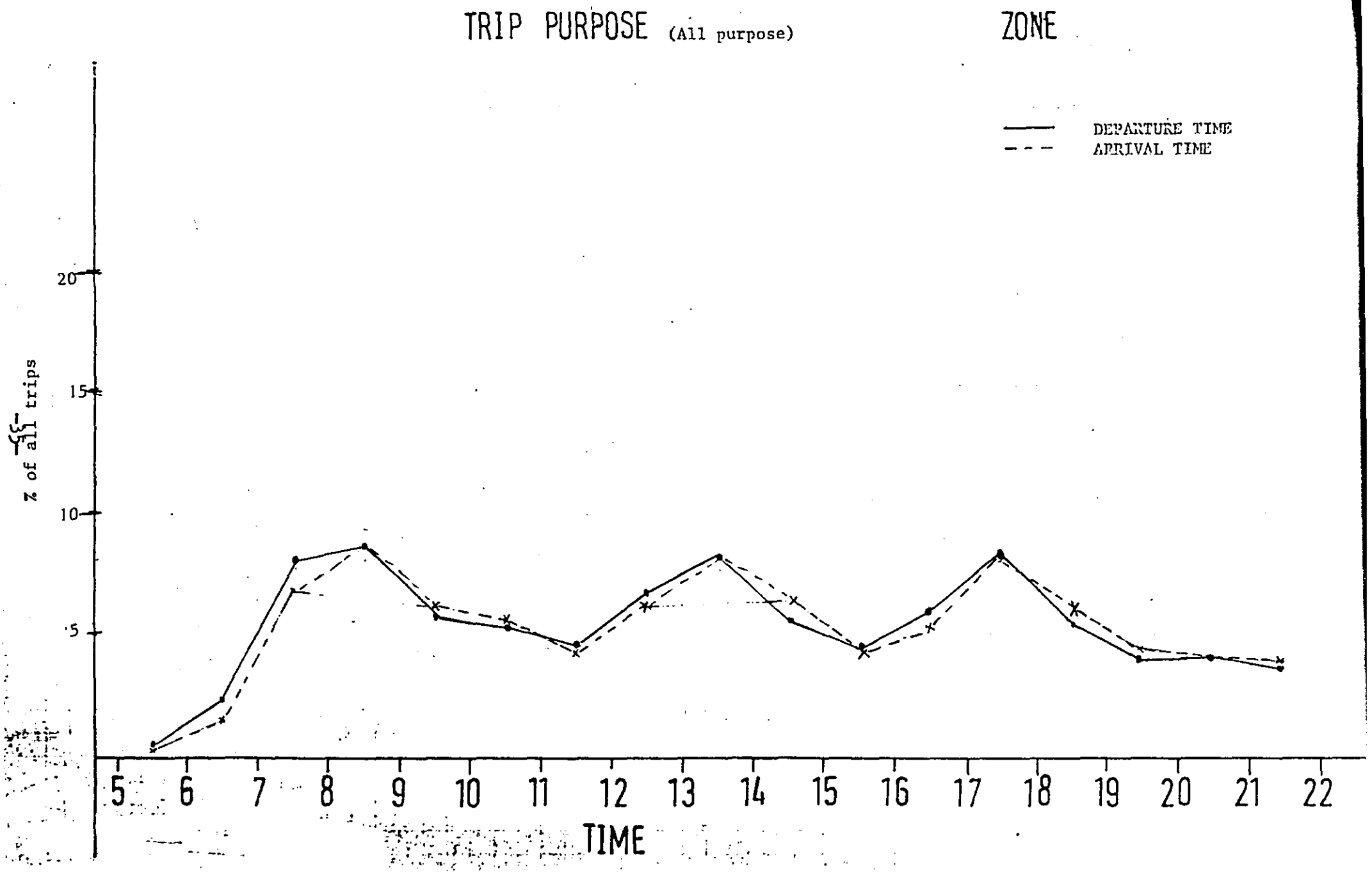


Figure 3-6 Departure time and arrival time

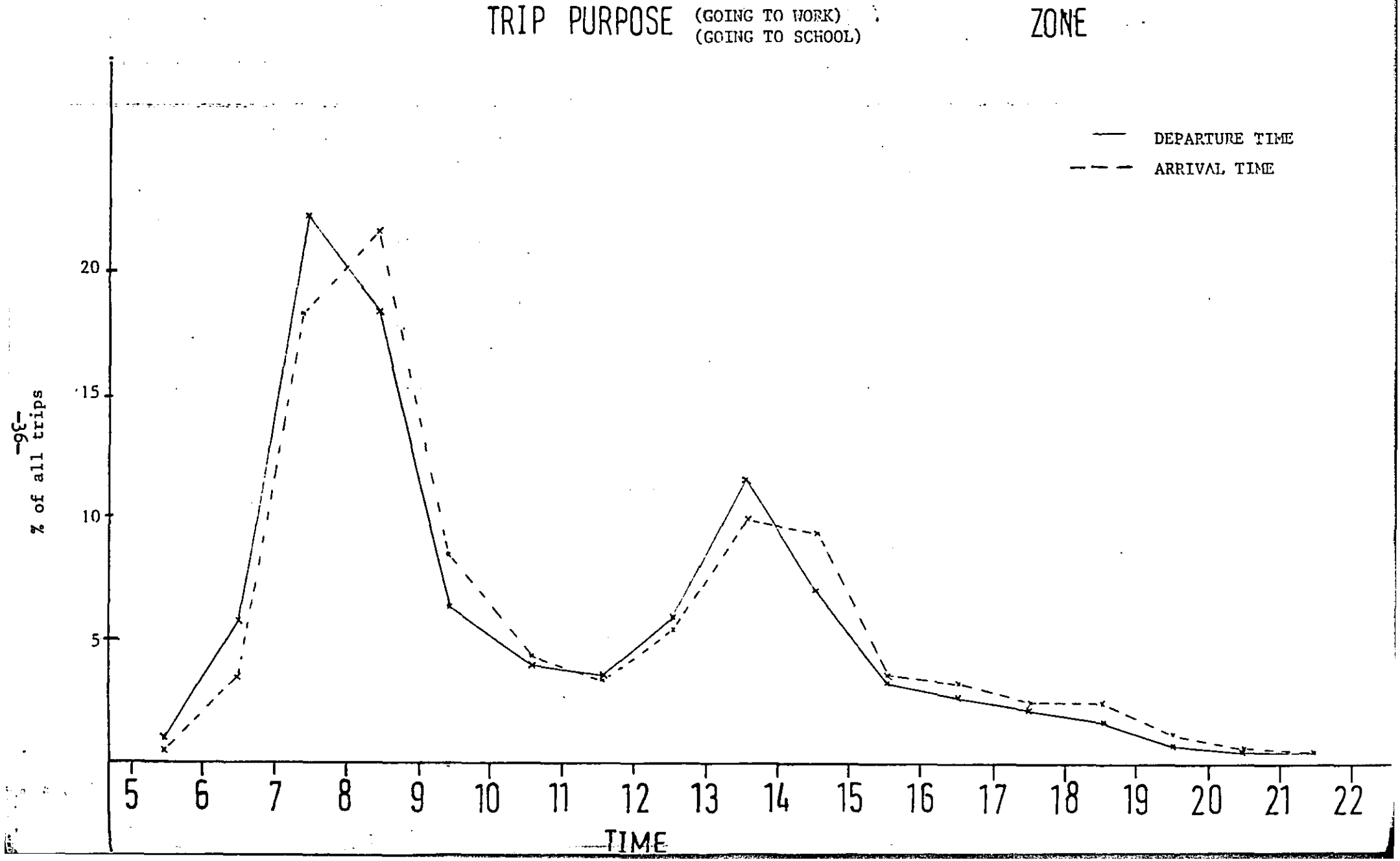


Figure 3-7 Departure time and arrival time

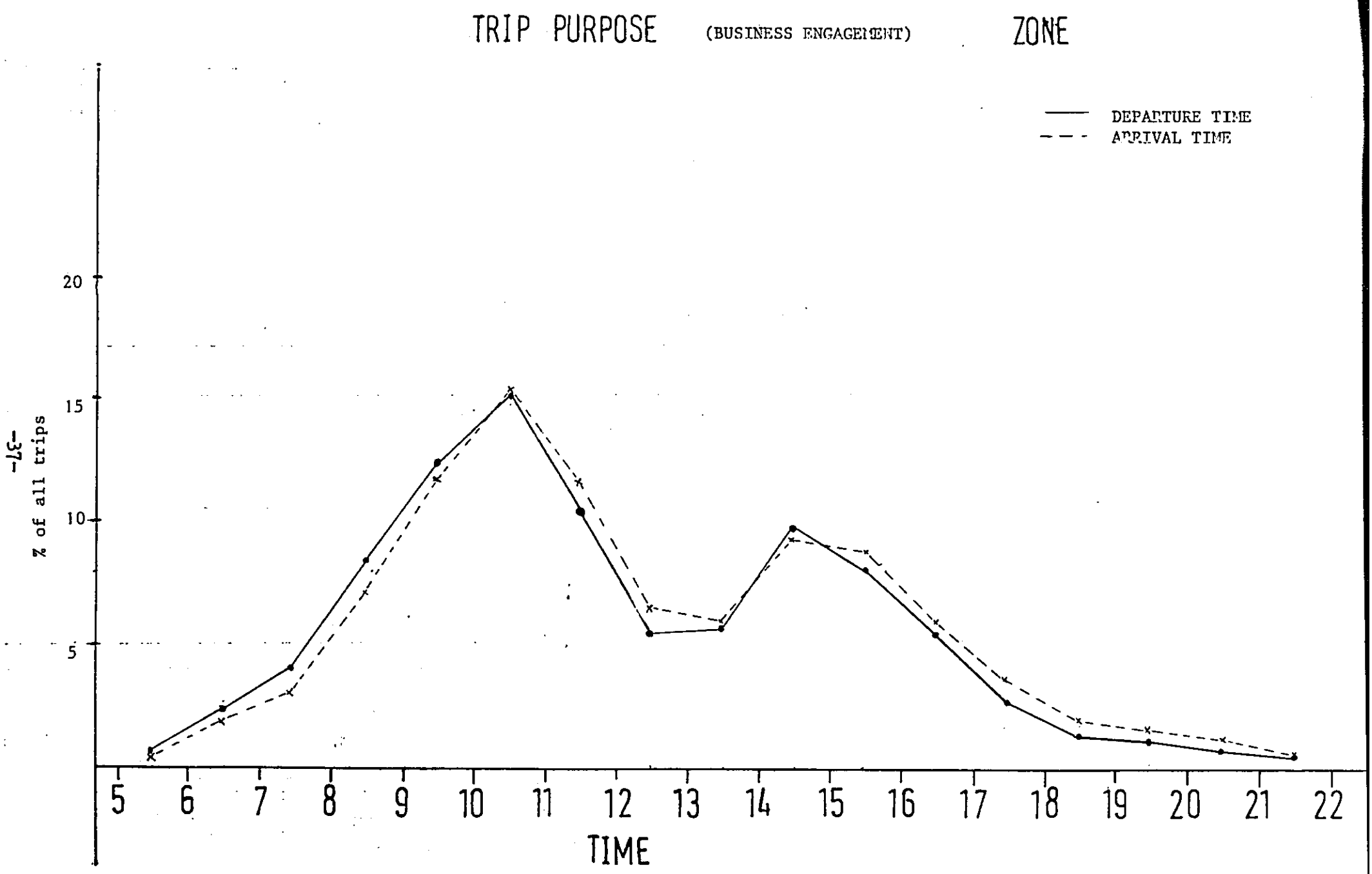


Figure 3-8 Departure time and arrival time

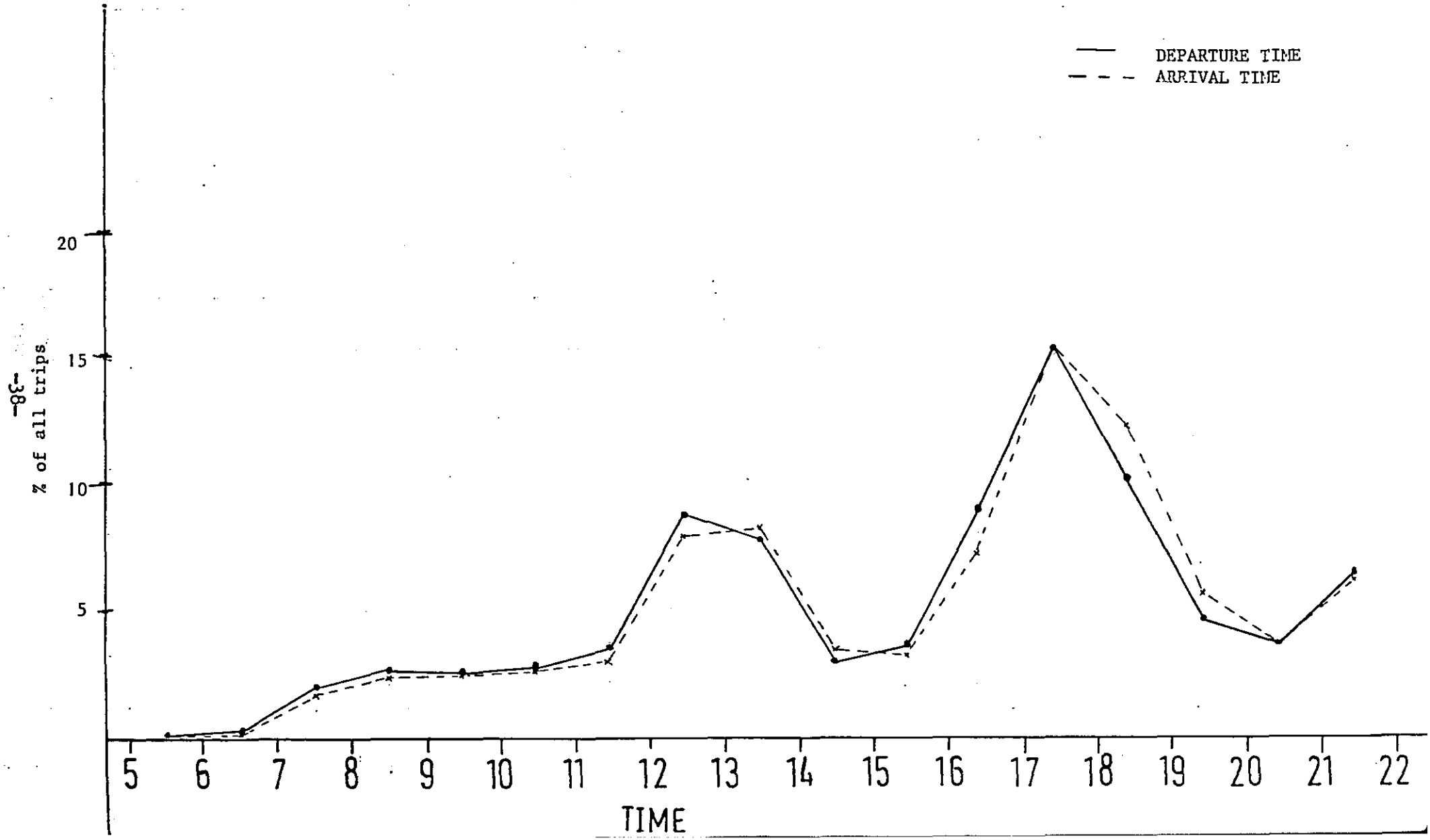
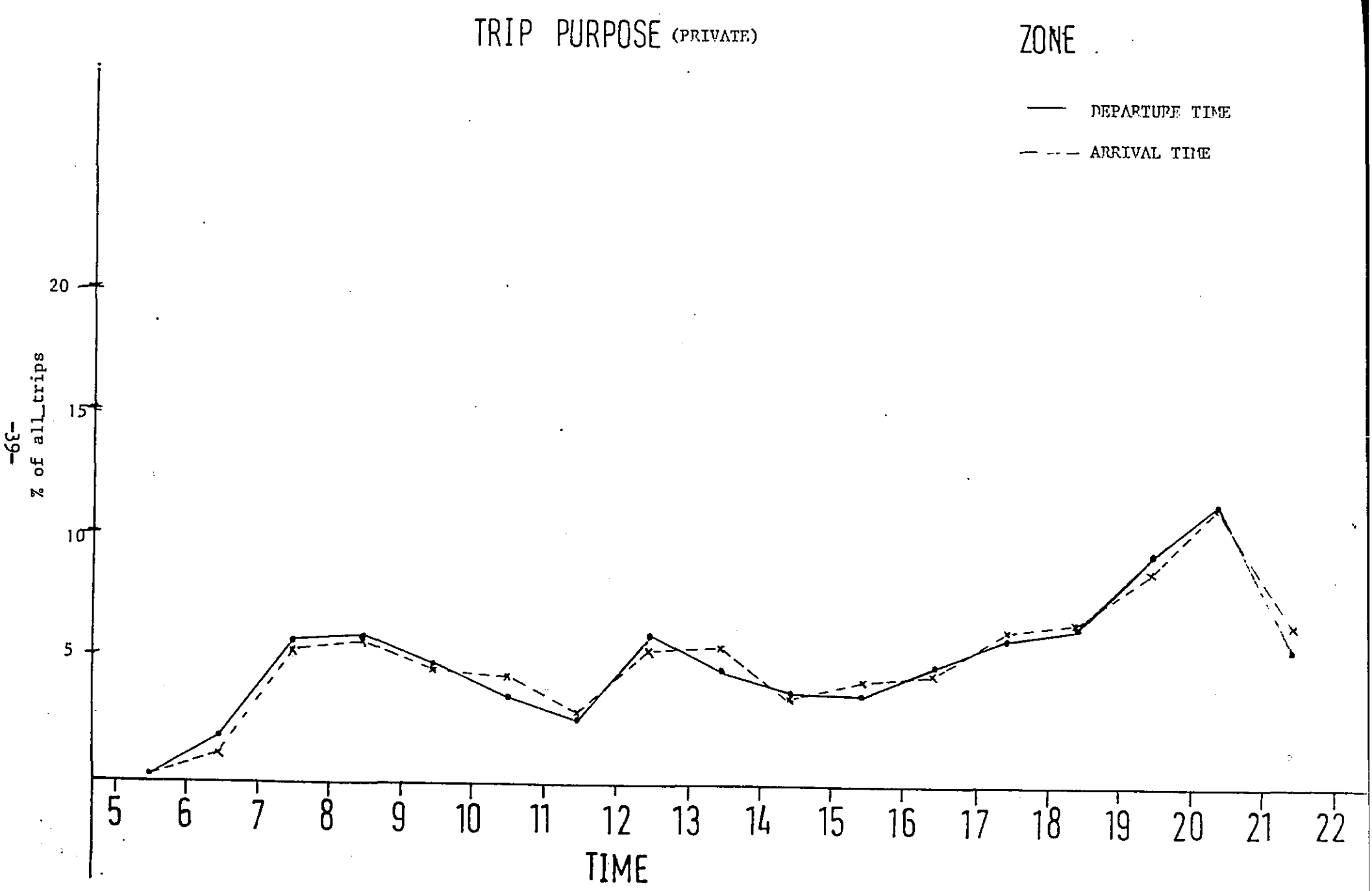
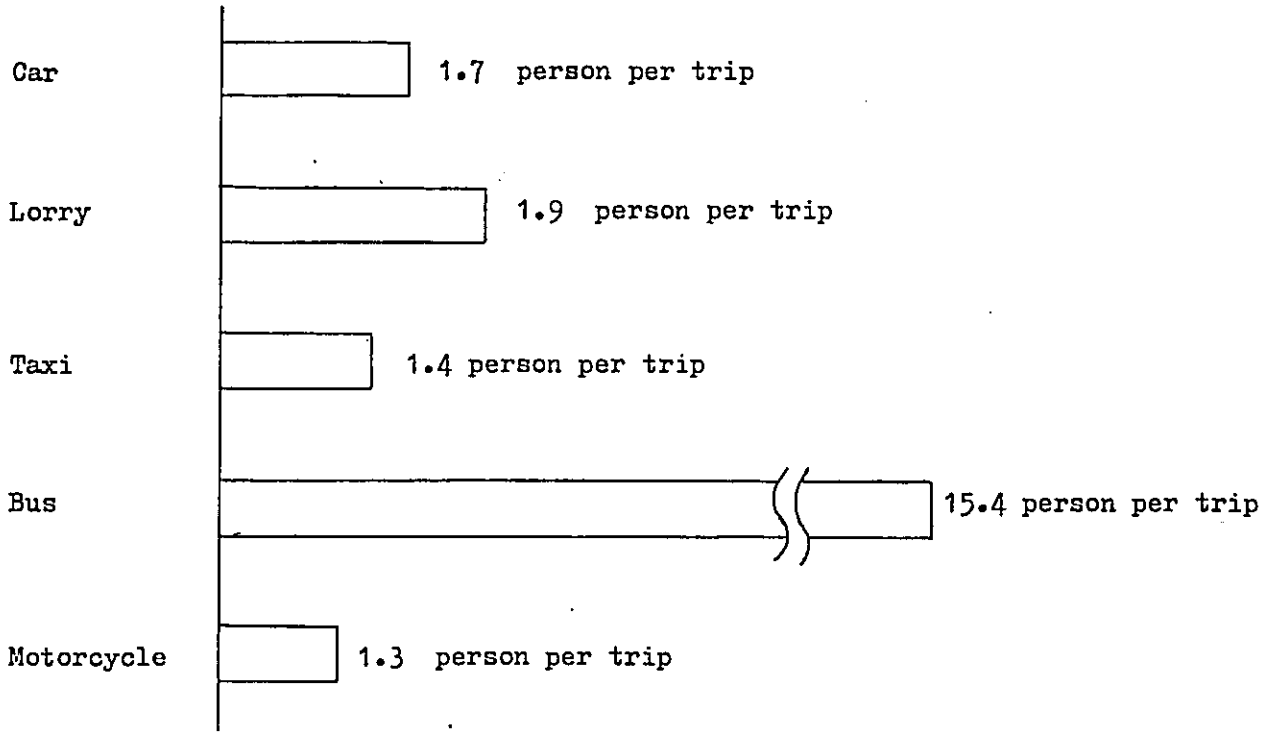


Figure 3-9 Departure time and arrival time



3-1-5 The average number of passengers per vehicle.

The average number of passengers (inclusing the driver) per vehicle is as follows :-



In the case of the taxi, the above figure does not include the driver but includes trips without passengers too.

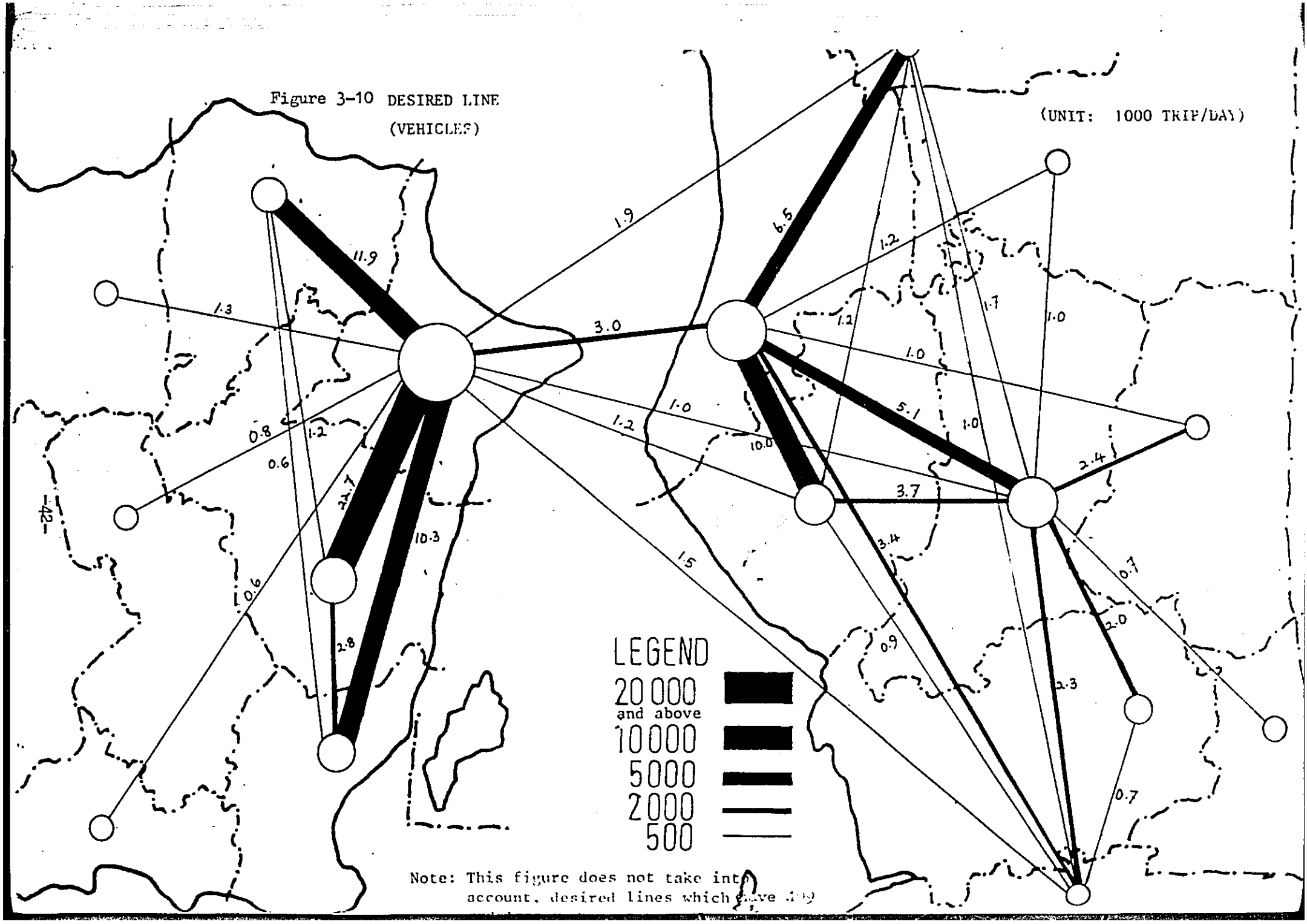
This 'no passenger trip' contributes to about 43 % of all the trips made by taxis. Thus, the actual average number of passengers per trip is 2.4 person (1.4/0.57).

3-2 Present O-D table

The desired line and the O-D tables are shown in the following figures and tables.

Figure 3-10 DESIRED LINE
(VEHICLES)

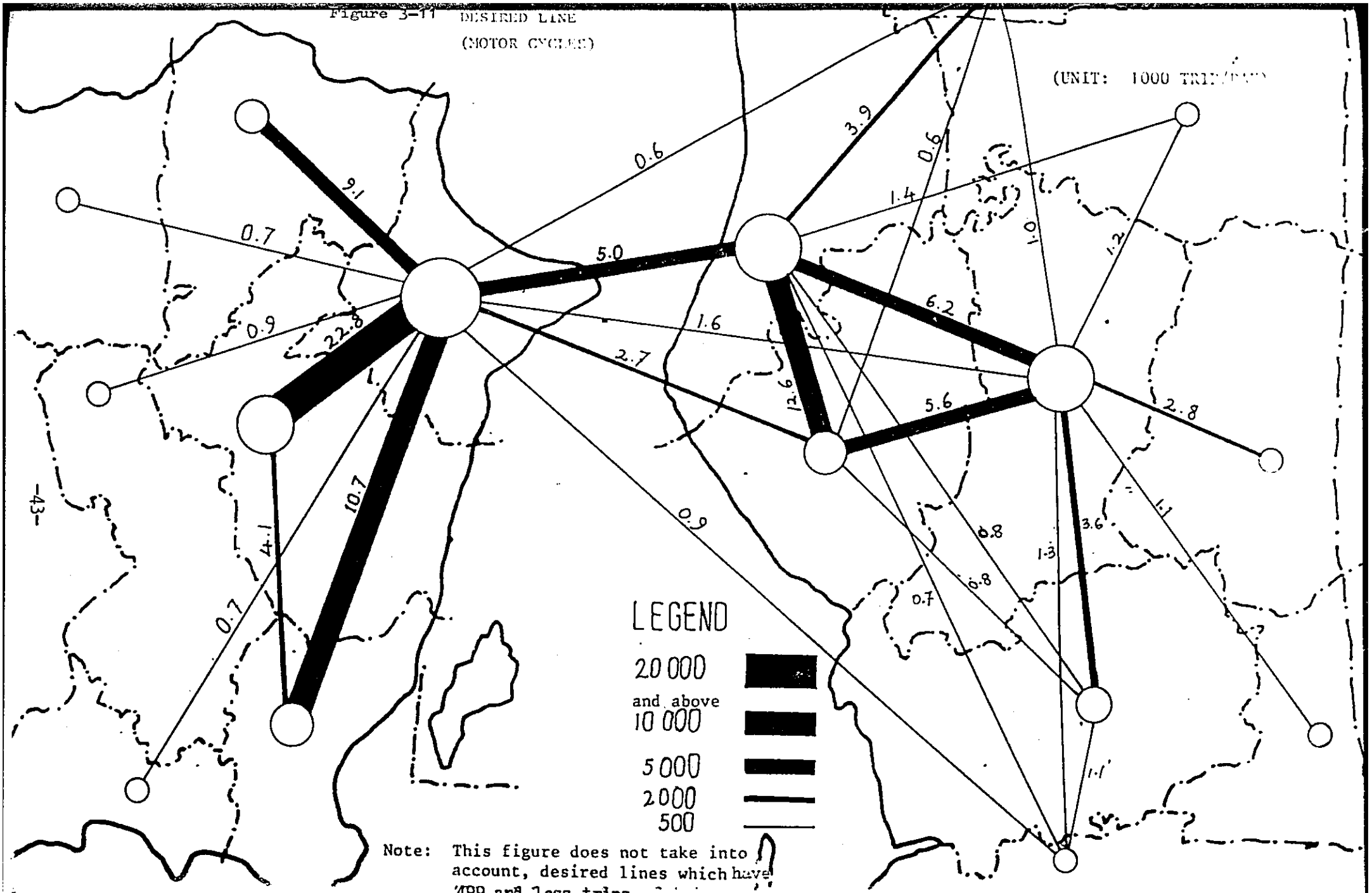
(UNIT: 1000 TRIP/DAY)



Note: This figure does not take into account, desired lines which have [illegible]

Figure 3-11 DESIRED LINE

(MOTOR CYCLES)



Note: This figure does not take into account, desired lines which have 499 and less trips

Table 3-5 CAR - TRIP TO WORK

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	05	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	38384	720	1663	1290	42057	447	250	42	0	739	42796	74	82	27	73	256	113	9	22	0	82	226	482	43278
2	1412	214	17	73	1716	29	51	11	0	91	1807	40	0	2	0	42	20	0	0	0	19	39	81	1888
3	4531	52	1077	503	6163	38	29	20	0	87	6250	0	13	0	24	37	0	0	0	0	0	0	37	6287
4	921	36	76	570	1603	18	0	0	0	18	1621	7	33	8	53	101	17	0	0	0	0	17	118	1739
SUB TOTAL	45248	1022	2833	2436	51539	532	330	73	0	935	52474	121	128	37	150	436	150	9	22	0	101	282	718	53192
5	150	0	9	17	176	5461	1116	401	25	7003	7179	0	0	0	0	0	450	92	48	6	116	712	712	7891
6	76	0	0	0	76	1087	905	238	0	2230	2306	0	0	0	0	0	69	15	9	0	28	121	121	2427
7	82	0	21	7	110	516	472	2719	227	2934	4044	0	0	0	0	0	116	70	164	23	131	504	504	4548
8	0	0	0	0	0	54	78	146	97	375	375	0	0	0	0	0	3	0	5	0	49	57	57	432
SUB TOTAL	308	0	30	24	362	7118	2571	3504	349	12542	13904	0	0	0	0	0	638	177	226	29	324	1394	1394	15298
TOTAL IN INTERNAL AREA	45556	1022	2863	2460	51901	7650	2901	3577	349	13477	66378	121	128	37	150	436	788	186	248	29	425	1676	2112	68490
91	74	40	0	7	121	0	0	0	0	0	121	0	0	0	0	0	0	0	0	0	0	0	0	121
92	82	0	13	33	128	0	0	0	0	0	128	0	0	0	24	24	9	0	0	0	0	9	33	161
93	27	2	0	8	37	0	0	9	0	9	46	0	0	0	0	0	0	0	0	0	0	0	0	46
94	73	0	24	53	150	0	0	0	0	0	150	0	0	8	0	8	0	0	0	0	0	0	8	158
SUB TOTAL	256	42	37	101	436	0	0	9	0	9	445	0	0	8	24	32	9	0	0	0	0	9	41	486
01	69	0	7	0	76	450	69	116	3	638	714	10	0	0	0	10	0	10	6	3	57	76	86	800
02	20	0	0	0	20	92	15	70	0	177	197	0	0	0	0	0	0	0	0	0	3	3	3	200
03	18	0	0	0	18	48	9	164	5	226	244	0	0	0	0	0	18	0	0	0	5	23	23	267
04	0	0	0	0	0	6	0	23	0	29	29	0	0	0	0	0	5	0	0	0	7	12	12	41
05	67	0	0	0	67	111	28	131	49	319	386	0	0	0	0	0	21	0	0	0	0	21	21	407
SUB TOTAL	174	0	7	0	181	707	121	504	57	1389	1570	10	0	0	0	10	44	10	6	3	72	135	145	1715
TOTAL IN EXTERNAL AREA	430	42	44	101	617	707	121	513	57	1398	2015	10	0	8	24	42	53	10	6	3	72	144	186	2201
GRAND TOTAL	45986	1064	2907	2561	52518	8357	3022	4090	406	14875	68393	131	128	45	174	478	841	196	254	32	497	1820	2298	70691

Table 3-6 CAR - BUSINESS TRIP

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	05	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	17242	914	951	988	20095	310	144	124	0	578	20673	58	59	21	28	166	225	9	17	0	203	454	620	21293
2	519	163	23	27	732	25	0	0	0	25	757	16	2	2	0	20	8	0	0	0	17	25	45	802
3	1040	27	171	266	1504	20	9	0	0	29	1533	0	8	0	5	13	0	0	9	0	9	18	31	1564
4	488	55	37	309	889	0	0	0	0	0	889	0	0	4	21	25	6	0	0	0	0	6	31	920
SUB TOTAL	19289	1159	1182	1590	23220	355	153	124	0	632	23852	74	69	27	54	224	239	9	26	0	229	503	727	24579
5	277	0	10	15	302	3673	981	550	24	5228	5530	0	10	0	0	10	422	83	145	19	285	954	964	6494
6	86	0	0	17	103	1019	169	314	8	1510	1613	0	0	0	6	6	48	17	15	14	35	129	135	1748
7	139	0	20	0	159	638	197	1133	41	2009	2168	0	0	0	0	0	97	38	166	47	133	481	481	2649
8	7	0	0	0	7	9	22	141	86	258	265	0	0	0	0	0	7	0	11	0	0	18	18	283
SUB TOTAL	509	0	30	32	571	5339	1369	2138	159	9005	9576	0	10	0	6	16	574	138	337	80	453	1582	1598	11174
TOTAL IN INTERNAL AREA	19798	1159	1212	1622	23791	5694	1522	2262	159	9637	33428	74	79	27	60	240	813	147	363	80	682	2085	2325	35753
91	58	16	0	0	74	0	0	0	0	0	74	0	0	2	0	2	0	0	0	0	0	0	2	76
92	59	2	8	0	69	0	0	0	0	0	69	0	0	0	4	4	0	0	0	0	0	0	4	73
93	21	2	0	4	27	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	27
94	28	0	5	21	54	0	15	0	0	15	69	0	0	0	0	0	9	0	0	0	0	9	9	78
SUB TOTAL	166	20	13	25	224	0	15	0	0	15	239	0	0	2	4	6	9	0	0	0	0	9	15	254
01	236	7	0	0	243	422	48	97	7	574	817	0	7	0	0	7	0	14	0	0	86	100	107	924
02	9	0.	0	0	9	83	17	38	0	138	147	0	0	0	0	0	0	0	0	0	4	4	4	151
03	0	0	10	0	10	145	15	166	11	337	347	0	0	0	0	0	0	0	0	0	10	10	10	357
04	0	0	0	10	10	19	14	47	0	80	90	0	0	0	0	0	6	0	0	0	0	6	6	96
05	168	0	0	10	178	285	35	133	0	453	631	0	0	0	6	6	60	7	0	0	0	67	73	704
SUB TOTAL	413	7	10	20	450	954	129	481	18	1582	2032	0	7	0	6	13	66	21	0	0	100	187	200	2232
TOTAL IN EXTERNAL AREA	579	27	23	45	674	954	144	481	18	1597	2271	0	7	2	10	19	75	21	0	0	100	196	215	2486
GRAND TOTAL	20377	1186	1235	1667	24465	6648	1666	2743	177	11234	35699	74	86	29	70	259	888	168	363	80	782	2281	2540	38239

Table 3-7 CAR - PRIVATE TRIP

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	05	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	32556	1467	979	315	35317	97	26	84	0	207	35524	114	97	31	60	302	104	0	9	0	165	278	580	36104
2	1187	357	17	14	1575	0	0	0	0	0	1575	39	0	2	0	41	0	8	0	0	31	39	80	1655
3	3065	106	547	162	3880	40	0	0	0	40	3920	2	8	0	0	10	8	0	0	0	9	17	27	3947
4	517	6	124	216	863	9	0	0	0	9	872	0	8	6	28	42	18	0	0	0	9	27	69	941
SUB TOTAL	37325	1936	1667	707	41635	146	26	84	0	256	41891	155	113	39	88	395	130	8	9	0	214	361	756	42647
5	328	7	20	7	362	4045	315	239	12	4611	4973	0	0	0	10	10	559	103	114	24	179	979	989	5962
6	131	0	0	0	131	1121	379	258	8	1766	1897	0	0	0	0	0	44	8	9	0	49	110	110	2007
7	169	0	0	10	179	438	90	3166	58	3752	3931	0	0	0	0	0	174	128	300	108	207	917	917	4848
8	10	0	0	0	10	14	14	274	56	358	368	0	0	0	0	0	3	14	14	12	35	78	78	446
SUB TOTAL	638	7	20	17	682	5618	798	3937	134	10487	11169	0	0	0	10	10	780	253	437	144	470	2084	2094	13263
TOTAL IN INTERNAL AREA	37963	1943	1687	724	42317	5764	824	4021	134	10743	53060	155	113	39	98	405	910	261	446	144	684	2445	2850	55910
91	114	39	2	0	155	0	0	0	0	0	155	0	0	0	0	0	0	0	0	0	0	0	0	155
92	97	0	8	8	113	0	0	0	0	0	113	0	0	0	0	0	8	0	0	0	0	8	8	121
93	31	2	0	6	39	0	0	0	0	0	39	0	0	0	0	0	0	0	0	0	0	0	0	39
94	60	0	0	28	88	9	0	0	0	9	97	0	0	0	0	0	0	0	0	0	0	0	0	97
SUB TOTAL	302	41	10	42	395	9	0	0	0	9	404	0	0	0	0	0	8	0	0	0	0	8	8	412
01	381	43	10	44	478	559	44	174	3	780	1258	0	14	0	10	24	0	35	6	3	75	119	143	1401
02	10	0	0	0	10	103	8	128	14	253	263	0	0	0	0	0	10	0	0	0	3	13	13	276
03	40	0	0	0	40	114	9	300	14	437	477	0	0	0	0	0	10	0	0	0	0	10	10	486
04	7	0	0	0	7	24	0	108	12	144	151	8	0	0	0	8	7	0	0	0	5	12	20	171
05	276	30	21	20	347	179	49	207	35	470	817	0	12	0	0	12	51	0	0	0	0	51	63	880
SUB TOTAL	714	73	31	64	882	979	110	917	78	2084	2966	8	26	0	10	44	78	35	6	3	83	205	249	3215
TOTAL IN EXTERNAL AREA	1016	114	41	106	1277	988	110	917	78	2093	3370	8	26	0	10	44	86	35	6	3	83	213	257	3627
GRAND TOTAL	38979	2057	1728	830	43594	6752	934	4938	212	12836	56430	163	139	39	108	449	996	296	452	147	767	2658	3107	59537

Table 3-8 CAR – TRIP HOME

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	5	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	47503	1699	5473	824	55499	409	76	123	26	634	56133	162	103	19	73	357	248	26	27	0	159	460	817	56950
2	1634	495	126	24	2279	17	0	0	0	17	2296	42	9	4	4	59	0	0	0	0	9	9	68	2364
3	1946	17	1132	63	3158	8	8	0	0	16	3174	4	16	0	24	44	9	0	0	0	11	20	64	3238
4	1569	73	510	533	2685	18	11	0	0	29	2714	2	20	0	30	52	20	0	0	0	9	29	81	2795
SUB TOTAL	52652	2284	7241	1444	63621	452	95	123	26	696	64317	210	148	23	131	512	277	26	27	0	188	518	1030	65347
5	428	12	21	0	461	6756	1598	815	56	9225	9686	0	0	0	0	0	601	110	83	29	327	1150	1150	10836
6	226	36	0	12	274	735	751	367	119	1972	2246	0	0	0	0	0	70	38	23	5	89	225	225	2471
7	128	0	20	0	148	458	521	4870	422	6271	6419	0	0	0	0	0	140	129	310	100	309	988	988	7407
8	0	0	0	0	0	11	0	261	231	503	503	0	0	0	0	0	3	19	18	9	77	126	126	629
SUB TOTAL	782	48	41	12	883	7960	2870	6313	828	17971	18854	0	0	0	0	0	814	296	434	143	802	2489	2489	21343
TOTAL IN INTERNAL AREA	53434	2332	7282	1456	64504	8412	2965	6436	854	18667	83171	210	148	23	131	512	1091	322	461	143	990	3007	3519	86690
91	162	42	4	2	210	0	0	0	0	0	210	0	0	0	4	4	0	0	0	0	0	0	4	214
92	103	9	16	20	148	0	0	0	0	0	148	0	0	0	4	4	8	0	0	0	9	17	21	169
93	19	4	0	0	23	0	0	0	0	0	23	0	0	0	4	4	9	0	0	0	0	9	13	36
94	73	4	24	30	131	8	9	8	0	25	156	0	0	0	0	0	17	0	0	0	0	17	17	173
SUB TOTAL	357	59	44	52	512	8	9	8	0	25	537	0	0	0	12	12	34	0	0	0	9	43	55	592
01	211	0	10	12	233	601	70	140	3	814	1047	0	21	0	23	44	0	101	3	0	122	226	270	1317
02	0	0	0	0	0	110	38	119	19	286	286	0	0	0	0	0	2	0	6	0	30	38	38	324
03	32	0	0	10	42	83	23	310	18	434	476	0	0	0	0	0	9	4	0	0	2	15	15	491
04	0	0	0	0	0	29	5	100	9	143	143	0	0	0	0	0	0	0	0	0	5	5	5	148
05	153	23	10	10	196	327	89	309	77	802	998	0	0	0	0	0	125	3	0	0	0	128	128	1126
SUB TOTAL	396	23	20	32	471	1150	225	978	126	2479	2950	0	21	0	23	44	136	108	9	0	159	412	456	3406
TOTAL IN EXTERNAL AREA	753	82	64	84	983	1158	234	986	126	2504	3487	0	21	0	35	56	170	108	9	0	168	455	511	3998
GRAND TOTAL	54187	2414	7346	1540	65487	9570	3199	7422	980	21171	86658	210	169	23	166	568	1261	430	470	143	1158	3462	4030	90688

Table 3-9 CAR - TOTAL

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	05	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	135696	4808	9072	3426	153002	1262	495	374	26	2157	155159	411	344	100	235	1090	690	44	74	0	610	1418	2508	157667
2	4754	1227	185	138	6304	71	51	11	0	133	6437	138	11	12	4	165	28	8	0	0	75	111	276	6713
3	10591	203	2929	995	14718	106	46	20	0	172	14890	6	45	0	53	104	17	0	9	0	29	55	159	15049
4	3499	169	745	1628	6041	45	11	0	0	56	6097	9	61	18	133	221	60	0	0	0	18	78	299	6396
SUB TOTAL	154540	6407	12931	6187	180065	1484	603	405	26	2518	182583	564	461	130	425	1580	795	52	83	0	732	1662	3242	185825
5	1190	19	60	40	1309	19917	4006	2000	116	26039	27348	0	10	0	10	20	2032	387	391	78	908	3796	3816	31164
6	521	36	0	29	586	3959	2202	1172	135	7468	8054	0	0	0	6	6	231	80	56	19	201	587	593	8647
7	522	0	62	17	601	2040	1274	11886	746	15946	16547	0	0	0	0	0	531	368	941	276	778	2894	2894	19441
8	17	0	0	0	17	87	114	819	469	1489	1506	0	0	0	0	0	17	33	47	21	160	278	278	1784
SUB TOTAL	2250	55	122	86	2513	26003	7596	15877	1466	50942	53455	0	10	0	16	26	2811	868	1435	394	2047	7555	7581	61036
TOTAL IN INTERNAL AREA	156790	6462	13053	6273	182578	27487	8199	16282	1492	53460	236038	564	471	130	441	1606	3606	920	1518	394	2779	9217	10823	246861
91	411	138	6	9	564	0	0	0	0	0	564	0	0	2	4	6	0	0	0	0	0	0	6	570
92	344	11	45	61	461	0	0	0	0	0	461	0	0	0	32	32	24	0	0	0	9	33	65	526
93	100	12	0	18	130	0	0	9	0	9	139	0	0	0	4	4	9	0	0	0	0	9	13	152
94	235	4	53	133	425	17	24	8	0	49	474	0	0	8	0	8	26	0	0	0	0	26	34	508
SUB TOTAL	1090	165	104	221	1580	17	24	17	0	58	1638	0	0	10	40	50	59	0	0	0	9	68	118	1756
01	896	50	28	56	1030	2032	231	531	17	2811	3841	10	42	0	34	86	0	161	16	6	340	523	609	4450
02	40	0	0	0	40	387	80	357	33	857	897	0	0	0	0	0	12	0	6	0	40	58	58	955
03	89	0	10	10	109	391	56	941	47	1435	1544	0	0	0	0	0	37	4	0	0	17	58	58	1602
04	7	0	0	10	17	78	19	276	21	394	411	8	0	0	0	8	17	0	0	0	16	33	41	452
05	669	53	31	42	795	904	201	778	160	2043	2838	0	12	0	6	18	257	10	0	0	0	267	285	3123
SUB TOTAL	1701	103	69	118	1991	3792	587	2883	278	7540	9531	18	54	0	40	112	323	175	22	6	413	939	1051	10582
TOTAL IN EXTERNAL AREA	2791	268	173	339	3579	3809	611	2900	278	7598	11169	18	54	10	80	162	382	175	22	6	422	1007	1169	12338
GRAND TOTAL	159581	6730	13226	6612	186149	31296	8810	19182	1770	61058	247207	582	525	140	521	1768	3988	1095	1540	400	3201	10224	11992	259199

Table 3-10 LORRY

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	05	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	11081	859	789	580	13309	188	62	86	13	349	13658	132	40	35	64	271	204	48	1	1	121	375	646	14304
2	821	135	367	37	1360	3	0	7	0	10	1370	31	2	0	0	33	0	0	0	0	7	7	40	1410
3	1255	444	607	400	2706	3	7	0	0	10	2716	4	1	0	18	23	0	0	3	0	0	3	26	2742
4	628	37	454	758	1877	3	13	3	0	19	1896	2	21	5	47	75	0	0	0	0	13	13	88	1984
SUB TOTAL	13785	1475	2217	1775	19252	197	82	96	13	388	19640	169	64	40	129	402	204	48	4	1	141	398	800	20440
5	294	3	2	18	317	2872	869	418	79	4238	4555	0	0	23	26	49	747	183	112	35	541	1618	1667	6222
6	102	0	9	25	136	853	364	552	9	1778	1914	0	0	0	9	9	328	156	135	19	254	892	901	2815
7	61	0	0	0	61	367	498	947	127	1939	2000	0	0	0	0	0	302	110	232	71	367	1082	1082	3082
8	14	0	0	0	14	79	34	55	90	258	272	0	0	0	7	7	35	17	63	10	178	303	310	582
SUB TOTAL	471	3	11	43	528	4171	1765	1972	305	8213	8741	0	0	23	42	65	1412	466	542	135	1340	3895	3960	12701
TOTAL IN INTERNAL AREA	14256	1478	2228	1818	19780	4368	1847	2068	318	8601	28381	169	64	63	171	467	1616	514	546	136	1481	4293	4760	33141
91	132	31	4	2	169	0	0	3	0	3	172	0	0	0	2	2	0	0	0	0	0	0	2	174
92	40	2	1	21	64	0	3	0	0	3	67	0	0	0	0	0	0	0	0	0	0	0	0	67
93	35	0	0	5	40	7	0	0	0	7	47	0	0	0	0	0	0	0	0	0	0	0	0	47
94	64	0	18	47	129	11	24	0	0	35	164	0	0	0	0	0	7	0	0	0	7	14	14	178
SUB TOTAL	271	33	23	75	402	18	27	3	0	48	450	0	0	0	2	2	7	0	0	0	7	14	16	466
01	134	0	3	0	137	747	328	302	35	1412	1549	9	0	0	0	9	0	26	3	0	179	208	217	1766
02	3	0	9	0	12	183	156	110	17	466	478	0	0	0	0	0	3	0	0	0	6	9	9	487
03	16	0	0	0	16	112	135	232	63	542	558	0	0	0	0	0	15	3	0	0	22	40	40	598
04	0	0	0	0	0	35	19	71	10	135	135	0	0	0	0	0	0	0	0	0	0	0	0	135
05	57	0	9	3	69	541	254	367	178	1340	1409	0	0	7	0	7	167	8	0	0	0	175	182	1591
SUB TOTAL	210	0	21	3	234	1618	892	1082	303	3895	4129	9	0	7	0	16	185	37	3	0	207	432	448	4577
TOTAL IN EXTERNAL AREA	481	33	44	78	636	1636	919	1085	303	3943	4579	9	0	7	2	18	192	37	3	0	214	446	464	5043
GRAND TOTAL	14737	1511	2272	1896	20416	6004	2766	3153	621	12544	32960	178	64	70	173	485	1808	551	549	136	1695	4739	5224	38184

Table 3-11 TAXI

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	05	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	1060	165	59	360	1644	0	13	0	0	13	1657	78	31	13	20	142	0	0	0	0	13	13	155	1812
2	154	5	3	34	196	0	0	0	0	0	196	4	0	0	0	4	0	0	0	0	0	0	4	200
3	39	3	3	17	62	0	0	0	0	0	62	0	0	0	0	0	0	0	0	0	0	0	0	62
4	340	45	20	12	417	0	0	0	0	0	417	0	4	0	4	8	0	0	0	0	0	0	8	425
SUB TOTAL	1593	218	85	423	2319	0	13	0	0	13	2332	82	35	13	24	154	0	0	0	0	13	13	167	2499
5	14	0	0	0	14	37	28	95	0	160	174	0	0	0	0	0	430	8	16	5	252	711	711	885
6	0	0	0	0	0	31	7	9	2	49	49	0	0	0	0	0	8	0	0	0	9	17	17	66
7	0	0	0	0	0	80	11	65	5	161	161	0	0	0	0	0	12	4	24	5	36	81	81	242
8	0	0	0	0	0	2	0	3	2	7	7	0	0	0	0	0	0	0	0	0	0	0	0	7
SUB TOTAL	14	0	0	0	14	150	46	172	9	377	391	0	0	0	0	0	450	12	40	10	297	809	809	1200
TOTAL IN INTERNAL AREA	1607	218	85	423	2333	150	59	172	9	390	2723	82	35	13	24	154	450	12	40	10	310	822	976	3699
91	78	4	0	0	82	0	0	0	0	0	82	0	0	0	0	0	0	0	0	0	0	0	0	82
92	31	0	0	4	35	0	0	0	0	0	35	0	0	0	4	4	0	0	0	0	0	0	4	39
93	13	0	0	0	13	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	13
94	20	0	0	4	24	13	0	0	0	13	37	0	0	0	0	0	0	0	0	0	0	0	0	37
SUB TOTAL	142	4	0	8	154	13	0	0	0	13	167	0	0	0	4	4	0	0	0	0	0	0	4	171
01	13	0	0	0	13	430	8	12	0	450	463	0	0	0	0	0	0	0	0	0	18	18	18	481
02	0	0	0	0	0	8	0	4	0	12	12	0	0	0	0	0	0	0	0	0	0	0	0	12
03	0	0	0	0	0	16	0	24	0	40	40	0	0	0	0	0	0	0	0	0	11	11	11	51
04	0	0	0	0	0	5	0	5	0	10	10	0	0	0	0	0	0	0	0	0	0	0	0	10
05	13	0	0	0	13	265	9	36	0	310	323	0	0	0	0	0	9	0	0	0	0	9	9	332
SUB TOTAL	26	0	0	0	26	724	17	81	0	822	848	0	0	0	0	0	9	0	0	0	29	38	38	886
TOTAL IN EXTERNAL AREA	168	4	0	8	180	737	17	81	0	835	1015	0	0	0	4	4	9	0	0	0	29	38	42	1057
GRAND TOTAL	1775	222	85	431	2513	887	76	253	9	1225	3738	82	35	13	28	158	459	12	40	10	339	860	1018	4756

Table 3-12 BUS

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	05	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	12057	174	442	724	13397	15	0	0	0	15	13412	20	0	0	0	20	0	0	0	0	47	47	67	13479
2	153	181	0	59	393	15	0	0	0	15	408	5	0	5	0	10	0	0	0	0	0	0	10	418
3	403	0	456	97	956	0	0	0	0	0	956	0	0	0	0	0	0	0	0	0	0	0	0	956
4	696	68	89	220	1073	0	0	0	0	0	1073	5	0	0	0	5	0	0	0	0	6	6	11	1084
SUB TOTAL	13309	423	987	1100	15819	30	0	0	0	30	15849	30	0	5	0	35	0	0	0	0	53	53	88	15937
5	0	17	0	0	17	1296	147	36	0	1479	1496	0	0	0	0	0	38	30	0	0	0	68	68	1564
6	0	0	0	0	0	127	104	101	50	382	382	0	0	0	0	0	24	0	5	10	0	39	39	421
7	0	0	0	0	0	52	88	747	139	1026	1026	0	0	0	0	0	10	0	10	10	0	30	30	1056
8	0	0	0	0	0	0	50	137	47	234	234	0	0	0	0	0	0	0	0	0	0	0	0	234
SUB TOTAL	0	17	0	0	17	1475	389	1021	236	3121	3138	0	0	0	0	0	72	30	15	20	0	137	137	3275
TOTAL IN INTERNAL AREA	13309	440	987	1100	15836	1505	389	1021	236	3151	18987	30	0	5	0	35	72	30	15	20	53	190	225	19212
91	20	5	0	5	30	0	0	0	0	0	30	0	0	0	5	5	0	0	0	0	0	0	5	35
92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93	0	5	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5
94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUB TOTAL	20	10	0	5	35	0	0	0	0	0	35	0	0	0	5	5	0	0	0	0	0	0	5	40
01	0	0	0	0	0	38	24	10	0	72	72	0	0	0	0	0	0	6	0	0	0	6	6	78
02	0	0	0	0	0	30	0	0	0	30	30	0	0	0	0	0	0	0	0	0	0	0	0	30
03	0	0	0	0	0	0	5	10	0	15	15	0	0	0	0	0	0	0	0	0	0	0	0	15
04	0	0	0	0	0	0	10	10	0	20	20	0	0	0	0	0	0	0	0	0	0	0	0	20
05	14	0	0	0	14	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	14
SUB TOTAL	14	0	0	0	14	68	39	30	0	137	151	0	0	0	0	0	0	6	0	0	0	6	6	157
TOTAL IN EXTERNAL AREA	34	10	0	5	49	68	39	30	0	137	186	0	0	0	5	5	0	6	0	0	0	6	11	197
GRAND TOTAL	13343	450	987	1105	15885	1573	428	1051	236	3288	19173	30	0	5	5	40	72	36	15	20	53	196	236	19409

Table 3-13 VEHICLES EXCEPT MOTOR-CYCLES

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	05	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	159900	6009	10364	5089	181362	1465	571	459	39	2534	183896	639	415	150	319	1523	893	92	75	1	788	1849	3372	187268
2	5885	1550	554	270	8259	89	51	18	0	158	8417	177	13	17	4	211	28	8	0	0	82	118	329	8746
3	12293	651	3996	1508	18448	109	53	20	0	182	18630	11	46	0	71	128	17	0	12	0	29	58	186	18816
4	5163	320	1307	2618	9408	48	24	3	0	75	9483	17	86	23	183	309	60	0	0	0	37	97	406	9889
SUB TOTAL	183241	8530	16221	9485	217477	1711	699	500	39	2949	220426	844	560	190	577	2171	998	100	87	1	936	2122	4293	224719
5	1494	39	62	59	1654	24126	5046	2549	194	31915	33569	0	10	23	37	70	3246	607	520	118	1703	6194	6264	39833
6	619	36	9	53	717	4912	2675	1832	197	9676	10393	0	0	0	15	15	590	236	196	48	464	1534	1549	11942
7	581	0	62	17	660	2540	1868	13643	1017	19068	19728	0	0	0	0	0	855	481	1206	362	1182	4086	4086	23814
8	31	0	0	0	31	168	198	1012	608	1986	2017	0	0	0	7	7	52	51	110	31	338	582	589	2606
SUB TOTAL	2725	75	133	129	3062	31806	9787	19036	2016	62645	65707	0	10	23	59	92	4743	1375	2032	559	3687	12396	12488	78195
TOTAL IN INTERNAL AREA	185966	8605	16354	9614	220539	33517	10486	19536	2055	65594	286133	844	570	213	636	2263	5741	1475	2119	560	4623	14518	16781	302914
91	639	177	11	17	844	0	0	3	0	3	847	0	0	2	11	13	0	0	0	0	0	0	13	860
92	415	13	46	86	560	0	3	0	0	3	563	0	0	0	36	36	24	0	0	0	9	33	69	632
93	150	17	0	23	190	7	0	9	0	16	206	0	0	0	4	4	9	0	0	0	0	9	13	219
94	319	4	71	183	577	41	48	8	0	97	674	0	0	8	0	8	33	0	0	0	7	40	48	722
SUB TOTAL	1523	211	128	309	2171	48	51	20	0	119	2290	0	0	10	51	61	66	0	0	0	16	82	143	2433
01	1042	50	31	56	1179	3246	590	855	52	4743	5922	19	42	0	34	95	0	193	18	6	536	753	848	6770
02	44	0	9	0	53	607	236	471	51	1365	1418	0	0	0	0	0	15	0	6	0	46	67	67	1485
03	105	0	10	10	125	520	196	1206	110	2032	2157	0	0	0	0	0	52	7	0	0	50	109	109	2266
04	7	0	0	10	17	118	48	362	31	559	576	8	0	0	0	8	17	0	0	0	16	33	41	617
05	753	53	40	44	890	1711	464	1182	338	3695	4585	0	12	7	6	25	434	18	0	0	0	452	477	5062
SUB TOTAL	1951	103	90	120	2264	6202	1534	4076	582	12394	14658	27	54	7	40	128	518	218	24	6	648	1414	1542	16200
TOTAL IN EXTERNAL AREA	3474	314	218	429	4435	6250	1585	4096	582	12513	16948	27	54	17	91	189	584	218	24	6	664	1496	1685	18633
GRAND TOTAL	189440	8919	16572	10043	224974	39767	12071	23632	2637	78107	303081	871	624	230	727	2452	6325	1693	2143	566	5287	16014	18466	321547

Table 3-14 MOTOR- CYCLES

O \ D	1	2	3	4	SUB TOTAL	5	6	7	8	SUB TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB TOTAL	01	02	03	04	05	SUB TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	200605	4488	10317	5397	220807	2818	1595	613	29	5055	225862	346	433	233	364	1376	146	70	86	87	312	701	2077	227939
2	4607	2002	156	41	6806	169	29	0	0	198	7004	233	10	41	5	289	28	0	0	0	0	28	317	7321
3	12463	310	7380	2095	22248	117	70	0	29	216	22464	20	91	58	57	226	0	0	0	0	59	59	285	22749
4	5323	77	2009	5598	13007	87	59	0	0	146	13153	11	154	67	230	462	28	0	0	0	28	56	518	13671
SUB TOTAL	222998	6877	19862	13131	262868	3191	1753	613	58	5615	268483	610	688	399	656	2353	202	70	86	87	399	844	3197	271680
5	2195	122	181	31	2529	40003	6198	3365	408	49974	52503	0	0	0	0	0	1966	694	236	75	375	3346	3346	55849
6	1128	62	31	0	1221	6411	5080	2703	374	14568	15789	0	0	31	0	31	275	181	113	40	175	784	815	16604
7	948	0	91	90	1129	2881	2901	45906	1806	53494	54623	0	0	0	0	0	523	623	1390	559	652	3747	3747	58370
8	62	0	31	0	93	388	412	1769	3226	5795	5888	0	0	0	0	0	14	15	65	114	571	779	779	6667
SUB TOTAL	4333	184	334	121	4972	49683	14591	53743	5814	123831	128803	0	0	31	0	31	2778	1513	1804	788	1773	8656	8687	137490
TOTAL IN INTERNAL AREA	227331	7061	20196	13252	267840	52874	16344	54356	5872	129446	397286	610	688	430	656	2384	2980	1583	1890	875	2172	9500	11884	409170
91	346	233	20	11	610	29	0	0	0	29	639	0	0	2	2	4	0	0	0	0	0	0	4	643
92	433	10	91	154	688	0	0	0	0	0	688	0	0	5	29	34	0	0	0	0	0	0	34	722
93	233	41	58	67	399	0	0	0	0	0	399	0	0	0	24	24	0	0	0	0	0	0	24	423
94	364	5	57	230	656	29	0	28	0	57	713	0	0	5	0	5	0	0	0	0	0	0	5	718
SUB TOTAL	1376	289	226	462	2353	58	0	28	0	86	2439	0	0	12	55	67	0	0	0	0	0	0	67	2506
01	457	0	0	0	457	1966	275	523	14	2778	3235	0	60	0	60	120	0	226	3	5	50	284	404	3639
02	62	0	0	0	62	694	181	623	15	1513	1575	0	0	0	0	0	22	0	0	12	27	61	61	1636
03	151	0	0	60	211	236	113	1390	65	1804	2015	0	0	0	0	0	21	14	0	22	40	97	97	2112
04	0	0	0	0	0	75	40	559	114	788	788	0	0	0	0	0	9	0	4	0	4	17	17	805
05	577	0	31	90	698	285	175	652	571	1683	2381	0	0	0	0	0	67	35	9	13	0	124	124	2505
SUB TOTAL	1247	0	31	150	1428	3256	784	3747	779	8566	9994	0	60	0	60	120	119	275	16	52	121	583	703	10697
TOTAL IN EXTERNAL AREA	2623	289	257	610	3781	3314	784	3775	779	8652	12433	0	60	12	115	187	119	275	16	52	121	583	770	13203
GRAND TOTAL	229954	7350	20453	13864	271621	56188	17128	58131	6651	138098	409719	610	748	442	771	2571	3099	1858	1906	927	2293	10083	12654	422373

4. The analysis of present traffic situation.

4-1 The attributes of vehicle owners

There are 69,990 vehicles and 105,100 motor-cycles in this study area. The bread down of these figures is as follows:

Table 4-1 The number of vehicles (unit : 1000 vehicles)

car	lorry	taxi	bus	total no. of vehicles	M/Cs.
59.3	9.4	0.4	0.9	69.9	105.1

In this section, some of the attrivutes of owners of vehicles obtained through the owner-interim survey, are shown

a) Form of ownership of vehicles
b) Sex
c) Age
d) Occupation
e) Size of household
f) Zone of working place
g) Type of establishment
h) Size of employment
i) Period of ownership
j) Frequency of usage for week

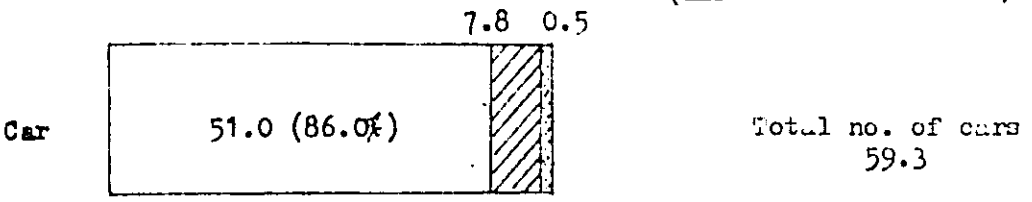
Note: The following types of vehicles, namely the lorry, taxi and bus are used only for specific purposes and owners of these types of vehicles are ~~therefore~~ different from other vehicle owners. Therefore in this analysis these types of vehicles are excluded.

4-1-1 Form of ownership

Of the two forms of ownership, the majority of vehicles and motor-cycles belong to the category of individual ownership, and the ratio for cars is 86% while that for motor-cycles is 97%.

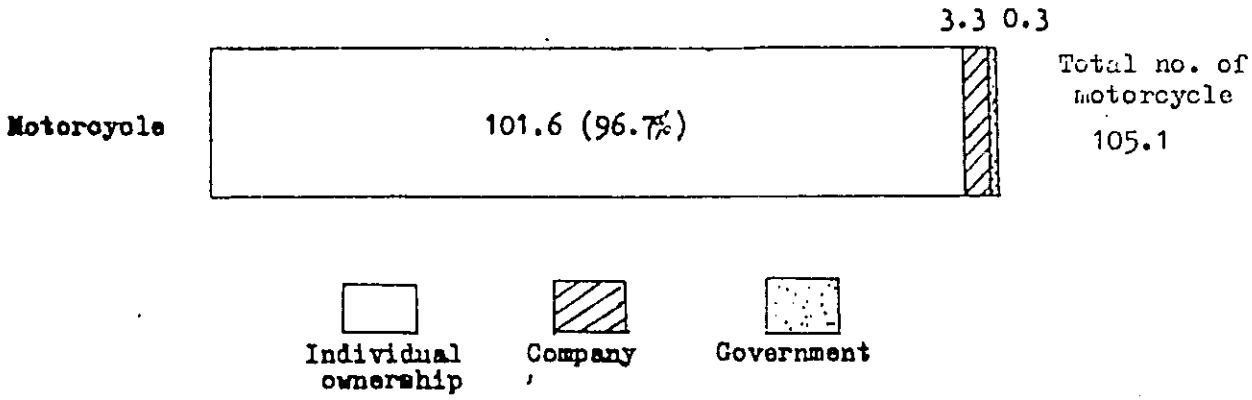
Fig 4-1 Ownership of car by individual, company and government

(unit : 1000 vehicles)



Ownership of motorcycle by individual, company and government

(unit : 1000 vehicles)



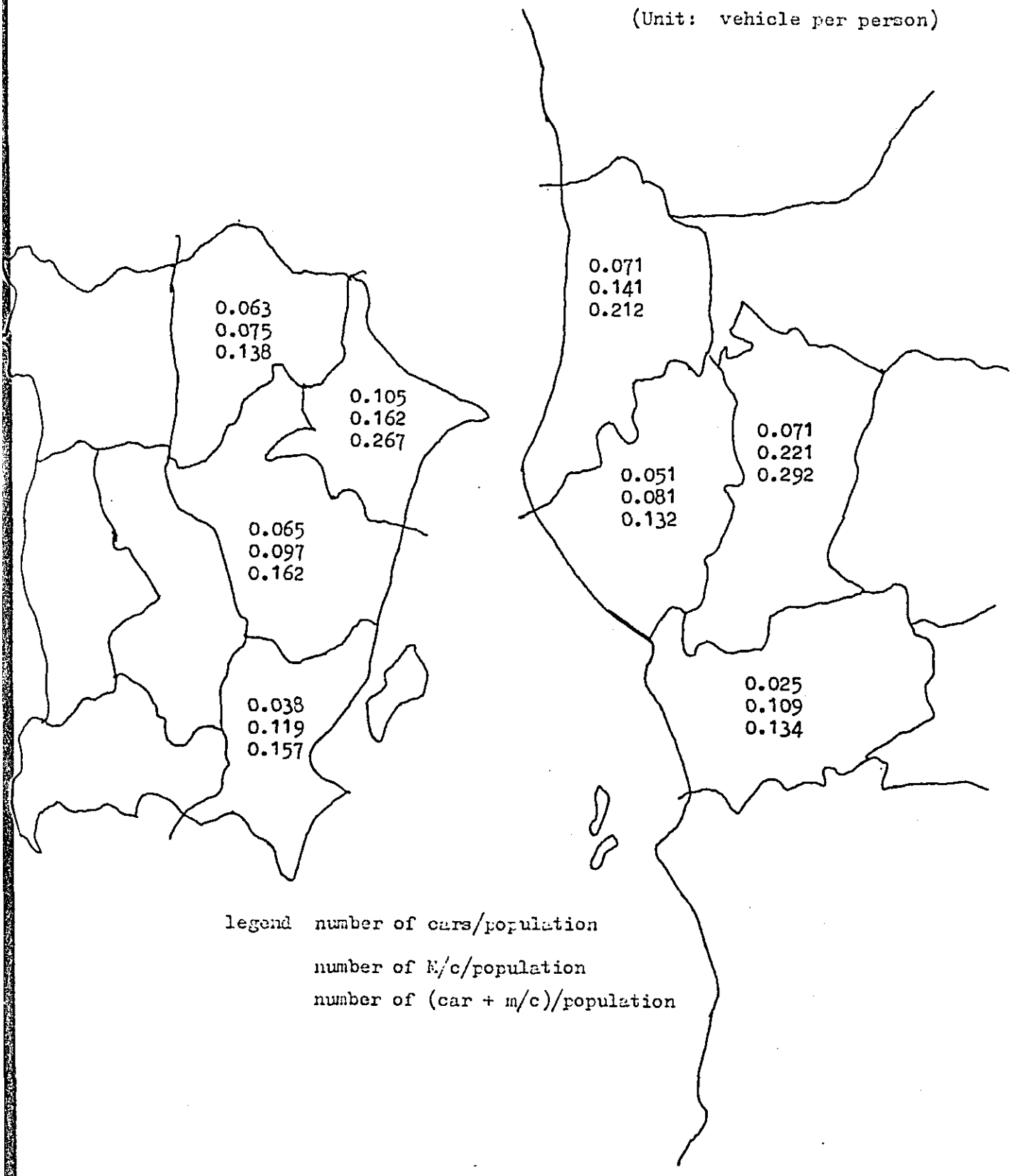
4-1-2 The situation of ownership by area.

The difference in the situation of ownership by area is as follows:-

Table 4-2 number of vehicles by zone

Vehicles large zone	Number of cars (A)	Number of motor-cycles (B)	Total population (C)	Unit of vehicle-ownership		
				A/C	B/C	A+B/C
1	35864	55271	341220	0.105	0.162	0.267
2	1703	2017	26980	0.063	0.075	0.138
3	4756	7156	73630	0.065	0.097	0.162
4	1063	3318	27870	0.038	0.119	0.157
Penang Island	43386	67762	469700	0.092	0.144	0.236
5	7906	15693	111312	0.071	0.141	0.212
6	2510	3985	49330	0.051	0.081	0.132
7	4793	14830	67210	0.071	0.221	0.292
8	655	2862	26310	0.025	0.109	0.134
Province Wellesley	15864	37370	230902	0.069	0.162	0.231
Study area	59250	105132	700602	0.085	0.150	0.235

Fig 4-2 **Unit of vehicle ownership by zone**



These figures show clearly the difference between the form of ownership in Penang Island and Province Wellesley.

In Penang Island, the unit of vehicle ownership of cars is higher, while in Province Wellesley, that of motor-cycles is higher.

There results show that urbanization process is progressing at a more rapid pace in Penang Island than in Province Wellesley.

4-1-3 The attributes of vehicle owners.

The attributes of individual vehicle owners obtained were:-

1) age
2) sex
3) size of household.

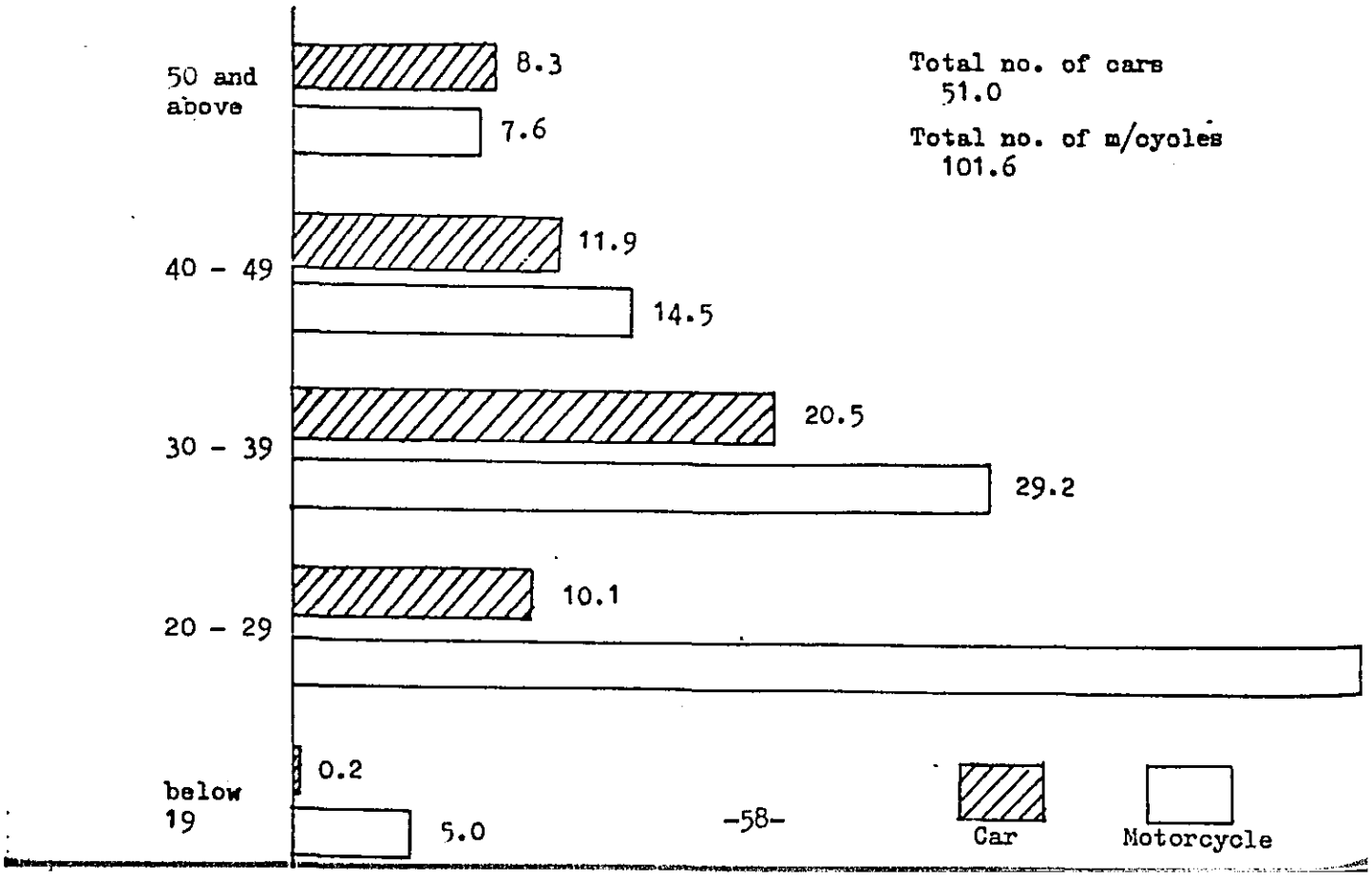
(1) Age and sex

The following figure shows the types of vehicles owned by age.

For the 40 years and above age group, the number of owner for cars and motor-cycles is almost the same, but in the age group of 20-29 year olds the number of owners for motor-cycles is 4.5 times more than that for cars.

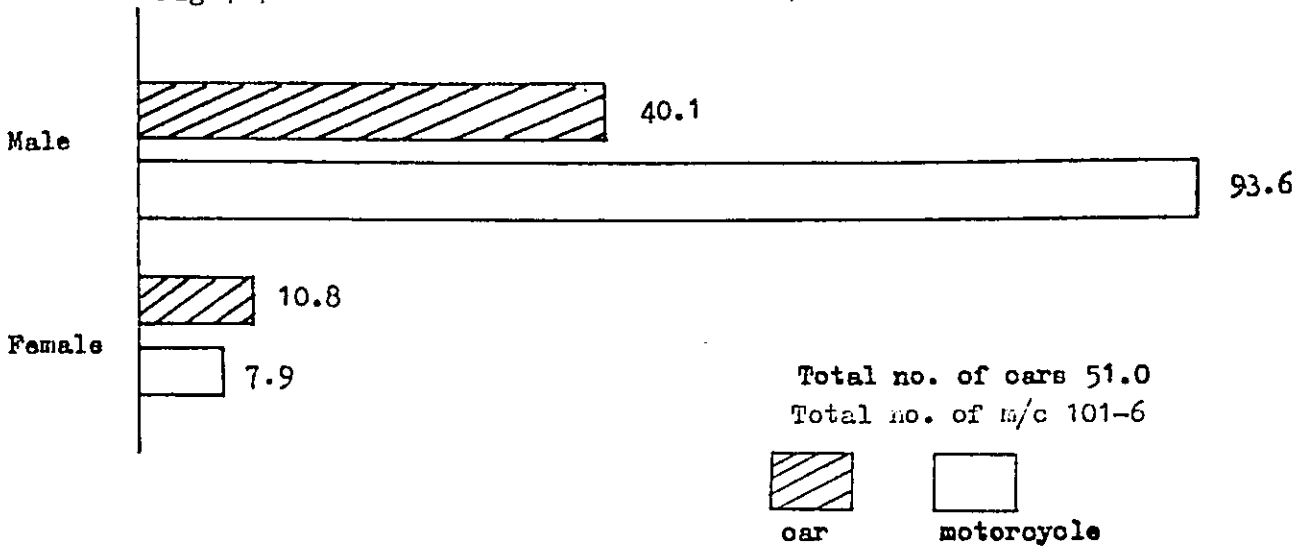
This shows that the majority of motor-cycles is owned by the younger generation, that is, about 50% of the motor-cycles is owned by people belonging to the 29 years and below age group.

Fig 4-3 Type of vehicles owned by age (unit : 1000 persons)



More males than females own cars and motor-cycles as a means of transport. This is particularly true in the case of motor-cycle ownership as 94% of motor-cycles but 97% of cars are owned by males.

Fig 4-4 Type of vehicle owned by sex (unit : 1000 persons)



From our population study, the data for the present population by sex and age was collected. Using these data, the unit of vehicle ownership can be obtained. The results are shown in table 4-3.

The unit of ownership of cars in the age-sex category of 30-39 year old males is 0.378 cars per person and those of motor-cycles in the age-sex group of 20-29 year old males is 0.700 motor-cycles per person.

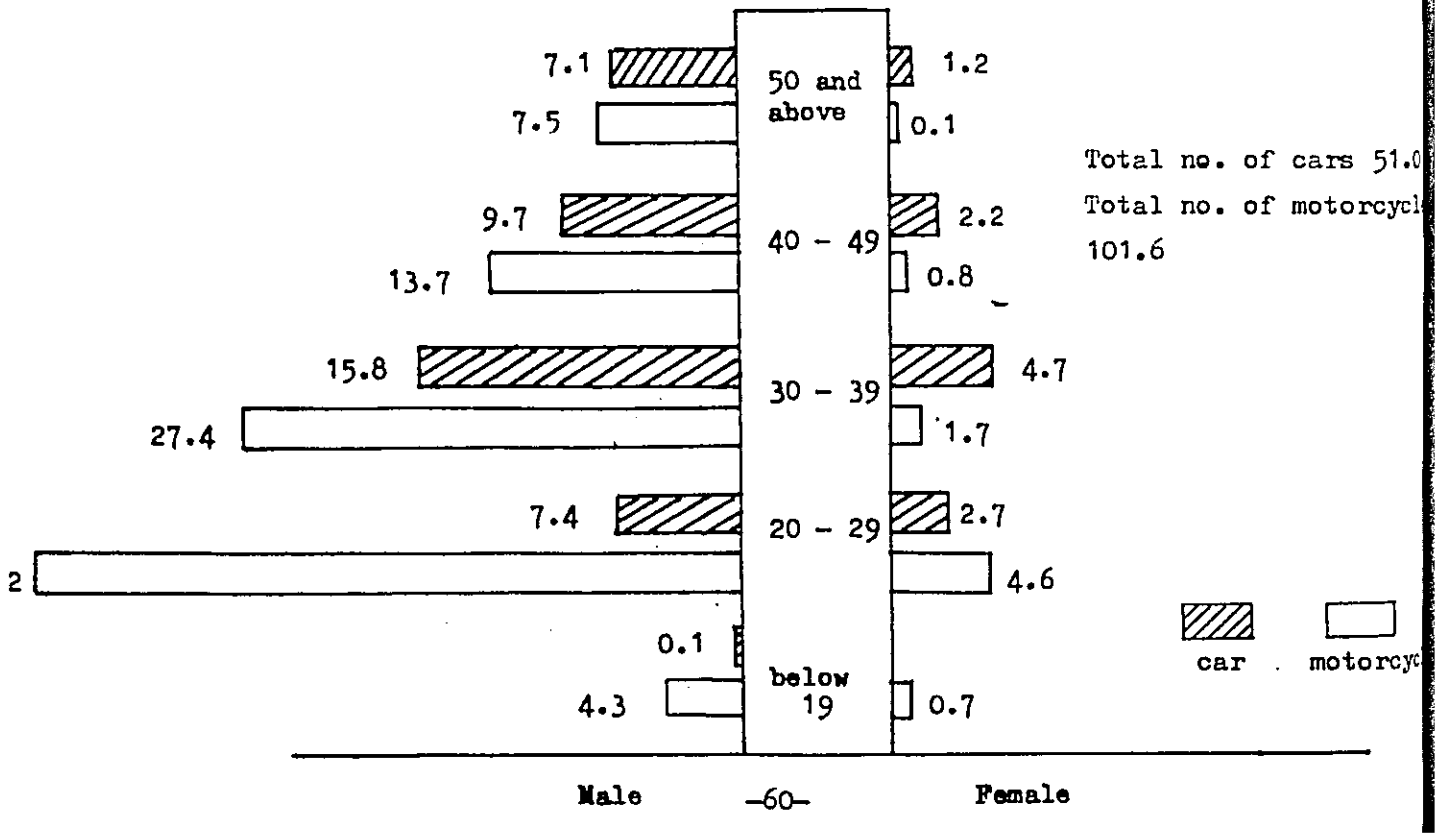
In the age-sex group of the 30-39 year old males, the unit of ownership of cars and motor-cycles is 1.034. This figure shows that some of these age-groups have 2 or more vehicle (that is, one car and one motor-cycle, 2 cars or 2 motor-cycles).

Table 4-5

Ownership of vehicles by agae and sex group (unit : 1000 persons)

sex / Age group	Male			Female			Total		
	Population	Cars	M/cs.	Population	Cars	M/cs.	Population	Cars	M/cs.
50 and above	46.6	7.1 0.152	7.5 0.161	48.1	1.2 0.025	0.1 0.002	94.7	8.3 0.088	7.7 0.080
40-49	33.0	9.7 0.294	13.7 0.415	33.6	2.2 0.065	0.8 0.024	66.6	11.9 0.179	14.5 0.218
30-39	41.8	15.8 0.378	27.4 0.656	43.8	4.7 0.107	1.7 0.039	85.6	20.5 0.239	29.2 0.341
20-29	58.3	7.4 0.127	40.8 0.700	62.1	2.7 0.043	4.6 0.074	120.4	10.1 0.084	45.4 0.377
18-19	16.2	0.1 0.006	4.3 0.265	17.4	0.0 0	0.7 0.040	33.6	0.2 0.006	5.0 0.149
total	195.9	40.1 0.025	93.6 0.478	205.0	10.9 0.053	7.9 0.039	400.0	51.0 0.127	101.6 0.253

Fig: 4-5 **Ownership of vehicles by sex and age (unit : 1000 persons)**



(2) Occupation

This attribute can be divided into two groups, viz. Those who are employed and those who are unemployed like students, housewives and the jobless.

The figures for this attribute is as follows:-

Table 4-4 Ownership of car and m/c by the employed and unemployed population. (unit : 1000 persons)

Employment status	Cars	M/cs.
employed	44.6	92.4
unemployed	6.4	9.2
total	510	101.6

From our population study, the ratio of the employed to the unemployed in 1979 is 31% (294000/996580) in Penang State. Therefore, the unit of vehicle ownership by occupation in the study area is as follows:-

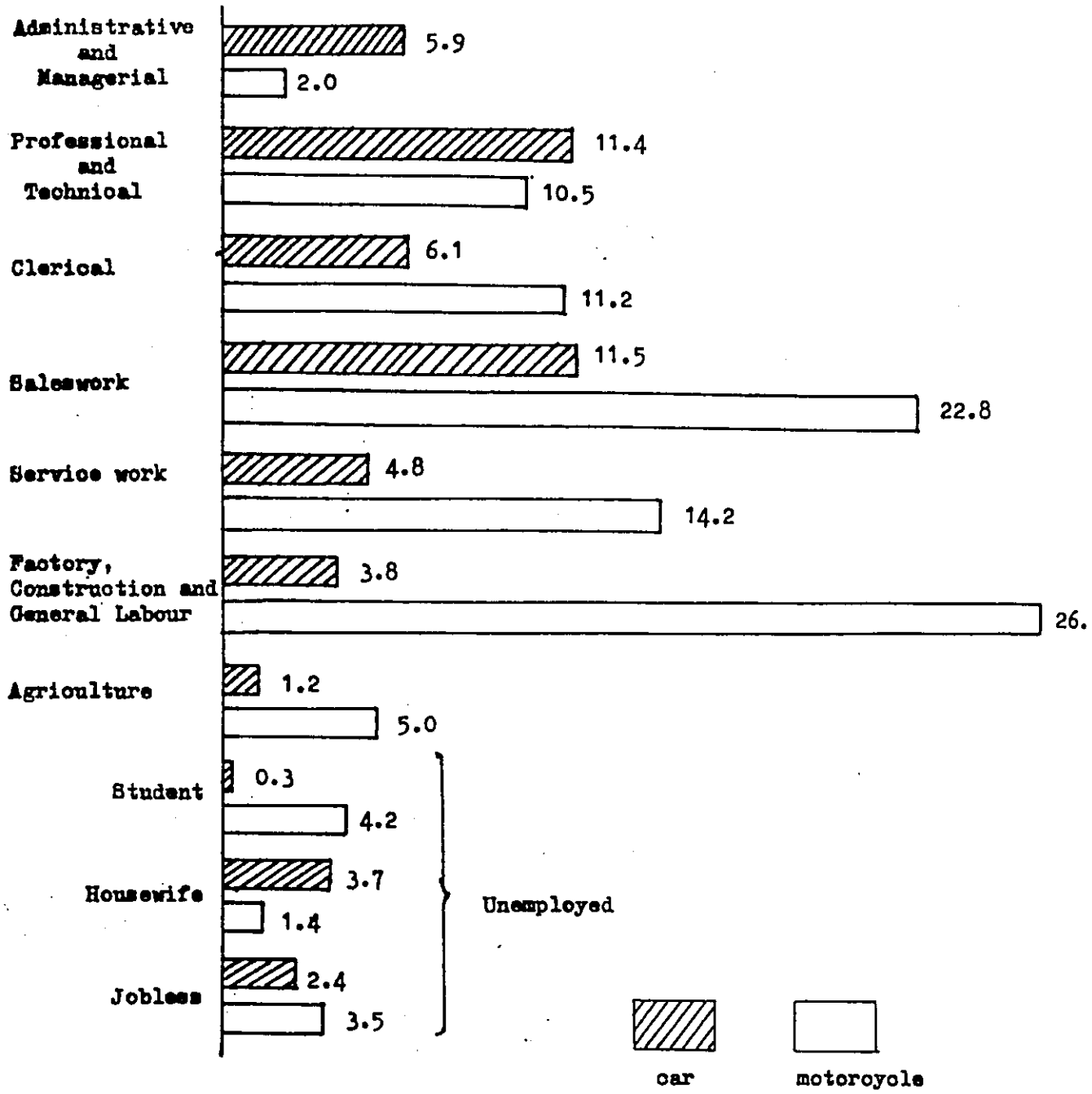
Table 4-5 Unit vehicle possesion of the employed and unemployed population. (unit : 1000 persons)

Employment status	Population	No.of vehicle		Unit vehicle possesion		
		Car	M/c.	Car	M/c	Total
employed	224.4	44.6	92.4	0.199	0.412	0.611
unemployed	499.5	5.4	9.2	0.011	0.018	0.029
total	723.9	51.0	101.6	0.070	0.140	0.210

From this table, it can be seen that the unit of vehicle ownership is 0.199 car and 0.412 motor-cycle per employed worker.

60% of the employed make use of cars and motor-cycles as their means of transport instead of using public transport.

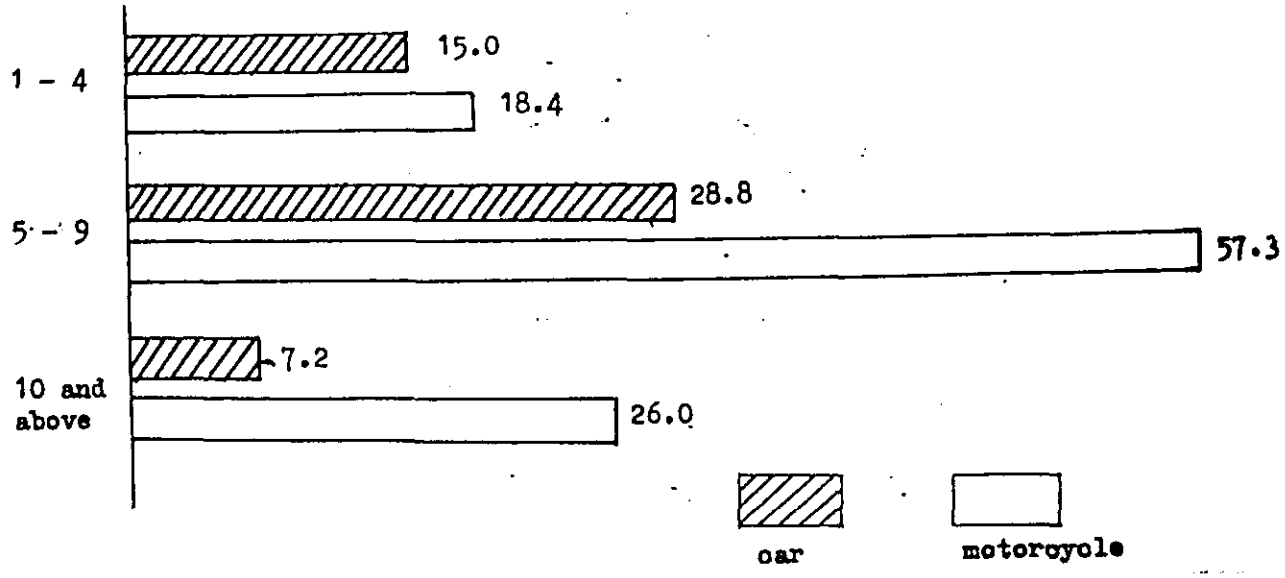
Fig: 4-6 Ownership of vehicles by type of occupation (unit : 1000 vehicles)



(3) Size of households by type of vehicles

In small households (i.e those having between 1-4 people), the ratio of cars to motor-cycles is almost 1 to 1, whereas at large households, the ratio is 1 to 4.

Fig: 4-7 Size of Household (unit : 1000 vehicles)



4-1-4 The characteristic by working place

The difference in the situation of ownership by working place is as follows:-

Table: 4-6 Situation of ownership by working place

large zone	Number of cars (A)	Number of motorcycles (B)	Employment (C)	Unit of vehicle ownership		
				A/C	B/C	A+B/C
1	20.7	38.4	83.4	0.247	0.458	0.705
2	0.5	1.7	3.5	0.143	0.486	0.629
3	7.2	11.2	30.4	0.237	0.368	0.605
4	1.6	5.0	11.0	0.145	0.455	0.600
Penang Island	30.0	56.3	128.6	0.233	0.438	0.671
5	7.7	16.0	44.7	0.172	0.358	0.530
6	1.8	6.7	21.9	0.082	0.306	0.388
7	4.9	12.3	23.8	0.206	0.517	0.723
8	0.2	1.2	5.5	0.036	0.218	0.254
Province Wellesley	14.6	36.1	95.8	0.152	0.377	0.529
Study area	44.6	92.4	224.4	0.199	0.412	0.611

Note: The actual size of employment in the study area in 1979 is 237,290. However, in this table the figure is for those living and working in the study area.

Fig 4-8 Ownership of vehicles by zone of working place (unit : 1000 vehicles)

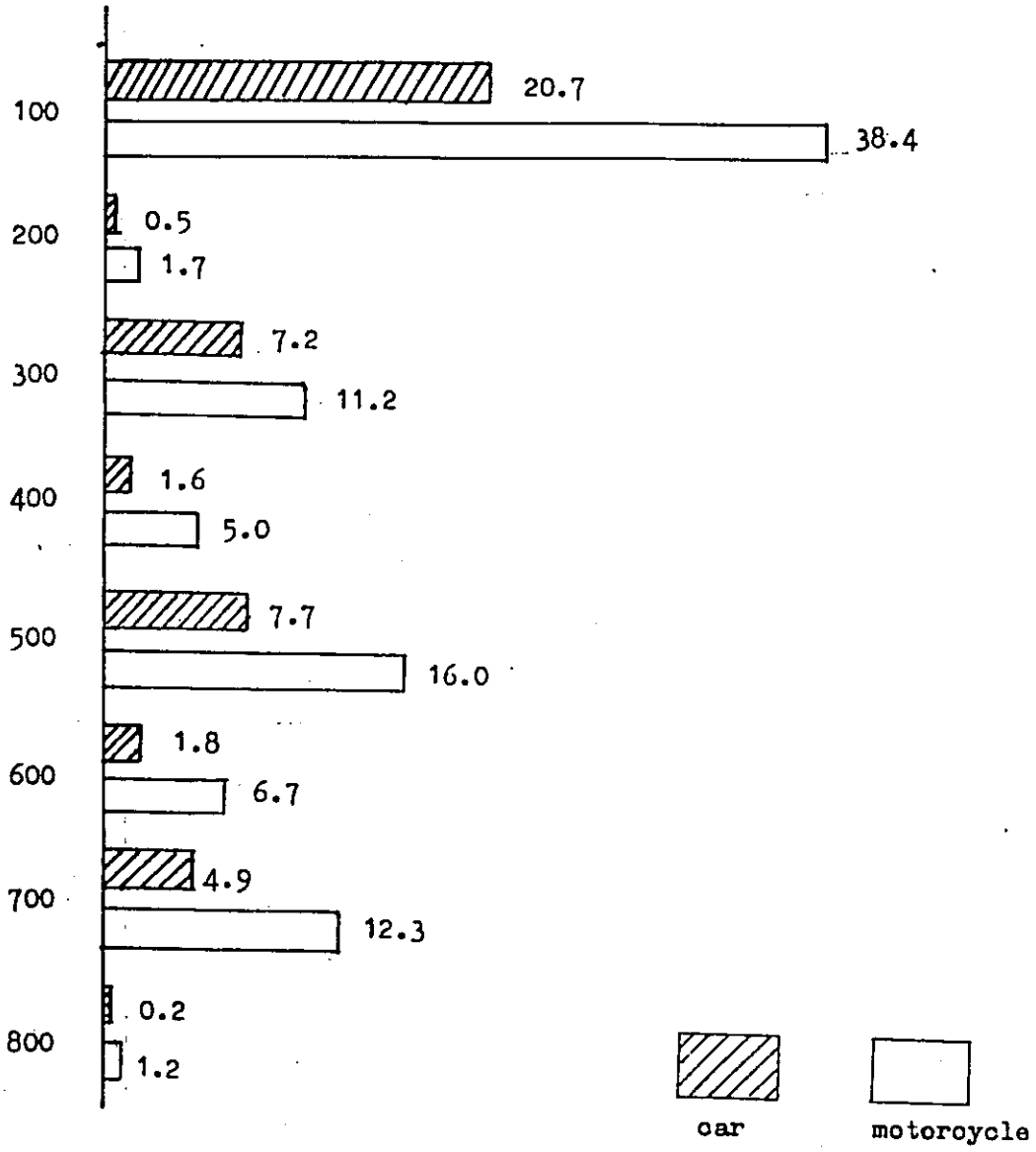
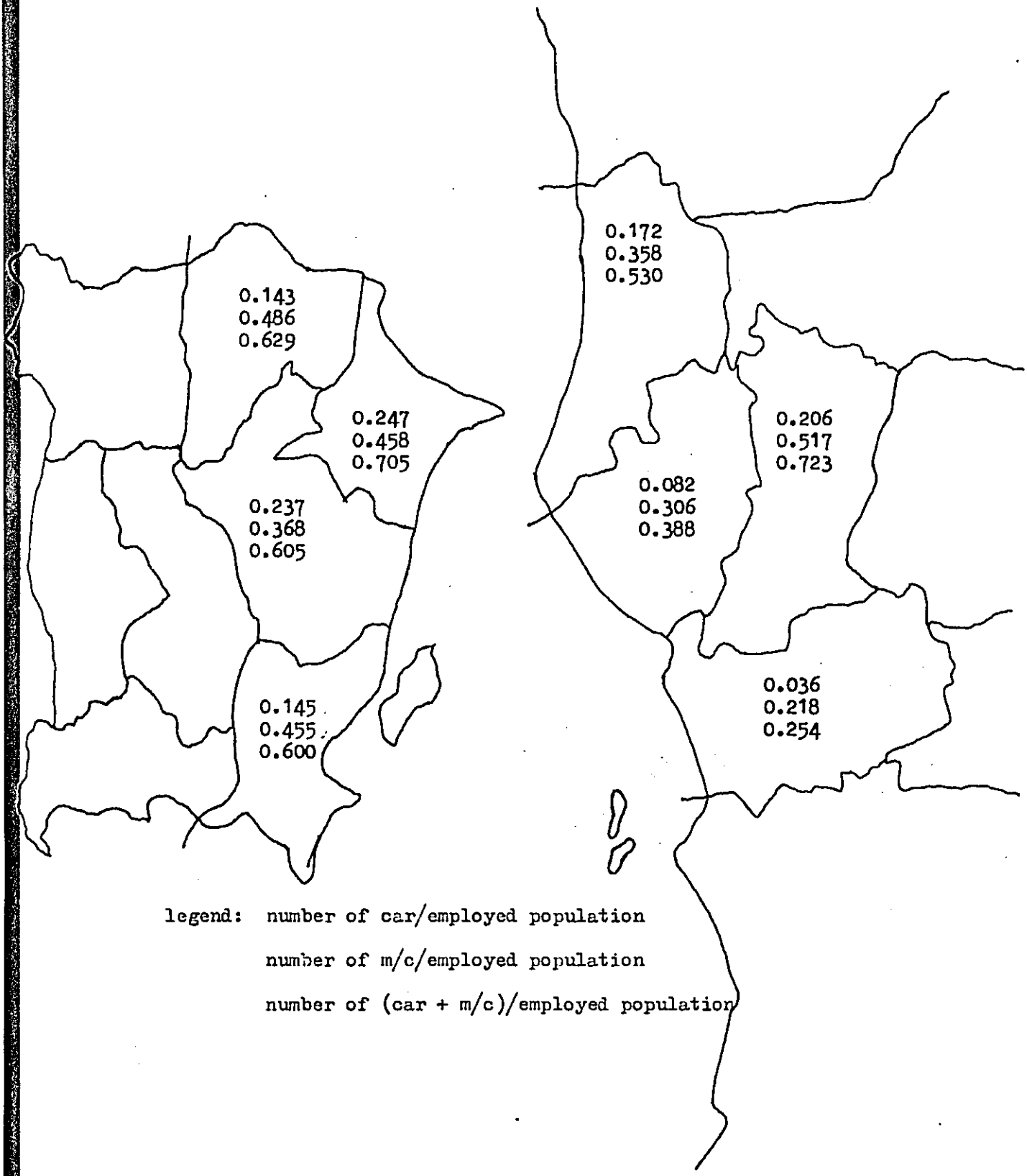


Fig. 4-9 **Unit of vehicle ownership by zone** of working place



legend: number of car/employed population

number of m/c/employed population

number of (car + m/c)/employed population

4-1-5 Type of establishment and size of employment

The ratio of cars to motor-cycles is almost 1 to 1 at government and finance/banking establishments.

Fig: 4-10 Ownership of vehicle by various types of establishment (unit : 1000 vehicles)

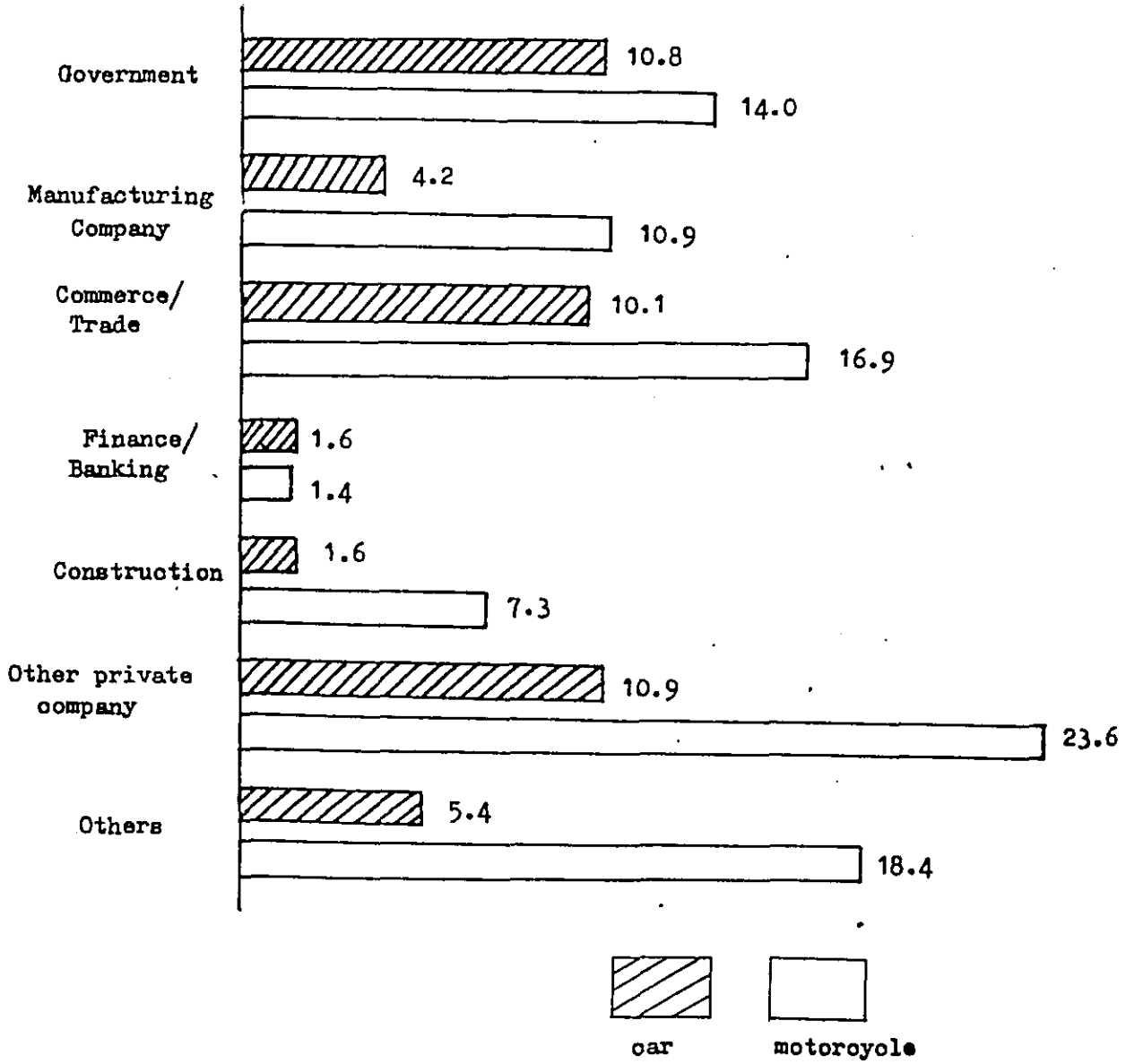
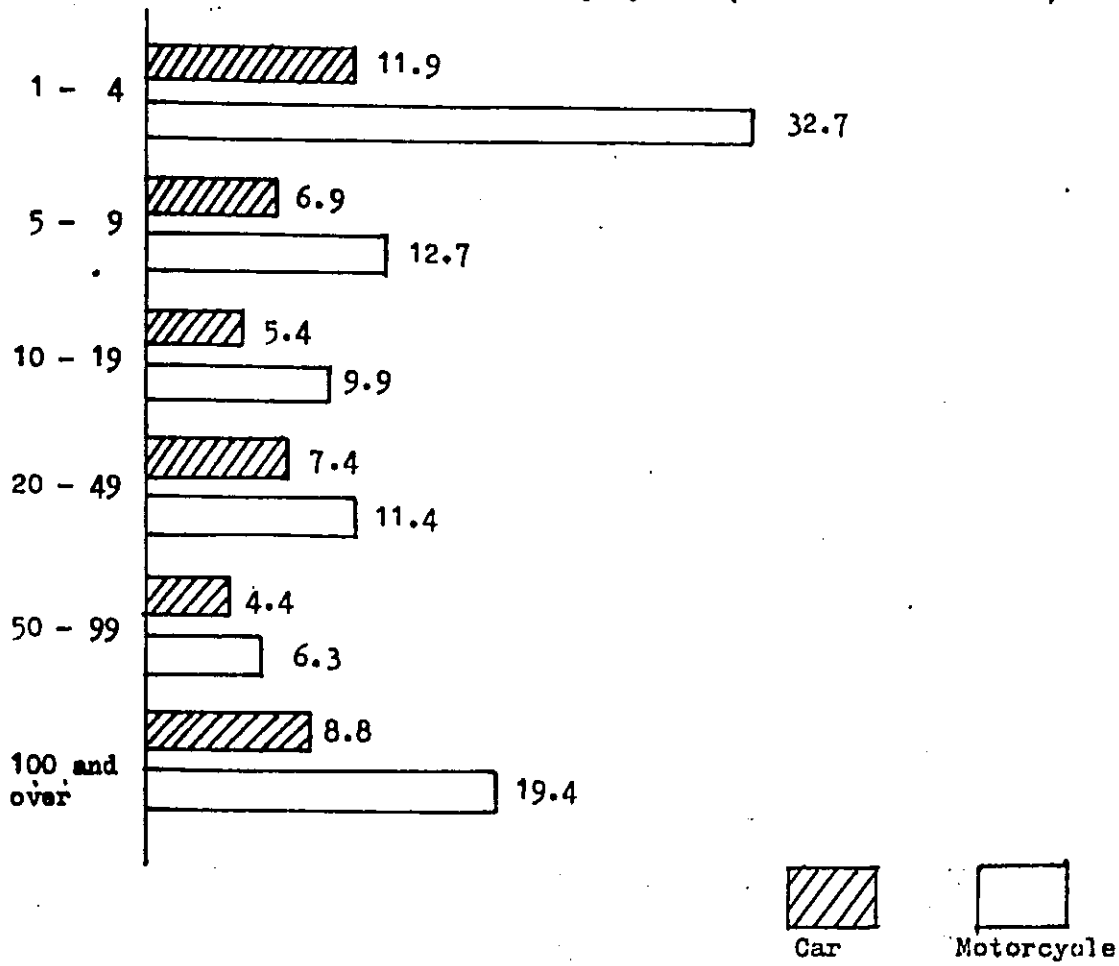


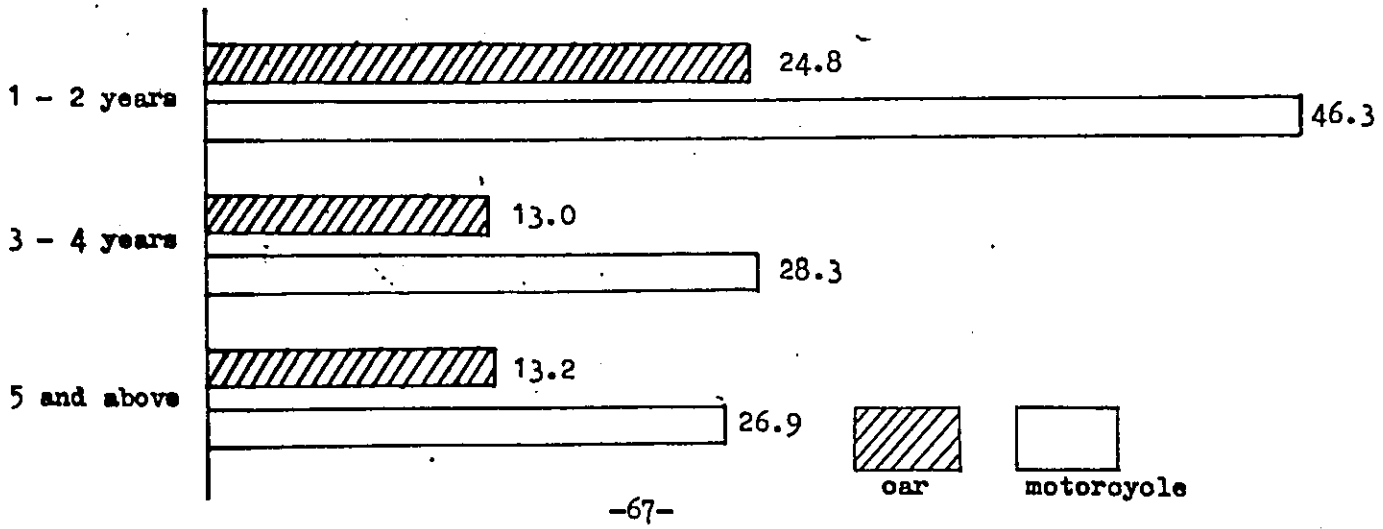
Fig: 4-11 **Vehicles owned by various sizes of employment (unit : 1000 vehicle)**



4-1-6 Period of ownership and frequency of usage of vehicles.

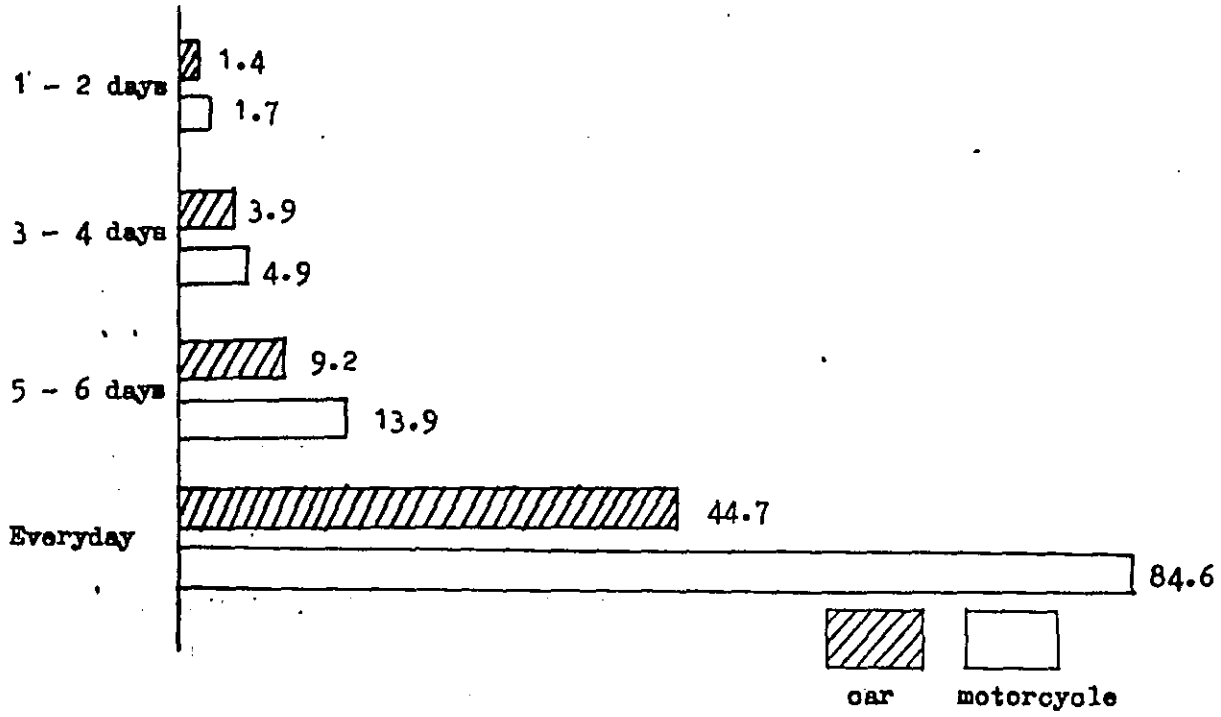
The majority of cars vehicles and motor-cycles are those owned for only 1-2 years, contributing to 49% and 46% of the totals respectively. This shows that the rate of possesion of cars is slightly more rapid than motor-cycle.

Fig: 4-12 **Period of Ownership (unit : 1000 vehicles)**



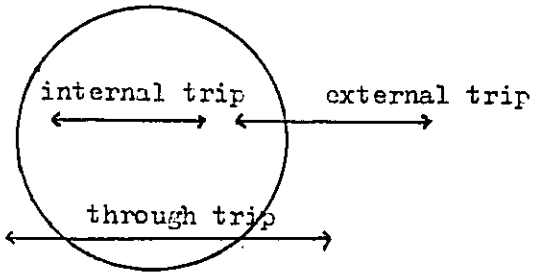
The percentage of car and motor-cycle owners who use the car and motor-cycle daily is 75% and 80% respectively. Only 2.4% and 1.6% of car and motor-cycle owners respectively use the vehicles for 2 days or less per week.

Fig: 4-13 Frequency of usage per week (unit : 1000 vehicles)



4-2 Analysis of trip production

The total number of trips in this study area is divided into the following 3 groups.



In this section, the analysis are carried out separately according to above-mentioned trip type.

4-2-1 Internal trip

(1) The unit trip production

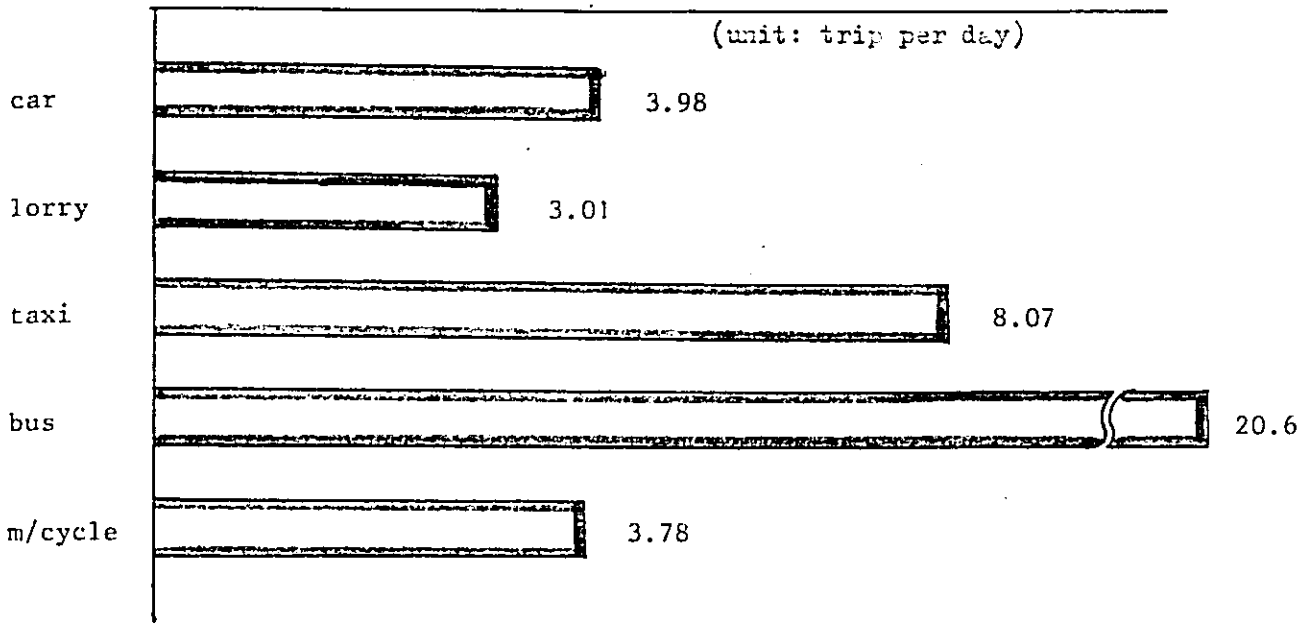
From the O-D table, we can obtain the unit trip production of each vehicle in the internal area.

Table: 4-7 The unit trip produotion

VEHICLE AND TRIP PURPOSE		NUMBER OF VEHICLES AND MOTORCYCLES IN INTERNAL AREA	NUMBER OF INTERNAL TRIPS	THE UNIT TRIP PRODUCTION (TRIP PER DAY)
CAR	going to work	-	66378	(1.12)
	business trip	-	33428	(0.56)
	private trip	-	53060	(0.90)
	going home	-	83171	(1.40)
		59250	236038	(3.98)
lorry		9415	28381	(3.01)
taxi		350	2723	(8.07)
bus		923	18987	(20.0)
VEHICLE		69938	286133	(4.09)
MOTOR-CYCLE	going home	-	113412	(1.08)
	business trip	-	40907	(0.39)
	private trip	-	83710	(0.84)
	going home	-	155286	(1.48)
		105132	379286	(3.78)
grand total		175070	683419	(3.90)

Average number of trips per day in the internal area are as follows :-

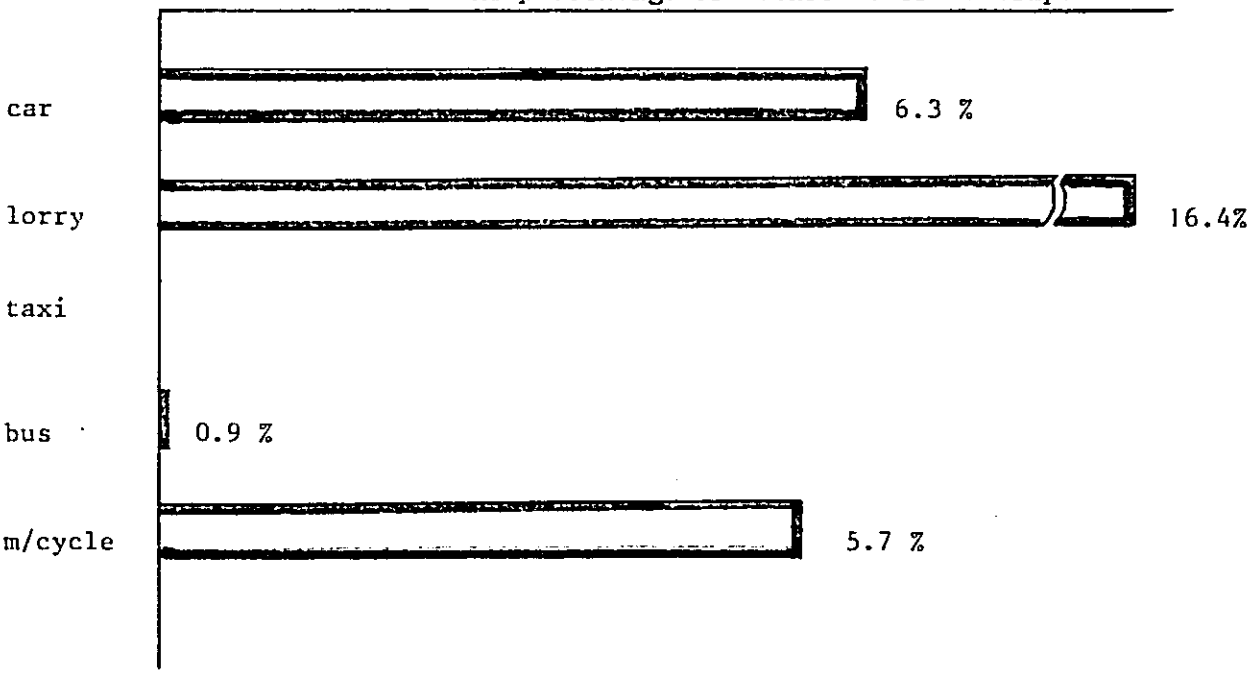
Fig: 4-14 Average number of trips (gross)



These figures include "vehicles of no trips".

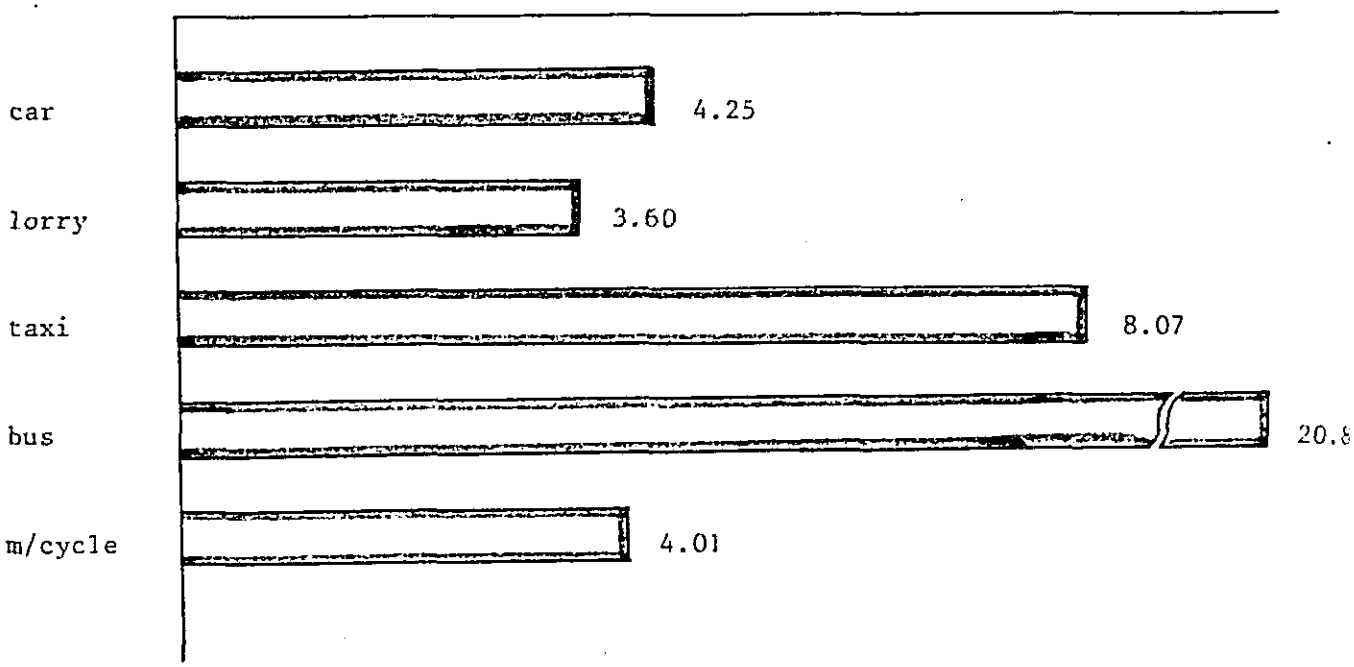
The percentage of "vehicles of no trips" is as follows :-

Fig: 4-15 The percentage of "vehicles of no trips"



Therefore the actual average number of trips per day of one vehicle is as follows :-

Fig: 4-16 The actual average number of trips (net)



(unit; trips per day)

These unit trip production by type of vehicle can be classified by characteristic of user. Therefore, using the category of form of ownership, sex, age and occupation, the unit trip production by characteristic of user are shown next table.

Table 4-3 Unit trip production by characteristic of user

		CAR	MOTORCYCLE
Form of ownership	Individual	3.92	3.74
	Company and Government	4.33	4.83
	Average	3.98	3.78
Sex	Male	3.95	3.78
	Female	3.79	3.29
	Average	3.92	3.74
Age	50 and above	3.77	3.80
	40 - 49	4.03	3.65
	30 - 39	3.92	3.75
	20 - 29	3.90	3.75
	Below 19	4.29	3.75
	Average	3.92	3.74
Occupation	Administrative and Managerial	4.17	3.69
	Professional amd Technical	4.00	3.88
	Clerical	3.80	3.98
	Sales work	3.96	3.91
	Service work	3.85	3.74
	Factory, construction and General labour	3.60	3.58
	Agriculture	3.45	3.67
	Student	3.90	3.41
	Housewife	4.10	3.54
	Unemployed	3.66	3.33
	Average	3.92	3.74

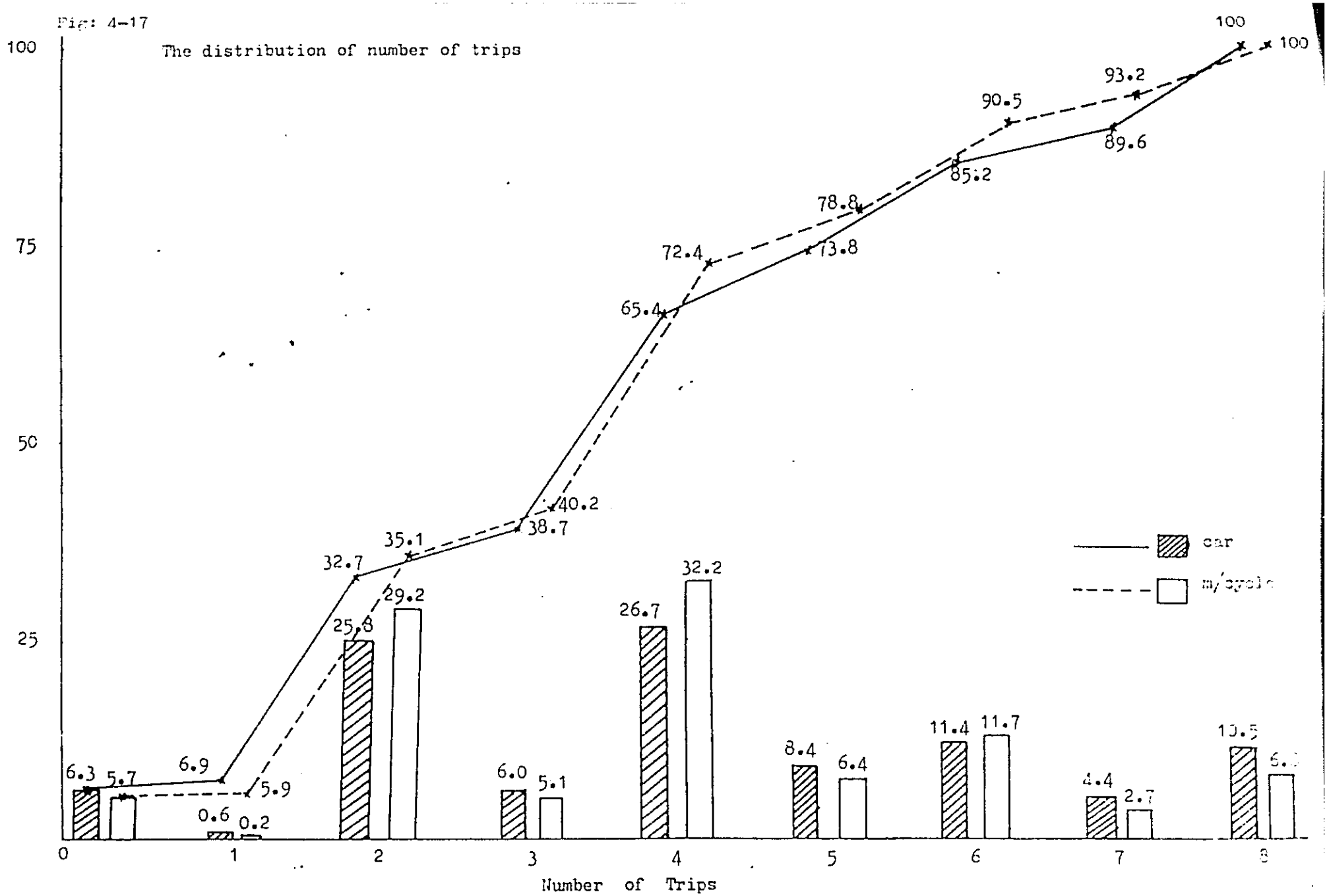
It seems that there are no particular difference by characteristic of owner. All of the unit trip production by characteristic are included within 4.3 - 3.6 for car and 4.0 - 3.2 for motorcycle.

Next figure shows the distribution of number of trips. From this figure, we can find that the cars made only 2 trips per day are 25.8% and the motorcycles are also 29.2%.

The most number of cars made 4 trips per day at 26.7% and the most number of motorcycles made 4 trips per day at 32.2%. The percentage of number of cars which made 4 trips and more trips per day is 65.4% and the percentage of number of motorcycles which made 4 trips and more trips per day is 72.4%. Therefore, more than half of cars and motorcycles are usually made 4 and more trips per day.

Fig: 4-17

The distribution of number of trips



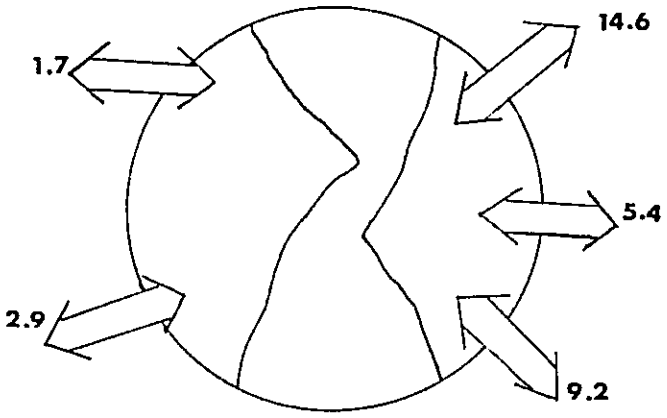
4-2-2 External trip and through trip.

Regarding external trip and through trip, the following data were obtained.

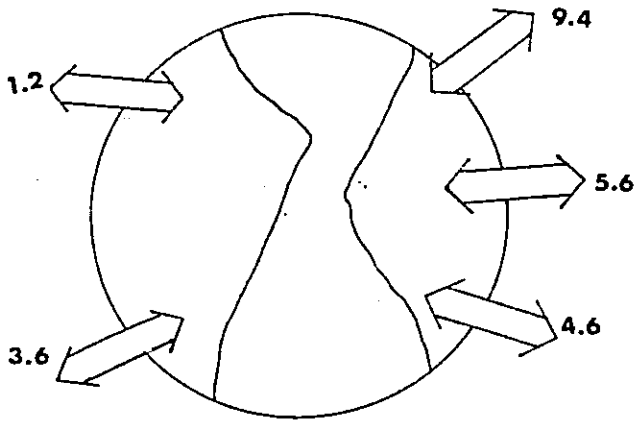
Figure 4-18 Traffic flow of external trip.

vehicles

(unit: 1000 vehicles)



motor-cycles



However, these data only concerned with the present situation. For the purpose of analysing long-distance trips, data which cover a wider area are required.

The Federal Route 1 and the East-West High way study are reviewed, after that, the method to be choosen for the the estimation of long-distance trips will be considered.

(1) Feasibility study between Alor Star and Changkat Jering.

This study area covers parts of Kedah, Penang and Perak.

PRE - CONDITIONS.

Forecasts of future growth of the following elements were prepared as premises in estimating future travel demand.

i) Population
ii) Employment
iii) Number of vehicles

i) Population

An average natural annual growth-rate of 2.7% is used for the population projection of the study area. However, due to the emigration of people from the study area, the growth rate has been adjusted to 2.4%, for the 21 year period from 1970 to 1991.

Table 4-9 Employment (unit: 1000 persons)

	Population	average annual growth rate (percent)
1970	1631.7	2.8
1981	2207.4	2.0
1991	2694.5	1.9
2001	3254.8	

ii) Employment

Due to the growth of the industrial (ie. mining and manufacturing), agricultral, construction, utilities, commercial, transport and services sectors, the Study Areas's employment is estimated to increase from 568,100 in 1978 to approximately 978,100 in 2001.

Table: 4-10 Employment (unit: 1000 persons)

	employment
1978	568.1
1981	642.9
1991	848.0
2001	978.1

iii) Number of vehicles

Vehicle ownership is expected to grow at a faster rate than population growth and the margin between all the states will diminish over the year 1980 - 2000.

Table: 4-11 Number of Vehicles (unit: 1000 vehicles)

		1978	1981	1991	2001
Kedah and Perlis	car (A)	33.0	50.0	102.0	152.0
	other vehicle	10.4	12.4	21.1	30.1
	m/c (B)	109.1	127.0	198.8	225.0
Penang	car (A)	63.8	74.0	120.0	169.0
	other vehicle	12.9	16.2	26.0	36.4
	m/c (B)	123.0	133.8	184.0	216.7
Perak	car (A)	76.3	97.7	168.0	240.0
	other vehicle	18.4	22.1	36.7	51.3
	m/c (B)	183.0	221.0	311.0	352.9

B. Methods of estimation

The computer modelling technique with some refinement is used for traffic forecast in this study.

The models used are:-

i) Highway Network Model.

ii) Highway Trip Model.

The inputs of these models are data on travel pattern, travel time and roadway characteristic. These datas were obtained from surveys.

i) Highway Network Models.

Computer simulation of the roadway network in the study area was developed for each study alternative tested. This network model include geographic distance between locations, average free-travel speeds and capacity data.

The current highway network (base-year Existing Network) was simulated as the first step in the modelling process.

Generated traffic was estimated by using a family of curves which related the magnitude of traffic induced to the proportion of travel time saved on a given trip.

The net effect of generated and degenerated traffic on the road system of the Study Area is an additional of 11984 trips in 2001 on the improved section of Route 1.

d) Traffic assignment.

Estimated use of the proposed improvement under study and the entire roadway system of the Study Area was derived from computer processing of appropriate combinations of network and trip tables.

Traffic was assigned to roadway links of the highway network model using the capacity restraint technique.

B. Results of traffic estimation

The existing unimproved route I has 61,500 trips as shown in the base year (1978) trip table. Regarding the 1981 trip forecast, the tables show the unimproved Federal Route I having 80800 trips while the network with Federal Route I improved has 21,100 trips. The growth rate over the 4 year period are 31.4 % and 31.9 % respectively. By 2001, traffic volume, are forecasted to increase by 129.6% even if Federal Route I remained unimproved, and by 143.5 % if Federal Route I (Butterworth - Alor Star/Jitra section) is improved.

SUMMARY OF TRIP TABLE

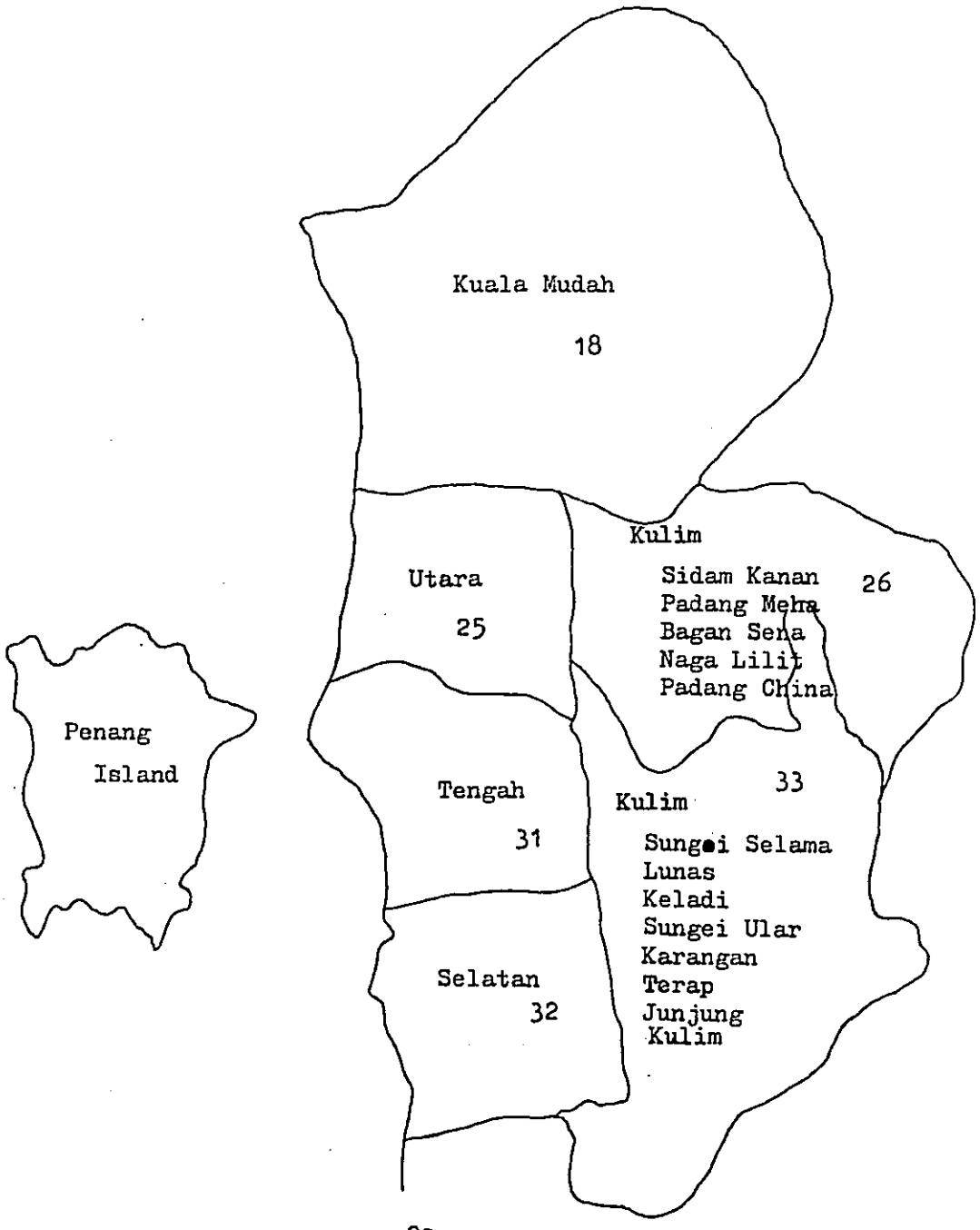
CAR	CONDITION	TOTAL VEHICLE TRIPS	
		Improved F.R. 1	Unimproved F.R. 1
1978	Current (Base-year)	N/A	61,500 (1.00)
1981	Forecast Opening Year	81,100 (1.32)	80,800 (1.31)
2001	Forecast Horizon Year	197,500 (3.21)	185,500 (3.02)
Per Cent Growth	1978 - 1981	31.9	31.4

N/A denotes Not Applicable.

2) Feasibility Study of the supporting road systems for the east-west highway.

This study area which covers a total of 12173 square miles, is made up of the following States; Kelantan, Kedah, Perak and Penang (excluding Penang Island). However, in this section, only the following areas as shown in Figure 4-19 will be described.

Figure 4-19 **The Study Areas.**



A. Pre-conditions

The following premises inputs are used to project the future traffic demand.

i) population
ii) employment
iii) income

i) Population

The projected zonal population for the years: 1978, 1985 and 2000 for zones 18, 25, 26, 31, 32, 33 are as follows:-

Table 4-12 :Population Projection (unit: 1000 person)

ZONE \ YEAR	1978	1985	2000
18	203.6	241.7	323.5
25	207.4	247.4	333.2
26	40.1	46.0	58.6
31	151.1	180.2	242.7
32	81.8	97.7	131.7
33	108.0	132.0	183.5

ii) Employment

The following table shows the projected employment by zone for 1978 and 2000, which are classified into primary, secondary and tertiary employment.

Table: 4-13 Employment Projection

(unit: 1000 persons)

ZONE	1978				1990			
	Primary	Secondary	Tertiary	Totall	Primary	Secondary	Tertiary	Total
18	32.2	6.1	20.7	59.0	35.1	9.4	32.3	76.8
25	18.3	13.5	26.7	58.5	15.6	19.5	42.9	77.9
26	7.1	-	-	7.1	7.2	-	-	7.2
31	10.4	8.7	17.6	36.7	9.8	12.2	26.8	48.8
32	9.9	3.1	7.2	20.2	10.2	5.4	11.3	26.9
33	19.7	3.8	14.1	37.6	22.1	6.8	23.2	52.0

(iii) Income

The projected average household income per month for the year 1978, 1985 and 2000 is tabulated in the below:-

Table: Income Projection

(unit: 1000 dollars)

Table 4-14 Average Household Income Per Month.

ZONE \ YEAR	1978	1985	2000
18	0.3	0.5	1.0
25	0.3	0.5	1.0
26	0.2	0.4	0.8
31	0.3	0.5	1.0
32	0.3	0.5	1.0
33	0.2	0.4	0.8

Methods of Estimation

Travel Forecasting Procedure

Technique used are as follows:-

	Intra-zonal trips	Inter-zonal trips
Travel by motor-cycles cars and buses	Exponential decay and gravity model	Trip generation and gravity model
Commercial goods vehicles (include trucks, vans)	Percentage	Flow patterns from development plans

Intra-zonal trips refer to trips made between towns and agricultural hinterland.

Inter-zonal trips include work and recreational trips.

Person Trip Demand Models

This section deals with the estimation of traffic volumes generated by the

I) Passenger vehicle Travel Forecast

II) Commercial vehicle Travel Forecast

I. Passenger Ve[illegible] on Travel

A) Estimation of [illegible] person [illegible]

The following [illegible] for [illegible]

i) Trip ge[illegible]

It is bas[illegible] category analy[illegible] a number of [illegible] ed. They are

a) [illegible]

b) [illegible]

c) [illegible]

d) trip [illegible]

These models [illegible] community is dependent on the popula[illegible] and vehicle ownership of their [illegible] were developed from data collected through compre[illegible] Let us [illegible] each of them.

a) Vehicle ownership model

This model [illegible] household income and vehicle ownership [illegible] propensity to own a vehicle [illegible] available in [illegible] model a set of [illegible] households is [illegible]

- no vehicle [illegible]
- motor-c[illegible]
- one car [illegible]
- many car[illegible]

A series [illegible] study in the different [illegible] types [illegible] level of urbanisation.

b) Income dist[illegible] model

The income [illegible] individual household by [illegible] sonal household income [illegible]

c) Trip produ[illegible]

These model[illegible] production

rates which are related to income levels and vehicle ownership for each of the zones in the study area. (refer to Table 4.3.2.)

d) Trip attraction model

This model relates the attractiveness of the zones to its population and employment opportunity.

ii) Trip distribution model

It predicts the origins and destinations of general trips. A standard gravity model is used. The model has the mathematical form:-

$$Vij = C.Pi.\ Aj.\ FTij.\ Kij$$

where Vij = volume of trips originating in zone i and attracted to zone j.

Pi = trips produced at zone i

Aj = trips attracted to zone j

Tij = travel time between i and j

F = friction factor which is a function of time

Kij = adjustment factor for special conditions such as socio-economic differences, large "perceived" barriers to travel (such as the Penang Island Ferry) etc.

C = normalization constant $\dfrac{1}{\left(\sum_{n=1}^{j} Aj\ F\ Tij\ Kij\right)}$

iii) Trip Assignment Model

The "all or nothing" model was used for the traffic assignment.

iv) Modal Split

The modal split procedure was based on the projected vehicle ownership rates, household categories, population density and urban structures.

B) Estimation of Intra Zonal Person Travel demand

Estimation is based on

i) a gravity model estimate of the total number of intra-zonal person trips for each zone and bench-mark year

ii) an allocation of intra-zonal trips to individual links

and an exponential decay function to obtain estimate of average link volumes.

Conversion of Person Trips to Passenger Vehicle Trips

The modal split which is based on the projected vehicle ownership rates, household categories, population density and urban structure was used to convert person trips to passenger vehicle trips.

II. Commercial Vehicle Travel Estimation

The estimation methods here are based on development plans and projections of freight inflow in to the study area.

The procedures involve the following:-

- Determination of freight flow resulting from export of forest and farm-based products.
- determine the routes to the destinations.
- freight flow was allocated between light vans and trucks based on traffic data in the study area.
- freight inflow to districts was projected in 2 different ways. They are determined on the basis of
  1) the proportion of flow of rural produce originating in each district and
  2) the urban/rural population distribution
- constant vehicles mixing was assumed throughout the study period.
- freight flow was converted to commercial vehicle trips on the basis of
  i) commodity tonnage
  ii) average loading of different commercial vehicle types
  iii) those goods which have been determined on the basis of proportion of flow of rural produce originating in each district.

The data obtained from HPPTU were used as data base for the forecasting procedures outlined above. In this way, agricultural commodities.and miscellaneous freight were estimated.

TABLE 4-15 PROJECTED TRAFFIC VOLUMES ON SEGMENT W9

Year	Motor-Cycle	Car	Van	Lorry	Bus	Total
Base Case						
1978	3,132	5,460	200	600	358	9,750
1985	3,427	5,971	290	870	392	10,950
1990	4,403	7,674	340	1,030	503	13,950
1995	5,303	9,242	360	1,090	605	16,600
2000	6,258	10,907	390	1,180	715	19,450
Alternative 1						
1978	1,215	2,135	80	240	130	3,800
1985	1,345	2,360	110	340	145	4,300
1990	1,723	3,013	140	440	184	5,500
1995	1,978	3,433	140	440	210	6,200
2000	2,218	3,855	160	480	237	6,950
Alternative 2						
1978	2,804	4,886	120	370	320	8,500
1985	3,077	5,361	180	530	352	9,500
1990	3,959	6,899	200	590	452	12,100
1995	4,823	8,406	200	650	551	14,650
2000	5,065	8,826	230	700	579	15,400

4-2-3 Traffic volume and number of vehicles.

We have no past-trend data concerning to the unit trip production. Instead of that, the data of traffic volume and number of vehicles can be obtained, therefore the relation between the both of them will be mentioned in this chapter.

A. Number of vehicles.

The past-trend data about the number of vehicles are shown as follows:

Table 4-16 The Trend Of The Number Of Vehicles

11	1965	1970	1975	1979	Average annual percent growth		
					1965 - 1970	1970 - 1975	1975 - 1979
Cars	20975	28326	45578	65352	6.2	10.0	9.4
Taxis	214	294	386	474	5.5	5.6	5.3
Lorries & vans	3211	5469	8475	11404	11.2	9.2	7.7
Buses	400	512	786	1073	5.1	8.9	8.1
Subtotal	24800	34601	55225	78303	6.9	9.8	9.1
Motorcycles	27126	47432	89311	124984	11.8	13.5	8.8
Total	51926	82033	144536	203287	9.6	12.0	8.9
Population	(697653)	776124	864771	(947530)	2.2	2.2	2.3

Note 1) excludes other vehicles
(e.g. tractors, road rollers, etc.)
2) Source of registration no. : R.I.M.V.
3) Source of population :
"population projections for the states of Peninsular Malaysia 1970 - 1980" Department of Statistics.

(B) Traffic Volume.

In Penang state, there are 25 stations for traffic census by J.K.R. These data are shown as follows:

Table 4-17 The Trend Of Traffic Volume

STN NO. \ YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
00F6	2140	2114	2842	3409	4462	4304	4492	-	4994	5930
00F7	8811	9448	10635	14261	18080	18242	21290	-	31018	32343
0B13	224	290	341	344	414	447	376	-	117	818
0B14	1073	1112	1306	1436	1784	1764	1969	-	2739	3009
0B15	3552	4116	4429	5262	6602	7442	8797	-	10094	10002
00S6	2241	2277	3164	3535	4132	4755	5026	-	7039	8254
0006	5726	6508	7026	7346	8948	10387	10069	-	11225	11097
0007	14712	13608	14882	11787	15423	18324	18517	-	20001	31675
0008	9299	9725	10127	12276	13920	12711	13876	-	16622	17691
0009	5967	6926	7230	8140	10176	10239	11550	-	14534	23350
0010	7085	7920	8027	8824	9954	9296	10880	-	12435	14059
006A	9991	10462	13453	12547	11795	12229	11297	-	14238	15257
00B1	800	960	1028	1088	1464	1541	2095	-	2077	2992
00B3	547	850	1254	1624	743	1237	879	-	1270	1179
00B4	2048	2824	2857	3170	2569	2762	4105	-	4061	5363
00B6	457	457	467	779	1088	1001	675	-	866	1026
00B7	1203	1134	1177	1116	1567	1521	1528	-	2166	2599
00B8	1627	2121	2387	2036	2798	2703	3943	-	3716	4970
00B9	2783	3093	2956	3255	3319	3510	3908	-	4962	4603
00S7	1205	1199	972	1365	1914	1979	1826	-	2699	2785
00S8	8567	9819	7583	8939	9628	10541	11913	-	11649	17208
00S9	4008	4480	6162	6594	7429	8666	9105	-	14487	15099
0B10	481	519	1104	493	534	460	548	-	627	818
0B11	826	877	867	1129	1310	1308	1542	-	2583	2122
0B12	970	1091	970	1001	1285	1254	1245	-	3719	2018
Total	82,800 (96,343)	103,930	113,246	121,756	141,338	148,623	161,451		199,938	236,266

( ): estimation

The volume of ferry traffic are as follows:

Table 4-18 Ferry Traffic In One Way Trips

(1000 persons and vehicles)

	Passenger	Bicycle	Motorcycle	Car	Truck
1965	10173.5	760.7	634.4	885.9	179.1
1966	10185.2	931.5	725.2	981.9	189.6
1967	10415.7	1047.8	905.7	997.0	203.0
1968	12622	1108	1228	1024	234
1969	12724	1048	1312	1006	246
1970	13596	1146	1464	1138	260
1971	14288	1156	1596	1236	268
1972	15748	1162	1894	1462	298
1973	16744	1216	2204	1632	342
1974	17954	1208	2596	1678	364
1975	18150	1186	2726	1970	376
1976	18586	1158	3420	2552	442
1977	19644	1084	3858	2900	486
1978	20484	-	4452	3210	564

Using these data, the relationship with the number of vehicles and the traffic volume are calculated as follows:

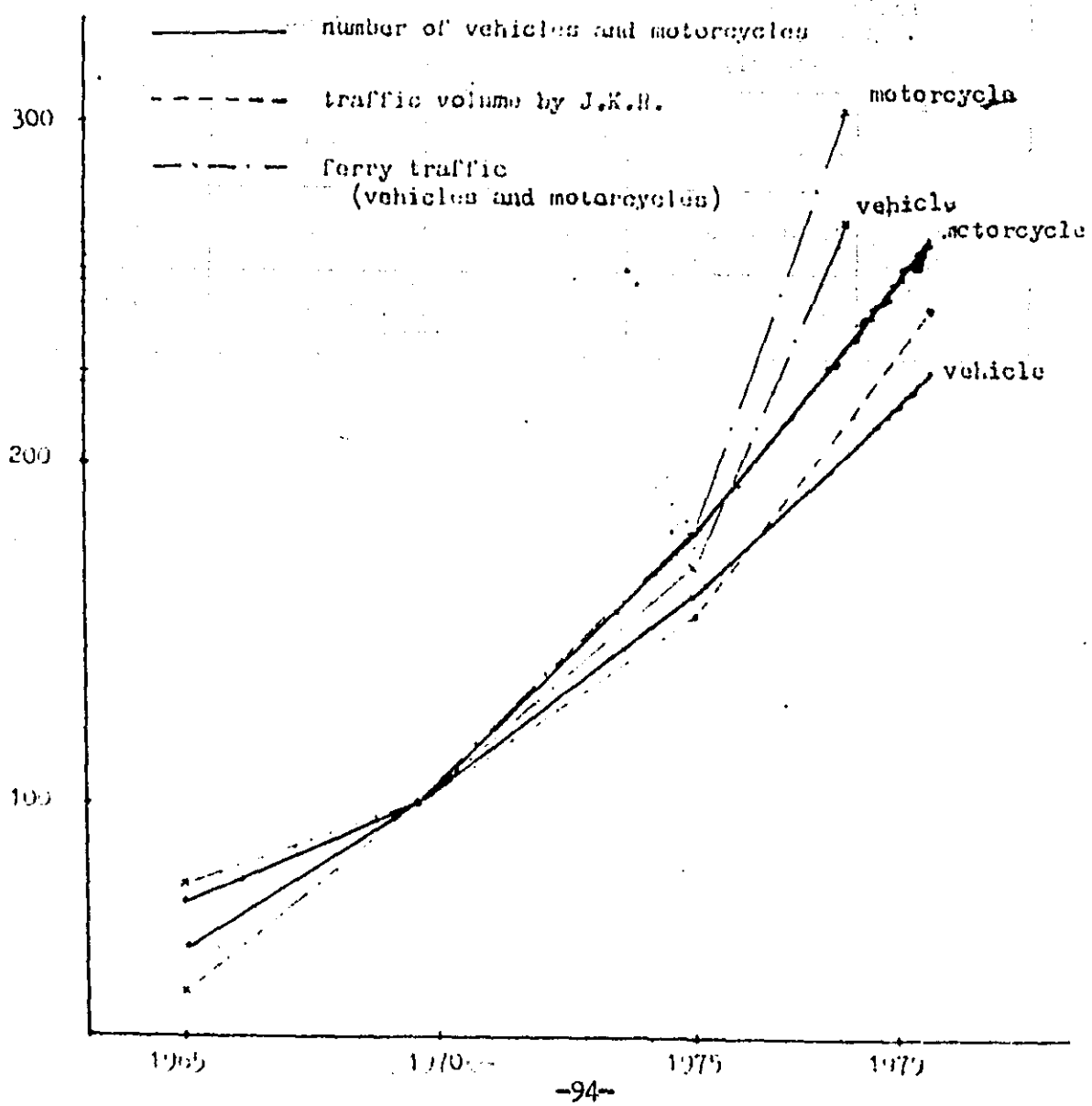
Table 4-19 Average Annual Percent Growth

		Average annual percent growth		
		1965 - 1970	1970 - 1975	1975 - 1979
Number of Vehicles	Vehicle	6.9	9.8	9.1
	Motorcycle	11.8	13.5	8.8
	Total	9.6	12.0	8.9
Traffic volume by J.K.R. (total)		-	9.1	12.3
Ferry	Vehicle	5.6	10.9	(17.2)
	Motorcycle	18.2	13.2	(17.8)
	Total	11.0	12.1	(17.5)

Table 4-20 Index Number

		Index Number			
		1965	1970	1975	1979
Number Of Vehicles	Vehicle	171.7	100	160	226
	Motorcycle	57.2	100	188	264
	Total	63.3	100	176	248
Traffic volume by J.K.R.		-	100	154	245
Ferry	Vehicle	76.2	100	168	(270)
	Motorcycle	43.3	100	186	(304)
	Total	59.4	100	177	(287)

Fig. 4-20 The trend of the index number



These figures show that the traffic volume are roughly following the number of vehicles excepting that the ferry traffic in 1975 - 1978 are increasing more than the increase of number of vehicles.

It can be said that the traffic volume up to this time increase in proportion to the number of vehicles or slightly exceed the increase of those. Therefore, it is estimated that the unit trip production is constant by year or may be slightly increased.

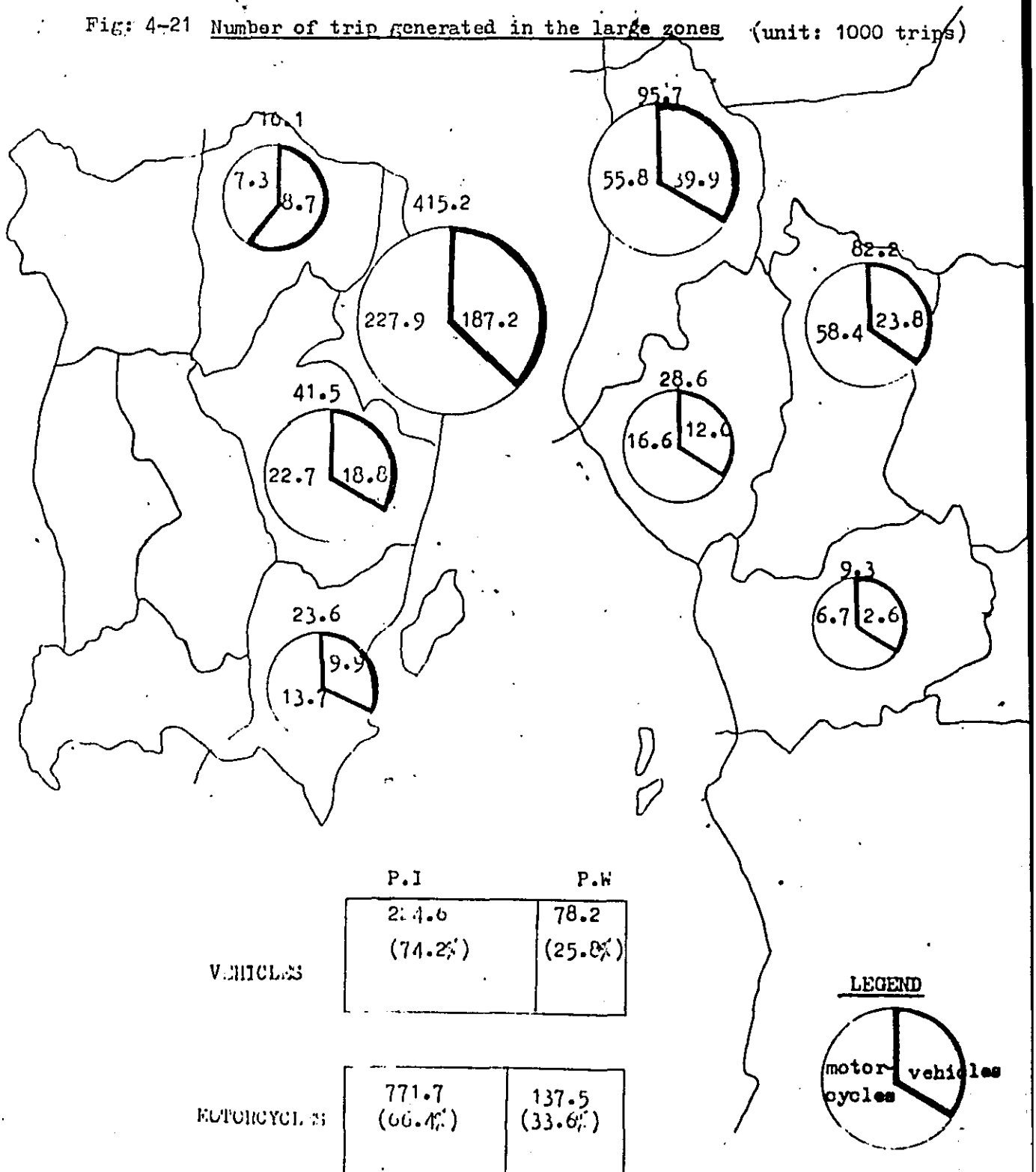
On the basis of these consideration, the unit trip production in future will be made use for the present value which were obtained though our traffic survey.

4-3 Analysis of Trip Generation and Attraction

4-3-1 Trip generation and attration

The total number of trips generated from the internal area is 303,000 trips per day for vehicles and 409,000 trips per day for motorcycles. The number of trips generated in the large zones are shown in the following figure and it is remarkable that the trips generated is made up of about 62% vehicles and 56% motorcycles.

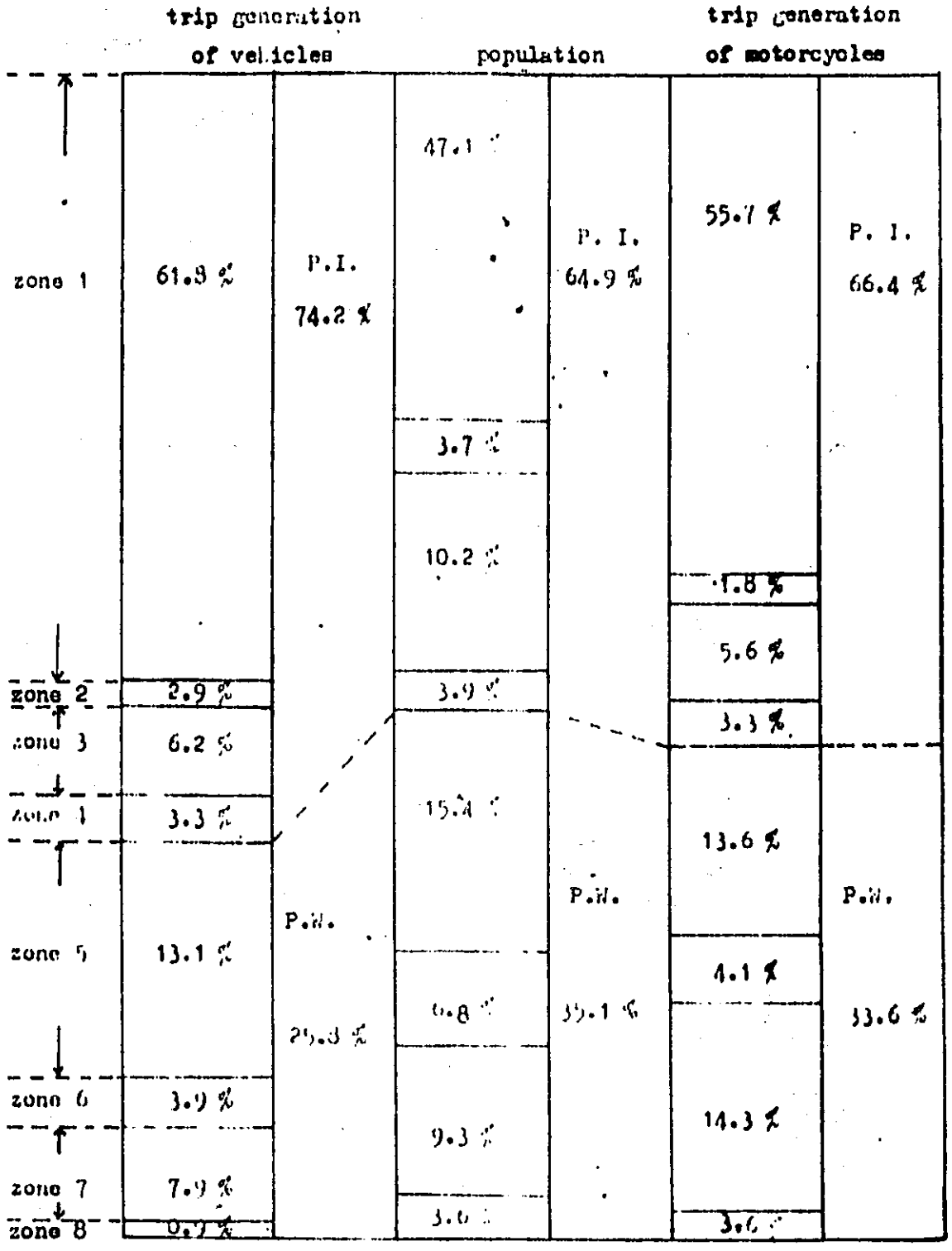
Fig: 4-21 Number of trip generated in the large zones (unit: 1000 trips)



	P.I	P.W
VEHICLES	224.6 (74.2%)	78.2 (25.8%)
MOTORCYCLES	771.7 (66.4%)	137.5 (33.6%)

The following figure shows the comparison between the composition of trip generation and the population in the large zone.

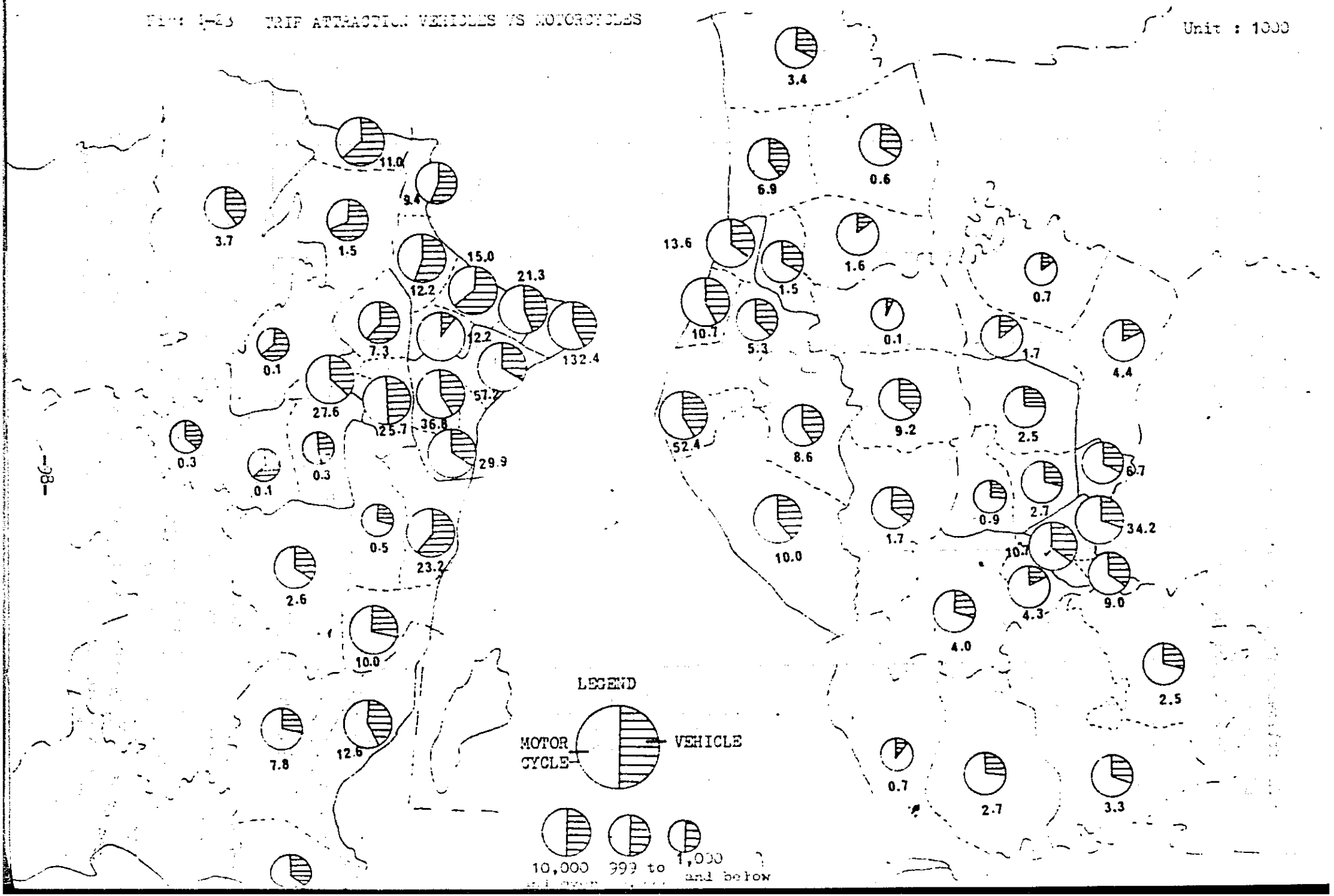
Fig: 4-22 Comparison between the composition of trip generation and the populatio



The composition of trip generation of motoroycles is almost the same as the population. This means that the trip generation of motoroycle is almost proportional to the population, whereas the trip generation of vehicles is not proportional to the population. The reason for this is that the trip generation of vehicles is related to the degree of urbanization in the area.

Fig. 4-23 TRIP ATTRACTION VEHICLES VS MOTORCYCLES

Unit : 1000



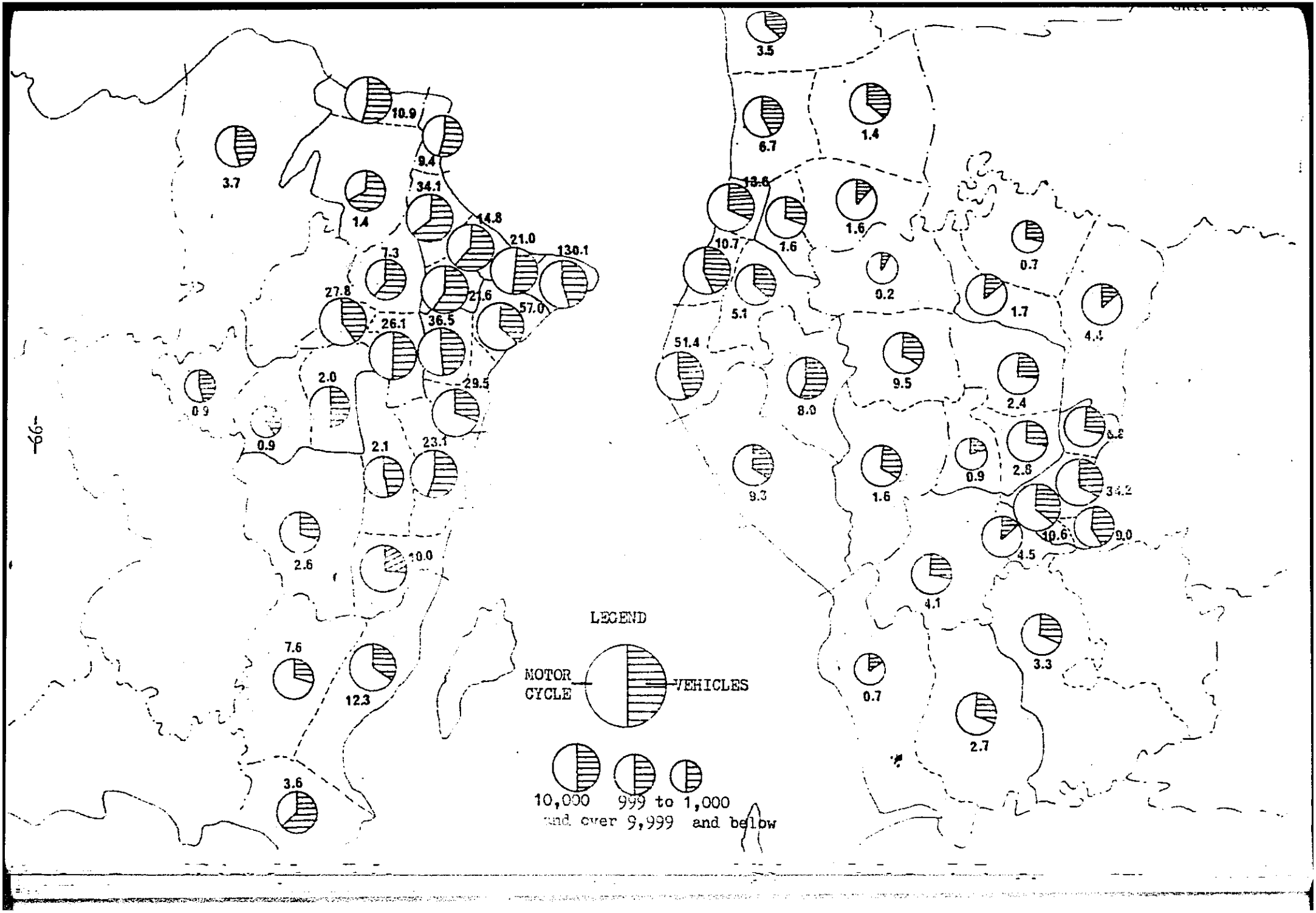

LEGEND
MOTOR CYCLE
VEHICLES
10,000 999 to 1,000
and over 9,999 and below
3.5
6.7
1.4
13.6
1.6
1.6
10.7
0.7
0.2
5.1
1.7
4.4
51.4
9.5
2.4
8.0
6.8
2.8
0.9
9.3
1.6
34.2
10.6
9.0
4.5
4.1
3.3
0.7
2.7
10.9
9.4
3.7
1.4
34.1
14.8
21.0
130.1
7.3
27.8
21.6
57.0
26.1
36.5
2.0
29.5
0.9
0.9
2.1
23.1
2.6
10.0
7.6
12.3
3.6

Fig: 4-25 TRIP GENERATION COMPOSITION OF TRIP PURPOSE (CAR).

Unit : 1000

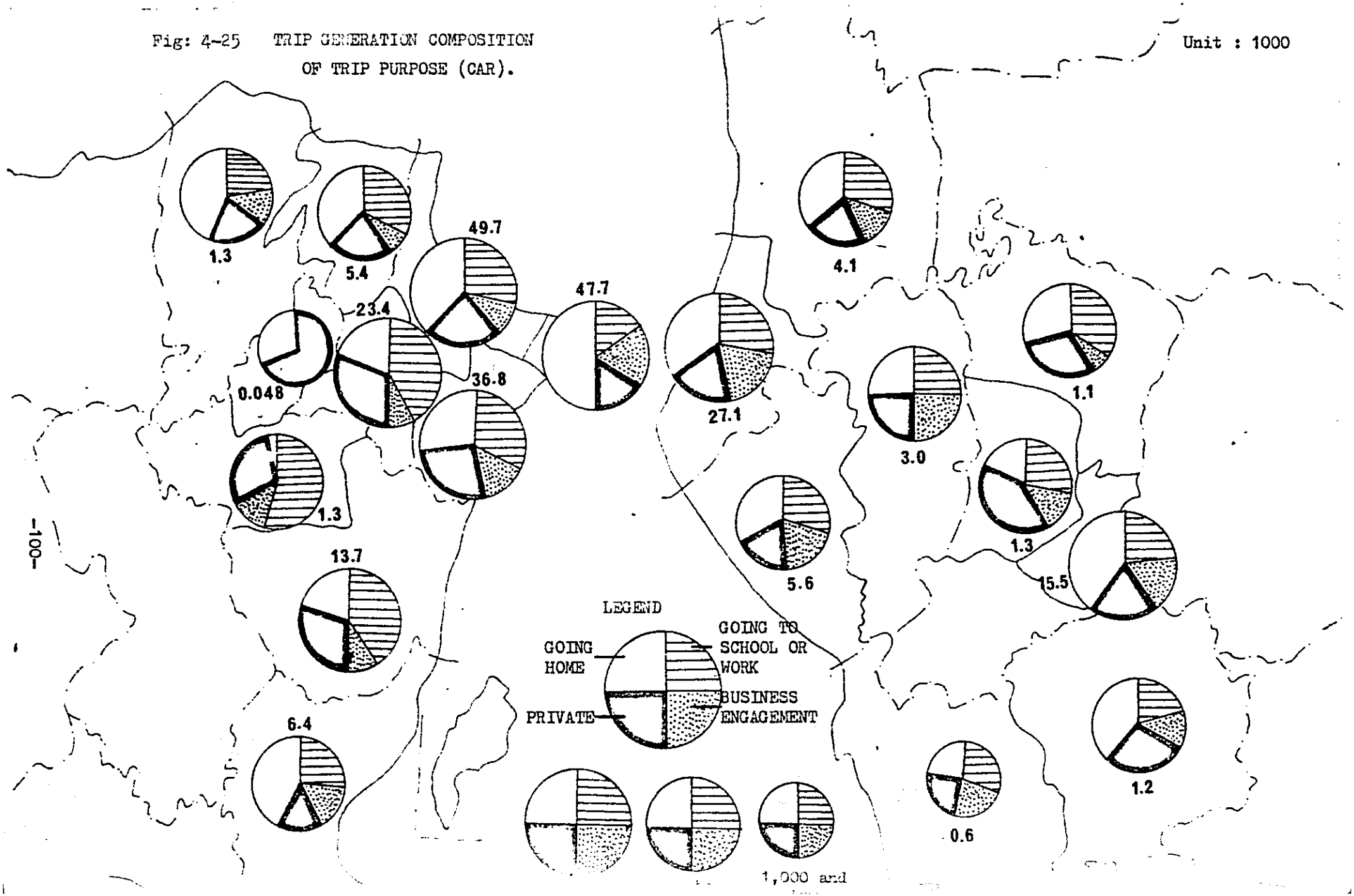
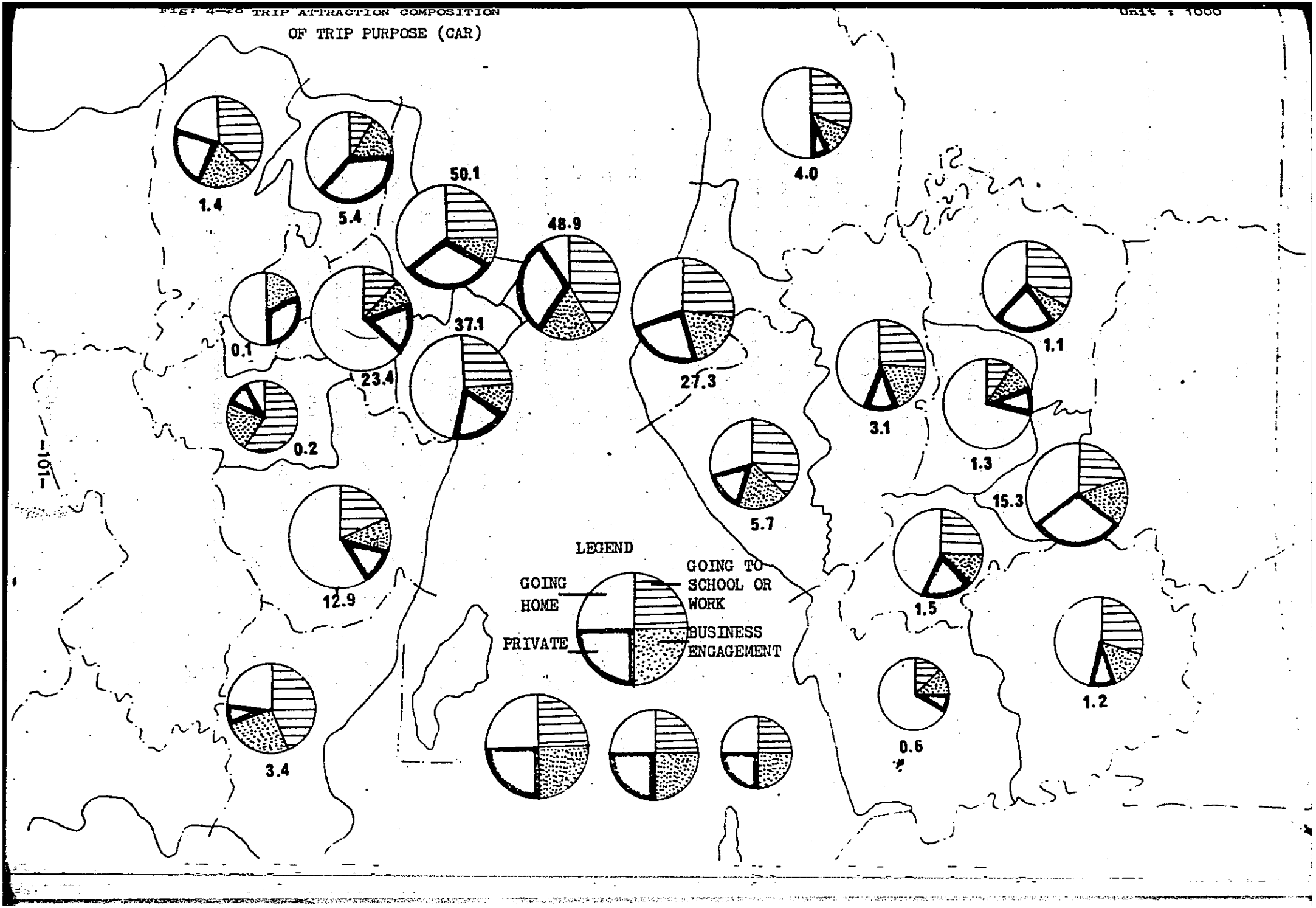


Fig. 4-26 TRIP ATTRACTION COMPOSITION OF TRIP PURPOSE (CAR)

Unit : 1000



4-3-2 The classification of zones

Each traffic zone has various characteristics. For instance, the commercial, the residential, the industrial and the business area come under one classification; that of land-use. High density, medium density and low density is another classification which makes use of population density.

In this section, another classification was attempted by using the results of traffic surveys. This classification is called the zone classification by traffic characteristics.

(1) Method of classification

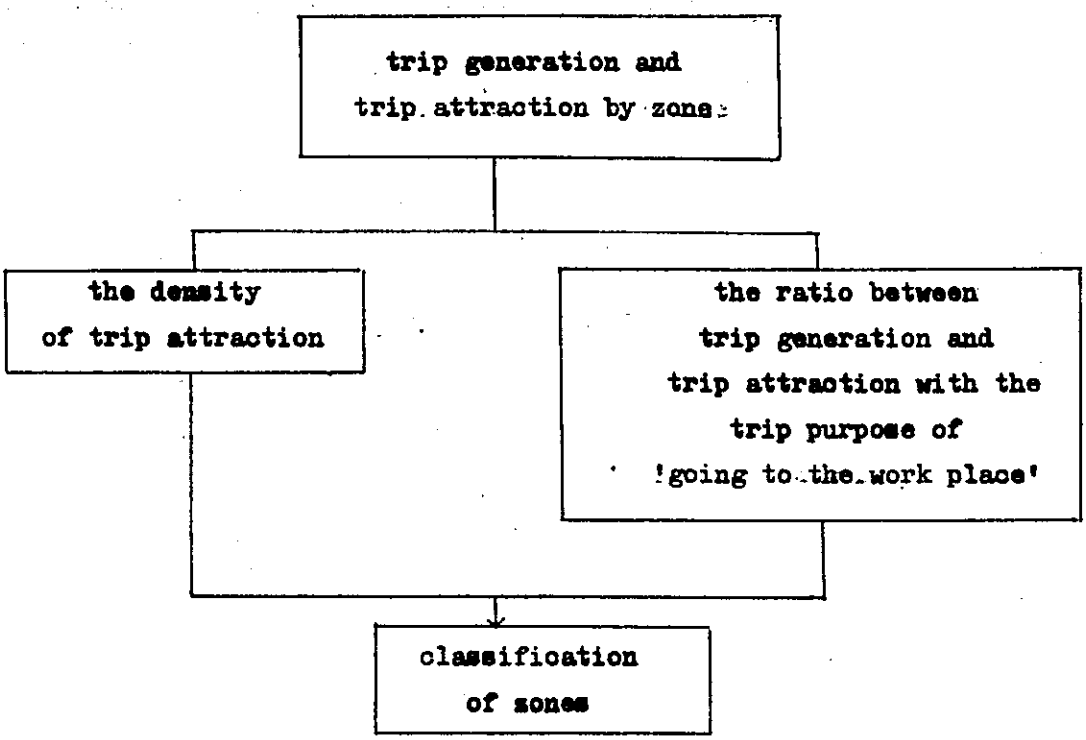
Through traffic surveys, the O-D table by vehicle type and trip purpose was obtained. The classification is done by using that O-D table. A lot of information which are related to the characteristics of the zones can be obtained from the O-D table, as for examples, the volume of trip generated and trip attracted and the composition of trip purpose which is the result of generated and attracted will be an indicator of the intensity of trip generation and attraction.

The urbanized zone has many 'attractive' facilities and they constitute the attractive forces of that zone. The more attractive the zone grow, the greater the number of trips attracted there. Therefore, the density of trip attraction is chosen as one of the indicators for classifying the zones.

Besides this, trip purpose is also useful for the classifying procedure. If the zone is a residential area, many trips with the trip purpose of 'going to the work place' will be generated from this zone and if the zone is a business area, many trips with the trip purpose of 'going to the work place' or 'business engagement' will be attracted into this zone. Therefore, the ratio of trip generation to trip attraction having the trip purpose of 'going to the work place' is used for the classification of the zones.

The classification is done according to the following flow chart.

Figure 4-27 Flow chart of zone classification.



(2) <u>The procedure of classification</u>

Following the above-mentioned method, the graph is plotted to classify the 57 zones in the study.

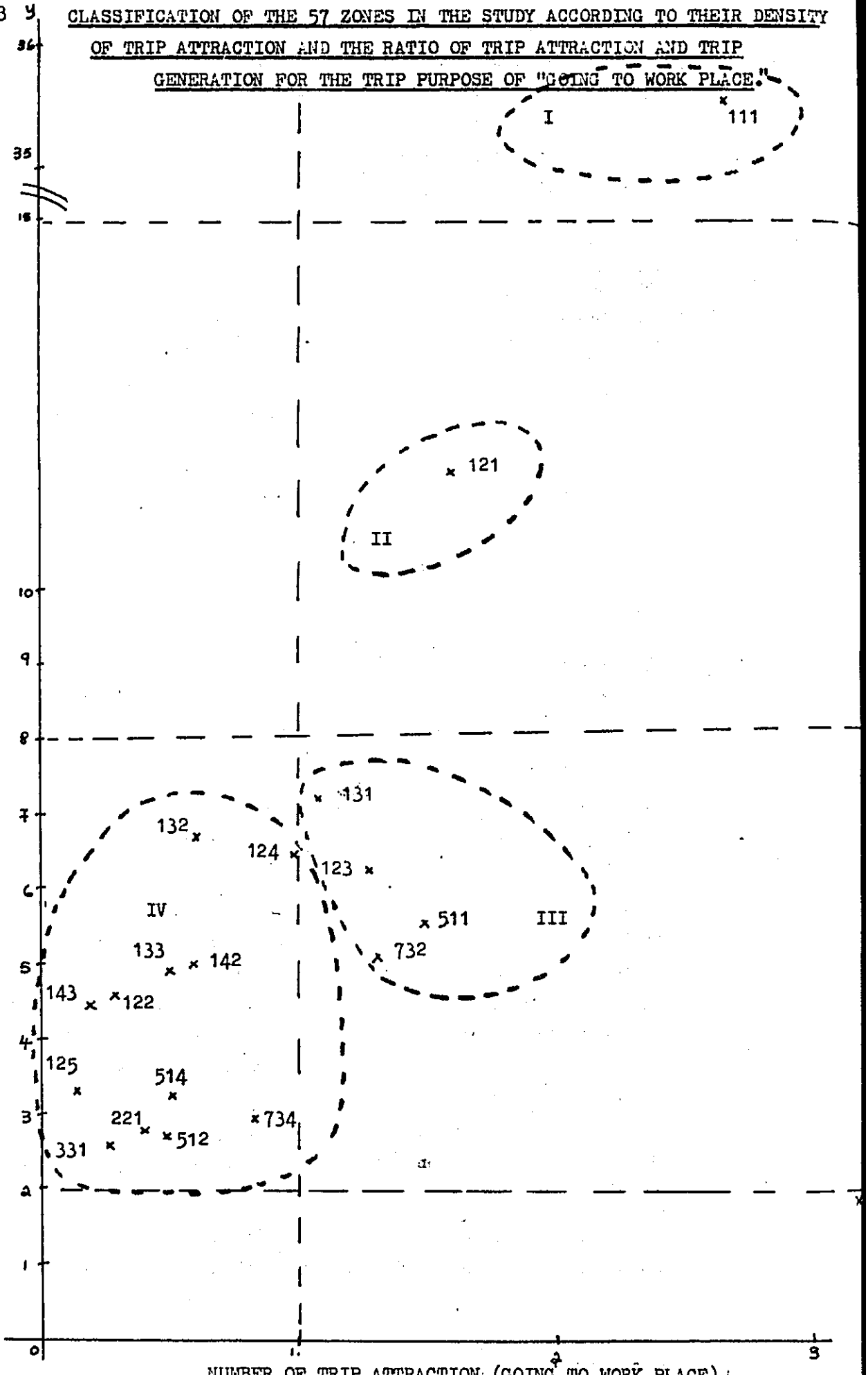
The Y-axis of the graph represents the density of trip attraction by area size. The density of trip attraction is used here for zone classification because it shows us how 'attrative' that particular zone is.

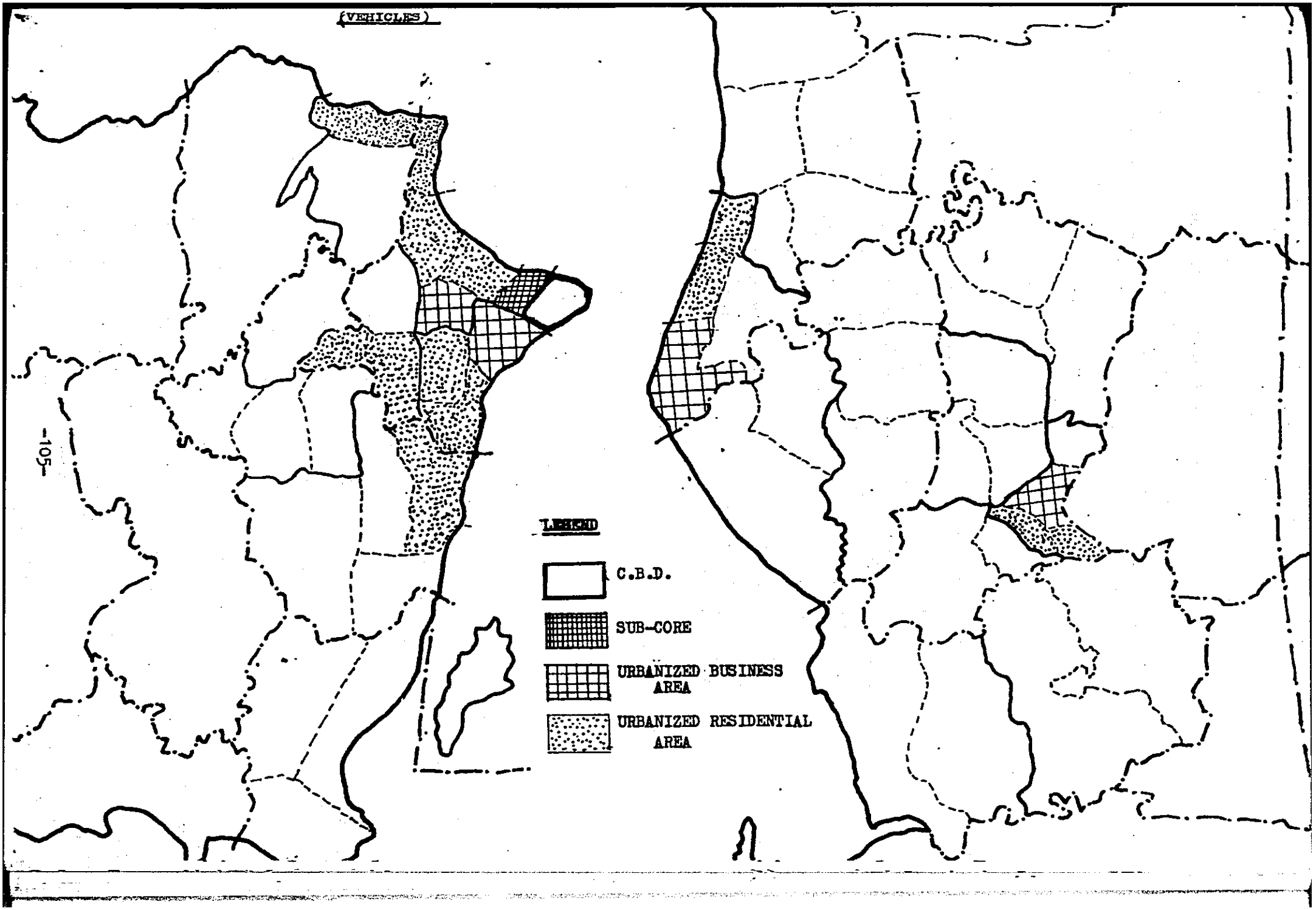
The X-axis of the graph represents ratio of trip attraction to trip generation with the trip purpose of 'going to work'. If this ratio is high, it implies that a particular zone is a business area since many trips with the trip purpose of 'going to work' will be attracted to that zone. The point where the ratio of trip attraction and generation is equal to I is chosen as the line of demarcation. Thus, those zones which lie to the right of the line where $x = 1$ is classified as business areas while those that lie on the left is classified as residential areas.

This classification can be seen in the following graph and the results of this classification is shown in Fig. 4 - 28

Fig: 4-28

CLASSIFICATION OF THE 57 ZONES IN THE STUDY ACCORDING TO THEIR DENSITY OF TRIP ATTRACTION AND THE RATIO OF TRIP ATTRACTION AND TRIP GENERATION FOR THE TRIP PURPOSE OF "GOING TO WORK PLACE."




(VEHICLES)
LEGEND
C.B.D.
SUB-CORE
URBANIZED BUSINESS AREA
URBANIZED RESIDENTIAL AREA

The results show that this classification is appropriate. From this, it can be concluded that the volume of trip generated and trip attracted by the zones which have been obtained through traffic surveys is accurate.

4-3-3 Analysis of trip generation and attraction

Usually, the regression method and the basic unit method are used for the analysis of trip generation and attraction. In this study both these methods will be examined. After which, the suitable method and suitable explanatory variables will be chosen.

(1) The basic unit method

The basic unit of trip generation is obtained by means of dividing the trip generation by the population of each zone. The results are shown in the following figure.

Fig: 4-30 The basic unit of trip generation (vehicles).

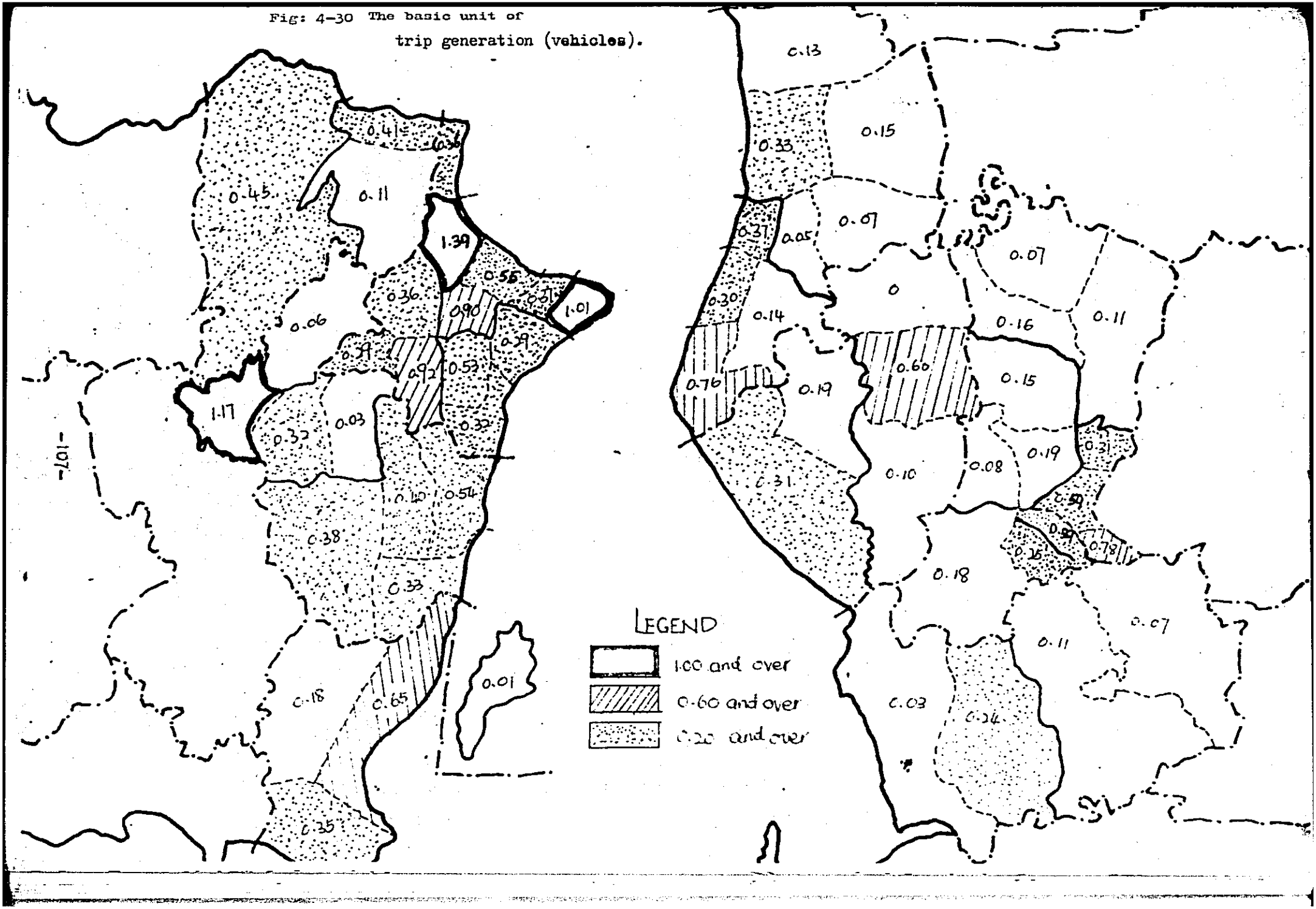


Fig: 4-31 The basic unit of trip generation (motorcycles).

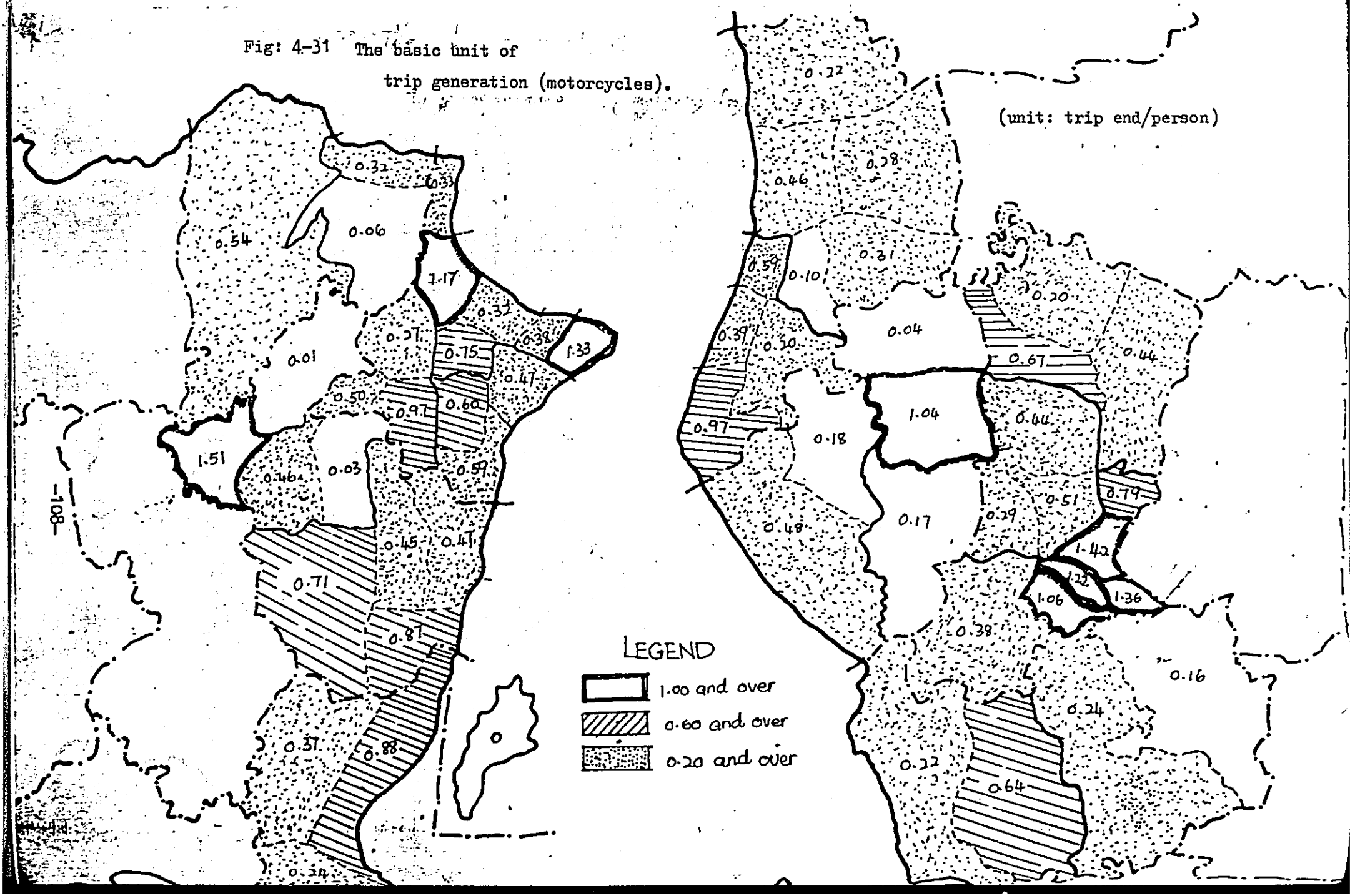


Table 4-21 **Trip generation of vehicles**

Zone code	Population (1979)	Cars	Cars / pop.	Vehicles	Veh / pop.	Motorcycles	M/c / pop.
11	55,450	47,704	0.86	55,999	1.01	74,143	1.33
121	27,980	9,516	0.34	10,458	0.37	10.529	0.38
122	17,060	9,074	0.53	9,416	0.55	5,467	0.32
123	13,080	9,970	0.76	11,797	0.90	9,840	0.75
124	13,350	16,814	1.26	18,531	1.39	15,600	1.17
125	13,630	4,346	0.32	4,908	0.36	4,452	0.33
12	85,100	49,720	0.58	55,110	0.65	45,888	0.54
131	75,080	16,574	0.22	21,459	0.29	35,455	0.47
132	32,300	12,974	0.40	17,152	0.53	19,329	0.60
133	32,630	7,282	0.22	10,354	0.32	19,138	0.59
13	139,980	36,830	0.26	48,966	0.35	73,922	0.53
141	11,550	3,629	0.31	4,158	0.36	3,098	0.27
142	13,820	10,582	0.77	12,719	0.92	13,341	0.97
143	35,290	9,160	0.26	10,275	0.29	17,547	0.50
14	60,660	23,371	0.39	27,152	0.45	33,986	0.56
1	341,190	157,625	0.46	187,226	0.55	227,939	0.67
211	14,890	4,503	0.30	6,123	0.41	4,804	0.32
212	8,380	888	0.11	928	0.11	513	0.06
21	23,270	5,391	0.23	7,051	0.30	5,317	0.23
22	3,710	1,318	0.36	1,686	0.45	2,004	0.54
2	26,980	6,709	0.25	8,737	0.32	7,321	0.27
31	1,620	48	0.02	92	0.06	18	0.01
321	33,050	699	0.02	950	0.03	1,002	0.03
322	1,150	271	0.24	363	0.32	524	0.46
323	320	339	1.06	373	1.17	484	1.51
32	34,520	1,309	0.04	1,686	0	2,010	0.06
331	22,950	10,601	0.46	12,386	0.54	10,701	0.47
332	2,460	759	0.31	977	0.40	1,098	0.45

Trip generation of vehicles

Zone code	Population (1979)	Cars	Cars / pop.	Vehicles	Veh / pop.	Motorcycles	M/c / pop.
333	8,300	1,636	0.20	2,731	0.33	7,244	0.87
334	2,360	637	0.27	888	0.38	1,678	0.71
335	1,420	8	0.01	8	0.01	0	0
33	37,490	13,679	0.36	17,019	0.45	20,721	0.55
3	73,630	15,036	0.20	18,797	0.25	22,749	0.31
411	8,050	3,374	0.42	5,223	0.65	7,115	0.88
412	13,760	1,486	0.11	2,528	0.18	5,068	0.37
413	6,060	1,535	0.25	2,137	0.35	1,448	0.24
4	27,870	6,395	0.23	9,888	0.35	13,671	0.49
sub-total	469,700	185,705	0.40	223,588	0.48	271,680	0.58
511	29,740	17,587	0.59	22,543	0.76	28,807	0.97
512	15,570	3,980	0.26	4,596	0.30	6,089	0.39
513	15,022	1,427	0.09	2,037	0.14	3,059	0.20
514	14,100	4,118	0.29	5,277	0.37	8,345	0.59
51	74,432	27,112	0.36	34,453	0.4	46,300	0.62
521	8,510	2,174	0.26	2,794	0.33	3,954	0.46
522	10,780	211	0.02	498	0.05	1,086	0.10
523	4,260	193	0.05	308	0.07	1,330	0.31
524	3,300	372	0.11	507	0.15	938	0.28
525	10,030	1,121	0.11	1,293	0.13	2,241	0.22
52	36,880	4,071	0.11	5,400	0.15	9,549	0.26
5	111,312	31,183	0.28	39,853	0.36	55,849	0.50
611	21,700	3,216	0.15	4,172	0.19	3,853	0.18
612	11,770	2,418	0.21	3,689	0.31	5,607	0.48
61	33,470	5,634	0.17	7,861	0.23	9,460	0.28
621	4,150	8	0	8	0	156	0.04
622	5,760	2,585	0.45	3,459	0.60	5,998	1.04
623	5,950	426	0.07	624	0.10	990	0.17

Trip generation of vehicles

Zone code	Population (1979)	Car	Car / pop.	Vehicles	Veh / pop.	Motorcycle	M/c / pop.
62	15,860	3,019	0.19	4,091	0.26	7,144	2.22
6	49,330	8,653	0.18	11,952	0.24	16,604	0.34
711	2,500	177	0.07	193	0.07	493	0.20
712	2,070	316	0.15	341	0.16	1,377	0.67
713	7,970	646	0.08	890	0.11	3,526	0.44
71	12,540	1,139	0.09	1,424	0.11	5,396	0.43
721	4,100	545	0.13	634	0.15	1,813	0.44
722	2,420	168	0.07	200	0.08	708	0.29
723	4,020	602	0.15	760	0.19	2,064	0.51
72	10,540	1,315	0.12	1,594	0.15	4,585	0.44
731	6,170	1,524	0.25	1,911	0.31	4,873	0.79
732	17,060	8,119	0.48	9,995	0.59	24,246	1.42
733	4,200	2,932	0.70	3,282	0.78	5,696	1.36
734	5,850	2,903	0.50	3,461	0.59	7,152	1.22
73	33,280	15,478	0.47	18,649	0.56	41,967	1.26
741	3,430	636	0.19	853	0.25	3,631	1.06
742	7,420	884	0.12	1,311	0.18	2,791	0.38
74	10,850	1,520	0.14	2,164	0.20	6.422	0.59
7	67,210	19,452	0.02	23,831	0.35	58,370	0.87
811	9,650	652	0.07	1,017	0.11	2,328	0.24
812	10,710	553	0.05	774	0.07	1,745	0.16
81	20,360	1,205	0.06	1,791	0.09	4,073	0.20
821	2,870	58	0.02	77	0.03	619	0.22
822	3,080	527	0.17	744	0.24	1,975	0.64
82	5,950	585	0.10	821	0.14	2,594	0.44
8	26,310	1,790	0.07	2,612	0.10	6,667	0.25
sub-total	254,162	61,078	0.24	78,248	0.31	137,490	0.54
Total	723,862	246,843	0.34	302,896	0.42	409,170	0.57

The basic unit of trip generation by zone is not constant, but it exhibits a certain trend, that is, the zones in the urban areas have a high basic unit while the zones in the rural areas have a low basic unit although there are some exceptions to this trend. These results show that the trip generation of a particular zone is dependent upon the character of that zone, and the character of that zone cannot be explained by only one factor. Therefore, it is advisable to use some explanatory factors in order to complete the traffic model for trip generation.

(2) The regression method

In the regression method, the least square method is used to obtain the regression equation. The regression equation consists of the explained variable and the explanatory variables. In this case, it is natural that the explained variable is the trip generation by zone while the explanatory variables make use of the following factor, i.e. the area by land-use, the floor size by purpose of buildings, the population and the employed population by industry etc.

For the purpose of drawing up the traffic model of trip generation, only some factors need be chosen. However, the following criteria must be observed:-

(1) The explanatory variables for the present and also for the estimated target year must be obtained.

(2) It has some causal relationship. The explanatory variables must not be chosen only from the degree of co-efficient of correlation.

Taking into consideration the above matter, some indices of population are choosen as the explanatory variables in this study as shown in the following table:-

Table 4-22 The explanatory variables

		Trip generation		Trip attraction	
		Resident population	Employees	Resident population	Employees
Car	Trip to work	0			0
	Business trip		0		0
	Private trip	0	0		0
	Trip home		0	0	
Lorry			0		0
Taxi		0	0	0	0
Bus		0	0	0	0
Motorcycle		0	0	0	0

The traffic model of trip generation and trip attraction which is drawn up by the least square method is as follows:-

Table 4-23 Trip model of trip generation and trip attraction

		Trip generation	Trip attraction
Car	Trip to work	$y = 0.0916\ xp + 0.844$ ($R = 0.774$)	$y = 0.405\ x_E - 404$ ($R = 0.884$)
	Business trip	$y = 0.172\ x_E - 80.7$ ($R = 0.894$)	$y = 0.172\ x_E - 80.7$ ($R = 0.894$)
	Private trip	$y = 0.0560\ xp + 0.0829\ x_E - 101$ ($R = 828$)	$y = 0.250\ x_E - 38.2$ ($R = 0.811$)
	Trip home	$y = 0.440\ x_E - 247$ ($R = 0.864$)	$y = 0.101\ xp + 177$ ($R = 0.711$)
Lorry		$y = 0.116\ x_E + 92.4$ ($R = 0.851$)	
Taxi		$y = 0.000941\ xp + 0.0186\ x_E - 12.2$ ($R = 0.770$)	
Bus		$y = 0.0242\ xp + 0.00728\ x_E - 44.5$ ($R = 0.736$)	
Motorcycle		$y = 0.340\ xp + 1.01\ x_E - 1514.5$ ($R = 0.945$)	

y = trip generation or trip attraction by zone

xp = population by zone

x_E = employed population by zone

R = co-efficient of correlation

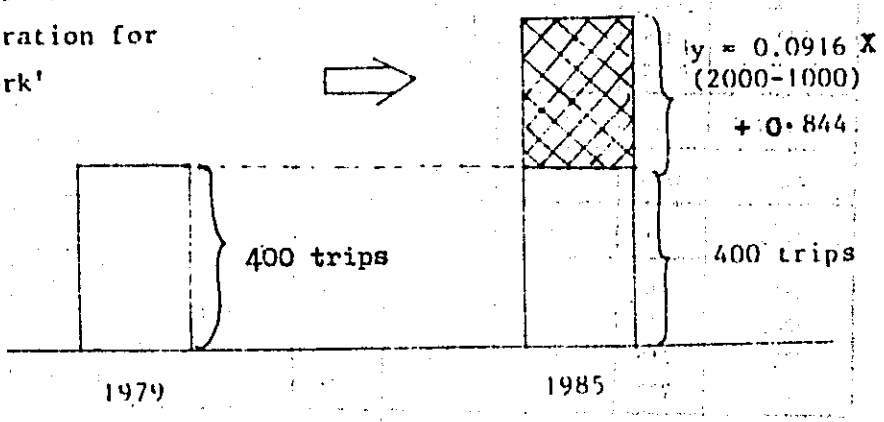
(3) Conclusion

For the model of trip generation and attraction, two methods were examined. The co-efficient of correlation of both methods show that the regression method is more suitable than the basic unit method for explaining the situation of trip generation and attraction. Therefore, the regression method was chosen for the generation/attraction model. However, the question is whether these models can explain the trip generation and attraction of each zone as each have their unique characteristics. Therefore, these model are to be used for the calculation of increasing trip generation/attraction from the year 1979 to 1985 or 2000. This is as follows :-

example :

Zone population 1000 persons ⇒ 2000 persons

The volume of trip generation for 'going work' ⇒



By using this method, present zonal characteristics will be considered.

Trip Generation (1979)

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
11(111)	7683	8660	8314	23047	47704	5233	1153	1909	55999	74143	130142
121	2363	1450	2346	3357	9516	613	28	301	10458	10529	20987
122	3016	493	2474	3091	9074	78	24	240	9416	5467	14883
123	2567	953	2209	4241	9970	611	62	1155	11797	9840	21637
124	4746	1755	3849	6464	16814	422	162	1129	18531	15600	34131
125	1698	380	1493	775	4346	81	80	401	4908	4452	9360
12	14390	5031	12371	17928	49720	1805	356	3226	55110	45888	100998
131	4465	3141	4091	4877	16574	3149	19	1717	21459	35455	56914
132	4549	1444	3186	3795	12974	1295	69	2811	17152	19329	36481
133	2716	1070	1565	1931	7282	1973	92	1007	10354	19138	29492
13	11730	5655	8842	10603	36830	6417	180	5535	48966	73922	122888
141	1596	301	1229	503	3629	113	30	386	4158	3098	7256
142	3897	861	2717	3107	10582	313	62	1762	12719	13341	26060
143	3982	785	2631	1762	9160	423	31	661	10275	17547	27822
14	9475	1947	6577	5372	23371	849	123	2809	27152	33986	61138
1	43278	21293	36104	56950	157625	14304	1812	13479	187226	227939	415615
211	1491	536	1151	1325	4503	1172	93	355	6123	4804	10927
212	119	75	224	470	888	2	8	30	928	513	1441
21	1610	611	1375	1795	5391	1174	101	385	7051	5317	12368
22(221)	278	191	280	569	1318	236	99	33	1686	2004	3690
2	1888	802	1655	2364	6709	1410	200	418	8737	7321	16058
31(311)	0	0	35	13	48	0	9	35	92	18	110
321	412	96	191	0	699	249	0	2	950	1002	1952
322	109	52	101	9	271	90	0	2	363	524	887
323	211	25	94	9	339	32	0	2	373	484	857
32	732	173	386	18	1309	371	0	6	1686	2010	3696
331	4341	840	2957	2463	10601	1098	33	653	12386	10701	23087
332	357	134	232	36	759	218	0	0	977	1098	2075
333	553	315	220	558	1646	813	11	262	2731	7244	9975
334	276	98	117	146	637	242	9	0	888	1678	2566
335	0	4	0	4	8	0	0	0	8	0	8
33	5555	1391	3526	3207	13679	2371	53	915	17019	20721	37740
3	6287	1564	3947	3238	15036	2742	62	956	18797	22749	41546

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
411	909	391	469	1605	3374	1001	10	838	5223	7115	12338
412	387	278	262	559	1486	856	53	133	2528	5068	7596
413	443	251	210	631	1535	127	362	113	2137	1448	3585
4	1739	920	941	2795	6395	1984	425	1084	9888	13671	23559
Sub-total	53192	24579	42647	65347	185705	20440	2499	15937	224588	271680	496268
511	3699	4010	2910	6968	17587	3440	670	847	22543	28807	51350
512	1047	944	1107	882	3980	378	60	178	4596	6089	10694
513	278	377	299	473	1427	491	26	93	2037	3059	5096
514	1576	560	902	1080	4118	860	112	187	5277	8345	13622
51	6600	5891	5218	9403	27112	5169	868	1305	34453	46300	80753
521	626	345	234	969	2174	528	16	76	2794	3954	6748
522	99	42	48	22	211	235	0	52	498	1086	1584
523	35	48	19	91	193	92	0	23	308	1330	1638
524	124	72	88	88	372	117	0	18	507	938	1445
525	407	96	355	263	1121	81	1	90	1293	2241	3534
52	1291	603	744	1433	4071	1053	17	259	5400	9549	14949
5	7891	6494	5962	10836	31183	6222	885	1564	39853	55849	95702
611	1170	577	729	740	3216	730	38	188	4172	3853	8025
612	478	443	554	943	2418	1218	9	45	3689	5607	9296
61	1648	1020	1283	1683	5634	1948	47	233	7861	9460	17321
621	0	0	8	0	8	0	0	0	8	156	164
622	701	709	619	556	2585	768	2	105	3459	5998	9457
623	78	19	97	232	426	99	17	83	624	990	1614
62	779	728	724	788	3019	867	19	188	4091	7144	11235
6	2427	1748	2007	2471	8653	2815	66	421	11952	16604	28556
711	103	8	33	33	177	16	0	0	193	493	686
712	128	18	126	44	316	19	0	6	341	1377	1718
713	153	21	220	252	646	206	18	20	890	3526	4416
71	384	47	379	329	1139	241	18	26	1424	5396	6820
721	136	93	231	85	545	86	2	1	634	1813	2447
722	55	46	61	6	168	23	9	0	200	708	908
723	169	79	185	169	602	119	11	28	760	2064	2824
72	360	218	477	260	1315	228	22	29	1594	4585	6179

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
731	252	276	485	511	1524	277	9	101	1911	4873	6784
732	1379	1116	1522	4102	8119	1374	150	353	9995	24246	34241
733	905	449	766	812	2932	290	11	49	3282	5696	8978
734	808	363	805	927	2903	361	16	181	3461	7152	10613
73	3344	2204	3578	6352	15478	2302	186	684	18649	41967	60616
741	152	86	191	207	636	54	11	152	853	3631	4484
742	308	94	223	259	884	257	5	165	1311	2791	4102
74	460	180	414	466	1520	311	16	317	2164	6422	8586
7	4548	2649	4848	7407	19452	3082	242	1056	23831	58370	82201
811	124	81	166	281	652	240	4	122	1017	2328	3345
812	122	58	159	214	553	138	0	83	774	1745	2519
81	246	139	325	495	1205	378	4	205	1791	4073	5864
821	14	5	9	30	58	8	0	11	77	619	696
822	172	139	112	104	527	196	3	18	744	1975	2719
82	186	144	121	134	585	204	3	29	821	2594	3415
8	432	283	446	629	1790	582	7	234	2612	6667	9279
Sub-Total	15298	11174	13263	21343	61078	12701	1200	1711	78248	137490	215738
Total	68490	35753	55910	86690	246843	33141	3699	19212	302896	409170	712066

The Percentage of Trip Generation (1979)

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
11(111)	5.9	6.65	6.39	17.71	36.66	4.02	0.89	1.47	43.03	56.97	100
121	11.26	6.91	11.18	16.0	45.34	2.9	0.13	1.43	49.83	50.17	100
122	20.26	3.31	16.62	20.77	60.97	0.52	0.16	1.61	63.27	36.73	100
123	11.86	4.40	10.21	19.60	46.08	2.82	0.29	5.34	54.52	45.48	100
124	13.91	5.14	11.28	18.94	49.26	1.24	0.47	3.30	54.29	45.71	100
125	18.14	4.06	15.95	8.28	46.43	0.86	0.85	4.28	52.44	47.56	100
12	14.25	4.96	12.25	17.75	49.23	1.79	0.35	3.19	54.57	45.43	100
131	7.85	5.52	7.19	8.57	29.12	5.53	0.03	3.02	37.70	62.30	100
132	12.47	3.96	8.73	10.40	35.56	3.55	0.19	7.71	47.02	52.98	100
133	9.21	3.63	5.31	6.55	24.69	6.69	0.31	3.41	35.11	68.89	100
13	9.55	4.60	7.20	8.63	29.97	5.22	0.15	4.50	39.85	60.15	100
141	22.0	4.15	16.94	6.93	50.0	1.56	0.41	5.32	57.30	42.70	100
142	14.95	3.30	10.43	11.92	40.61	1.20	0.24	6.76	48.81	51.19	100
143	14.31	2.82	9.46	6.33	32.92	1.52	0.11	2.38	36.93	63.07	100
14	15.50	3.18	10.76	8.71	38.23	1.39	0.20	4.60	44.41	55.59	100
1	10.41	5.12	8.69	13.70	37.93	3.44	0.44	3.24	45.05	54.84	100
211	13.65	4.91	10.53	12.13	41.21	10.73	0.85	3.25	56.04	43.96	100
212	8.26	5.20	15.54	32.62	61.62	0.14	0.56	2.08	64.40	35.60	100
21	13.02	4.94	11.12	14.41	43.59	9.49	0.82	3.11	57.01	42.99	100
22(221)	7.53	5.18	7.59	15.42	35.72	6.40	2.68	0.89	45.69	54.31	100
2	11.75	5.0	10.31	14.72	41.78	8.78	1.25	2.60	54.41	45.59	100
32(311)	0	0	31.82	11.82	43.64	0	8.18	0.32	83.64	16.36	100
321	21.11	4.92	9.78	0	35.81	12.76	0	0.10	48.67	51.33	100
322	12.29	5.86	11.39	1.02	30.55	10.15	0	0.23	40.92	59.08	100
323	24.62	2.92	10.97	1.05	39.56	3.73	0	2.33	43.52	56.48	100
32	19.81	4.68	10.44	0.49	35.42	10.04	0	1.62	45.62	54.38	100
331	18.80	3.64	12.81	10.67	45.91	4.76	0.14	2.83	53.65	46.35	100
332	17.20	6.46	11.18	1.73	36.58	10.51	0	0	47.08	52.92	100
333	5.54	3.16	2.21	5.59	16.50	8.15	0.11	2.63	27.38	72.62	100
334	10.76	3.82	4.56	5.69	24.82	9.43	0.35	0	34.61	65.39	100
335	0	50	0	50	100	0	0	0	100	0	100
33	14.72	3.69	9.34	8.50	36.25	6.28	0.14	2.42	45.10	54.90	100
3	15.13	3.76	9.50	7.79	36.19	6.60	0.15	2.30	45.24	54.67	100

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
411	7.37	3.17	3.80	13.0	27.35	8.11	0.08	6.79	42.33	57.67	100
412	5.09	3.66	3.45	7.36	19.56	11.27	0.70	1.75	33.28	66.72	100
413	12.36	7.00	5.86	17.60	42.82	3.54	10.10	3.15	59.61	40.39	100
4	7.38	3.91	3.99	11.86	27.14	8.42	1.80	4.60	41.97	58.03	100
Sub-total	10.72	4.95	8.59	13.17	37.42	4.12	0.50	3.21	45.26	54.74	100
511	7.20	7.81	5.67	13.57	34.25	6.70	1.30	1.65	43.90	56.10	100
512	9.79	8.83	10.35	8.25	37.22	3.53	0.56	1.66	42.98	56.94	100
513	5.46	7.40	5.87	9.28	28.00	9.64	0.51	1.82	39.97	60.03	100
514	11.57	4.11	6.62	7.93	30.23	6.31	0.82	1.37	38.74	61.26	100
51	8.17	7.30	6.46	11.64	33.57	6.40	1.07	1.62	42.66	57.34	100
521	9.28	5.11	3.47	14.36	32.22	7.82	0.24	1.13	41.40	58.60	100
522	6.25	2.65	3.03	1.39	13.32	14.83	0	3.28	31.44	68.56	100
523	2.14	2.93	1.16	5.56	11.78	5.62	0	1.40	18.80	81.20	100
524	8.58	4.98	6.09	6.09	25.74	8.10	0	1.25	35.09	64.91	100
525	11.52	2.72	10.05	7.44	31.72	2.29	0.03	2.55	36.59	63.41	100
52	8.64	4.03	4.98	9.59	27.23	7.04	0.11	1.73	36.12	63.88	100
5	8.25	6.79	6.23	11.32	32.58	6.50	0.92	1.63	41.64	58.36	100
611	14.58	7.19	9.08	9.22	40.07	9.10	0.47	2.34	51.99	48.01	100
612	5.14	4.77	5.96	10.14	26.01	13.10	0.10	0.48	39.68	60.32	100
61	9.51	5.89	7.40	9.72	32.53	11.25	0.27	1.35	45.38	54.62	100
621	0	0	4.88	0	4.88	0	0	0	4.88	95.12	100
622	7.41	7.50	6.55	5.88	27.33	8.12	0.02	1.11	36.58	63.42	100
623	4.83	1.18	6.01	14.37	26.39	6.13	1.05	5.14	38.66	61.34	100
62	6.93	6.48	6.44	7.01	26.87	7.72	0.17	1.67	36.41	63.59	100
6	8.50	6.12	7.03	8.65	30.30	9.86	0.23	1.47	41.85	58.15	100
711	15.01	1.17	4.81	4.81	25.80	2.33	0	0	28.13	71.87	100
712	7.45	1.05	7.33	2.56	18.39	1.11	0	0.35	19.85	80.15	100
713	3.46	0.48	4.98	5.71	14.63	4.66	0.41	0.45	20.15	79.85	100
71	5.63	0.69	5.56	4.82	16.70	3.53	0.26	0.38	20.88	79.12	100
721	5.56	3.80	9.44	3.47	22.27	3.51	0.08	0.04	25.91	74.09	100
722	6.06	5.07	6.71	0.66	18.50	2.53	0.99	0	22.03	77.97	100
723	5.98	2.80	6.55	5.98	21.32	4.21	0.39	0.10	26.91	73.09	100
72	5.83	3.53	7.72	7.21	21.28	3.69	0.36	0.47	25.80	74.20	100

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
731	3.71	4.07	7.15	7.53	22.50	4.08	0.13	1.49	28.20	71.80	100
732	4.03	3.26	4.44	1.98	23.71	4.01	0.44	1.03	29.19	70.81	100
733	10.08	5.00	8.53	9.04	32.66	3.23	0.12	0.55	36.56	63.44	100
734	7.61	3.42	7.59	8.73	27.39	3.40	0.15	1.71	32.61	67.39	100
73	5.52	3.64	5.90	10.48	25.53	3.80	0.31	1.13	30.77	69.23	100
741	3.39	1.92	4.26	4.62	14.18	1.20	0.25	3.39	19.02	80.98	100
742	7.51	2.29	5.44	6.31	21.55	6.27	0.12	4.02	31.96	68.04	100
74	5.36	2.10	4.82	5.43	17.70	3.62	0.19	3.70	25.20	74.80	100
7	5.53	3.22	5.90	9.01	23.66	3.75	0.29	1.28	28.99	71.01	100
811	3.71	2.42	4.96	8.40	19.49	7.17	0.12	3.65	30.40	69.60	100
812	4.84	2.30	6.31	8.50	21.95	5.48	0	3.30	30.73	69.27	100
81	4.20	2.37	5.54	8.44	20.55	6.45	0.07	3.50	30.54	69.46	100
821	2.01	0.72	1.29	4.31	8.33	1.15	0	1.59	11.06	88.94	100
822	6.33	5.11	4.12	3.82	19.38	7.21	0.11	0.66	27.36	72.64	100
82	5.45	4.22	3.54	3.92	17.13	5.97	0.09	0.85	24.04	75.96	100
8	4.66	3.05	4.81	6.78	19.29	6.27	0.08	2.52	28.15	71.85	100
Sub-total	7.09	5.18	6.15	4.89	28.31	5.89	0.56	7.93	36.27	63.73	100
Total	9.62	5.02	7.85	12.17	34.67	4.65	0.52	2.70	42.54	57.46	100

Trip Attraction (1979)

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
11(111)	21201	10136	13329	4237	48912	5330	1028	1855	57124	75240	132364
121	3523	1048	2098	2943	9619	661	36	302	10613	10661	21274
122	744	324	3468	4676	9220	86	22	211	9536	5415	14951
123	3384	805	3124	2686	10001	664	73	1182	1924	10236	12160
124	4705	1742	4981	5540	16971	476	155	1115	18715	16058	34773
125	236	355	793	2909	4297	82	111	415	4908	4462	9370
12	12592	4274	14464	18754	50108	1969	397	3225	5696	46832	102528
131	4903	2232	3074	6417	16630	3302	37	1724	21695	35547	57242
132	2759	1109	2476	6617	12967	1324	73	2664	17031	19747	36778
133	1331	912	1371	3928	7547	2000	101	1095	0742	19130	29872
13	8993	4253	6921	16962	37144	6626	211	5483	49468	74424	123892
141	233	276	495	2562	3571	102	31	416	4119	3181	7300
142	2229	821	2042	5524	10619	332	76	1731	12762	12933	25695
143	738	617	1728	6148	9227	378	32	633	10271	17344	27615
14	3200	1714	4264	14234	23417	812	139	2780	27152	33458	60610
1	45986	20377	38979	54187	159581	14737	1775	13343	89440	229954	419394
211	586	788	1033	2098	4511	1239	116	387	6256	4782	11038
212	18	69	690	75	853	39	8	30	931	542	1473
21	604	857	1723	2173	5364	1278	124	417	7187	5324	12511
22(221)	460	329	334	241	1366	233	9[illegible]	33	1722	2026	3748
2	1064	1186	2057	2414	6730	1511	22[illegible]	450	8919	7350	16269
31(311)	0	11	17	29	56	0	9	35	101	43	144
321	46	43	12	9	110	37	0	2	148	163	311
322	30	11	0	0	41	0	0	0	41	36	77
323	61	0	9	0	70	16	0	2	88	169	257
32	137	54	21	9	221	53	[illegible]	4	277	368	645
331	2249	673	1426	6237	10594	1100	43	683	12419	10790	23209
332	79	3	9	0	91	57	0	2	150	367	517
333	342	416	192	684	1636	779	24	263	2704	7205	9909
334	100	74	63	383	620	283	9	0	913	1680	2593
335	0	4	0	4	8	0	0	0	8	0	8
33	2770	1170	1690	7308	12949	2219	76	948	16194	20042	36236
3	2907	1235	1728	7346	13226	2272	85	987	16572	20453	37025

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
411	1645	739	187	849	3421	978	15	896	5308	7329	12637
412	473	368	259	470	1574	869	64	115	2624	5151	7775
413	443	560	384	221	1617	49	352	94	2111	1384	3495
4	2561	1667	830	1540	6612	1896	431	1105	10043	13864	23907
SUB-TOTAL	52518	24465	43594	65467	186149	20416	2513	15836	224974	271621	496595
511	5172	4494	4979	3215	17854	3431	671	855	22809	29567	52376
512	611	661	587	2189	4045	346	60	180	4630	6092	10722
513	619	503	212	171	1501	460	28	93	2085	3217	5302
514	785	522	652	1985	3937	874	109	183	5107	8447	13554
51	7187	6180	6430	7560	27337	5111	868	1311	34631	47323	81954
521	1006	335	132	859	2326	541	16	87	2972	3941	6913
522	18	12	0	162	192	187	0	50	430	1115	1545
523	44	33	31	83	189	60	0	21	270	1359	1629
524	29	14	25	65	132	24	0	14	170	393	563
525	73	74	134	841	1120	81	3	90	1294	2057	3351
52	1170	468	322	2010	3959	893	19	262	5136	8865	14001
5	8357	6648	6752	9570	31296	6004	887	1573	39767	56188	95955
611	729	553	410	1579	3267	679	56	192	4193	4401	8594
612	1440	543	171	307	2459	1273	9	48	3787	5766	9553
61	2169	1096	581	1886	5726	1952	65	240	980	10167	18147
621	0	0	0	8	8	0	0	0	8	140	148
622	686	503	289	1173	2651	756	2	103	3507	5727	9234
623	167	67	64	132	425	58	9	85	576	1094	1670
62	853	570	353	1313	3084	814	11	188	4091	6961	11052
6	3022	1666	934	3199	8810	2766	76	428	2071	17128	29199
711	102	2	12	0	116	16	0	0	132	585	717
712	88	0	16	204	307	19	0	6	332	1348	1680
713	180	70	185	231	668	212	18	20	915	3522	4437
71	370	72	213	435	1091	247	18	26	1379	5455	6834
721	60	68	18	396	542	110	2	1	654	1811	2465
722	3	2	9	154	168	39	9	0	215	677	892
723	89	43	73	403	610	103	10	28	752	1993	2745
72	152	113	100	953	1320	252	21	29	1621	4481	6102

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
731	249	202	350	652	1448	320	2	111	1878	4795	6673
732	1802	1423	3030	1783	8036	1283	167	340	9827	24356	34183
733	469	356	462	1601	2888	330	13	43	3275	5661	8936
734	675	391	576	1303	2879	405	16	186	3486	7222	10708
73	3195	2372	4358	5339	15251	2338	198	680	18466	42034	60500
741	123	78	130	308	640	54	11	154	857	3471	4328
742	250	108	137	387	880	262	5	162	1309	2690	3999
74	373	186	267	695	1520	316	16	316	2166	6161	8327
7	4090	2743	4938	7422	19182	3153	253	1051	23632	58131	81763
811	194	79	101	266	637	247	4	127	1015	2328	3343
812	139	22	74	295	531	174	2	81	789	1715	2504
81	333	101	175	561	1168	421	6	208	1804	4043	5847
821	20	10	0	37	66	8	0	11	85	617	702
822	53	66	37	382	536	192	3	17	748	1991	2739
82	73	76	37	419	602	200	3	28	833	2608	3441
8	406	177	212	980	1770	621	9	236	2637	6651	9288
SUB-TOTAL	15875	11234	12836	21171	61078	12544	1225	3151	78107	138098	216205
TOTAL	68393	35699	56430	86658	247227	20416	3738	18987	303054	409719	712773

The Percentage of Trip Attraction (1979)

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
11(111)	16.01	7.66	10.07	3.20	36.95	4.03	0.78	1.40	43.16	56.84	100
121	16.56	4.93	9.86	13.83	45.27	3.11	0.17	1.42	49.89	50.11	100
122	4.98	2.17	23.20	31.28	61.67	0.58	0.15	1.41	63.78	36.22	100
123	27.83	6.62	25.69	22.09	82.25	5.46	0.60	9.72	15.82	84.18	100
124	13.53	5.00	14.32	15.93	48.81	1.37	0.45	3.21	53.82	46.18	100
125	2.52	3.79	8.46	31.05	45.86	0.88	1.18	4.43	52.38	47.62	100
12	12.28	4.17	14.11	18.29	48.87	1.92	0.39	3.13	54.32	45.68	100
131	8.57	3.90	5.37	11.21	29.05	5.77	0.06	3.01	37.90	62.10	100
132	7.50	3.02	6.73	17.99	35.26	3.60	0.20	7.24	46.31	53.69	100
133	4.46	3.05	4.59	13.15	25.26	0.67	0.34	3.67	35.96	64.04	100
13	7.26	3.43	5.59	13.69	29.98	5.35	0.17	4.42	39.93	60.07	100
141	3.19	3.78	6.78	35.10	48.92	1.40	0.42	5.70	56.42	43.58	100
142	8.67	3.20	7.95	21.50	41.33	1.30	0.30	6.74	49.67	50.33	100
143	2.67	2,23	6.26	22.26	33.41	1.37	0.12	2.30	37.19	62.81	100
14	5.28	2.83	7.04	23.48	38.64	1.34	0.23	4.58	44.80	55.20	100
1	10.96	4.86	9.29	12.92	38.05	3.51	0.42	3.17	45.17	54.83	100
211	5.31	7.14	9.36	19.01	40.87	11.22	1.05	3.51	56.68	43.32	100
212	1.22	4.68	46.84	5.09	57.91	2.65	0.54	2.04	63.20	36.80	100
21	4.83	6.85	13.77	17.37	42.87	10.22	0.99	3.33	57.45	42.55	100
22(221)	12.27	8.78	8.91	6.43	36.45	6.22	1.61	0.88	45.94	54.06	100
2	6.54	7.29	12.64	14.84	41.37	9.29	1.36	2.70	54.82	45.18	100
31(311)	0	7.64	11.81	20.14	38.89	0	6.25	24.31	70.14	29.86	100
321	14.79	13.83	3.86	2.89	35.37	11.90	0	0.64	47.59	52.41	100
322	38.96	14.29	0	0	53.25	0	0	0	53.25	46.75	100
323	23.74	0	3.50	0	27.24	6.23	0	0.78	34.24	65.76	100
32	21.24	8.37	3.26	1.40	34.26	8.22	0	0.620	42.95	57.05	100
331	9.69	2.90	6.14	26.87	45.65	4.74	0.19	2.94	53.51	46.49	100
332	15.28	0.58	1.74	0	17.60	11.03	0	0.39	29.01	70.99	100
333	3.45	4.2	1.94	6.9	16.5	7.86	0.24	2.65	27.29	72.71	100
334	3.86	2.85	2.43	14.77	23.91	10.91	0.35	0	35.21	64.79	100
335	0	50	0	50	100	0	0	0	100	0	100
33	7.64	3.23	4.67	0.17	5.74	6.12	0.21	2.62	44.7	55.3	100
3	7.85	3.36	4.67	19.84	35.72	6.14	0.23	2.67	44.76	55.24	100

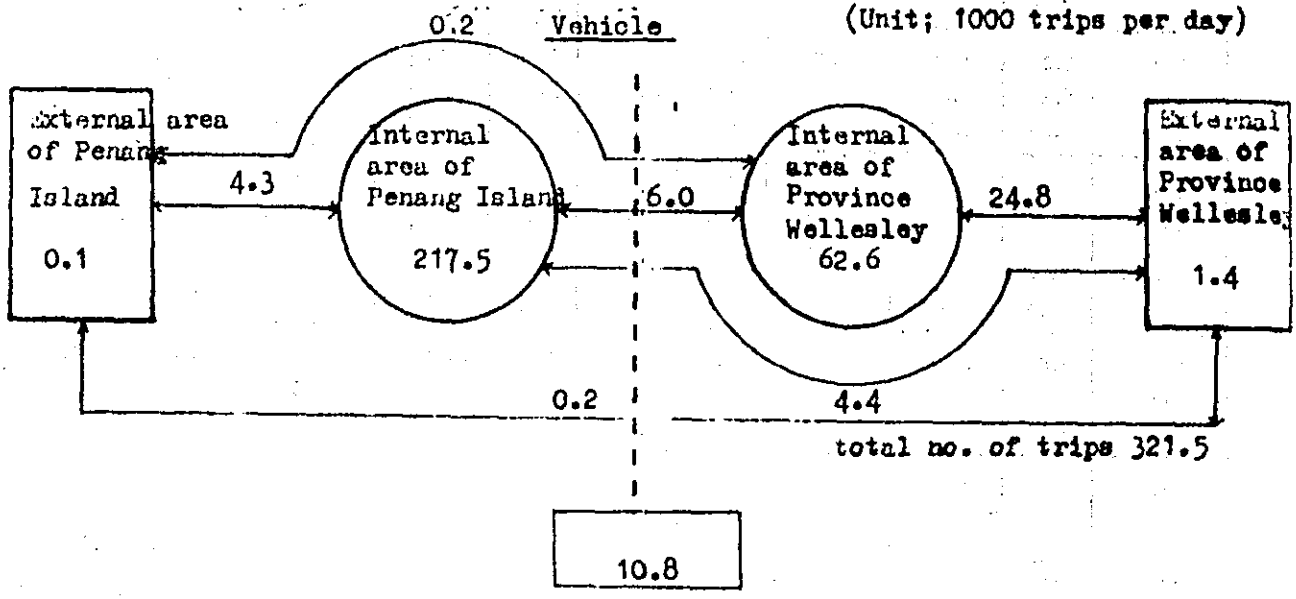
ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
411	13.02	5.85	1.48	6.72	27.07	7.74	0.12	7.09	42	57.99	99.99
412	6.08	4.73	3.33	6.05	20.24	11.18	0.82	1.48	33.75	66.25	100
413	12.68	16.02	10.00	6.32	46.27	1.40	10.07	2.69	60.4	39.6	100
4	10.71	6.97	3.47	6.44	27.66	7.93	1.8	4.60	42	57.99	99.99
SUB-TOTAL	10.58	4.93	8.78	13.19	37.49	4.11	0.51	3.19	45.3	54.7	100
511	9.87	8.58	9.51	6.14	34.09	6.55	1.28	1.63	43.55	56.45	100
512	5.7	6.16	5.47	20.42	37.73	3.23	0.56	1.68	43.18	56.82	100
513	11.67	9.49	4	3.26	28.31	8.68	0.53	1.75	39.32	60.68	100
514	5.79	3.85	4.81	14.65	29.05	6.45	0.8	1.35	37.68	62.32	100
51	8.77	7.54	7.85	9.22	33.36	6.24	1.06	1.60	42.26	57.74	100
521	14.55	4.85	1.91	12.43	33.65	7.83	0.23	1.26	42.99	57.01	100
522	1.17	0.77	0	10.49	12.43	12.10	0	3.24	27.83	72.17	100
523	2.7	2.03	1.9	5.1	11.6	3.68	0	1.29	16.57	83.43	100
524	5.15	2.49	4.44	11.55	23.45	4.26	0	2.49	30.2	69.8	100
525	2.18	2.21	4	25.1	33.42	2.42	0.1	2.69	38.62	61.38	100
52	8.36	3.34	2.3	14.36	28.28	6.38	0.14	1.87	36.68	63.32	100
5	8.71	6.93	7.04	9.97	32.62	6.25	0.92	1.57	41.44	58.56	100
611	8.48	6.43	4.77	18.37	38.01	7.90	0.65	2.23	48.79	51.21	100
612	15.07	5.68	1.79	3.21	25.74	13.33	0.09	0.50	39.64	60.36	100
61	11.95	6.04	3.2	10.39	31.55	10.76	0.36	1.32	43.97	56.03	100
621	0	0	0	5.41	5.41	0	0	0	5.41	94.59	100
622	7.43	5.45	3.13	12.7	28.71	8.19	0.02	1.12	37.98	62.02	100
623	10	4.01	3.83	7.9	25.45	3.47	0.54	5.09	34.49	65.51	100
62	7.72	5.16	3.19	11.88	27.9	7.37	0.1	1.70	37.02	62.98	100
6	10.35	5.71	3.2	10.96	30.17	9.47	0.26	1.33	41.34	58.66	100
711	14.23	0.28	1.67	0	16.18	2.23	0	0	18.41	81.59	100
712	5.24	0	0.95	12.14	18.27	1.13	0	0.36	19.76	80.24	100
713	4.06	1.58	4.17	5.21	15.06	4.78	0.41	0.45	20.62	79.38	100
71	5.41	1.05	3.12	6.37	15.96	3.61	0.26	0.38	20.18	79.82	100
721	2.43	2.76	0.73	16.06	21.99	4.46	0.08	0.04	26.53	73.47	100
722	0.34	0.22	1.01	17.26	18.83	4.37	1.01	0	24.1	75.9	100
723	3.24	1.57	2.66	14.68	22.22	3.75	0.36	1.02	27.4	72.6	100
72	2.49	1.85	1.64	15.6	21.63	4.13	0.34	0.48	26.57	73.43	100
731	3.73	3.03	5.25	9.77	21.7	4.80	0.03	1.66	28.14	71.86	100
732	5.27	4.16	8.86	5.2	23.51	3.75	0.49	0.99	28.75	71.25	100

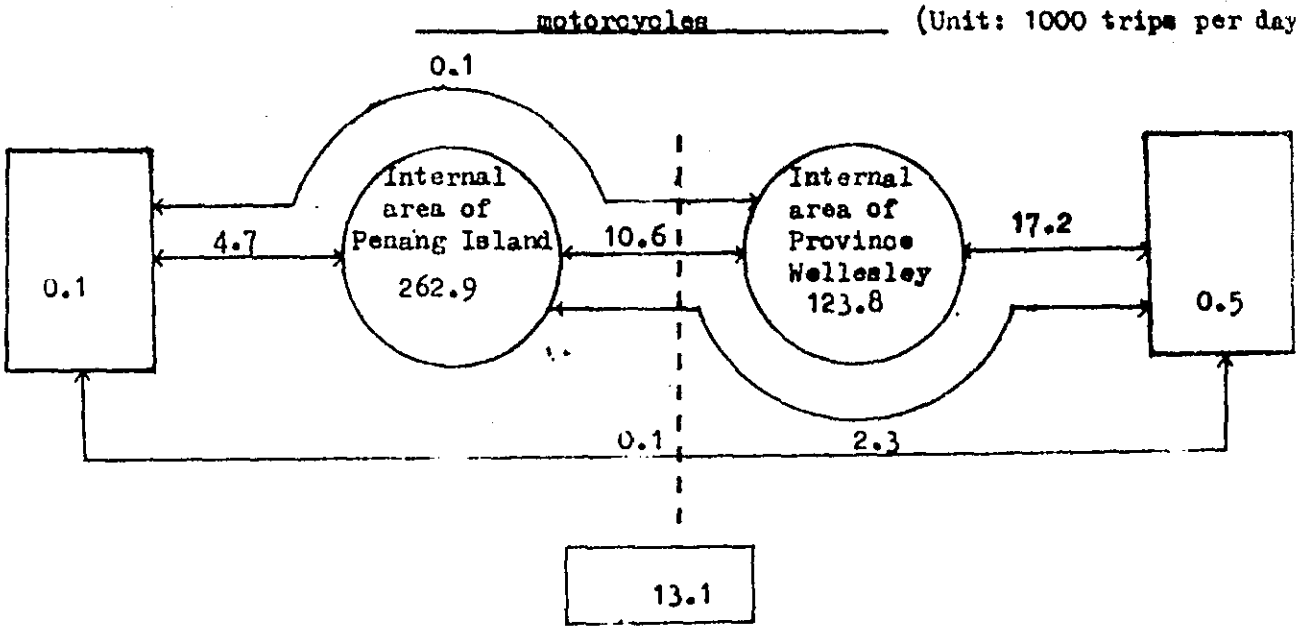
ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
733	5.25	3.98	5.17	17.92	32.32	3.69	0.15	0.48	36.65	63.35	100
734	6.3	3.65	5.38	12.17	26.89	3.78	0.15	1.74	32.56	67.44	100
73	5.28	3.92	7.20	8.82	25.21	3.86	0.33	1.12	30.52	69.48	100
741	2.84	1.80	3.00	7.12	14.79	1.25	0.25	3.56	19.80	80.20	100
742	6.25	2.70	3.43	9.68	22.01	6.55	0.13	4.05	32.73	67.27	100
74	4.48	2.23	3.21	8.35	18.25	3.79	0.19	3.79	26.01	73.99	100
7	5.00	3.35	6.04	9.08	23.46	3.86	0.31	1.25	28.90	71.10	100
811	5.80	2.36	3.02	7.96	19.05	7.39	0.12	3.80	30.36	69.64	100
812	5.55	0.88	2.96	11.78	21.21	6.95	0.08	3.23	31.51	68.49	100
81	5.70	1.73	2.99	9.59	19.98	7.20	0.10	3.56	30.85	69.15	100
821	2.85	1.42	0	5.27	9.40	1.14	0	1.57	12.11	89.89	100
822	1.94	2.41	1.35	13.95	19.57	7.01	0.11	0.62	27.31	72.69	100
82	2.12	2.21	1.08	12.18	17.49	5.81	0.09	0.81	24.21	75.79	100
8	4.37	1.91	2.28	10.55	19.06	6.69	0.10	2.54	28.39	71.61	100
SUB-TOTAL	7.34	5.20	5.94	9.79	28.25	5.80	0.57	1.46	36.13	63.87	100
TOTAL	9.60	5.01	7.92	12.16	34.69	2.86	0.52	2.66	42.52	57.48	100

4-4 Analysis of Trip Distribution.

The trip distribution in this study area is as follows :-

Figure 4-32 Trip distribution.

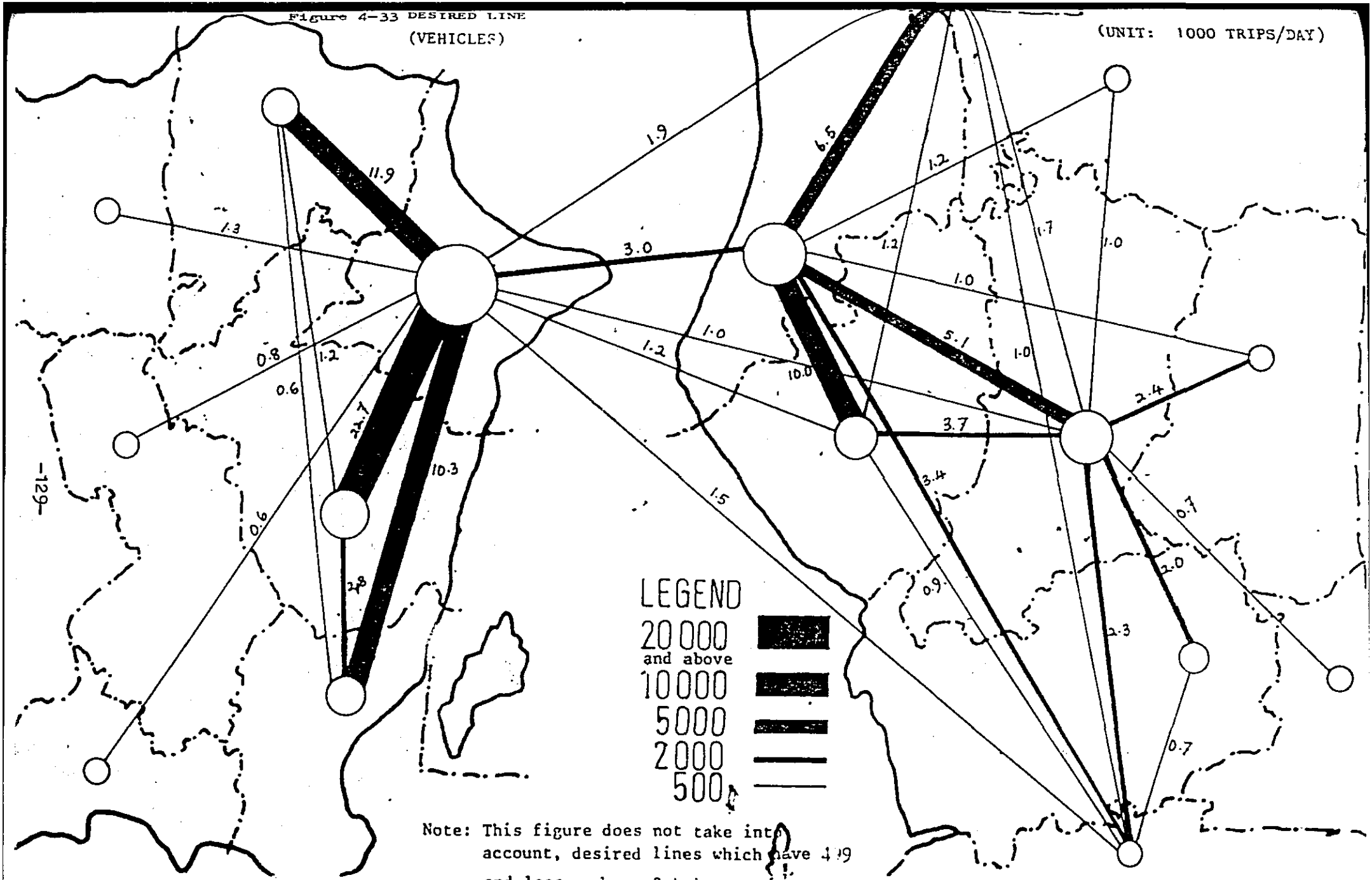




The desired line can be seen in the following fig. It shows that in Penang Island, radial traffic which concentrates into large zone 1 (George Town City) is conspicuous and contribute to a large part of the traffic in Penang Islan, while in Province Wellesley, traffic which go to and return from zone 5 (Butterworth), zone 6 (Prai area) and zone 7 (Bukit Mertajam) form a triangular traffic flow.

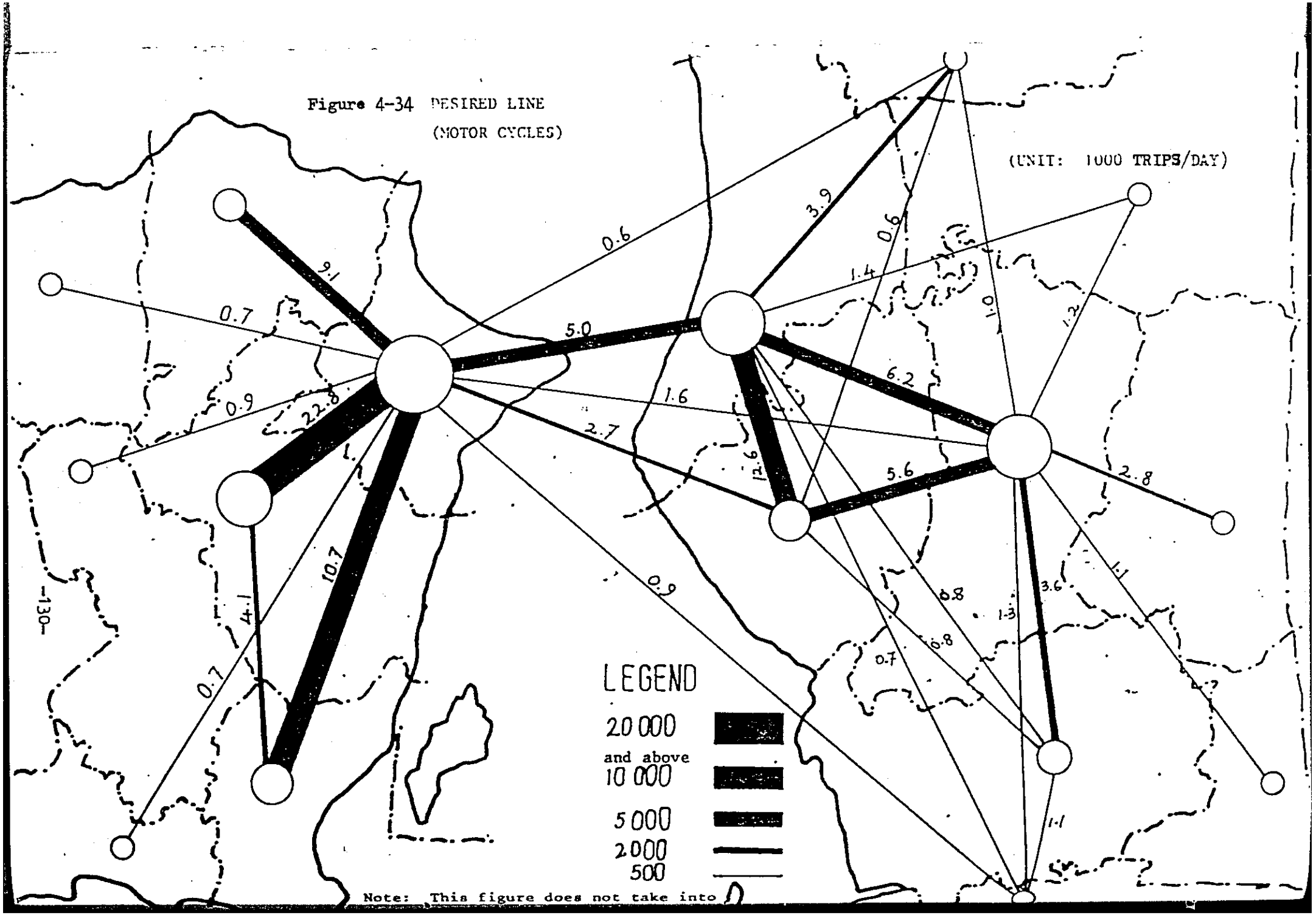
Figure 4-33 DESIRED LINE
(VEHICLES)

(UNIT: 1000 TRIPS/DAY)



Note: This figure does not take into account, desired lines which have 499 and less number of trips.

Figure 4-34 DESIRED LINE
(MOTOR CYCLES)



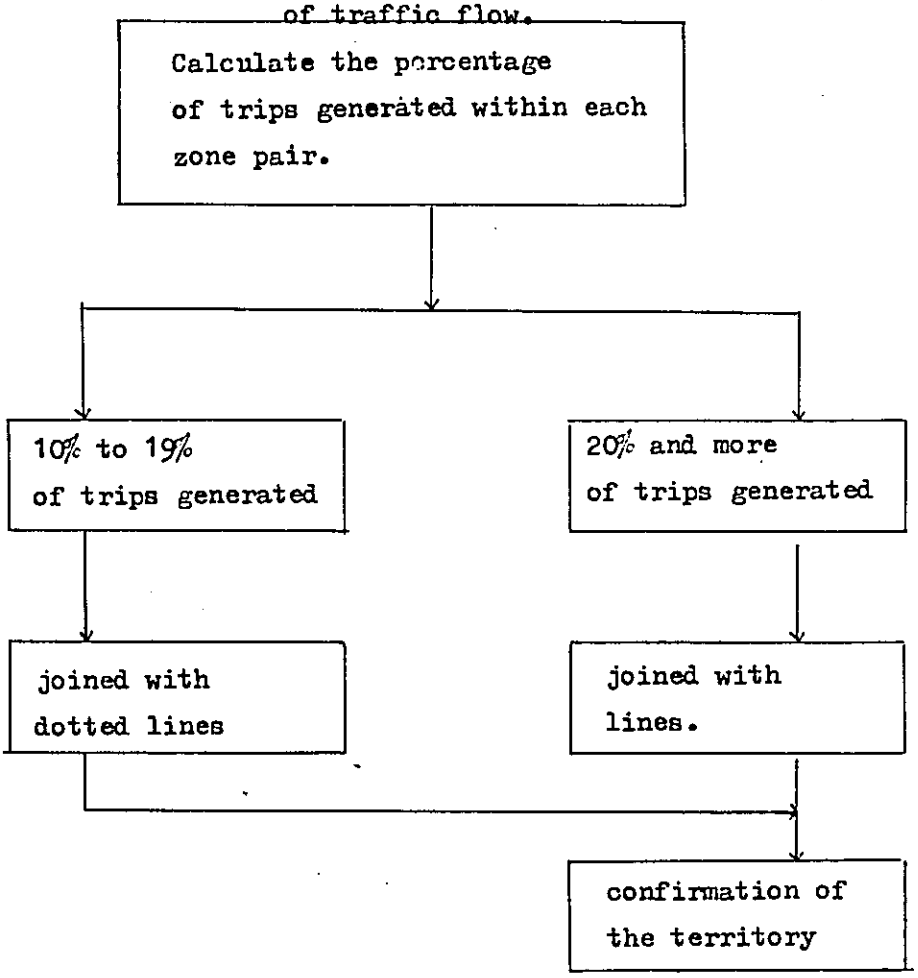
Note: This figure does not take into

4-4-1 The territory of traffic flow

From the O - D table by trip purpose, it is possible to know the territory of traffic flow formed.

The figures no. 4-34 to show this are drawn by the following method.

Figure 4-35 Method for classification of the territory of traffic flow.



The following figures number 4-35, 4-36, 4-37, 4-38, 4-39 and 4-40 are drawn by using the following O-D table.

O-D table

Car	Trip to work
	Business trip
	Private trip
Motor-cycle	Trip to work
	Business trip
	Private trip

Looking at figure 4-35 . . . we find that there are three territories in this study area and the territory with zone 111 as its centre the widest area with zone 511 and then zone 732 coming second and third respectively.

In the territory map of business trips of cars, the territories of zone 511 and 732 are joined.

This suggests that there is a possibility the future traffic situation will be like this.

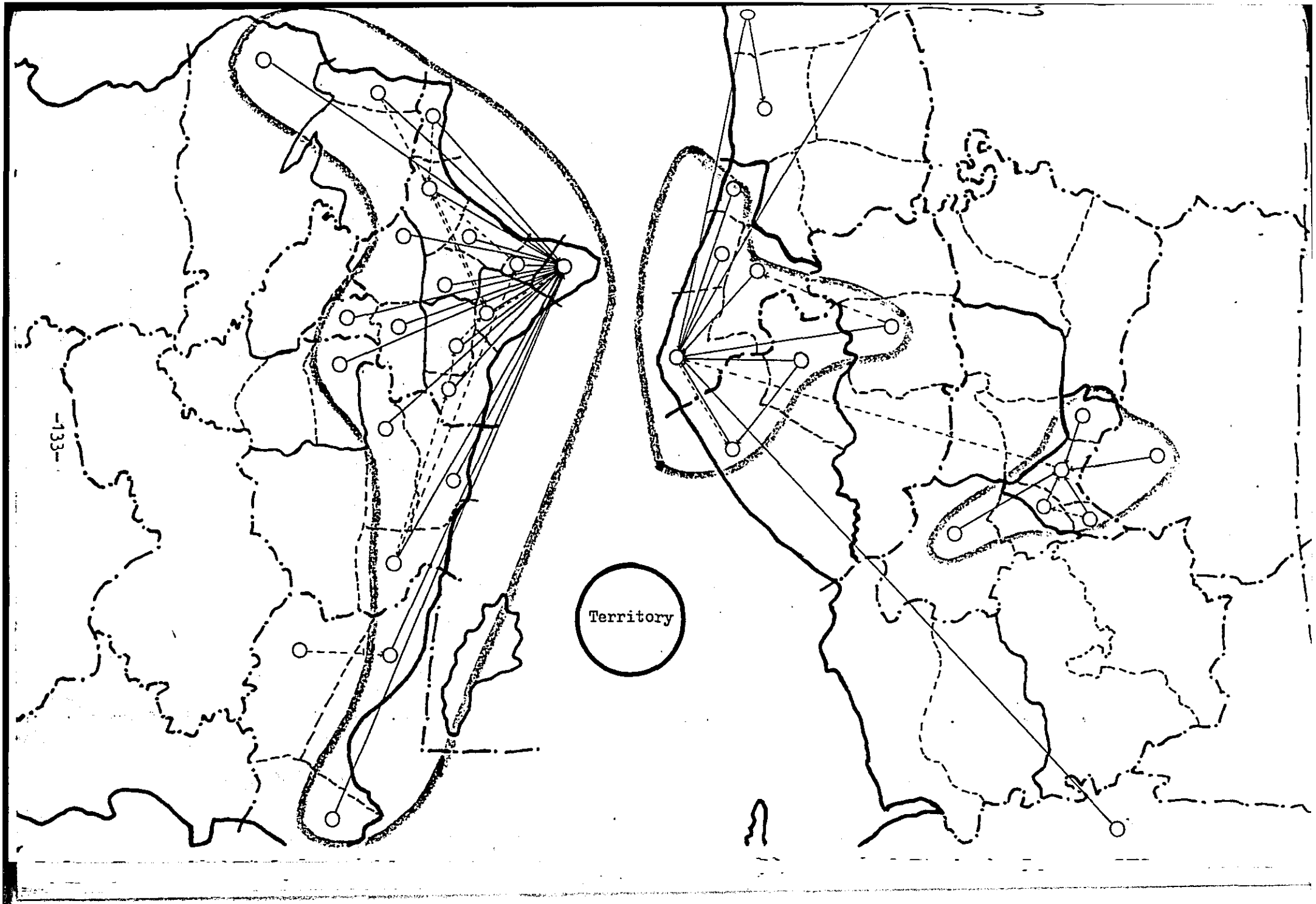
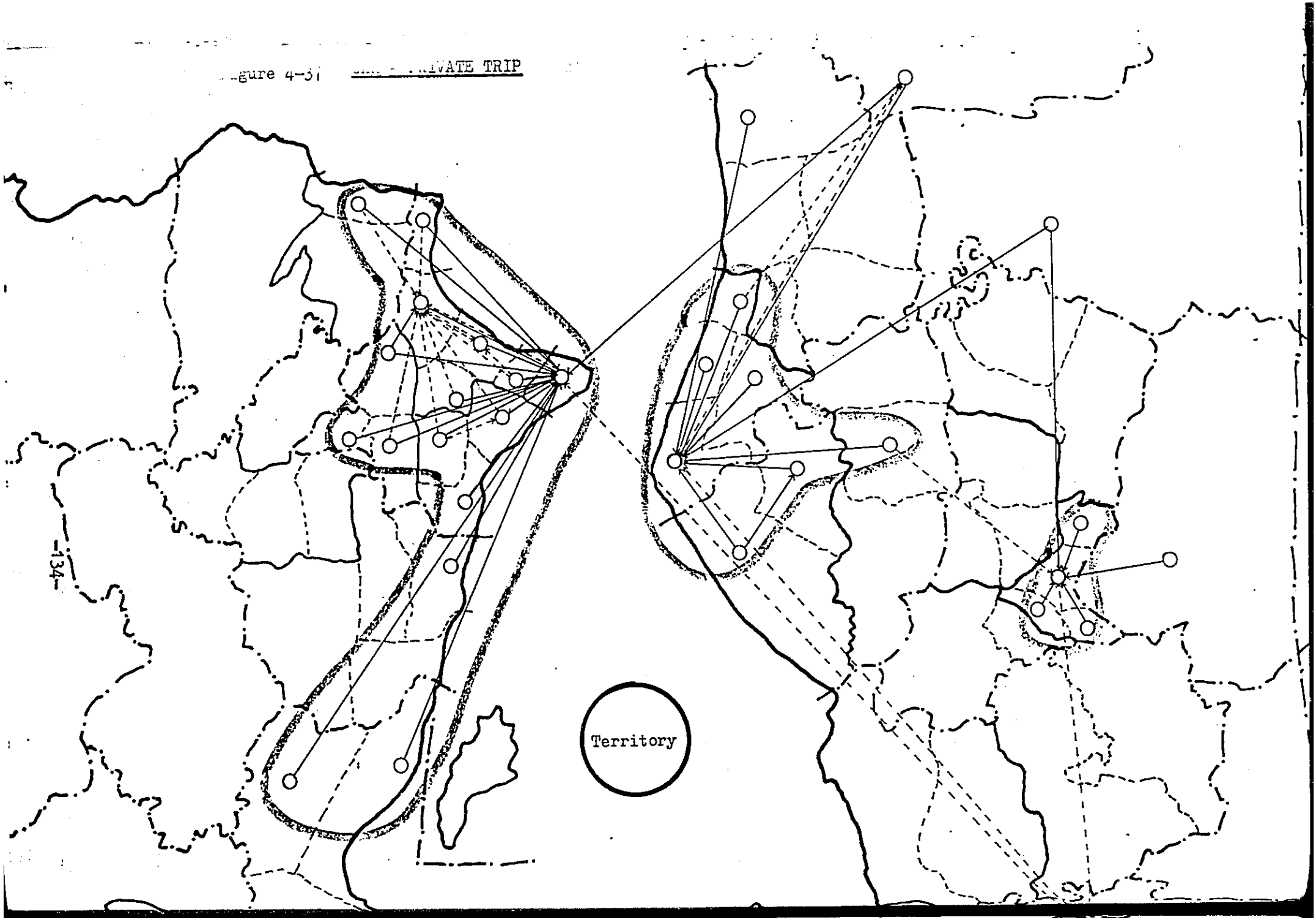
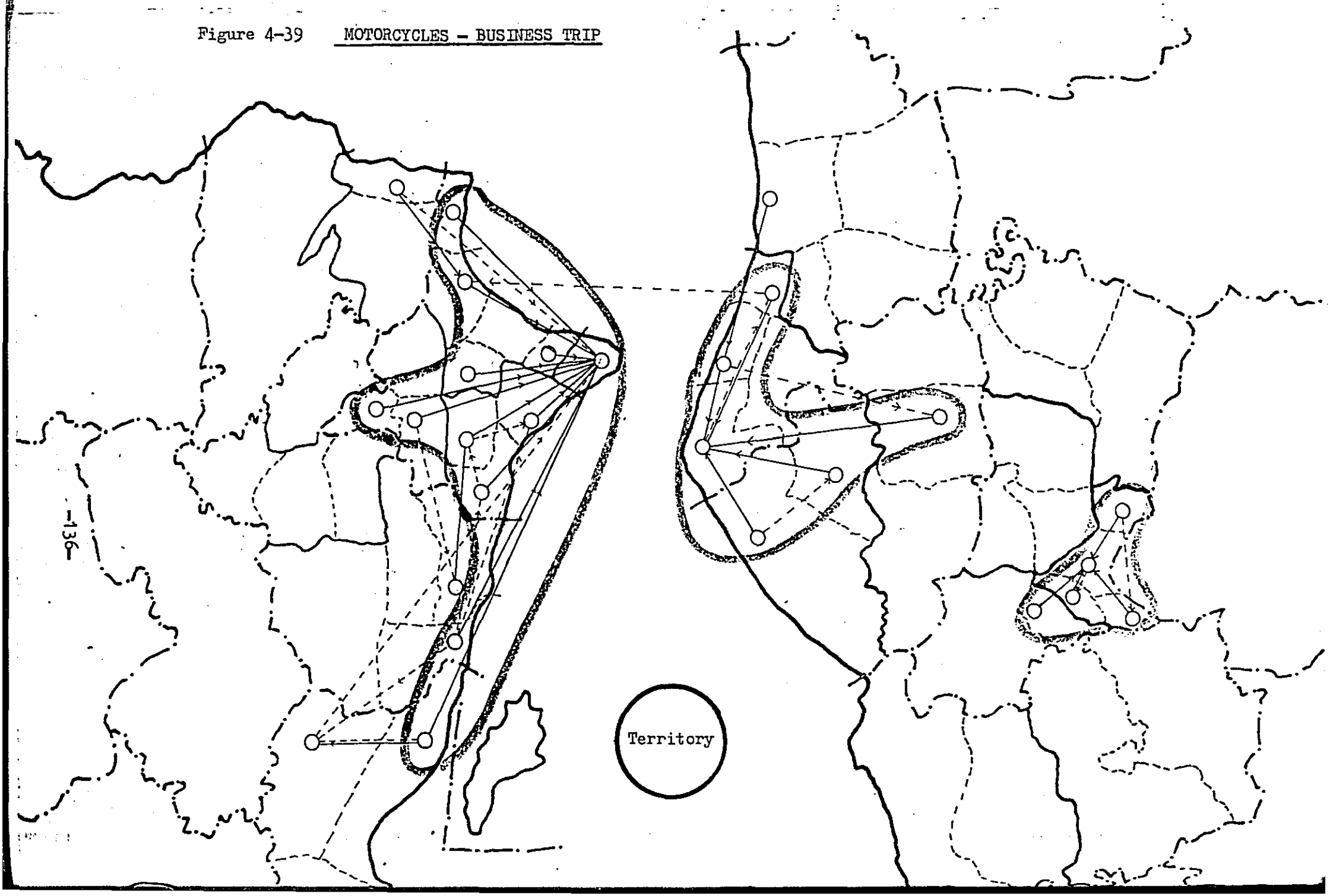

Territory

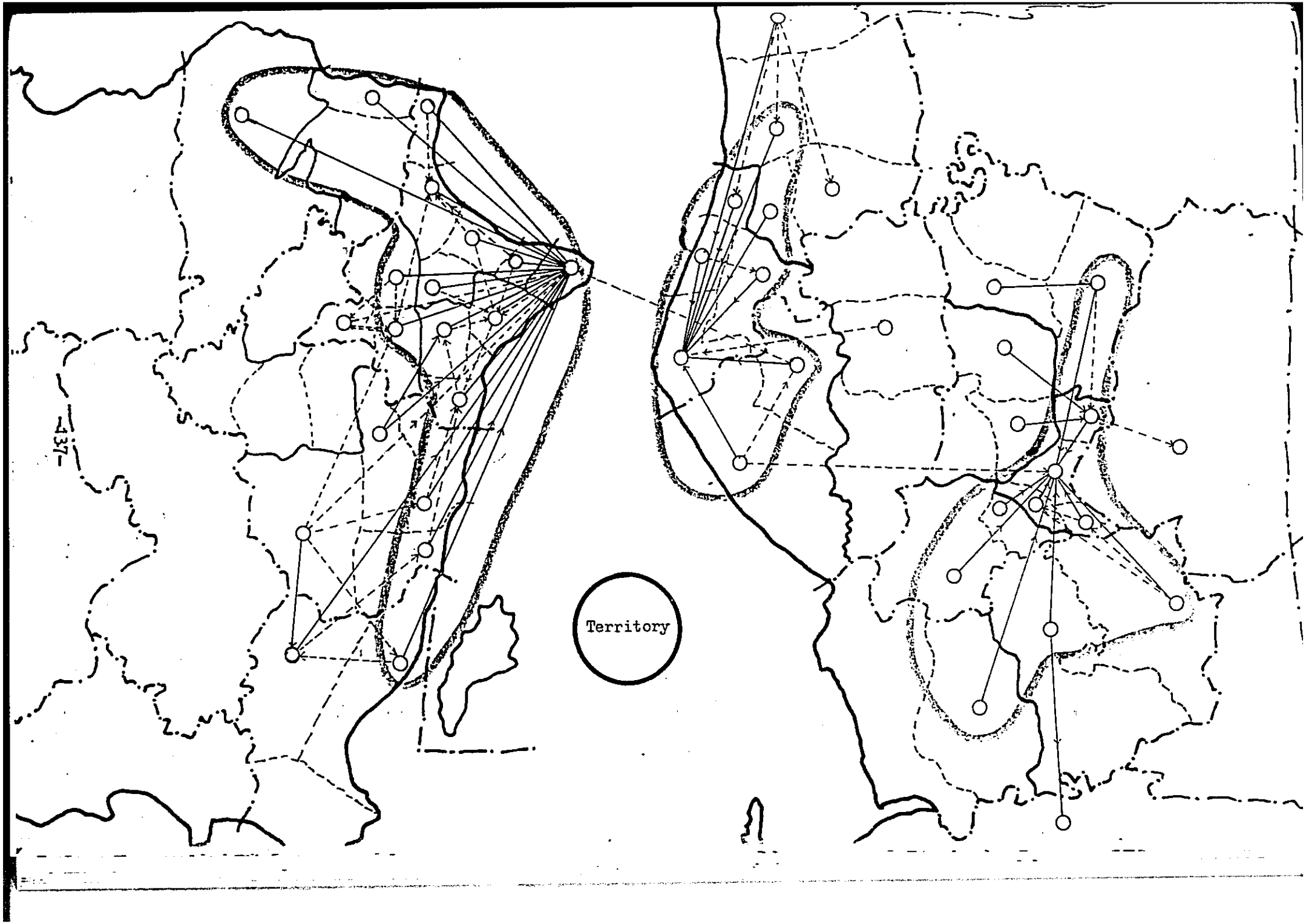
Figure 4-31 [illegible] PRIVATE TRIP



Territory

Figure 4-39 MOTORCYCLES - BUSINESS TRIP




Territory

4-4-2 The time distance

Trip distribution is a result of trip generation and the time distance between the origin and the destination.

The time distance can be obtained from the car-owner Interview survey by substracting the arrival time from the departure time and also from the road net work model.

In this study, a comparizon between both these values is done, after which the model method is made use of for the evaluation of the time distances between each zone pairs.

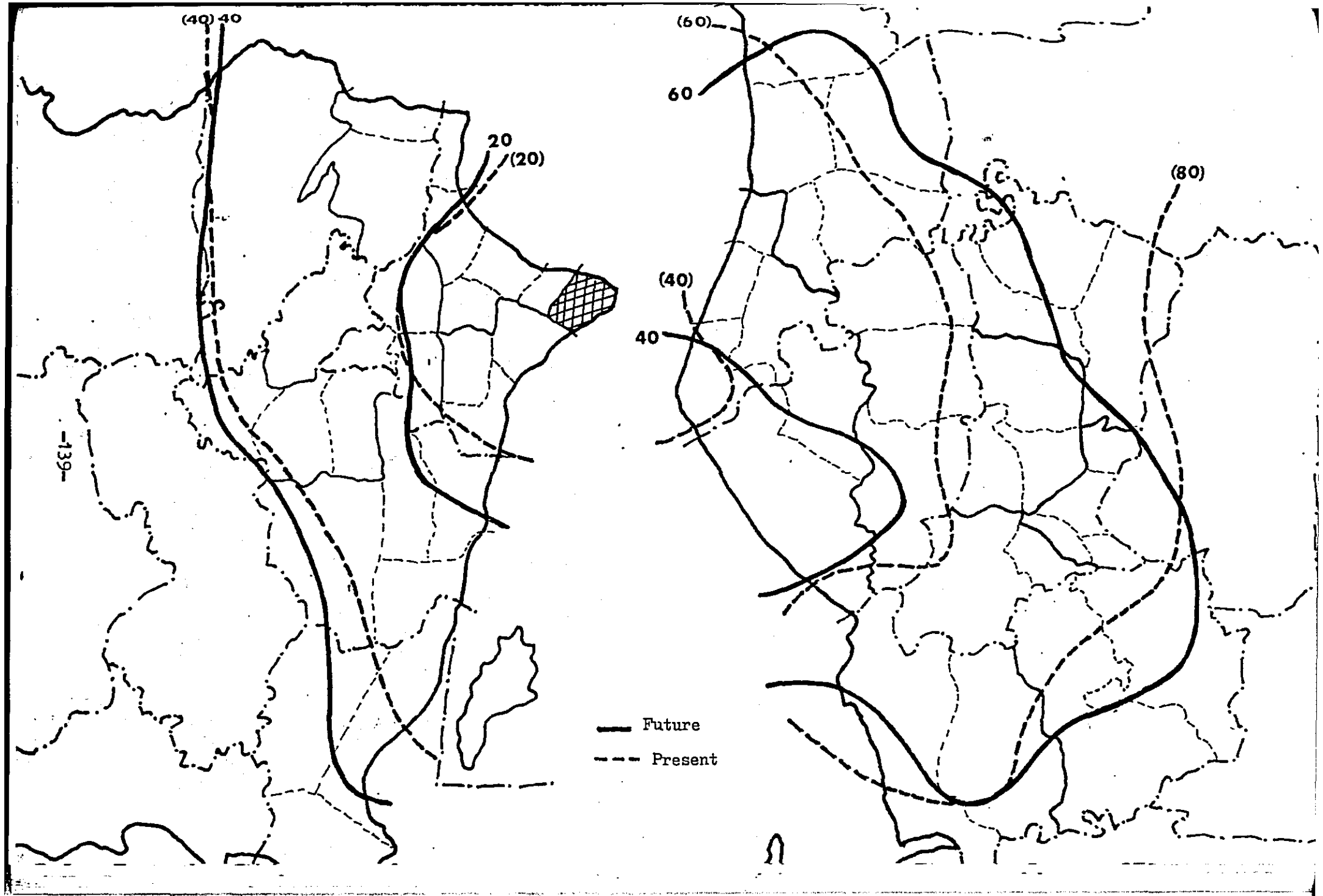
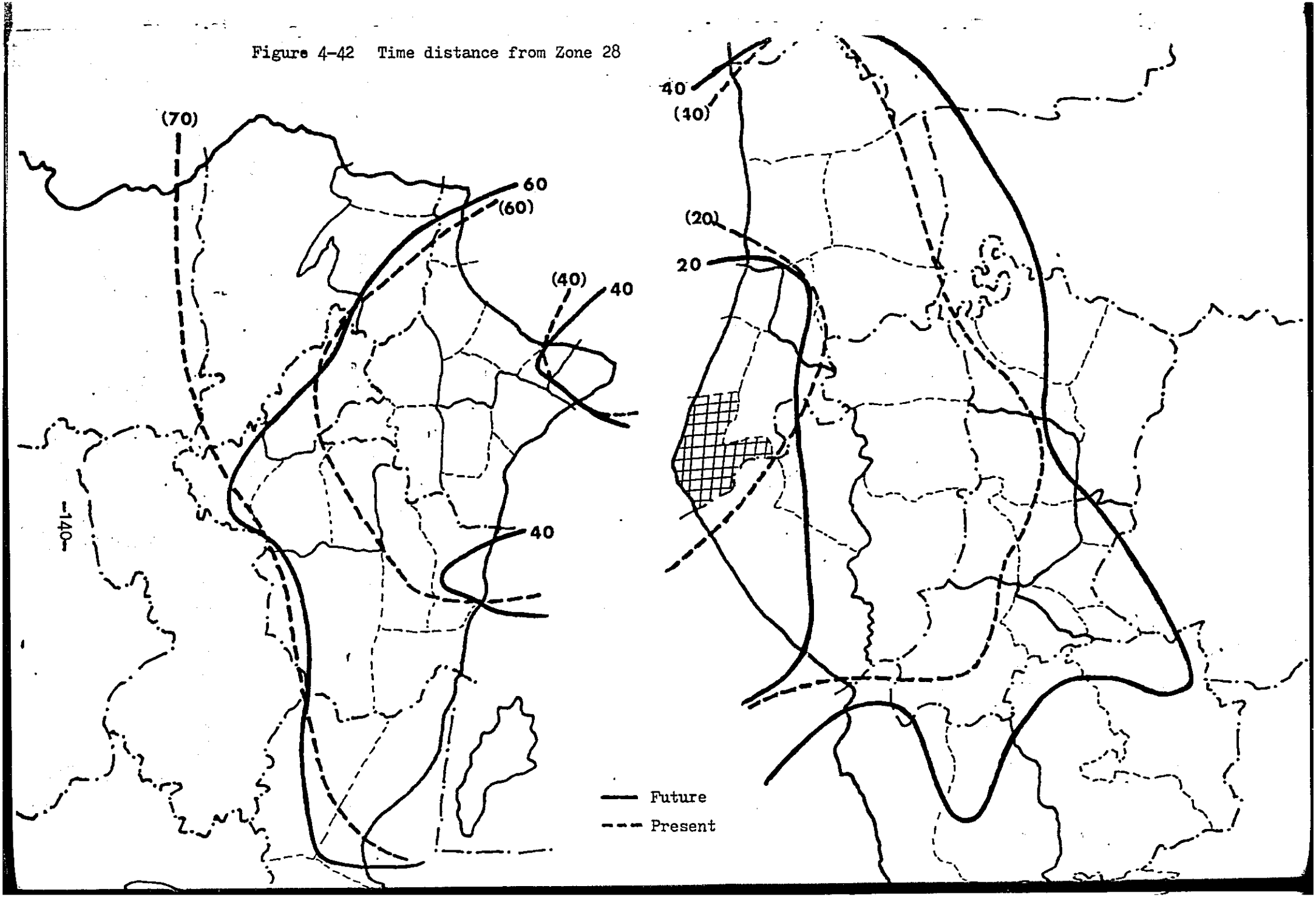
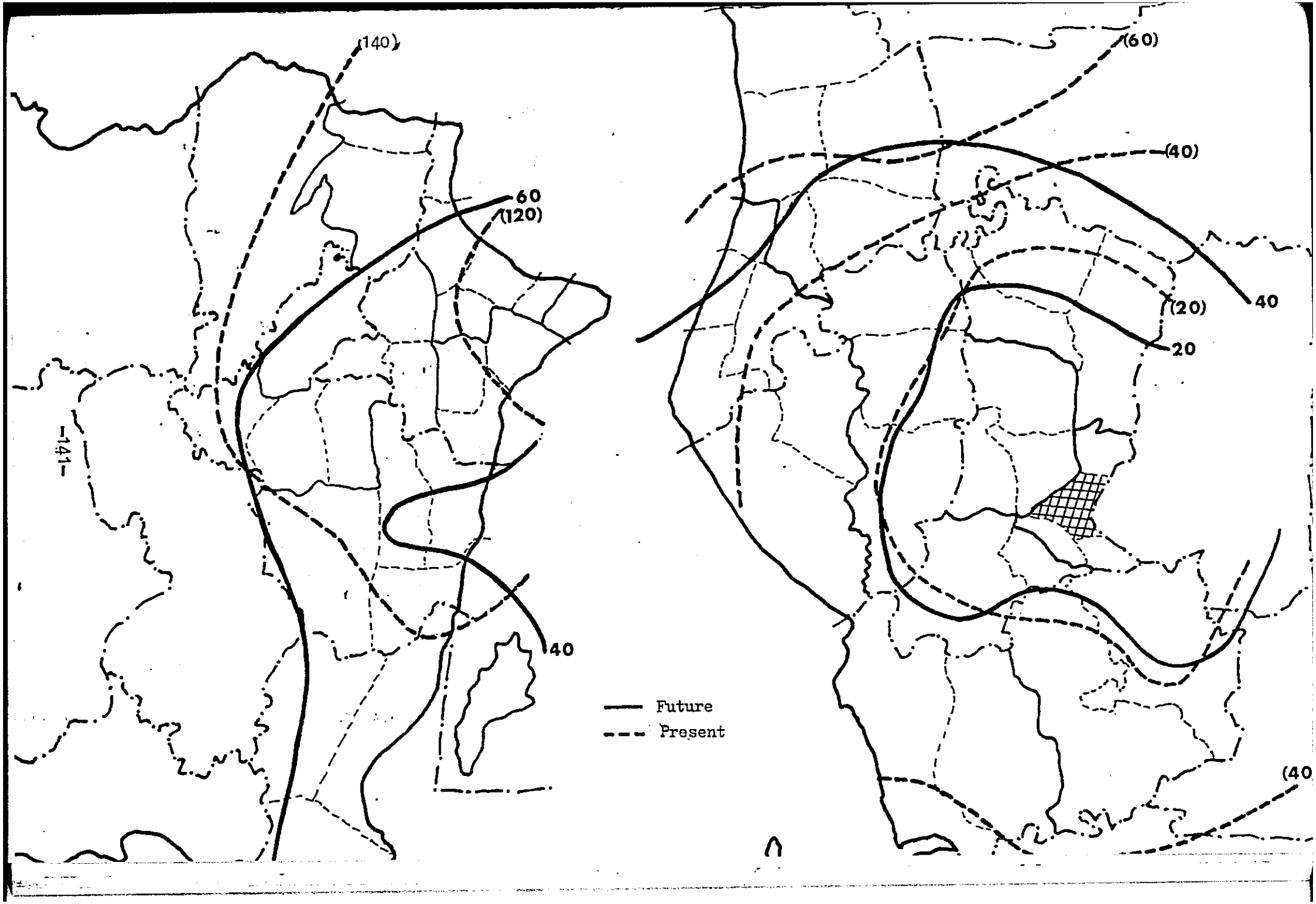

(40)
40
20
(20)
(60)
60
(80)
(40)
40
Future
Present

Figure 4-42 Time distance from Zone 28




(140)
60
(120)
40
(60)
(40)
(20)
40
20
(40)
Future
Present

4-4-3 The formulation of the trip distribution model.

Before formulating the trip distribution model, some trip distribution models which have been formulated by predecessors are first introduced.

(1) Method of trip distribution

Trip distribution models may be divided into two groups:-

A. The Direct Method compites the numbaer of trips between two zones within one step.

B. The Indirect Method distributes the total number of trips generated within a zone between all the zones of attraction.

A. Methods for the direct calculation of trip distribution.

A-1 Gravity Model

The gravity model which has taken its name from a version of the "Lill's Reisegesetz" is as follow:

$$Tij = \alpha \frac{gi.\ Aj}{tij^{\sigma}}$$

Tij : number of trips between zone i and j

gi, Aj: the "mass" of zoned i and j respectively

tij : distance from i to j

While Lill considered his law a natural law similar to that of Newton's Law of Gravity, it is considered a simple way of giving a reasonable description of the travel pattern of a particular area at a particular time. Therefore, a large number of models have been established which more of were devived from the original model.

A-2 Multiple Regression Models

In a number of cases in California, Osofsky applied multiple regression to derive models for traffic between two zones of the following form:

$Tij = K1,X1 + K2,X2 + \cdots$

Tij : number of trips between zone i and j

K1,K2: parameters for zone i

X1,X2: variables referring to zone j

B. Methods for the Indirect Calculation of trip distribution.

B-1 Growth Factor Methods

The growth factor F is the ratio of the present to the future number of trips attracted to and generated from a given area.

a. Uniform Growth Factor

The simplest possible Growth Factor Model is,

$$Tij' = Tij \times F$$

Tij' : the future number of trips between zone i and j

Tij : the observed number of trips between zone i and j

F : a uniform growth factor for the entire area

b. The Average Factor Method

c. The Detroit Method

d. The Fratar Method

e. The Subjective Growth Factor Method

The contents of these models (b, c, d, e) are not included as their methods are similar to model a.

B-2 The present pattern method

This method typically makes use of the above mentioned growth factor models.

Therefore, to use this model the present O-D table is needed.

(2) The formulation of the trip distribution model.

For the purpose of estimating the trip distribution, the following two methods are representative. One is the present pattern method and the other is the model method. Usually, the former is used for short term estimation or when it is auticipated that the land-use pattern will not be subject to too much change.

On the other hand, the model method which is designed for adjusting to the change in land-use pattern, is suitable for long term estimation.

In our land-use plan, it is perceived that the future land-use pattern would be different from the present pattern. In addition to this, the main flow of traffic would be diverted because the linkage plan and the east-west highway plan would have reached fruition and concequently there would be a change

in the major road network. As a result of the above, the most popular method was chosen for our estimation and this is the gravity model method.

The gravity model is as follows:-

$$Tij = \alpha gi.aj \cdot tij - \gamma$$

Tij : number of trips between zone i and j.

gi : total number of trip generation in zone i.

ai : total number of trip attraction in zone i.

α : constant of proportion.

γ : exponent of gravity model

The esponents of the gravity model is estimated by the trip purpose or vehicle type through the least square method applied to the relationship between the present O-D tables and the present travel time of each zone pairs.

The results from using the model for all the zone pairs in the study area are as follows:-

Table 4-24 Formula of Trip Distribution

		The Formula of trip distribution
Car	trip to work	$Tij = 1.147 \frac{Ai^{0.340} gj^{0.424}}{tij^{0.624}}$
	business trip	$Tij = 0.461 \frac{Ai^{0.402} gj^{0.398}}{tij^{0.396}}$
	private trip	$Tij = 0.749 \frac{Ai^{0.398} gj^{0.404}}{tij^{0.576}}$
	trip home	$Tij = 1.269 \frac{Ai^{0.415} gj^{0.367}}{tij^{0.709}}$
Lorry		$Tij = 1.737 \frac{Ai^{0.355} gj^{0.381}}{tij^{0.635}}$
Taxi		$Tij = 0.0998 \frac{Ai^{0.425} gj^{0.413}}{tij^{0.115}}$
Bus		$Tij = 0.523 \frac{Ai^{0.417} gj^{0.407}}{tij^{0.419}}$
Motor-cycle		$Tij = 0.237 \frac{Ai^{0.514} gj^{0.510}}{tij^{1.100}}$

However, the use of one formula alone is not enough to explain the present traffic distribution. The reason is because the traffic pattern in Penang Island, Province Wellesley and across the strait each hand their unique charcteristics. Therefore, the formulae are drawn up according to following areas.

Table 4-25 Table denotes formulae used for the internal and external areas of Penang Island and Province Wellesley.

O \ D		Internal area		External area	
		Penang Island	Province Wellesley	Penang Island	Province Wellesley
internal area	Penang Island	1	2	3	4
	Province Wellesley	5	6	7	8
external area	Penang Island	9	10	11	12
	Province Wellesley	13	14	15	16

The results of these procedures is that one trip distribution formula is made up of 16 formulae from each area pair.

Refering to figures 4-44, 4-45, 4-46, 4-47, 4-48, 4-49, 4-50 and 4-51 all values above the line are the actual values while those below the line are the estimated values using this model.

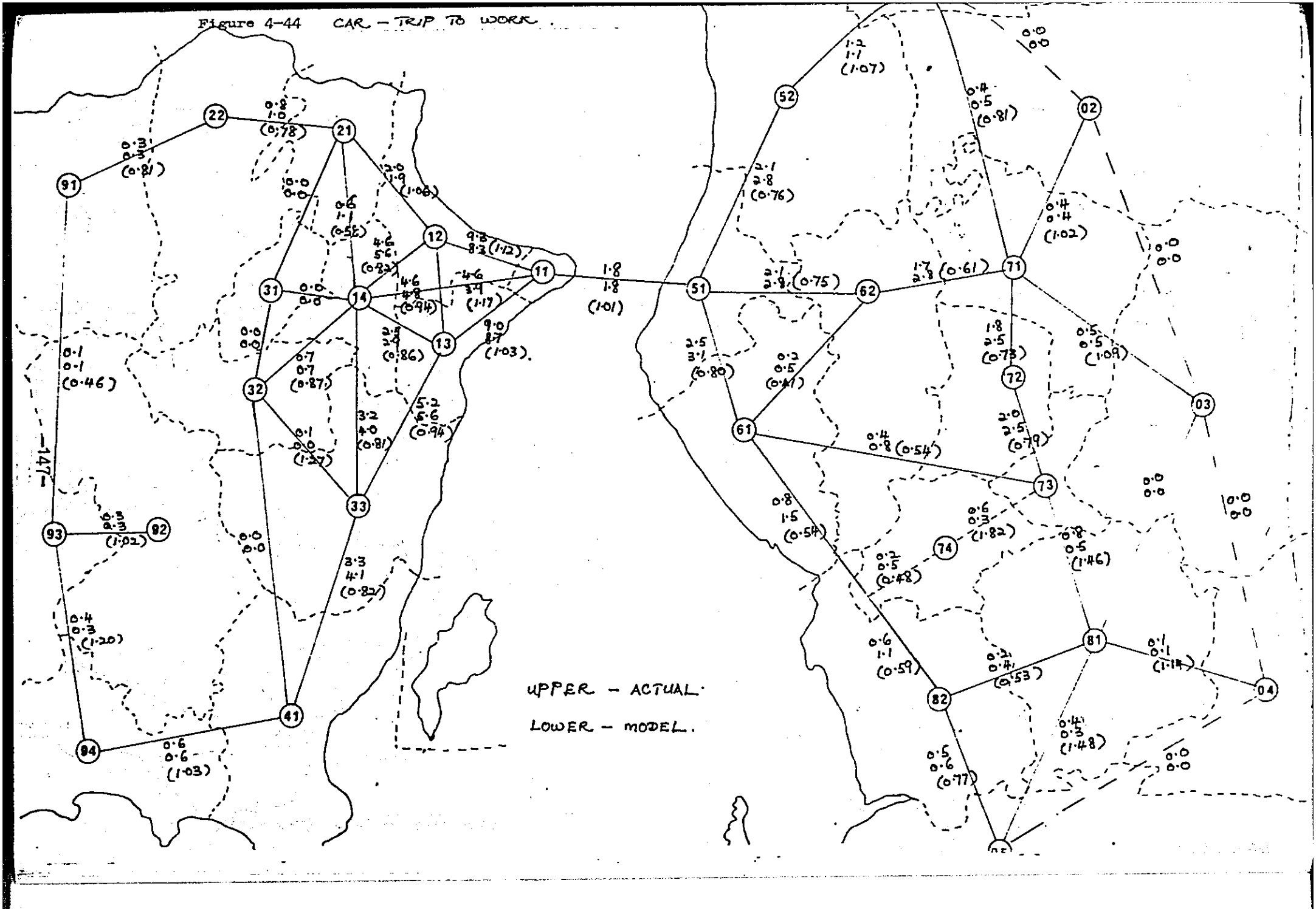
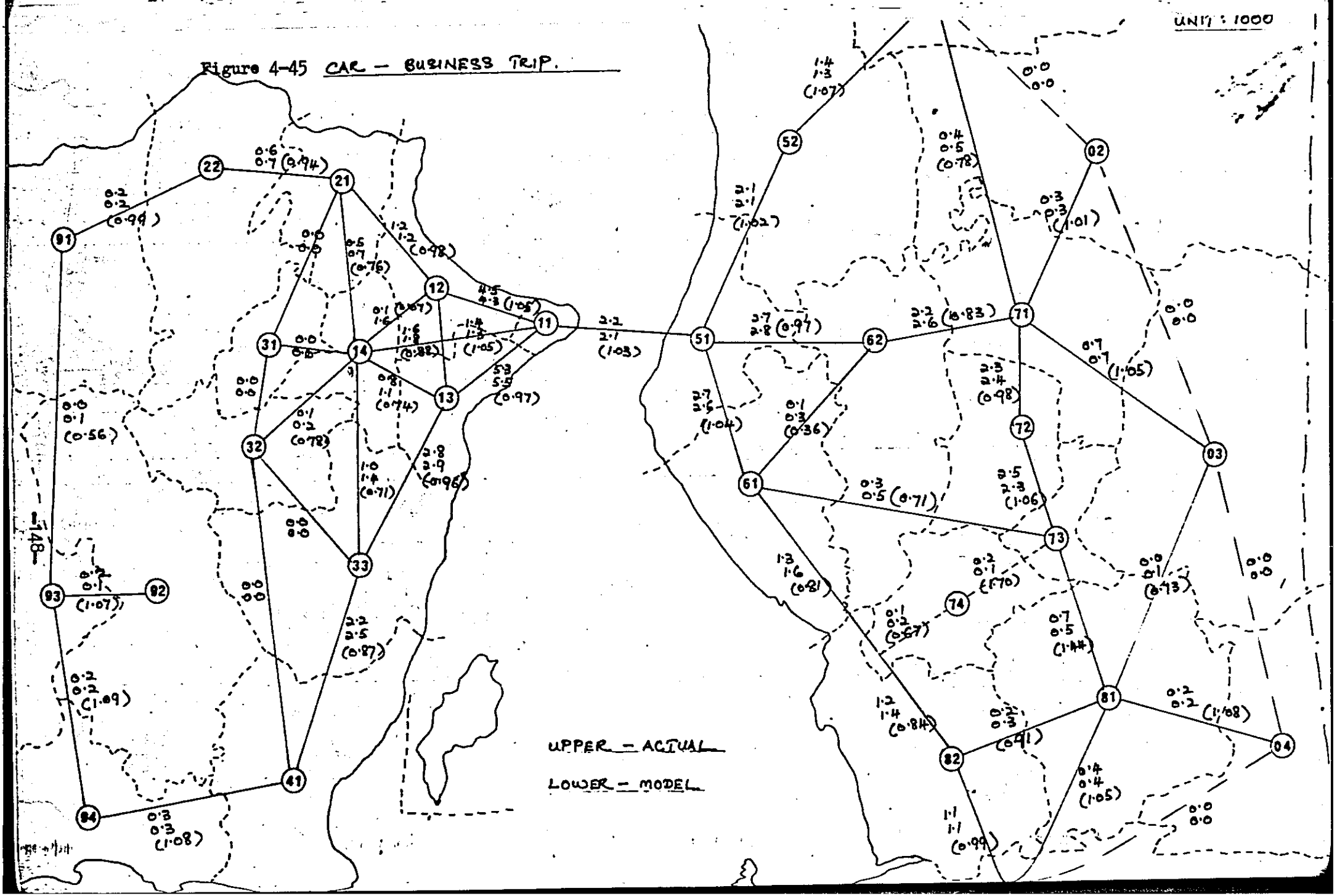


Figure 4-44 CAR – TRIP TO WORK
UPPER – ACTUAL
LOWER – MODEL.
91
22
21
12
11
31
14
13
32
33
41
93
92
94
52
02
51
62
71
72
03
61
73
74
81
82
04
1.8
1.8
(1.01)
0.8
1.0
(0.78)
0.3
0.3
(0.81)
2.0
1.9
(1.06)
0.0
0.0
0.6
1.1
(0.56)
9.8
8.3
(1.12)
4.6
5.6
(0.82)
4.6
4.8
(0.94)
4.6
3.4
(1.17)
0.0
0.0
2.8
2.0
(0.86)
9.0
8.7
(1.03)
0.1
0.1
(0.46)
0.7
0.7
(0.87)
3.2
4.0
(0.81)
5.2
5.6
(0.94)
0.1
0.0
(1.27)
0.3
0.3
(1.02)
0.0
0.0
3.3
4.1
(0.82)
0.4
0.3
(1.20)
0.6
0.6
(1.03)
1.2
1.1
(1.07)
0.4
0.5
(0.81)
2.1
2.8
(0.76)
0.4
0.4
(1.02)
0.0
0.0
2.1
2.9
(0.75)
1.7
2.8
(0.61)
2.5
3.1
(0.80)
0.2
0.5
(0.47)
1.8
2.5
(0.73)
0.5
0.5
(1.09)
0.0
0.0
0.4
0.8
(0.54)
2.0
2.5
(0.79)
0.0
0.0
0.8
1.5
(0.54)
0.6
0.3
(1.82)
0.2
0.5
(0.48)
0.8
0.5
(1.46)
0.0
0.0
0.6
1.1
(0.59)
0.2
0.4
(0.53)
0.1
0.1
(1.14)
0.4
0.3
(1.48)
0.5
0.6
(0.77)
0.0
0.0

Figure 4-45 CAR — BUSINESS TRIP.



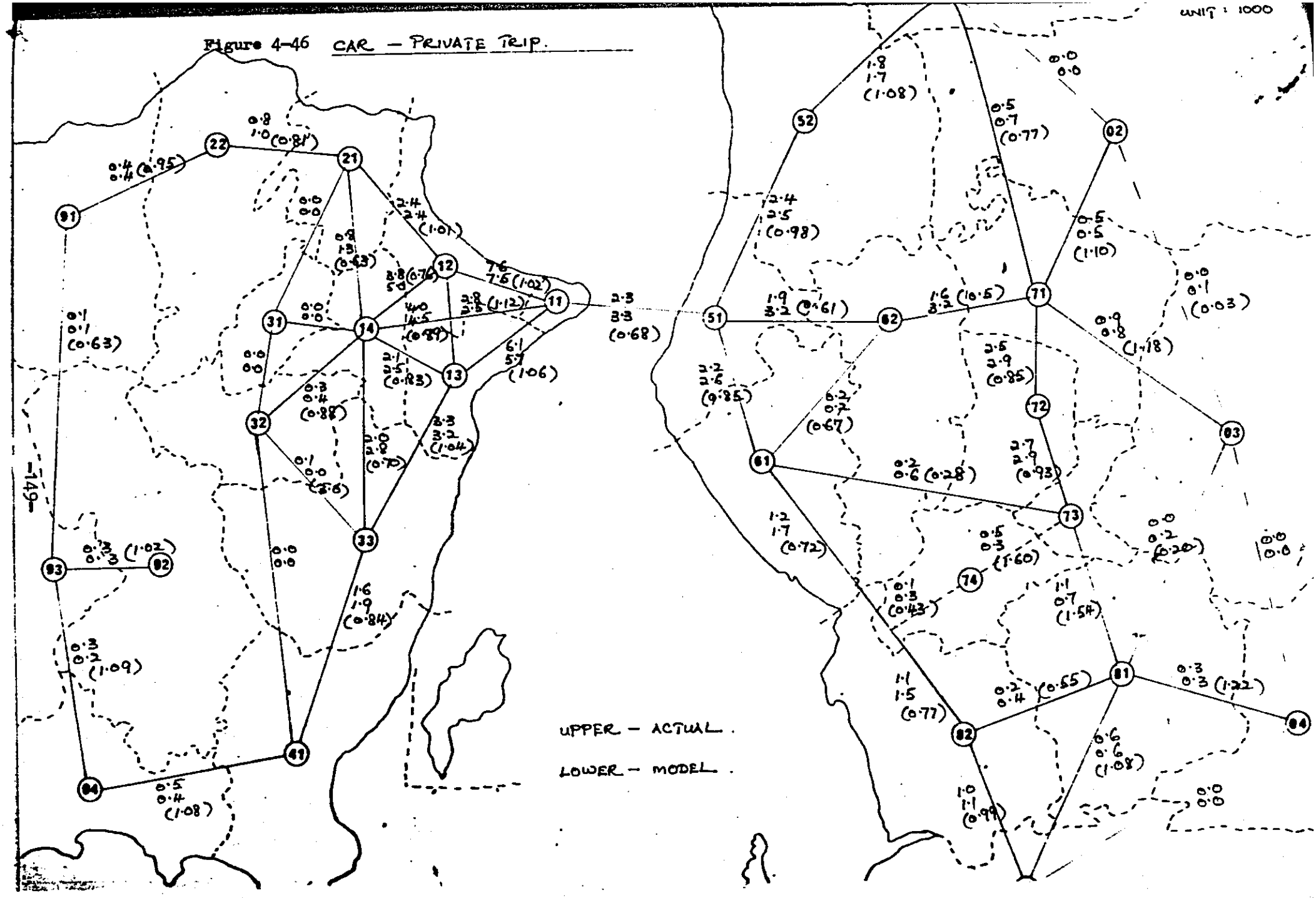
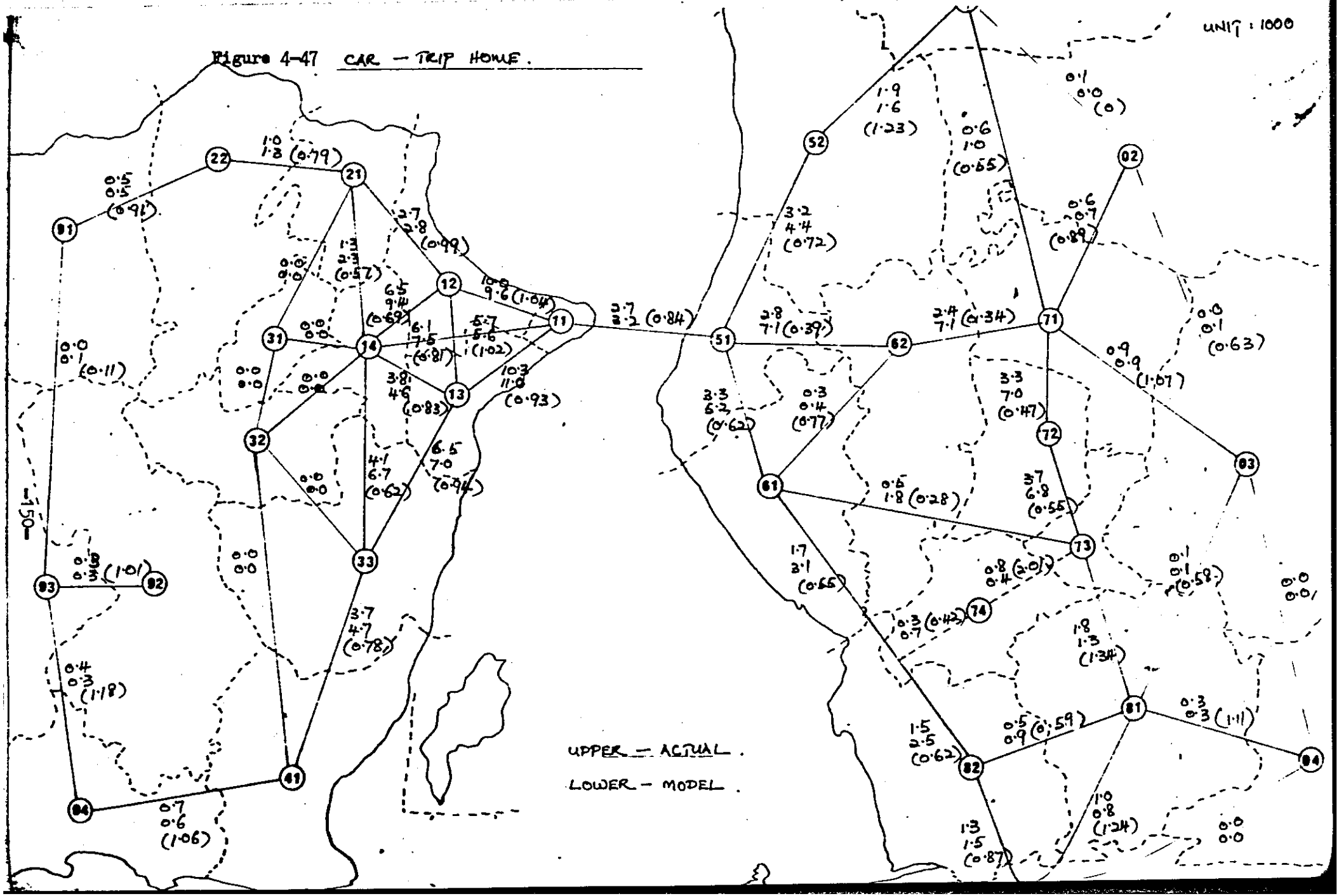


Figure 4-46 CAR – PRIVATE TRIP.
UNIT : 1000
UPPER – ACTUAL.
LOWER – MODEL.
-149-

Figure 4-47 CAR — TRIP HOME.



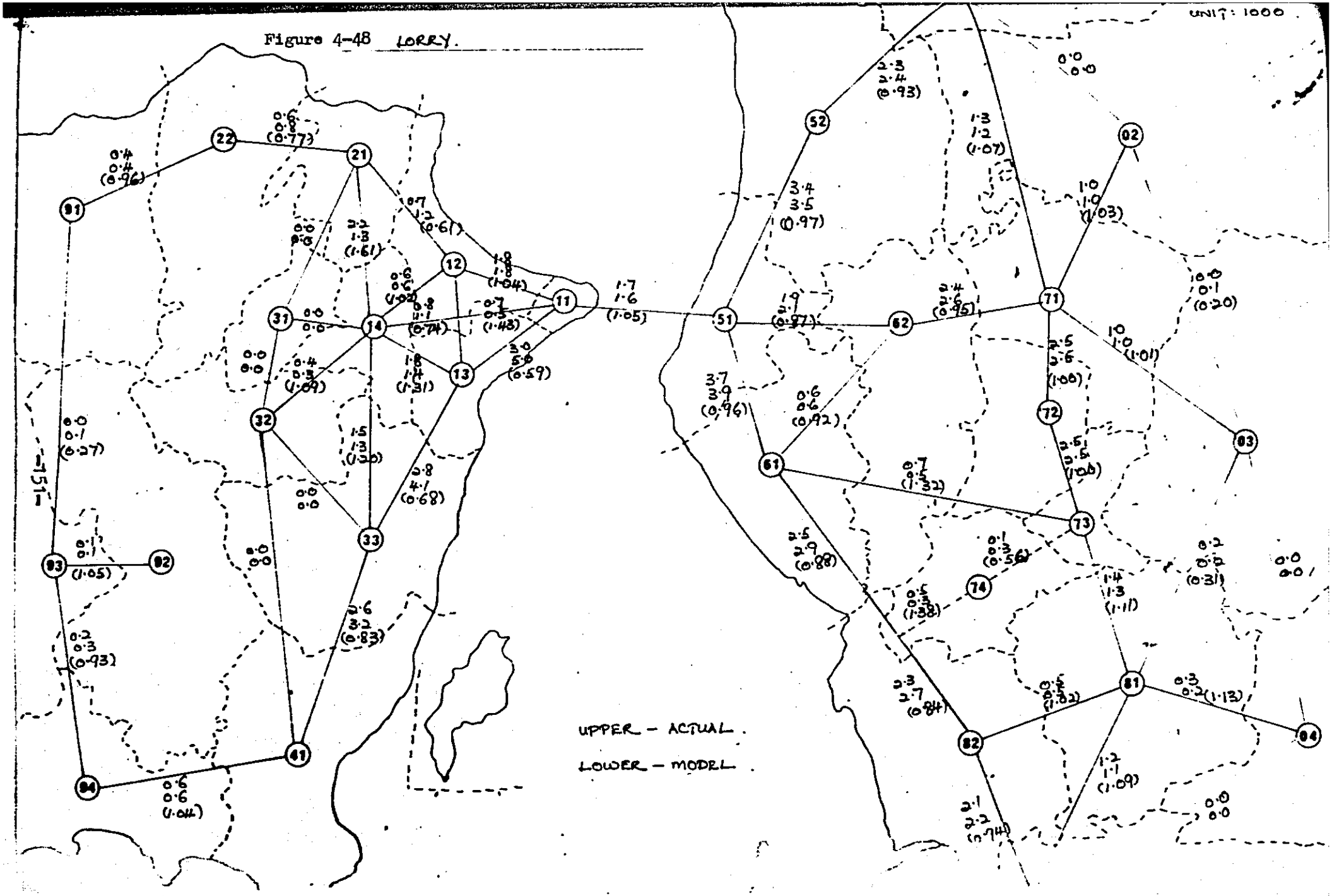


Figure 4-48 LORRY.
UNIT: 1000
UPPER – ACTUAL.
LOWER – MODEL.

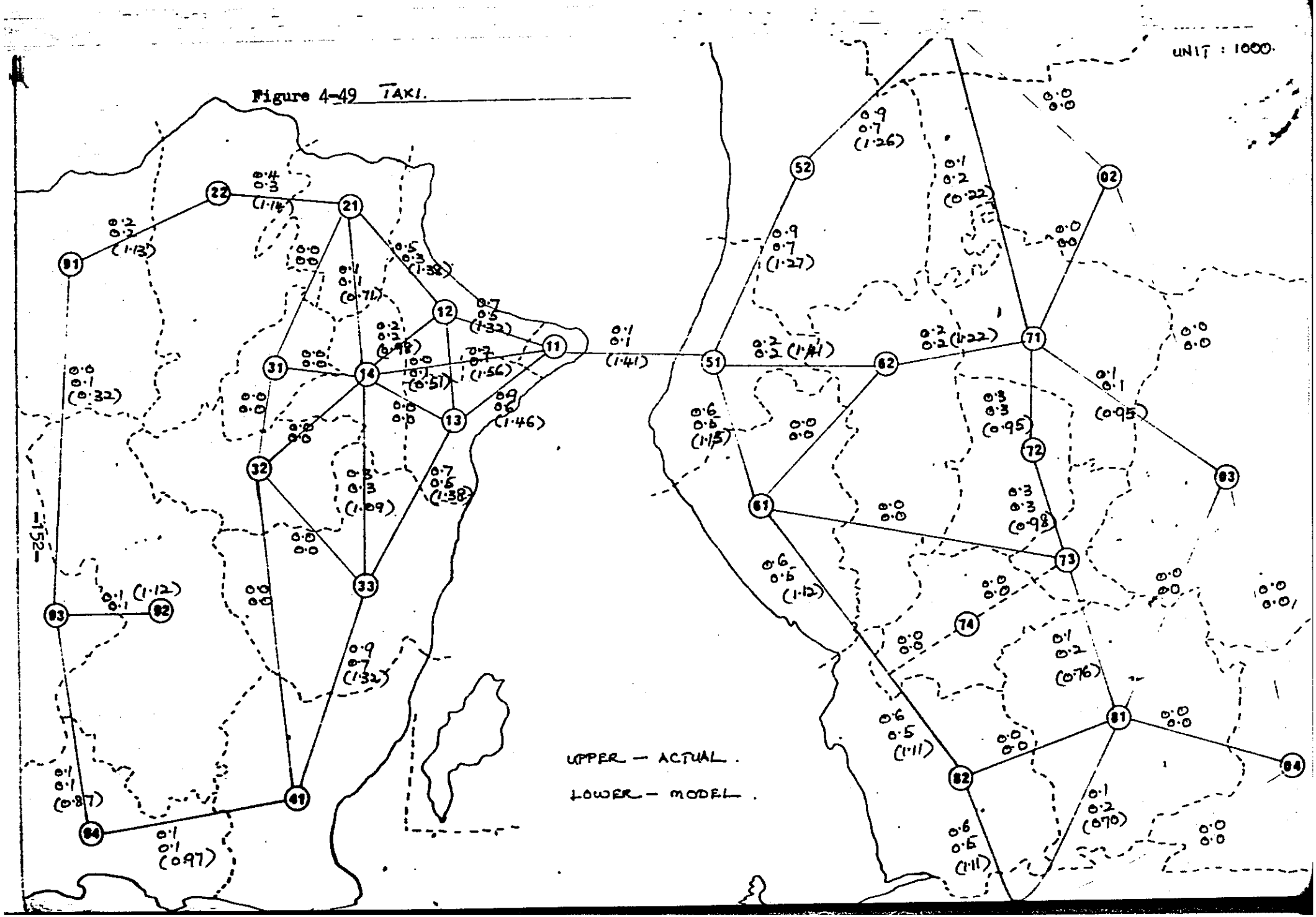


Figure 4-49 TAKI.
UNIT : 1000.
UPPER — ACTUAL.
LOWER — MODEL.
-152-

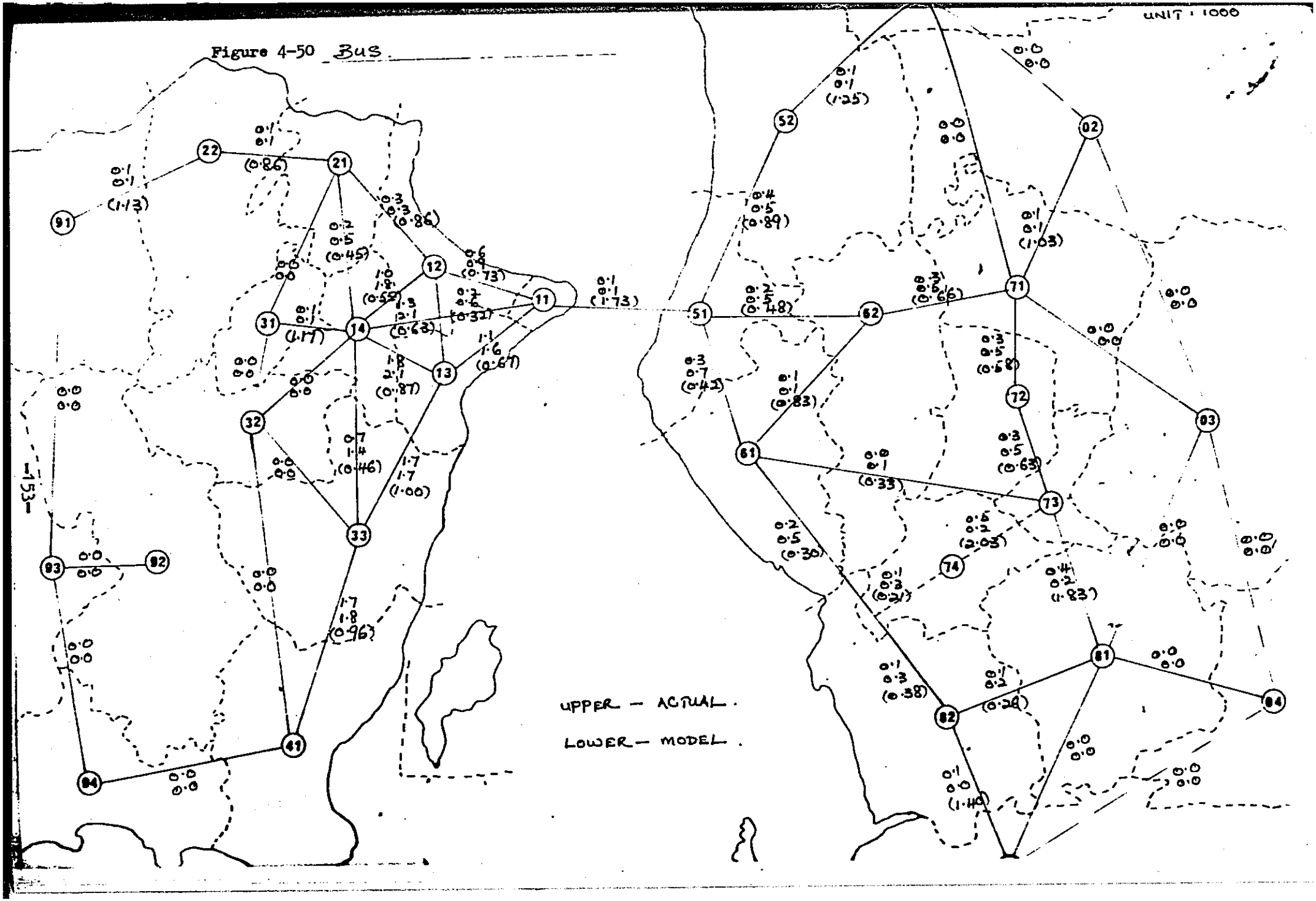


Figure 4-50 Bus
UNIT : 1000
UPPER — ACTUAL.
LOWER — MODEL.
-153-

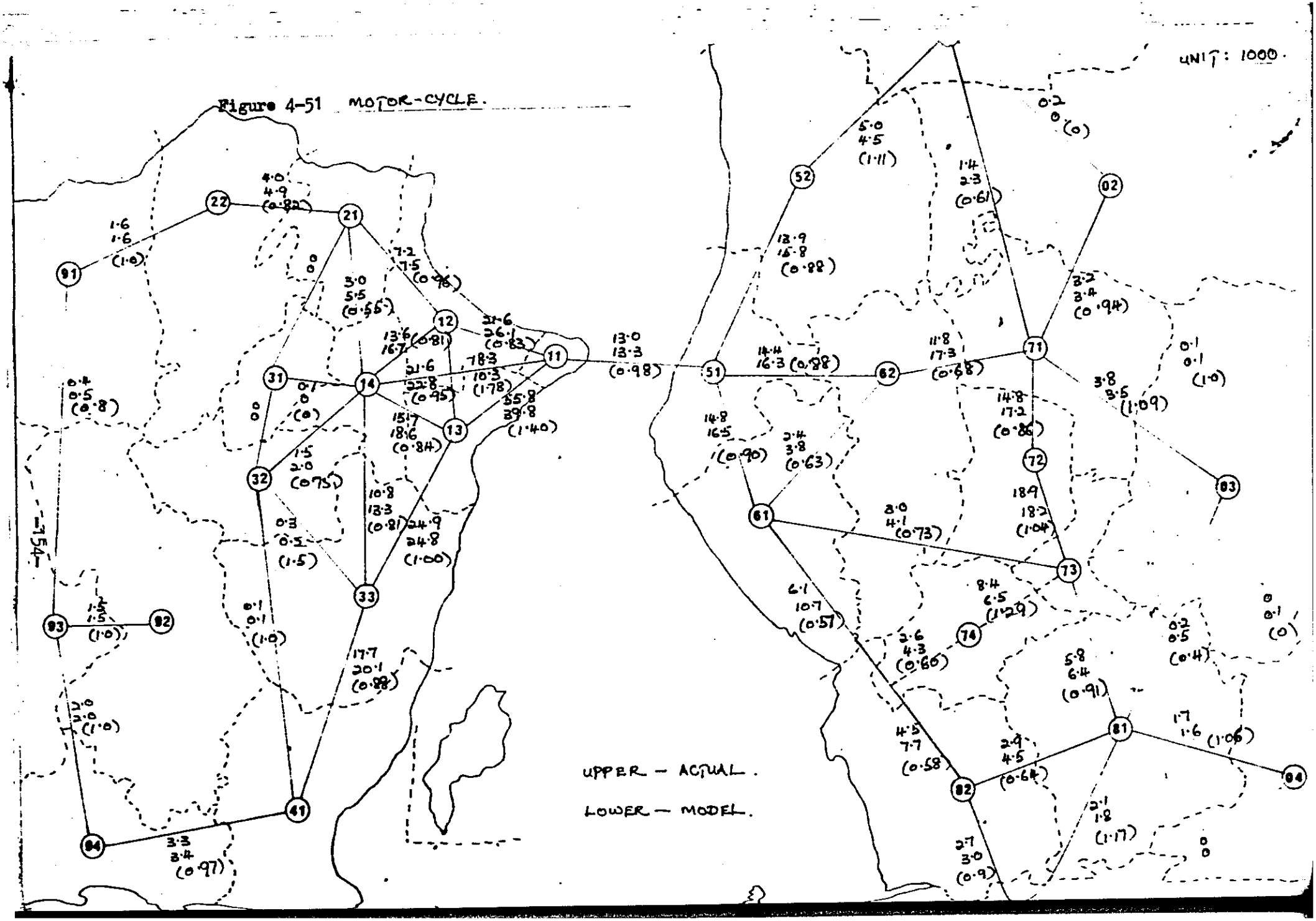


Figure 4-51 MOTOR-CYCLE.
UNIT: 1000.
UPPER — ACTUAL.
LOWER — MODEL.
91
92
93
94
22
21
12
11
31
14
13
32
33
41
51
52
02
71
62
72
73
61
74
81
82
83
84
1.6 1.6 (1.0)
4.0 4.9 (0.82)
7.2 7.5 (0.96)
3.0 5.5 (0.55)
13.6 16.7 (0.81)
21.6 26.1 (0.83)
13.0 13.3 (0.98)
21.6 22.8 (0.95)
78.3 10.3 (1.78)
15.7 18.6 (0.84)
35.8 39.8 (1.40)
0.4 0.5 (0.8)
0.1 0 (0)
1.5 2.0 (0.75)
10.8 13.3 (0.81)
24.9 24.8 (1.00)
0.3 0.5 (1.5)
1.5 1.5 (1.0)
0.1 0.1 (1.0)
17.7 20.1 (0.88)
2.0 2.0 (1.0)
3.3 3.4 (0.97)
5.0 4.5 (1.11)
0.2 0 (0)
1.4 2.3 (0.61)
12.9 15.8 (0.88)
14.4 16.3 (0.88)
11.8 17.3 (0.68)
3.2 3.4 (0.94)
0.1 0.1 (1.0)
3.8 3.5 (1.09)
14.8 17.2 (0.86)
14.8 16.5 (0.90)
2.4 3.8 (0.63)
18.9 18.2 (1.04)
8.0 4.1 (0.73)
6.1 10.7 (0.57)
8.4 6.5 (1.29)
2.6 4.3 (0.66)
0.2 0.5 (0.4)
0 0.1 (0)
5.8 6.4 (0.91)
4.5 7.7 (0.58)
2.9 4.5 (0.64)
1.7 1.6 (1.06)
2.1 1.8 (1.17)
2.7 3.0 (0.9)
0 0

4-5 Traffic assignment

4-5-1 The procedure of traffic assignment

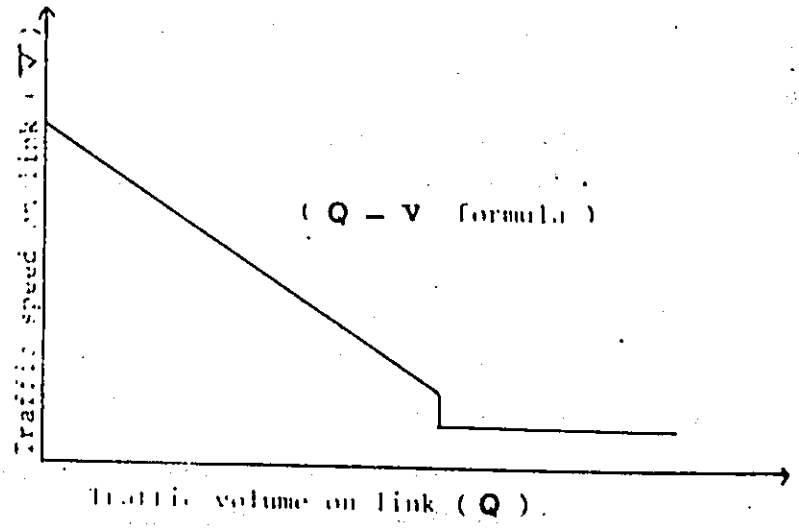
Through traffic assignment, the traffic volume on each road can be estimated. The procedure for traffic assignment is explained below.

(1) Each link of the road network has its own relationship between the traffic volume and the travel time. In this relationship the travel time increases with respect to the increase in the traffic volume already assigned. The travel time increases very rapidly as the traffic volume approaches the road capacity.

(2) The traffic demand of each O-D pair is assigned to the shortest route in relation to the travel time decided upon by the above relationship.
The so-called "all or nothing" method is used.

(3) The traffic demand of O-D pairs is divided into several lots and the travel time is calculated repeatedly according to the traffic volume already assigned on a link at the assignment of each lot.
The shortest route is obtained by the above calculations.
The above procedure is repeated until all the lots of each O-D pair are assigned. Therefore, it rarely happens that the traffic demand of a particular O-D pair concentrates on a particular route.
The relationship between the traffic volume and the travel time is calculated from the following figures.

Fig: 4-52 Q-V Formula



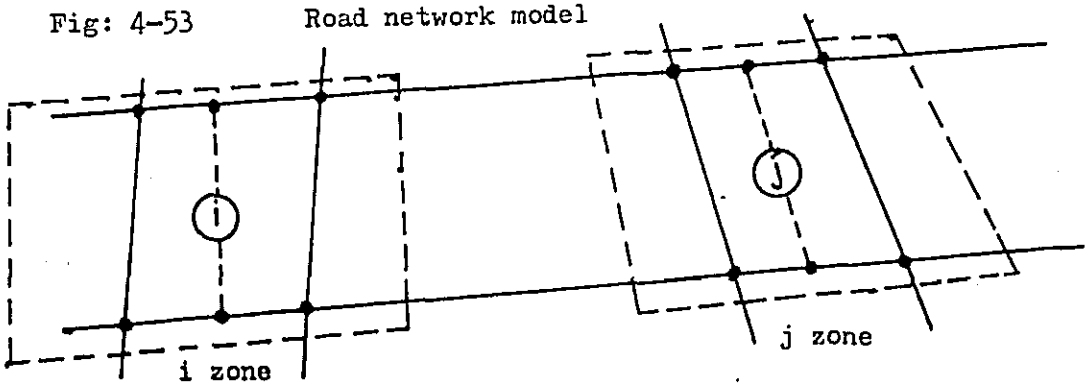
The travel time is estimated by dividing the length of the link by the traffic speed on the link obtained in this relationship by applying the traffic volume which has already been assigned. In the case of the linkage and the ferry collect tolls, the toll is added to the travel time which corresponds to the toll paid. To convert the toll paid to the travel time, divide the toll by the time value.

4-5-2 Road network model

For the purpose of estimating the traffic assignment, we need the time distance between each zone pairs.

For this purpose, it is necessary to formulate the road network model. This model consits of links and nodes as shown in Fig. 4-53.

Fig: 4-53 Road network model



(Node)

i j : node of generation and attraction.
This node represents the zone. Therefore, this node is arranged at the zone center.

• : node of connection
The connecting points between links.

(Link)

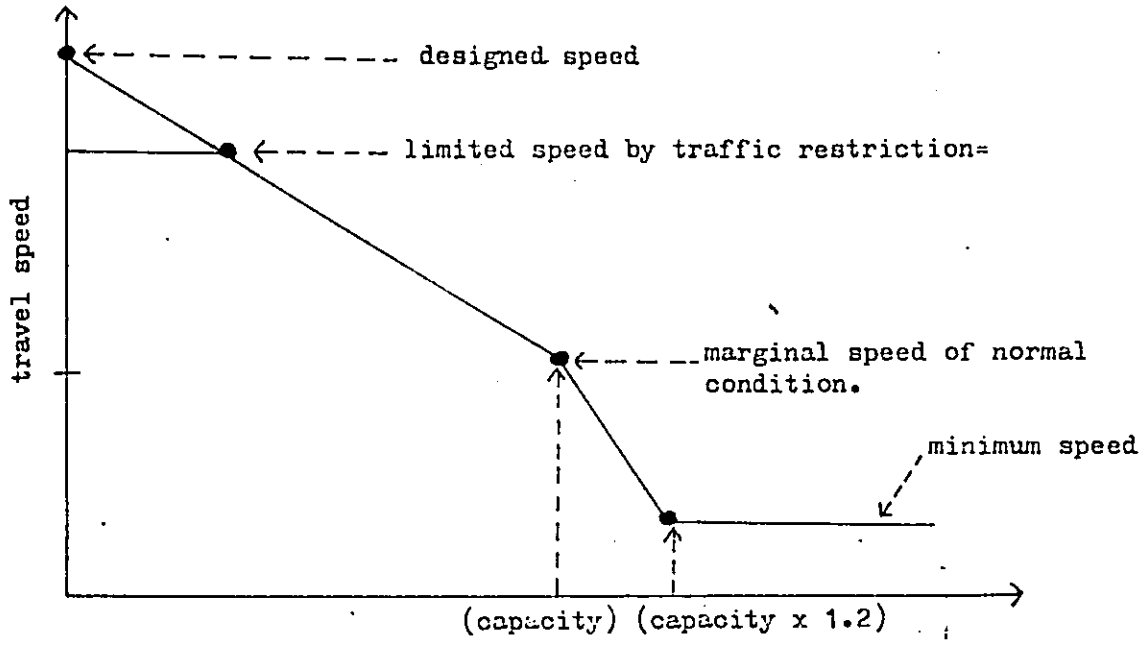
——— : actual link
This link represents the road.

- - - - : dummy link
This link is an assumed link done for the purpose of making traffic assignment an actuality.

To obtain the traffic volume which is very close to the traffic volume on each road, the Q - V formula is then applied on each link of one direction.

The Q - V formula expresses the relationship between the traffic volume and the travel time. It is known that the more the more the traffic volume increases, the more the travel speed decreases. Therefore the Q - V formula is determined by type of road as follows:-

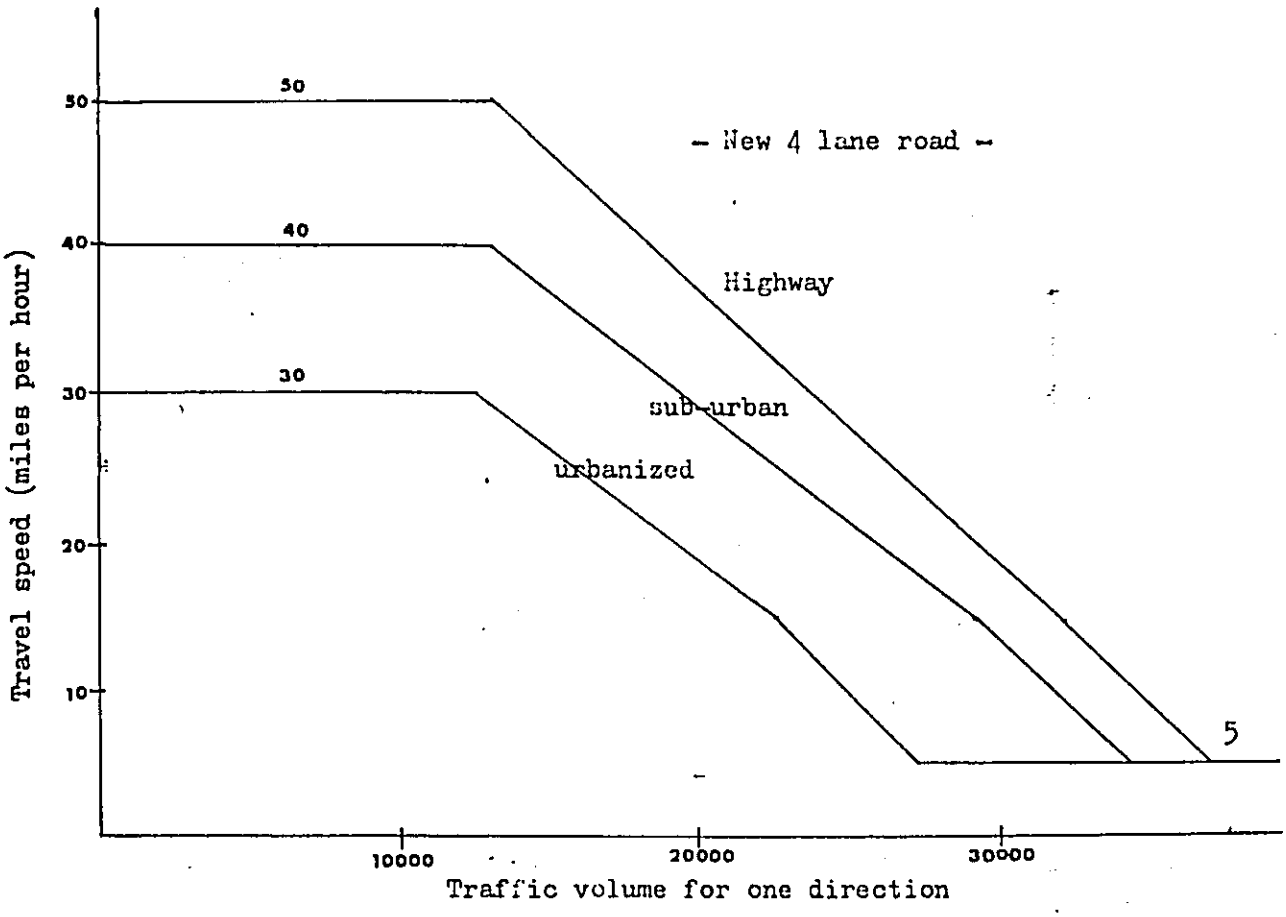
Fig. : 4 - 54 Q - V formula

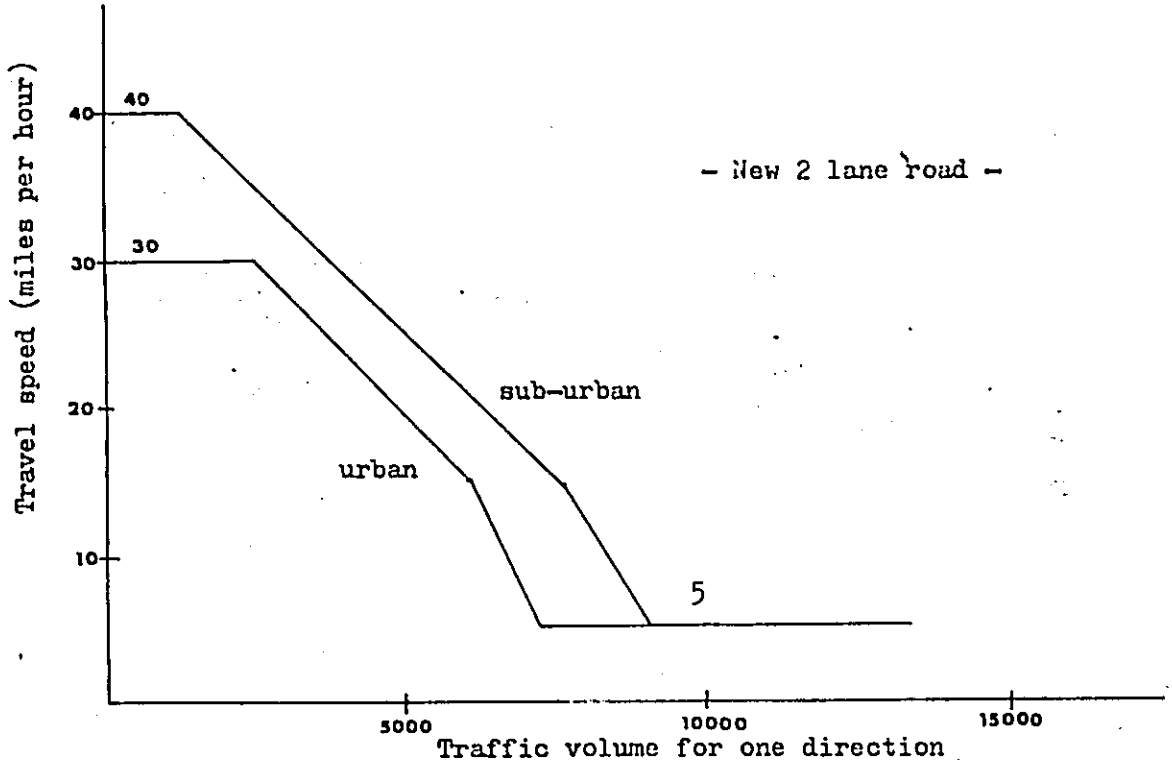


Traffic volume on each link for one direction.

Table 4 - 27 Q - V Formula for vehicle.

Area	No. of lane	Type of road	speed (miles per hour)				Capacity for one direction
			designed	limited	marginal	minimum	
Urbanized Area	4	new	50	30	15	5	22500
		existing	40	30	15	5	18000
	2	new	40	30	15	5	6000
		existing (A)	40	30	15	5	4000
		existing (B)	35	30	15	5	3500
		existing (C)	30	30	10	5	3000
Sub-urban Area	4	new	60	40	15	5	29000
		existing	50	40	15	5	20500
	2	new	45	40	15	5	7500
		existing (A)	40	40	15	5	5000
		existing (B)	35	35	10	5	4000
Highway	4	new	80	50	15	5	32000


- New 4 lane road -
50
40
30
Highway
sub-urban
urbanized
5
Travel speed (miles per hour)
50
40
30
20
10
10000
20000
30000
Traffic volume for one direction


- New 2 lane road -
40
30
sub-urban
urban
5
Travel speed (miles per hour)
40
30
20
10
5000
10000
15000
Traffic volume for one direction

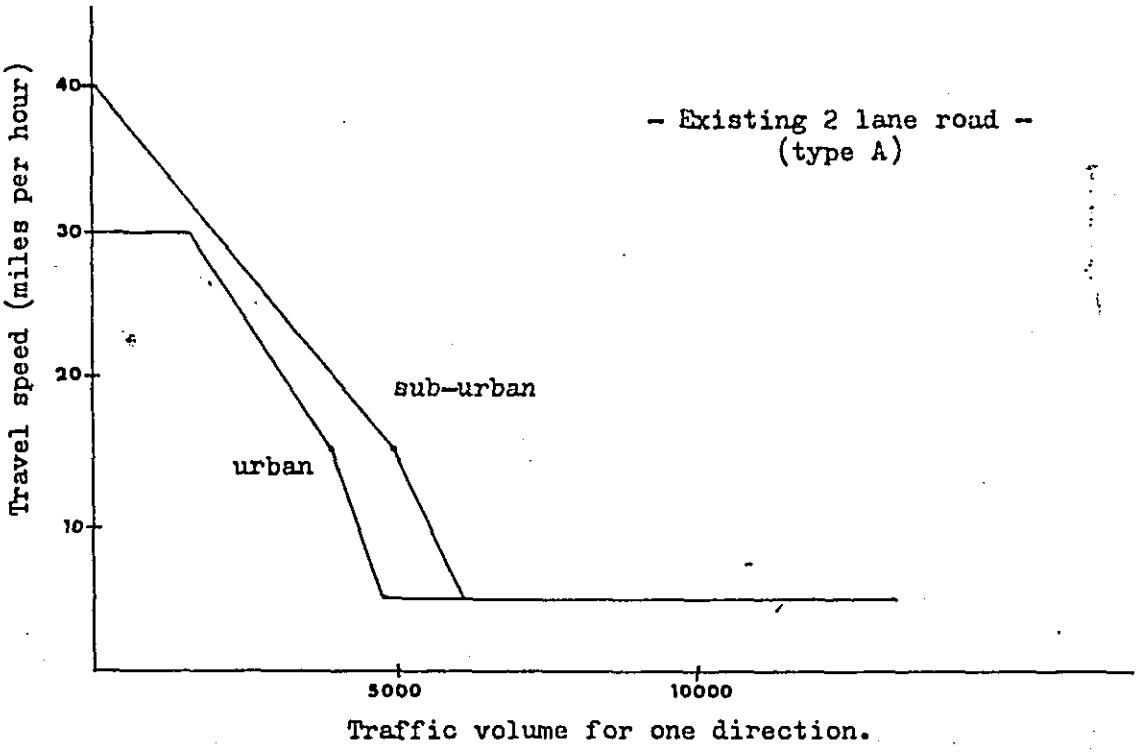


Table 4 - 28 Q - V Formula for motorcycle.

Area	no. of lane	speed				capacity for one direction
		design	limited	marginal	minimum	
Urbanized Area	4	25	20	10	5	3500
	2	25	20	10	5	2500
Sub-urban Area	4	30	25	10	5	4000
	2	30	25	10	5	3000
High-way	4	30	25	10	5	4000

Concerning the ferry, a specific T - V formula is prepared especially for the waiting time which is expressed by the following formula. This formula is derived from our ferry survey.

Fig: 4-55 Waiting time for vehicles

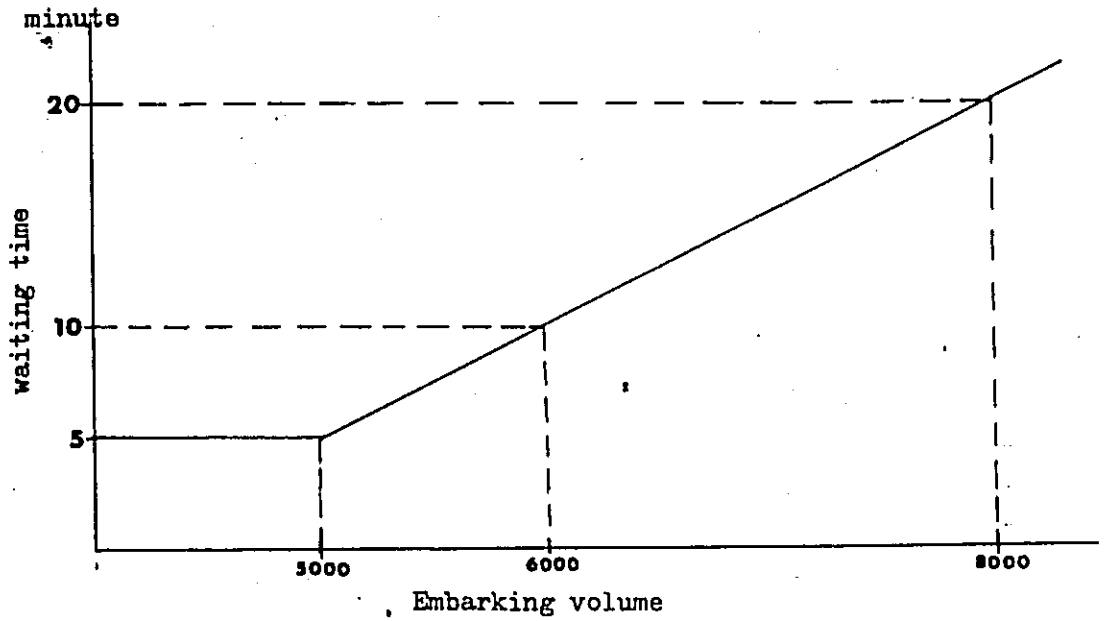
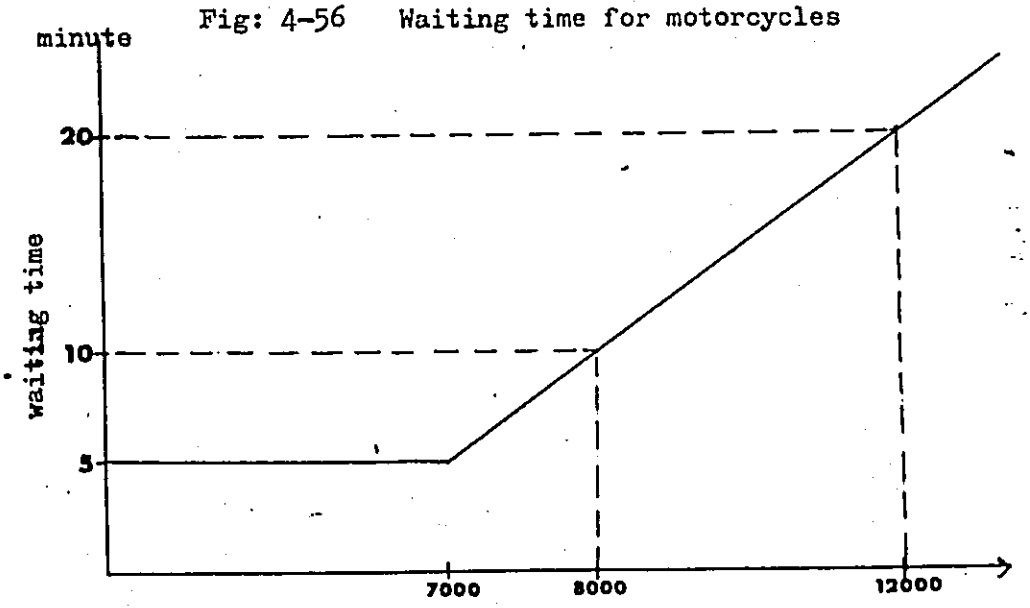


Fig: 4-56 Waiting time for motorcycles



4-5-3 The method of estimating traffic volume.

Various methods can be used for the purpose of estimating traffic volume. However, it is possible to divide them into two methods, namely, the direct and the indirect method.

(1) The objects in a traffic plan.

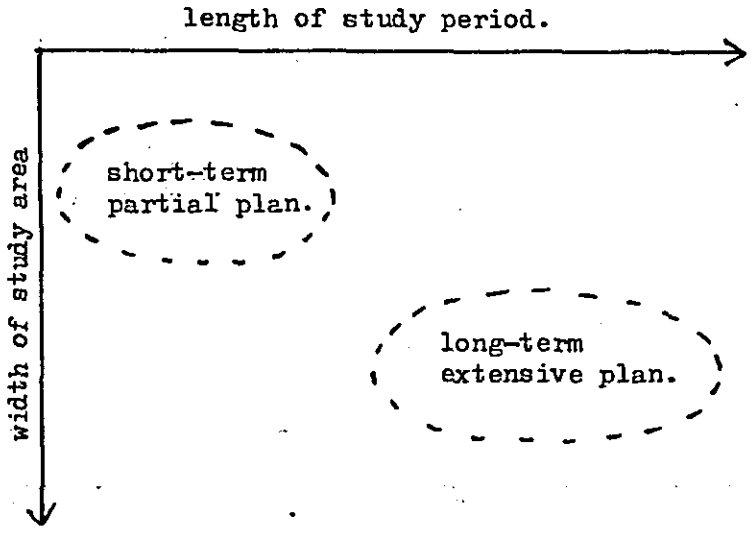
The objects in a traffic plan consist of various contents, ie. major roads, streets, intersections, traffic signals and other traffic facilities.

These objects can be seen from two points of views. One is from the point of view of the planning period while the other is from the point of view of the study area.

Generally speaking, the objects of a traffic plan have the following tendency, viz, the longer the planning period, the larger the study area. For example, the plan for a highway network requires the long-term aspect as well as the large study area because that plan must take into consideration the long-term prospects and the ability of the highway to cope with the movements of long trips.

On the other hand, improvement of intersections must be an urgent measure in the urbanized city. Therefore, the planning period must be short and the study area small enough to require only a short-term partial plan.

Therefore, it is not difficult to divide the objects of a traffic plan as follows:-



(2) The methods of estimating the traffic volume.

When drawing up traffic palns, it is usual that some estimation of future traffic volume is required and this is obtained from studying the traffic at the respective traffic facilities which are involved in the plan.

The method of estimating the traffic volume must correspond to the objectives of the traffic plan. For the purpose of dealing with urgent matters, it is useless if the target year is fixed too far in the future and it is also useless if a partial plan involves too large an area.

Taking the above-mentioned conditions into consideration it is better that for the short-term partial plan the direct method is used while for the long-term extensive plan the indirect method is more suitable. Of course another way is to combine both methods.

First, the contents of both methods are explained and then the features of these methods are shown.

A. The Direct Method.

For short-term estimation, the traffic volume can be estimated by making use of the trends of previous traffic volumes. In this instance, the future volume is estimated from the past-to-present traffic volume data directly without any transformation of the estimating factors.

This is the reason why this method is called the 'direct method'.

As the future demands are forecasted directly, it has the following advantages, viz, it is easy to estimate the volume, the estimation is unexpectedly accurate in so far as it is a short-term target.

However, by using this method, it is difficult to consider the environmental factors, as for example the land-use pattern, population distribution etc. To take these factors into consideration, we must sutdy the extensive area, not the partial area.

Therefore this method is suitable for the short-term partial plan.

B. The Indirect Method.

This method uses certain means in the estimation of future traffic volume.

In the case of estimating the traffic volume on road networks the O-D table is almost the only means used. By using the O-D table, we can estimate the future traffic demands which also take into consideration the changes in the environment.

The increase of population in some zones can be seen in the increase in the trip generation in these zones. Also, the reduction of the distance between some zones through the improvement of roads can be seen in the increase in the trip distribution between these zones.

Therefore, by using the O-D table, we can broadly grasp the future traffic movements.

However, in order to estimate the O-D table, we must divide the area into several traffic zones. By virtue of this we cannot discuss the facilities found within the zones. Even if one zone includes many roads, these roads stand for one zone.

Therefore, the traffic plan is limited by the size of the traffic zone. This method is suitable for long-term estensive plans but unsuitable for detailed plans.

C. Conclusion.

The features of both methods are shown in the following table.

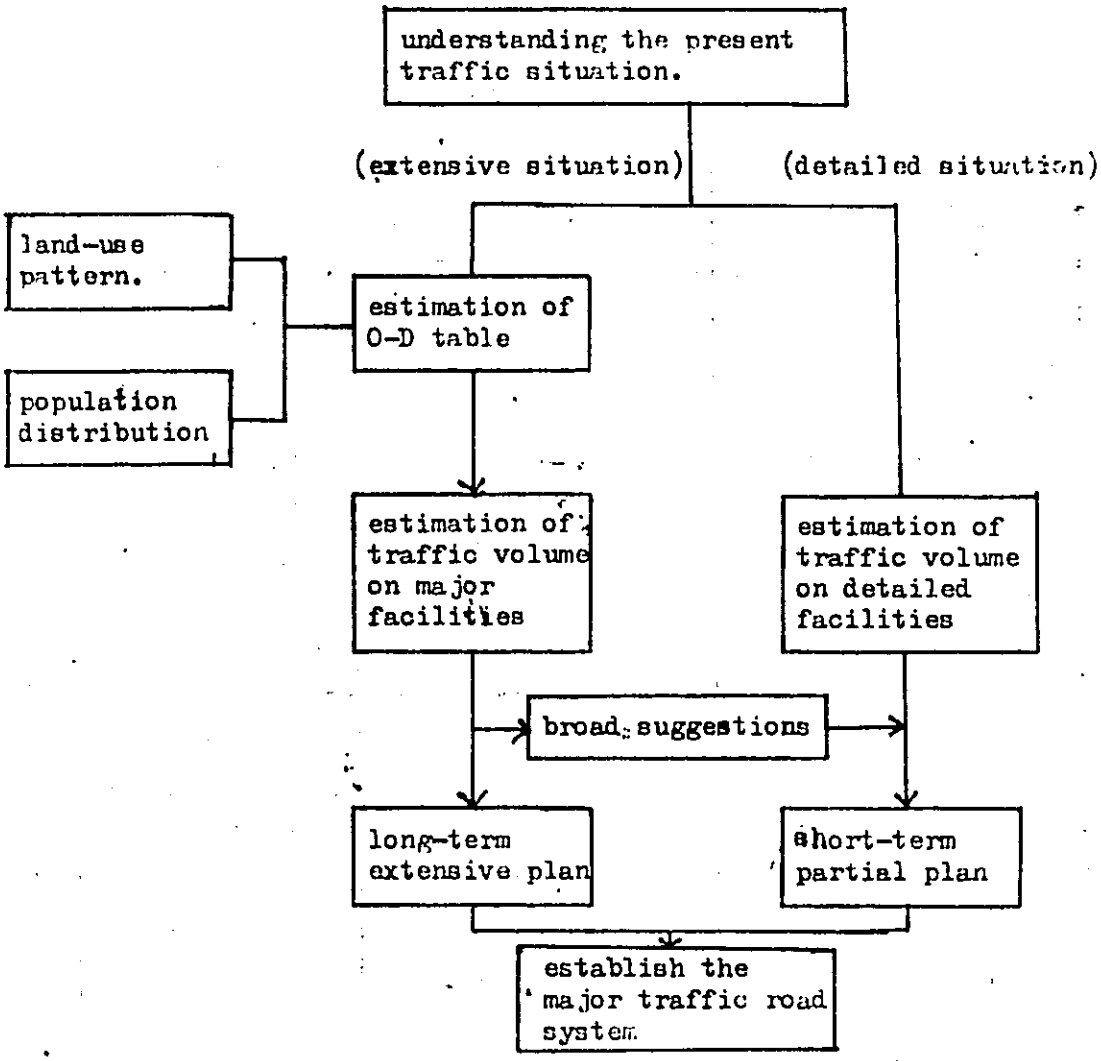
Table 4-28 Direct and indirect methods.

	Direct method	Indirect method
Functions	It is the way to estimate the traffic volume directly from the past-to-present traffic volume data.	It is the way to estimate the traffic volume by using the O-D table directly.
Advantages	(1) the detailed volume can be forecasted (for short-term estimation). (2) it does not entail too much working expenses.	(1) the estensive movement can be forecasted. (2) it takes into consideration the changes in the environment e.g. the land-use pattern.
Disadvantages	(1) it is not suitable for long term estimations. (2) it cannot grasp the movements in the extensive area.	(1) it is hard to do a detailed estimation. (it suffers from the limitations for the zone) (2) it entails heavy working expenditure.
Conclusion	it is suitable for the short-term partial plan.	it is suitable for the long-term extensive plans.

Taking the above conclusions into consideration, it would be suitable to use the indirect method for the main estimating work in order to establish the major traffic road system.

However, it is necessary to make use of the direct method in order to solve the problem of detailed facilities which the indirect method cannot cope with.

The above discussion can be expressed in following flow-chart:-



4-5-4 **Results of present traffic assignment**

As a conclusion, it is emphasised that, this traffic assignment was conducted through using the O-D table. Therefore, the size of the traffic zone limits the traffic assignment. The detailed traffic volume on each road cannot be obtained from this method and besides there is more traffic than there actually should be around the zone node which represents a particular zone because all the trip generation and attraction of one zone are generated and attracted to/from this node.

Therefore, when looking at the results of trip assignment, there constrains must be given consideration.

Fig. : 4-57 The result of traffic assignment (Present)

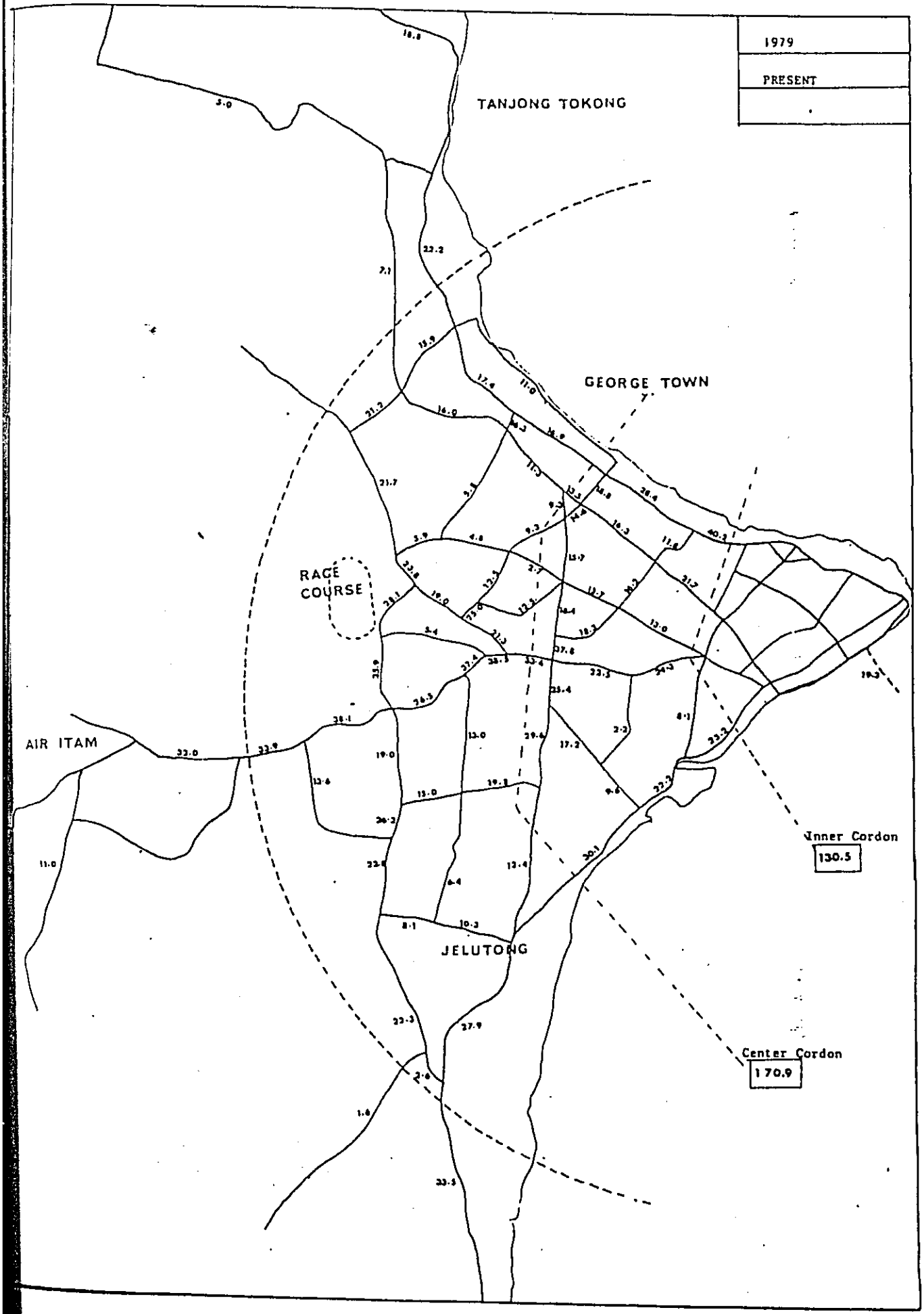
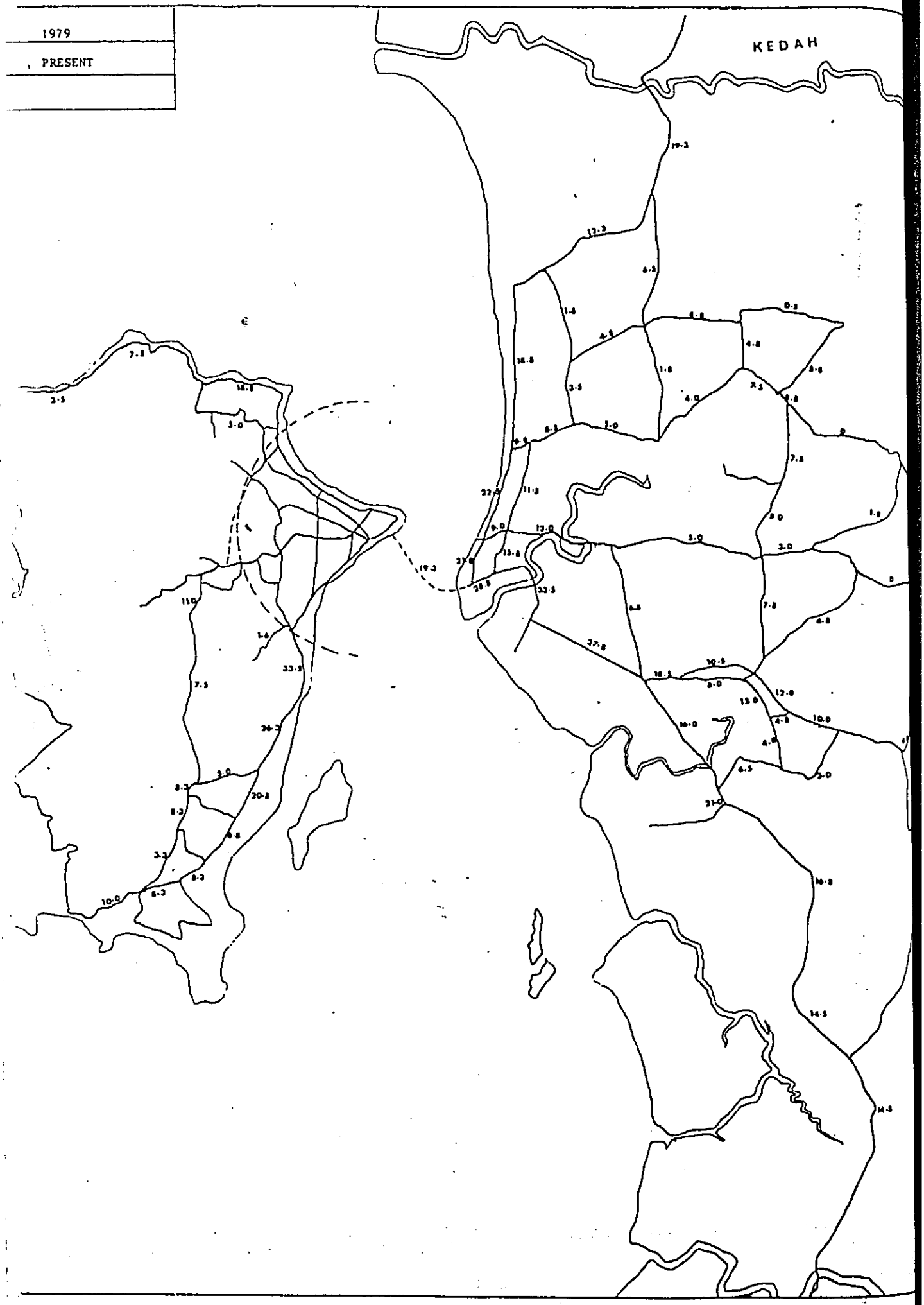


Fig. : 4-57 The result of traffic assignment (present)



5 The premise

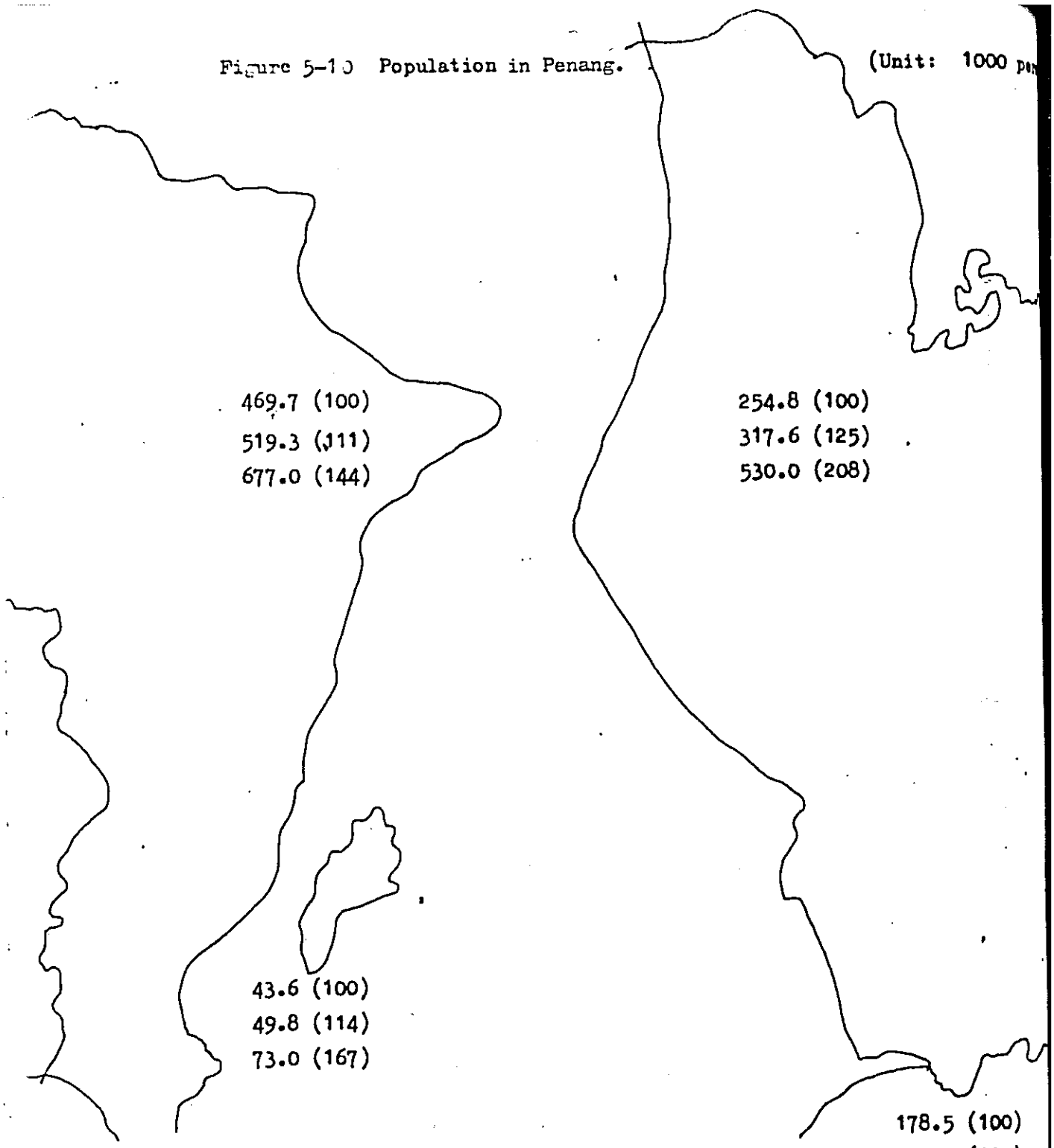
For the purpose of estimating future traffic demand, some premises must be first be laid down, that is, land-use by zone, population by zone and the cargo volume of port etc.

These figures have already been estimated by our population study and port study. In this section, these premises will be summarized.

5-1 Population and employed population.

The following population is forecasted on the basis of the land-use pattern.

Figure 5-10 Population in Penang. (Unit: 1000 p



(unit: 1000 persons)

	Penang State	Study Area
1979	946.6 (100)	723.9 (100)
1985	1090.0 (115)	836.9 (116)
2000	1550.0 (164)	1207.0 (167)

( ) Growth rate

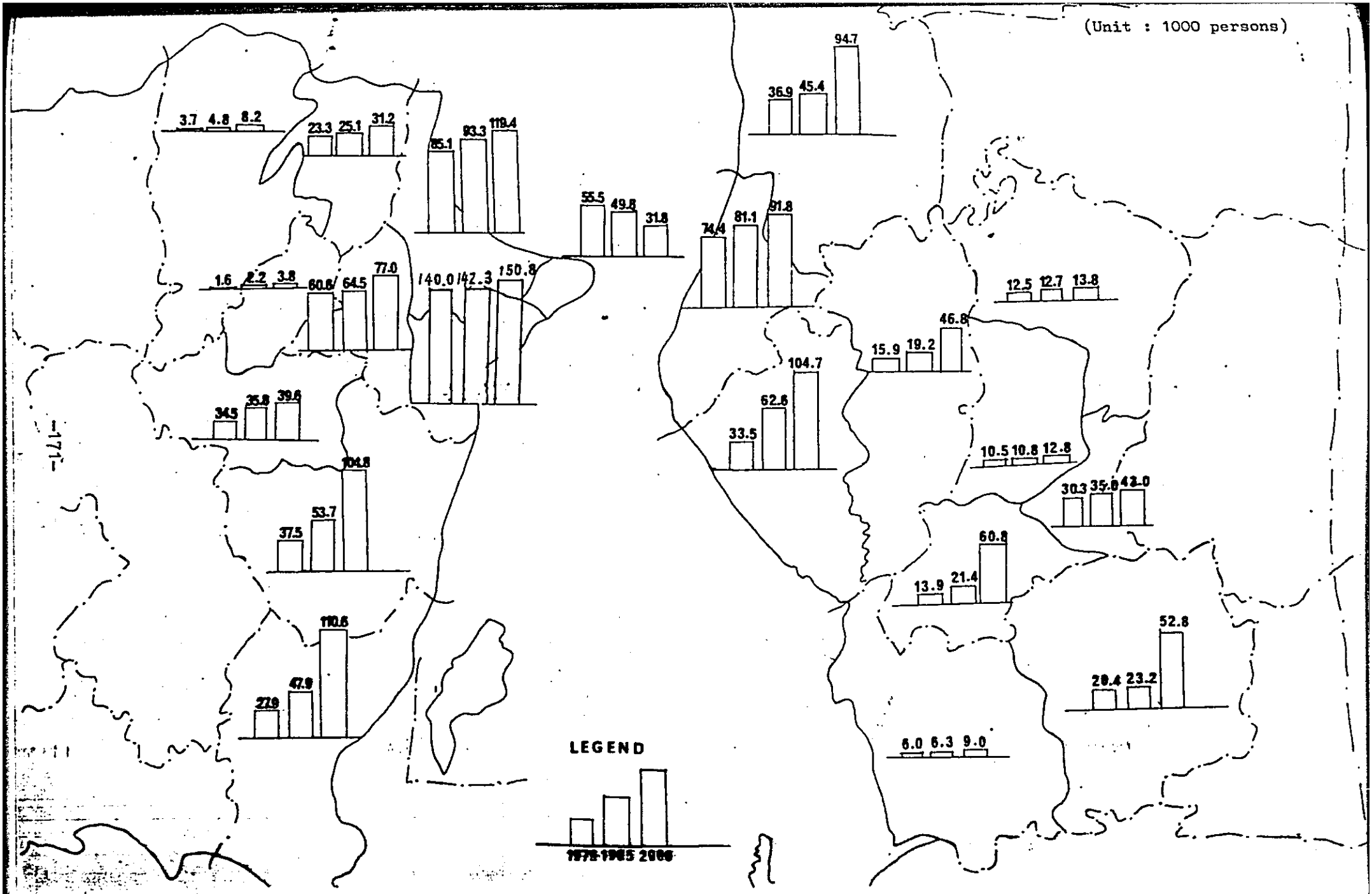
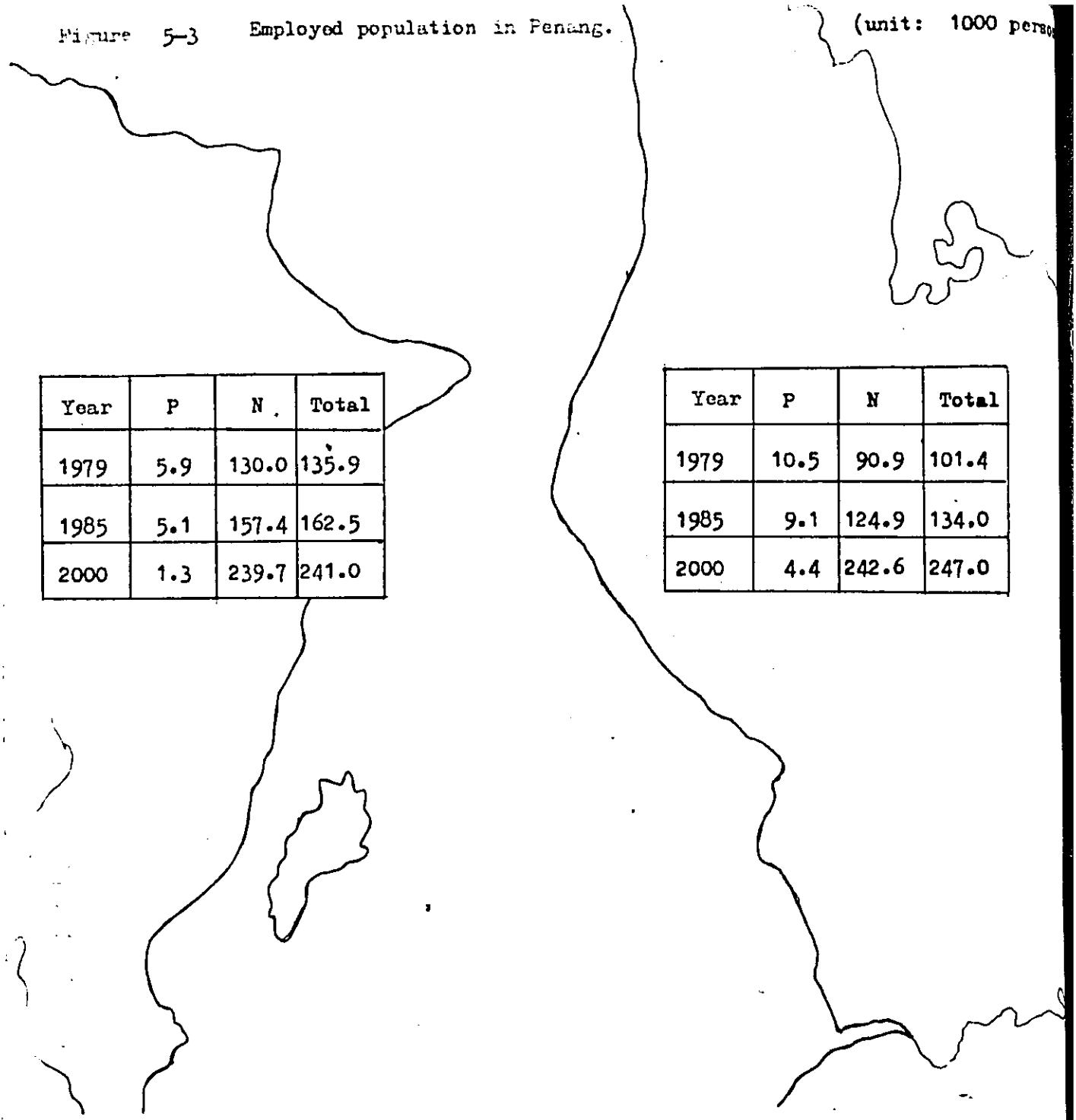

(Unit : 1000 persons)
3.7 4.8 8.2
23.3 25.1 31.2
85.1 93.3 119.4
55.5 49.8 31.8
36.9 45.4 94.7
74.4 81.1 91.8
1.6 2.2 3.8
60.8 64.5 77.0
140.0 142.3 150.8
12.5 12.7 13.8
15.9 19.2 46.8
104.7
62.6
33.5
34.5 35.8 39.6
10.5 10.8 12.8
30.3 35.8 42.0
104.8
53.7
37.5
60.8
13.9 21.4
110.6
47.9
27.9
52.8
28.4 23.2
6.0 6.3 9.0
LEGEND
1975 1985 2000

Figure 5-3 Employed population in Penang. (unit: 1000 pers



Year	P	N	Total
1979	5.9	130.0	135.9
1985	5.1	157.4	162.5
2000	1.3	239.7	241.0

Year	P	N	Total
1979	10.5	90.9	101.4
1985	9.1	124.9	134.0
2000	4.4	242.6	247.0

	Penang State	Study Area
1979	294.0 (100)	237.3 (100)
1985	350.7 (119)	296.5 (125)
2000	541.7 (184)	488.0 (206)

( ) Growth rate

P : Primary
N : Non-primary

(Unit : 1000 persons)

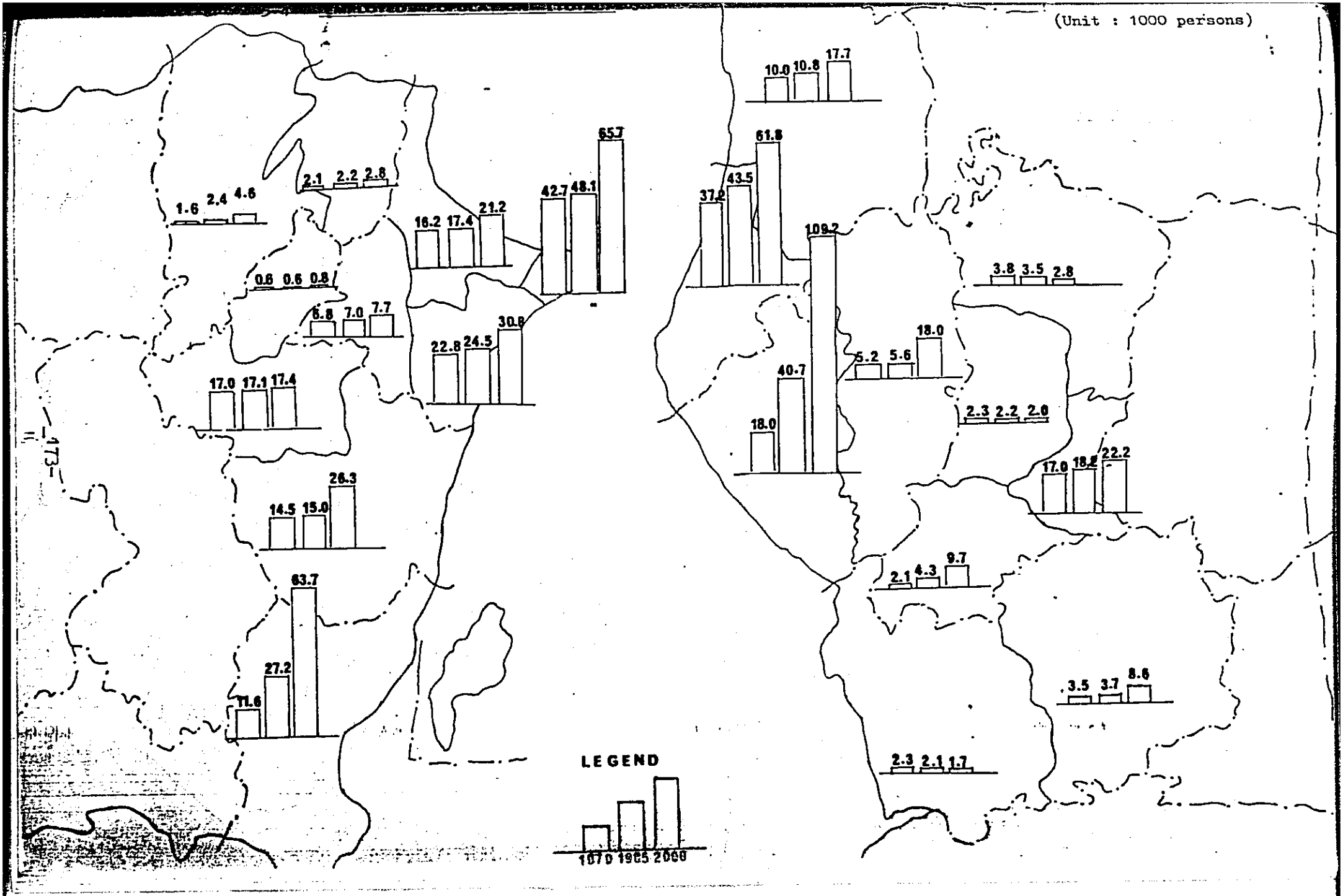


Figure 5-5 EMPLOYED POPULATION (EXCLUDING PRIVATE SECTOR)

(Unit : 1000 persons)

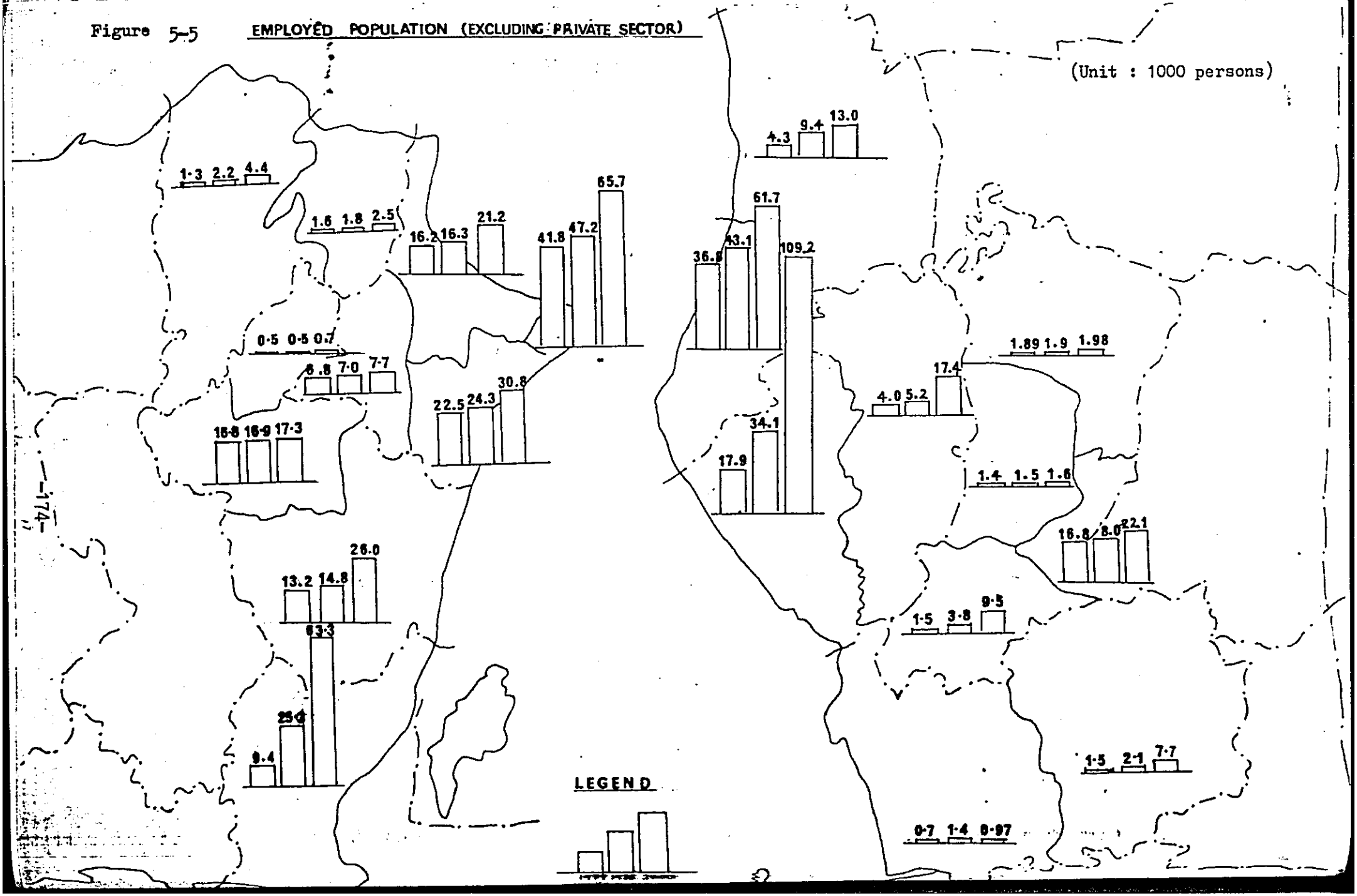


Table 5-1 Employed population by industry in Penang State.

(Unit : 1000 person)

Year / Industry	1979	1985	2000
Primary	53.7	46.3	21.7
Secondary	92.1	127.2	245.4
Tertially	148.3	177.2	274.6
Employed population (A)	294.1	350.7	541.7
Population (B)	946.6	1090.0	1550.0
A/B x 100	31.1 %	32.2 %	34.9%

Table 5-2 Population by age in Penang State.

(Unit : 1000 person)

Year / Age	1979	1985	2000
0 - 14	347.4 (36.7)	390.2 (35.8)	510.0 (32.8)
15- 64	563.2 (59.5)	657.3 (60.3)	979.7 (63.0)
65 and over	36.0 (3.8)	42.5 (3.9)	65.3 (4.2)
Population	946.6	1090.0	1550.0

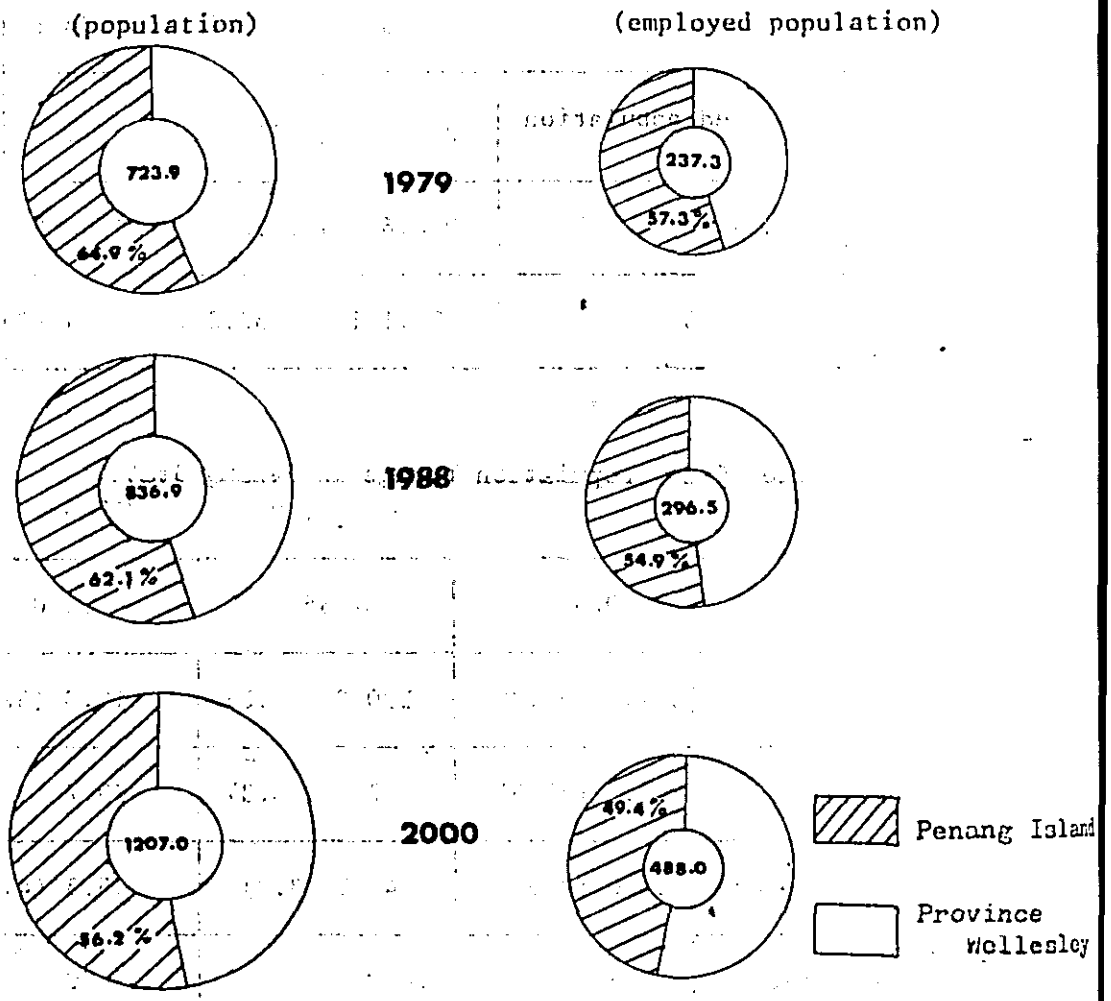
( ) : percentage

5-2 Comparison Between Penang Island and Province Wellesley.

The following figures show population as well as the employed population of Penang Island and Province Wellesley.

These figures indicate that in the future Province Wellesley will experience a great deal of development and also as a result of various existing conditions, the potential for development of Province Wellesley will be as great as that of Penang Island.

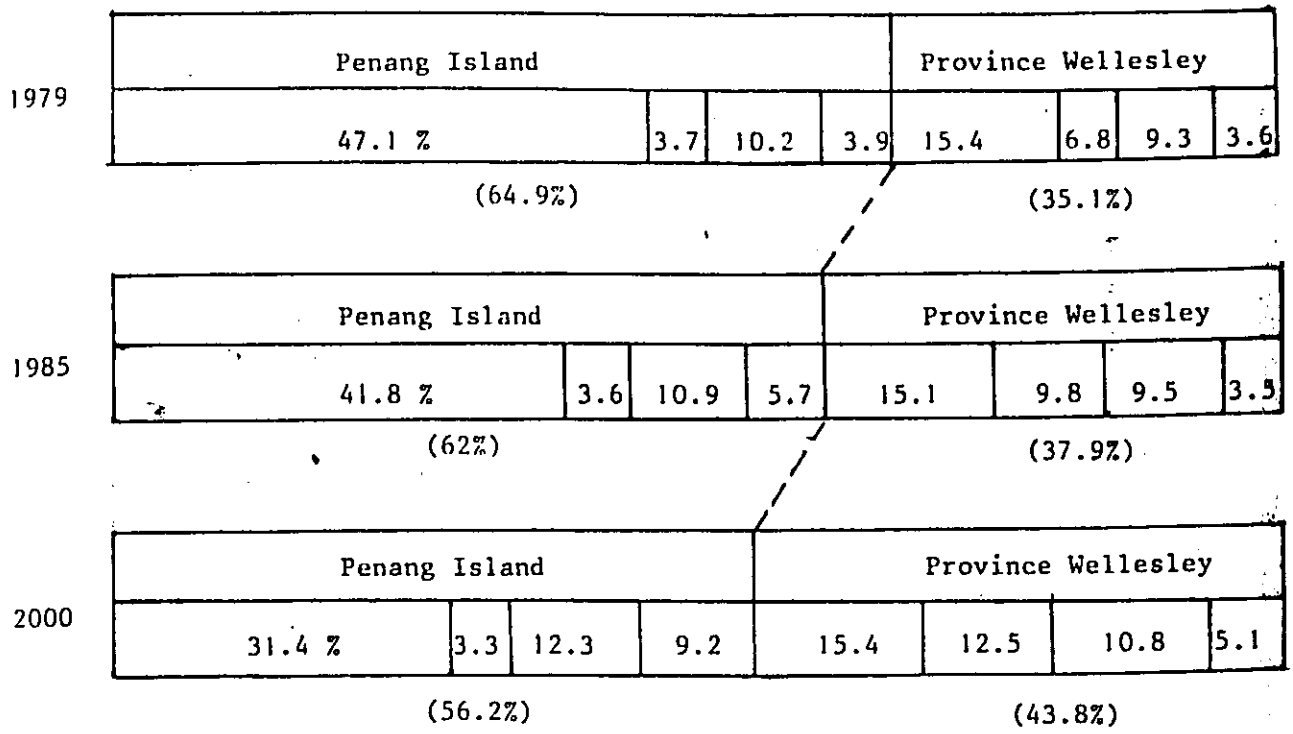
figure 5-6 The percentage of population as well as the employed population.



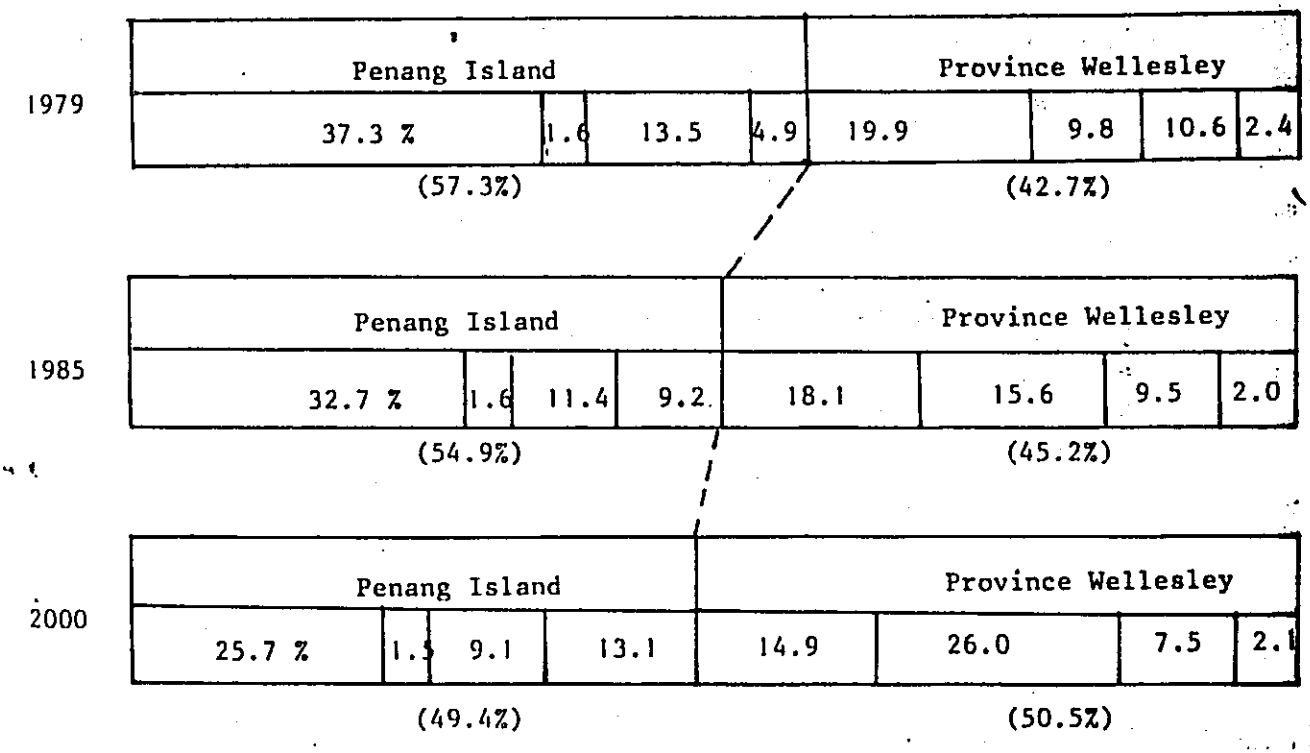
These figures suggest that the traffic volume in Province Wellesley will increased rapidly and the total number of trips will be close to that in Penang Island.

Therefore, traffic problems will arise in Province Wellesley as well in Penang Island.

The trend of the composition of population by large zone.

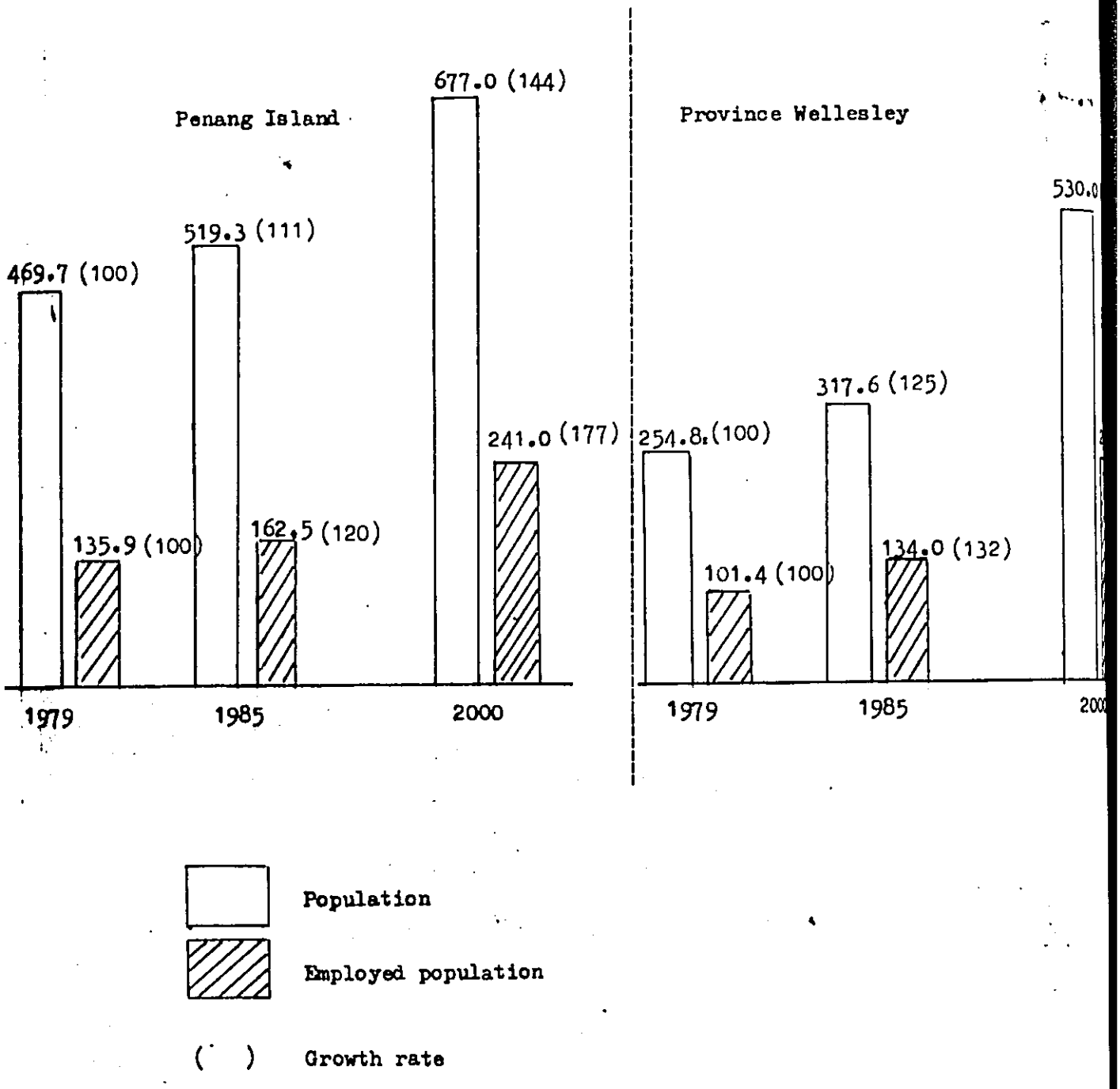


The trend of the composition of employed population by large zone.



( ): Total Percentage

Figure 5-7 Population and employed population



SUMMARY TABLE OF POPULATION DISTRIBUTION

Greater Penang Area, 1979, 1985 and 2009.

	1979		1985		2000		Average Annual Growth Rate (%)		
	Number	Per Cent	Number	Per Cent	Number	Per Cent	1979 - 85	1985-2000	1979-2000
100	341,220	66.5	349,900	60.6	378,900	50.5	0.4	0.5	0.5
200	26,980	5.3	29,940	5.3	39,440	5.3	1.8	1.9	1.8
300	73,630	14.3	91,590	16.4	148,080	19.7	3.7	3.0	3.4
400	27,870	5.4	47,890	8.9	110,590	14.8	9.4	5.4	6.8
Internal Total	469,700	91.5	519,320	91.2	677,000	90.3	1.7	1.8	1.8
External	43,550	8.5	49,780	8.8	73,000	9.7	2.3	2.4	2.4
Penang Is. Total	513,250	100.0	569,100	100.0	750,000	100.0	1.7	1.8	1.8
500	111,310	25.7	126,630	24.1	186,440	23.3	2.2	2.5	2.5
600	49,330	11.4	81,770	16.4	151,440	18.9	8.8	3.9	5.5
700	67,210	15.5	79,710	15.3	130,390	16.3	2.8	3.2	3.2
800	26,310	6.1	29,510	5.6	61,730	7.7	1.9	4.7	4.1
Internal Total	254,160	58.7	317,620	61.9	530,000	66.3	3.8	3.3	3.6
External	178,500	41.3	293,820	38.1	270,000	33.7	2.2	1.8	2.0
Pro. Wellesley Total	433,330	100.0	520,900	100.0	800,000	100.0	3.1	2.9	3.0

EMPLOYED POPULATION DISTRIBUTION PLAN

Penang State, 1979, 1985 and 2000.

	1979			1985			2000			Average Annual Growth Rate %	
	Primary	Non-Primary	Total	Primary	Non-Primary	Total	Primary	Non-Primary	Total	1979-85	1985-2000
100	1,310	87,260	88,570	1,120	95,830	96,950	0	125,400	125,400	1.6	1.7
200	690	2,990	3,680	590	4,060	4,650	400	6,930	7,330	4.0	3.1
300	1,710	30,430	32,140	1,490	32,240	33,730	480	44,020	44,500	0.1	1.8
400	2,220	9,350	11,570	1,910	25,290	23,380	380	63,330	63,710	12.4	6.9
500	2,110	45,110	47,220	1,830	51,720	53,550	850	72,050	72,900	2.1	2.0
600	1,260	21,900	23,160	1,090	45,210	46,300	510	126,570	127,080	12.2	6.9
700	3,510	21,640	25,150	3,030	25,140	28,170	1,510	35,250	36,760	1.9	1.8
800	3,590	2,210	5,800	3,100	2,870	5,970	1,570	8,750	10,320	- 0.5	3.7
Internal Total	16,400	222,600	239,000	14,150	282,360	296,510	5,700	482,300	488,000	3.7	3.4
External Total	37,250	17,750	55,000	32,150	22,040	54,190	16,000	37,700	53,700	0.0	0.0
Grand Total	53,650	240,350	294,000	46,300	304,400	350,700	21,700	520,000	541,700	3.0	2.9

5-3 Number of vehicles.

The trend in motor-vehicle ownership is one of the key-indicators of traffic growth and this is useful tool for evaluating past traffic trends and future volumes.

A. Motor-vehicle Registration Trend.

Recently, there has been a dramatic increase in the registration of motor-vehicles in Malaysia, specificallly Penang State.

Table 5-3 and 5-4 show the trends for Peninsular Malaysia and Penang State.

Table 5-3 Motor-vehicle Registration Trend ②

(Peninsular Malaysia)

(unit : 100 vehicles)

Year / Motor-vehicles ①	1965	1970	1975	1977	Average annual percentage growth		
					1965-1970	1970-1975	1975-1977
Cars	154.3	231.5	398.0	492.3	8.4	11.5	11.4
Taxis	5.2	6.7	9.0	10.9	5.2	6.0	10.0
Lorries & vans	41.9	55.8	92.2	112.0	5.9	10.5	10.0
Buses	3.8	5.9	8.7	10.5	9.2	8.0	10.0
Sub-total	205.2	299.9	507.9	625.7	7.9	11.1	10.9
Motor-cycles	175.8	350.0	722.3	951.1	14.8	15.6	14.9
Population (1000s) ③		8809.6	10062.5	10659.4		2.7	2.8

Note: 1) excludes other motor-vehicles (eg. tractors, road-rollers, etc.)

2) source: Road Transport Department

3) source: "Population Projection for the States of Peninsular Malaysia, 1970 - 1980" Department of Statistics.

Table 5-4 Motor-vehicle Registration Trend ②

(Penang State)

Year / Motor-vehicle ①	1965	1970	1975	1979	Average annual percentage gro		
					1965-1970	1970-1975	1975-19
Cars	20975	28326	45578	65352	6.2	10.0	9.4
Taxis	214	294	386	474	5.5	5.6	5.3
Lorries	3211	5469	8475	11404	11.2	9.2	7.7
Buses	400	512	786	1073	5.1	8.9	8.1
Sub-total	24800	34601	55225	78303	6.9	9.8	9.1
Motor-cycles	27126	47432	89311	124984	11.8	13.5	8.8
Total	51926	82033	144536	203287	9.6	12.0	8.9
Population ③	697653	776124	864771	947530	2.2	2.2	2.3

Note: 1) excludes other vehicles
(eg. tractors, road-rollers, etc.)

2) source: R.I.M.V.

3) source: "Population Projections for the States of Peninsular Malaysia 1970 - 1980" Department of Statistics.

These tables show that the annual percentage growth was the highest for the period 1970 - 1975 after 1975 these figures decreased slightly. It goes without saying that the absolute figures are on the increase after 1975.

Table 5-6 Estimated vehicles volume by using least square method

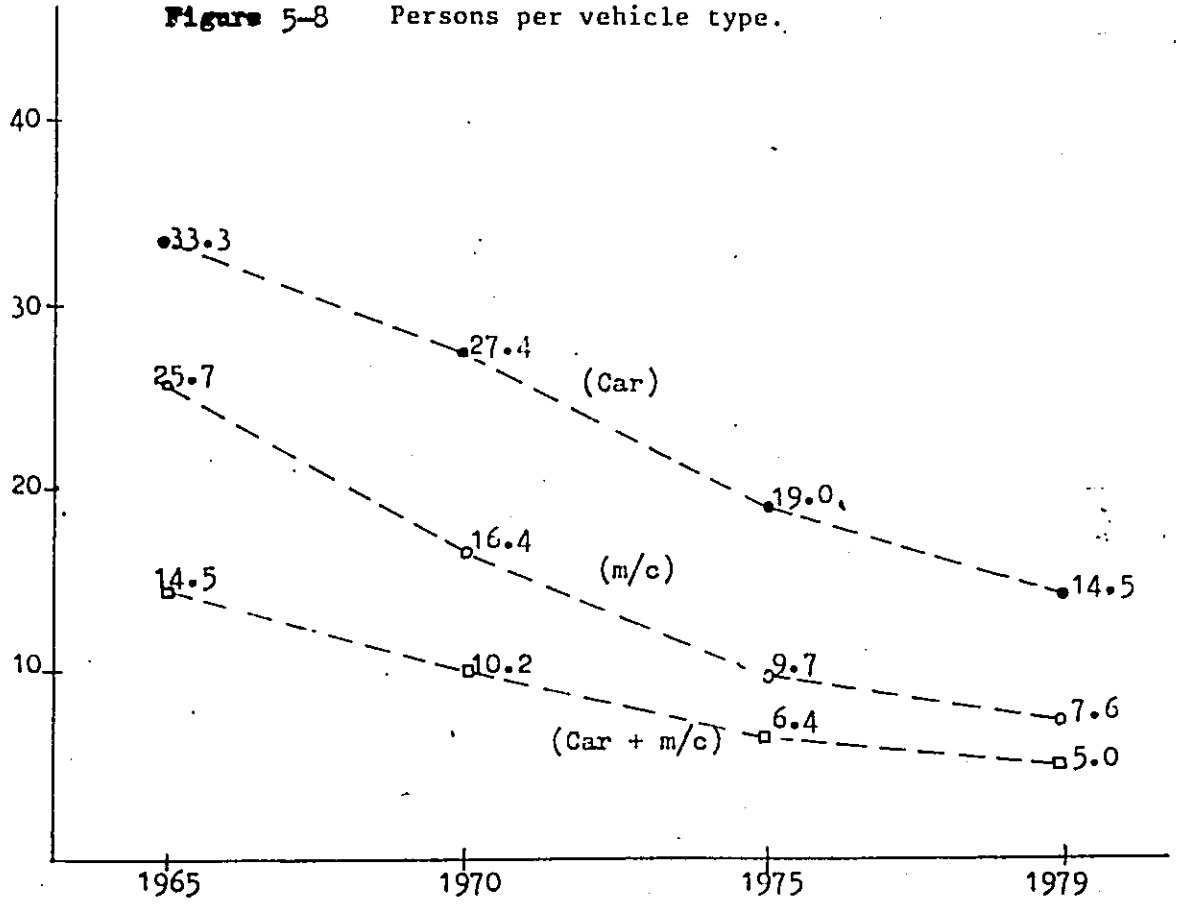
Vehicles	1965	1970	1975	1979	Estimation	
					1985	2000
Cars	20975	28326	45578	65352	80428	127922
M/cycles	27126	47432	89311	124984	162685	269122

B-2. Estimation by using the relationship of the indicators concerned.

These indicators are usually the population figures, household size and income, accurate present and future values cannot be obtained during the study period. Therefore, only the population figures are used as a means of estimating the number of vehicles.

In figure which shows 'persons per vehicle type' we find that the figures are decreasing year by year and the shape of the graph looks like the exponential curve.

Figure 5-8 Persons per vehicle type.



● Car
o Motorcycle
□ Car and Motorcycle

Table 5-7 Calculation of persons per vehicle type.

		1965	1970	1975	1979
Population A		697653	776124	864771	947530
Car B		20975	28326	45578	65352
Motorcycle C		27126	47432	89311	124984
Car & motorcycle D		48101	75768	124889	190336
Persons by vehicle type	B/A	33.3	27.4	19.0	14.5
	C/A	25.7	16.4	9.7	7.6
	D/A	14.5	10.2	6.4	5.0

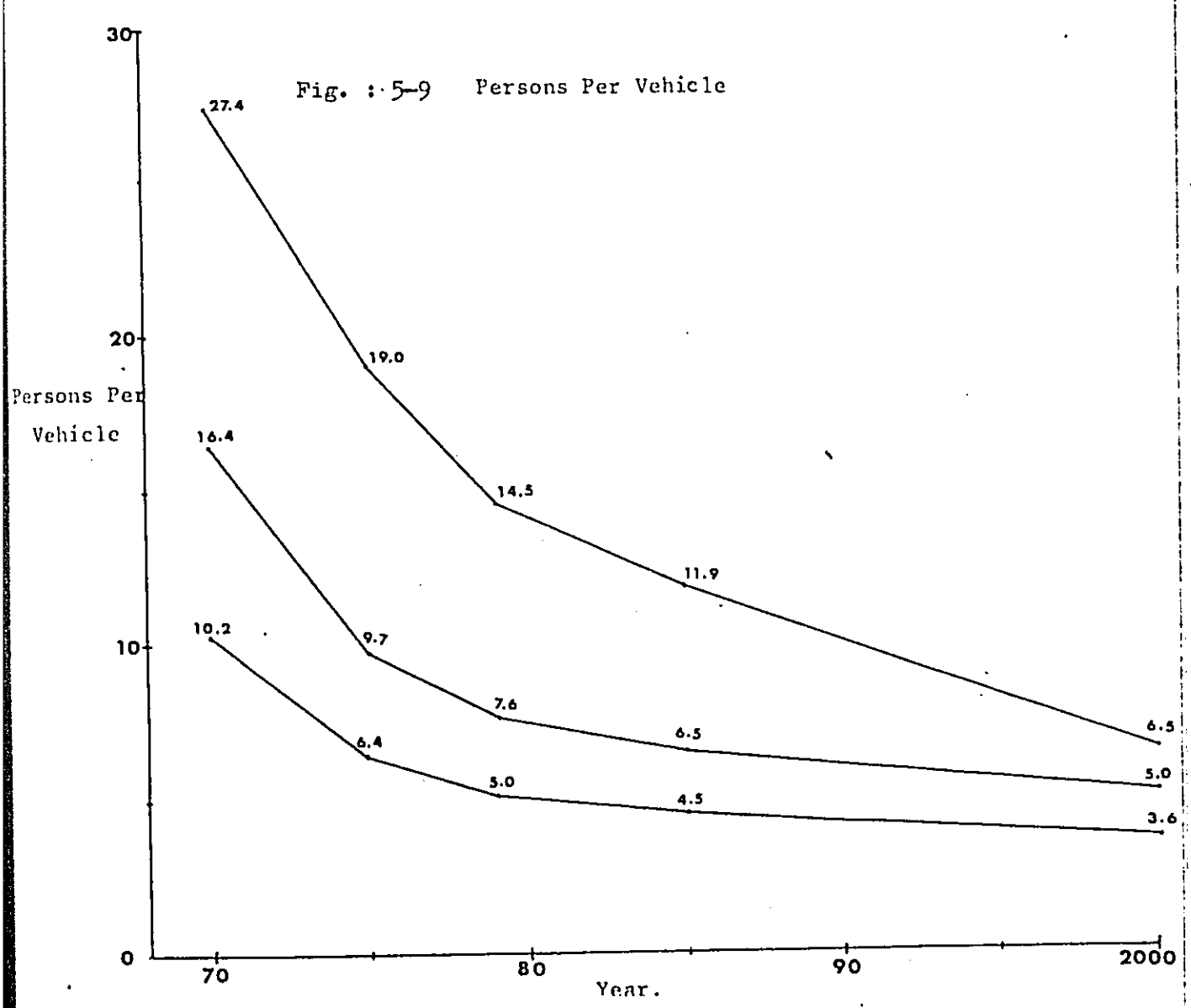
Therefore, the exponential function is applied for the purpose of drawing the curve to estimate the future number of vehicles.

The results as obtained from using the exponential curve are as follows.

Table: 5-8 Persons per vehicle . (Unit : persons per vehicle)

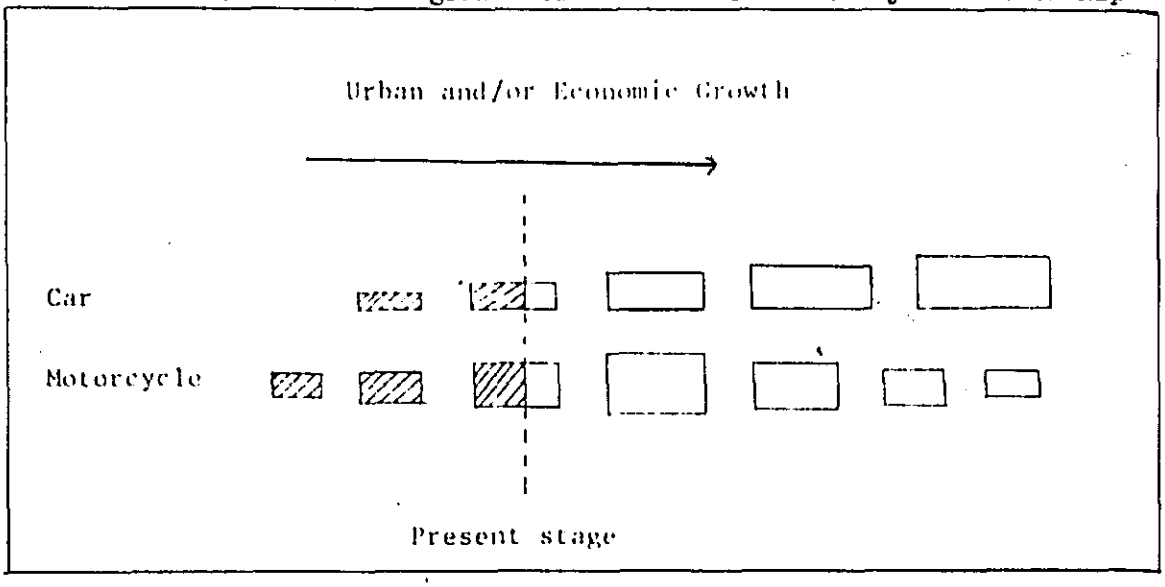
	70	75	79	85	2000
Car	27.4	19.0	14.5	11.9	6.5
M/C.	16.4	9.7	7.6	6.5	5.0
Car + M/C.	10.2	6.4	5.0	4.5	3.6

Fig. : 5-9 Persons Per Vehicle



A developed nation's urban history show that the modes of transport envolved parallel with the development of cities and urban incomes rose. It has been observed that Penang follows the evolutionary transition illustrated by the chart below:-

Figure 5-10 The trends of the growth of vehicles and motorcycles ownership



Previous Stage

Future Stage

The growth rate for motor-cycles does not seem to be following the present trend.

In time to come, it will be decreasing rapidly with the rate of urbanisation and economic growth.

The number of motor-cycles is estimated by subtracting the number of cars from the number of cars and motor-cycles.

Ownership for the other types of vehicles can also be estimated by the trend method.

The number of vehicles according to type is shown as follows:-

In time to come, it will be decreasing rapidly in live with the rate of urbanization and economic growth.

The number of motor-cycles is estimated by subtracting the number of cars from the number of cars and motor-cycles.

The results of the estimation are as follows:-

Table 5-9 Estimated motor-cycles volume (unit:1000 motorcycles)

	1970	1979	1985	2000
Population	776.1	947.5 (100)	1090.0 (115)	1550.0 (164)
Number of cars & m/cycles	75.8	190.3	231.9	360.5
Number of cars	28.3	65.4 (100)	91.6 (140)	161.5 (247)
(Persons per car)	(27.4)	(14.5)	(11.9)	(9.6)
Number of m/cycles	47.4	125.0 (100)	140.3 (112)	199.0 (159)
(Persons per m/cycle)	(16.4)	(7.6)	(7.7)	(7.8)

Ownership for the other types of vehicles can also be estimated by the trend method.

The number of vehicles according to type is shown as follows:-

Table 5-10 The number of vehicle in Penang State

Vehicles	1979	1985	2000
Car	65.4	91.6	161.5
Taxi	0.5	0.7	1.2
Lorry	11.4	16.0	28.3
Bus	1.1	1.5	2.7
Sub-total	78.3 (100)	109.9 (140)	193.8 (248)
Motorcycle	125.0 (100)	140.3 (112)	199.0 (170)
Grand total	203.3	250.2	392.8

( ) Growth rate (unit: 1000 vehicles)

Table: 5-11 Number of vehicles in Penang State.

(unit:1000 vehi

	70	75	79	85	2000
Car	28.3 (100)	45.6 (161)	65.4 (231)	91.6 (324)	238.5 (842)
Lorry	5.5 (100)	8.5 (155)	11.4 (207)	16.0 (291)	35.5 (645)
Taxi	0.3 (100)	0.4 (133)	0.5 (167)	0.7 (233)	2.1 (700)
Bus	0.5 (100)	0.8 (160)	1.1 (220)	1.5 (300)	3.1 (620)
Sub-total	34.6 (100)	55.2 (160)	28.3 (226)	109.8 (317)	279.2 (807)
M/C	47.4 (100)	89.3 (188)	125.0 (264)	150.6 (317)	192.1 (405)

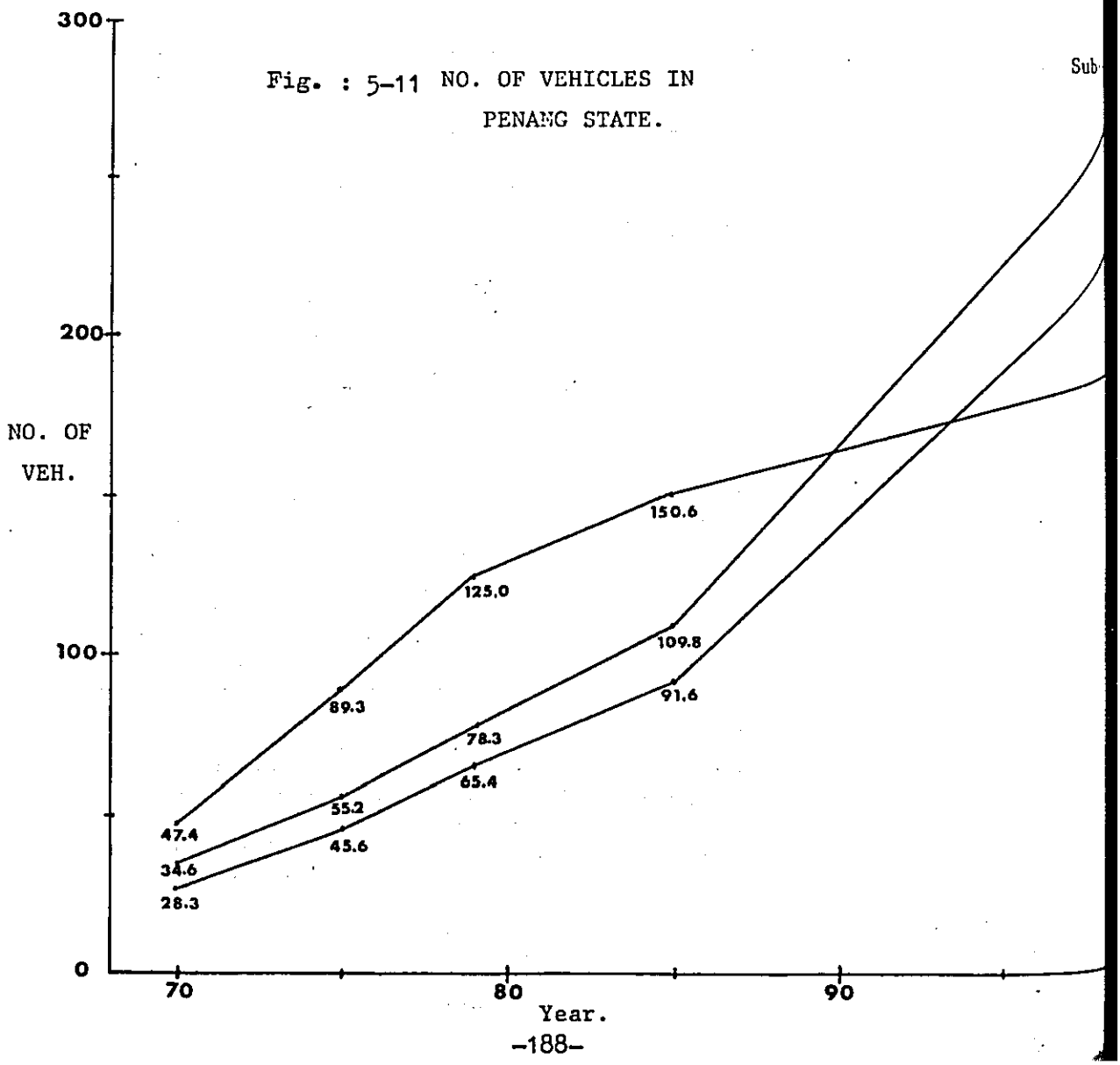


Fig. : 5-11 NO. OF VEHICLES IN PENANG STATE.

C. The number of vehicles in the study area.

The number of vehicles by area is estimated by distributing the increase in the number of vehicles since 1979 to each area according to the increase in the population by area since 1979.

Table: 5 - 12 Number of vehicles in Internal Area. (unit: 1000 vehicles)

	79	85	2000
Car	59.3 (100)	79.8 (135)	202.6 (342)
Lorry	9.4 (100)	13.0 (138)	28.8 (306)
Taxi	0.4 (100)	0.6 (150)	1.9 (475)
Bus	0.9 (100)	1.2 (133)	2.5 (278)
Sub-total	69.9 (100)	94.6 (135)	235.7 (337)
M/C.	105.1 (100)	124.0 (118)	155.0 (147)
Population / no of total	4.13	3.83	3.09

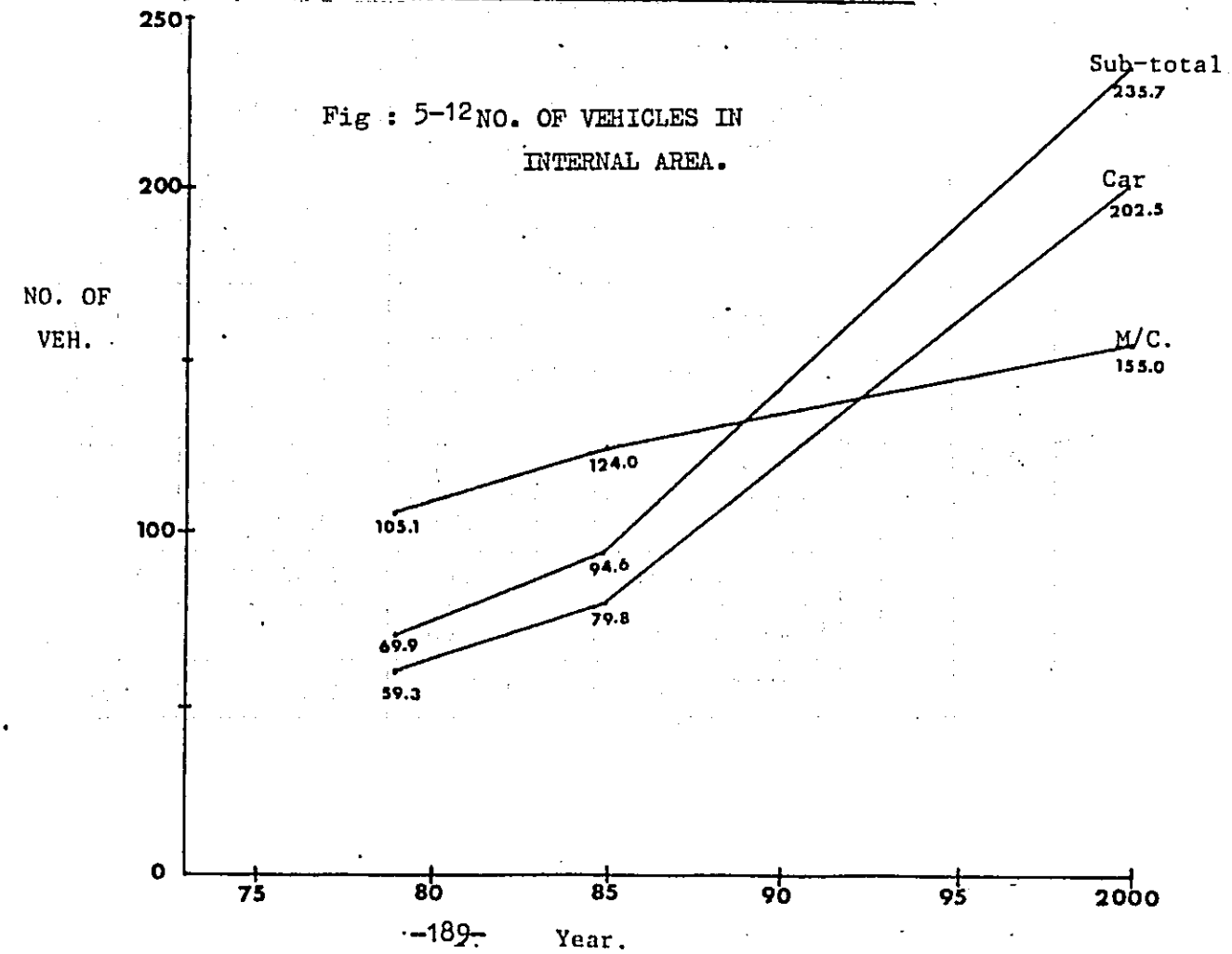


Fig : 5-12 NO. OF VEHICLES IN INTERNAL AREA.

5-4 Summary of the premise.

Table 5 - 13 Summary table of the premise.

(Unit:1000 person, ve

			1979	1985	2000
Population and Employment	Population	P.I	469.7 (100)	519.3 (111)	677.0 (144)
		P.W	254.2 (100)	317.6 (125)	530.0 (208)
		INTERNAL AREA	723.9 (100)	836.9 (116)	1207.0 (167)
		Penang State	946.6 (100)	1090.0 (115)	1550.0 (164)
		Internal/Penang	76.5 %	76.8 %	77.9 %
	Employment	P.I	135.9 (100)	162.5 (120)	241.0 (177)
		P.W	101.4 (100)	134.0 (132)	247.0 (244)
		Internal Area	237.3 (100)	296.5 (125)	488.0 (206)
		Penang State	294.0 (100)	350.7 (119)	541.7 (184)
		Internal/Penang	80.7 %	84.5 %	90.0 %
Number of Vehicles	Car	P.I	44.7 (100)	57.9 (130)	130.9 (293)
		P.W	14.6 (100)	21.9 (150)	71,7 (491)
		Internal Area	59.3 (100)	79.8 (135)	202.6 (342)
		Penang State	65.4 (100)	91.6 (140)	238.5 (365)
		Internal/Penang	90.6 %	87.1 %	84.9 %
	Vehicle	P.I	50.7 (100)	67.5 (133)	147.6 (291)
		P.W	19.2 (100)	27.1 (141)	88.1 (459)
		Internal Area	69.9 (100)	94.6 (135)	235.7 (237)
		Penang State	78.3 (100)	109.8 (140)	279.2 (357)
		Internal/Penang	89.3 %	86.2 %	84.4 %
	Motorcycle	P.I	67.8 (100)	77.9 (115)	84.4 (124)
		P.W	37.4 (100)	46.1 (123)	70.6 (189)
		Internal Area	105.1 (100)	124.0 (118)	155.0 (147)
		Penang State	125.0 (100)	150.6 (120)	192.1 (154)
		Internal/Penang	84.1 %	82.0 %	80.7 %

6 Estimation of future traffic demand.

6-1 Outline of the flow-chart for estimation and some definition.

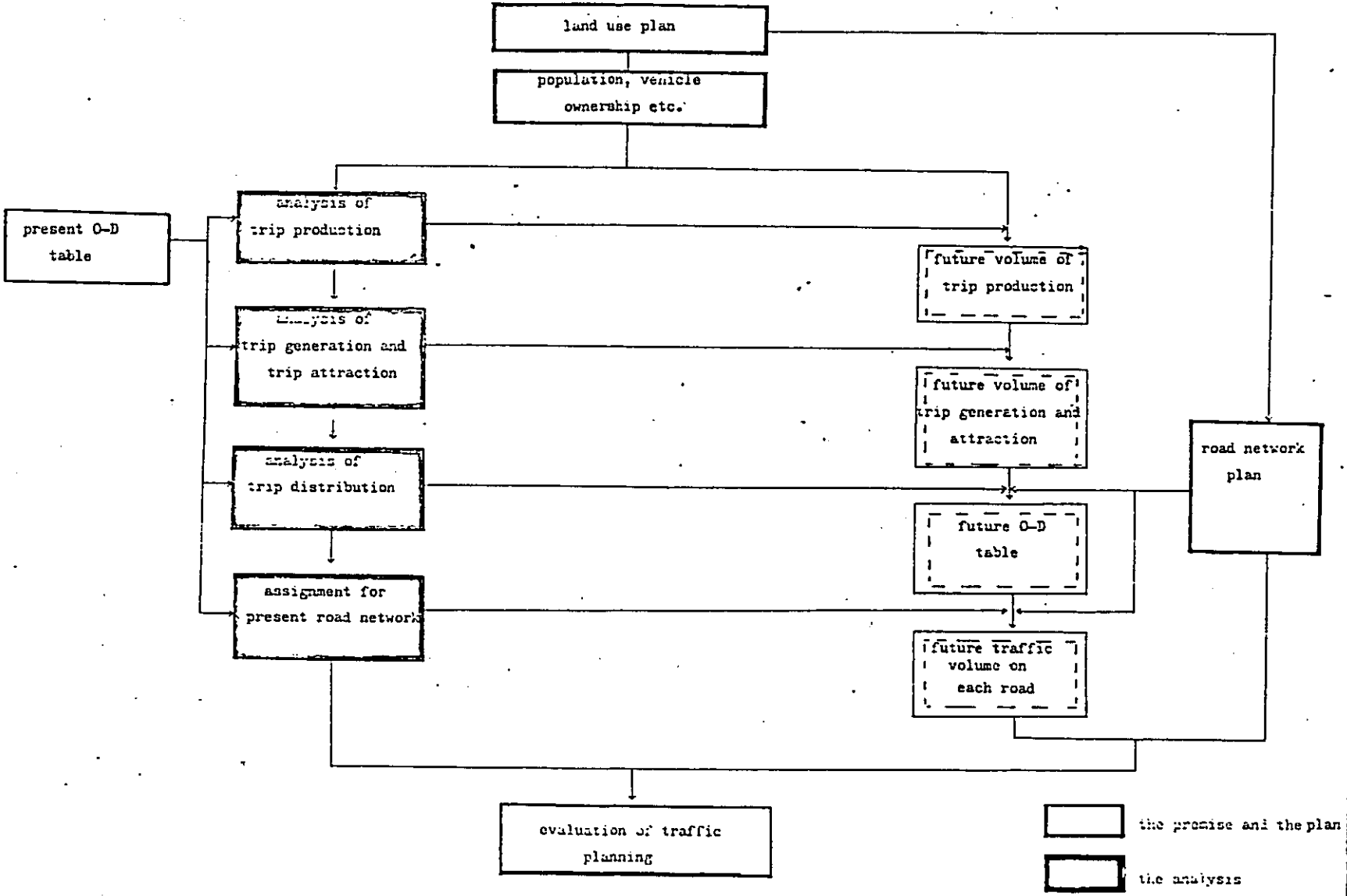
(1) Outline of the flow-chart.

The analysis of the present traffic situation was done in chapter 3. The estimation for the future traffic demand will be carried out on the basis of this analysis and the mentioned premise.

The flow-chart is as follows:-

The procedure of estimation are consisted with four steps, that is, trip production, trip generation and attraction, trip distribution (O-D table) and traffic assignment.

Figure 6-1 Flow chart for the future traffic demand estimation



(2) Some definition about traffic words

① Passenger Car Units

Vehicles of different types require different amounts of road space because of variations in size and performance. In order to allow for this in capacity measurements for roads and junctions, traffic volume are expressed in passenger car units (p.c.u.).

In 'Roads in Urban Areas' (published by Ministry of Transport Scottish Development Department), these p.c.u. are defined as following table.

In this study, we use the following figure as p.c.u. of urban standards.

Table 6-1 Passenger Car Units

Class of vehicle	Equivalent value in passenger car units (pcu's)			
	Urban standards	Rural standards	Round-about design	Traffic signal design
Private car, taxi, motor-cycle combination, light goods vehicle (up to 30 cwt. unladen)	1.00	1.00	1.00	1.00
Motor-cycle (solo), motor scooter, moped	0.50	0.75	0.75	0.33
Medium or heavy goods vehicle (over 30 cwt. unladen), horse-drawn vehicle	2.00	3.00	2.80	1.75
Bus, coach, trolley bus, tram	3.00	3.00	2.80	2.25
Pedal-cycle	0.33	0.50	0.50	0.20

('Roads in Urban Areas')

② Carriage-way Capacity

Approximately practical capacities of urban roads between junction are defined as following Table in above-mentioned report.

Table 6-2 Practical capacities of two-way urban roads

Effective width of carriageway in feet (excluding refuges or central reserve)	2-lane			3-lane		4-lane			6-lane			Remarks
	20'	22'	24'	30'	33'	40'	44'	48'	60'	66'	72'	
Description	Capacity in pcu's per hour for BOTH directions of flow					Capacity in pcu's per hour for ONE direction of flow						(for definitions of road types see Section 2.1)
Urban motorway with grade separation and no frontage access								3,000			4,500	Applicable to the high category of *distributor*
All-purpose road with no frontage access, no standing vehicles permitted and negligible cross-traffic	1,200	1,350	1,500	2,000	2,200	2,000	2,200	2,400	3,000	3,300	3,600	Appropriate for all-purpose *distributors*
All-purpose street with high-capacity junctions and 'No Waiting' restrictions	800	1,000	1,200	1,600	1,800	1,200	1,350	1,500	2,000	2,250	2,500	Applicable to those *distributors* and *access roads* where access to development is free but capacity is not usually restricted by junctions
									2,200 for dual carriageways	2,450	2,700	

'Roads in Urban Areas'

The average daily capacity are calculated as following formula.

$$\text{Average daily capacity} = \frac{\text{practical capacity per hour}}{\text{ratio of peak-hour traffic demand}}$$

Concerning to the ratio of peak-hour traffic demand, 10.0% in 2-lane roads 12% in 4 - lane roads are applied from traffic volume survey in Penang.

Therefore, the capacities are decided as follows;

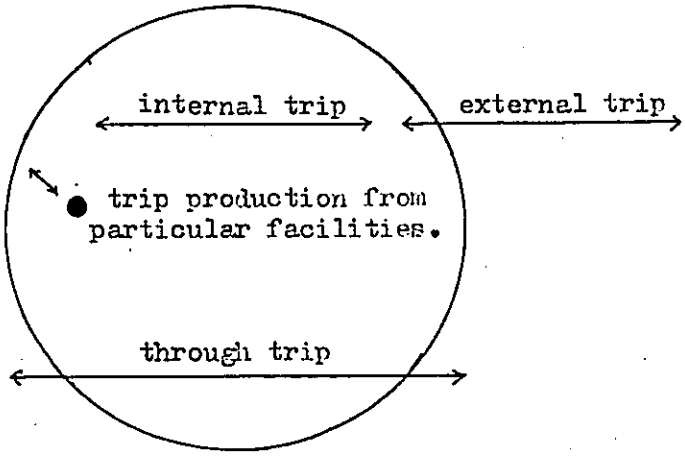
Table 6-3 The Daily Capacity

		Urbanized Area		Sub-Urban Area		High-way
		existing	new road	existing	new road	
2 lane	Capacity per hour	800 (22')	1200 (24')	1000 (22')	1500 (24')	
	Ratio of peak hour	10%	10%	10%	10%	
	Daily capacity	8000	12000	10000	15000	
4 lane	Capacity per hour for one direction	1200 (44')	1500 (48')	1350 (44')	2400 (48')	3000 (48')
	Ratio of peak hour	12%	12%	12%	15%	17%
	ratio of one direction	55%	55%	55%	55%	55%
	Daily capacity	36000	45000	41000	58000	64000

6.2 Estimation of Future O-D Table.

6.2.1 Trip Production

The future traffic volume, related to the study area is divided into the following types viz internal trip, external trip, through trip and trip production from specific facilities.



With regards to 'internal trip', 'external trip' and 'through trip', they have already been explained in chapter 1. 'Particular facilities' in this section means the new port, other port facilities and the airport.

These facilities will produce more traffic than that produced as a result of population increase. This is because there will be a rapid increase in the volume of cargo handled by the port and also in the volume of air passengers. Therefore, trip production from these facilities must be considered separately from the usual trip production.

(1) Internal trip

The internal trip production is estimated by multipling the number of vehicles with the unit trip production already determined in this analysis.

Table 6-4 Number of Trip in Internal Area

		Car	Lorry	Taxi	Bus	Sub-Total	M/C
Number of Vehicle	1979	59.3	9.4	0.4	0.9	69.9	105.1
	1985	79.8	13.0	0.6	1.2	94.6	124.0
	2000	202.6	28.8	1.9	2.5	235.7	155.0
Number of Trip	1979	236.0	28.4	2.7	19.0	286.1	397.3
	1985	312.9	39.1	4.8	24.7	381.5	437.7
	2000	710.7	86.7	15.3	51.5	864.2	449.5

However, some explanation is needed regarding the unit trip production of cars and motor-cycles.

As future number of cars and motor-cycle shows, these number will increase with the increase in population and the level of income.

The average possession number per person about private car will increase from 0.08 in 1979 to 0.10 in 1985 and 0.17 in 2000. Also, those number about motor-cycle will be 0.15 in 1985, o.14 in 2000 from 0.14 in 1979.

In any case, the ownership of private cars and motor-cycles per person and per household will increase without doubt.

As the number of private cars and motor-cycles increase, the unit trip production per day will decrease. It is proved by the results of many surveys in advanced countries.

Therefore, in the estimation of the volume of trip production by private cars and motor-cycles, we consider these situation and the unit trip production are settled to be slightly decreased figure from present one according to the increased ratio of car and motor-cycle possession.

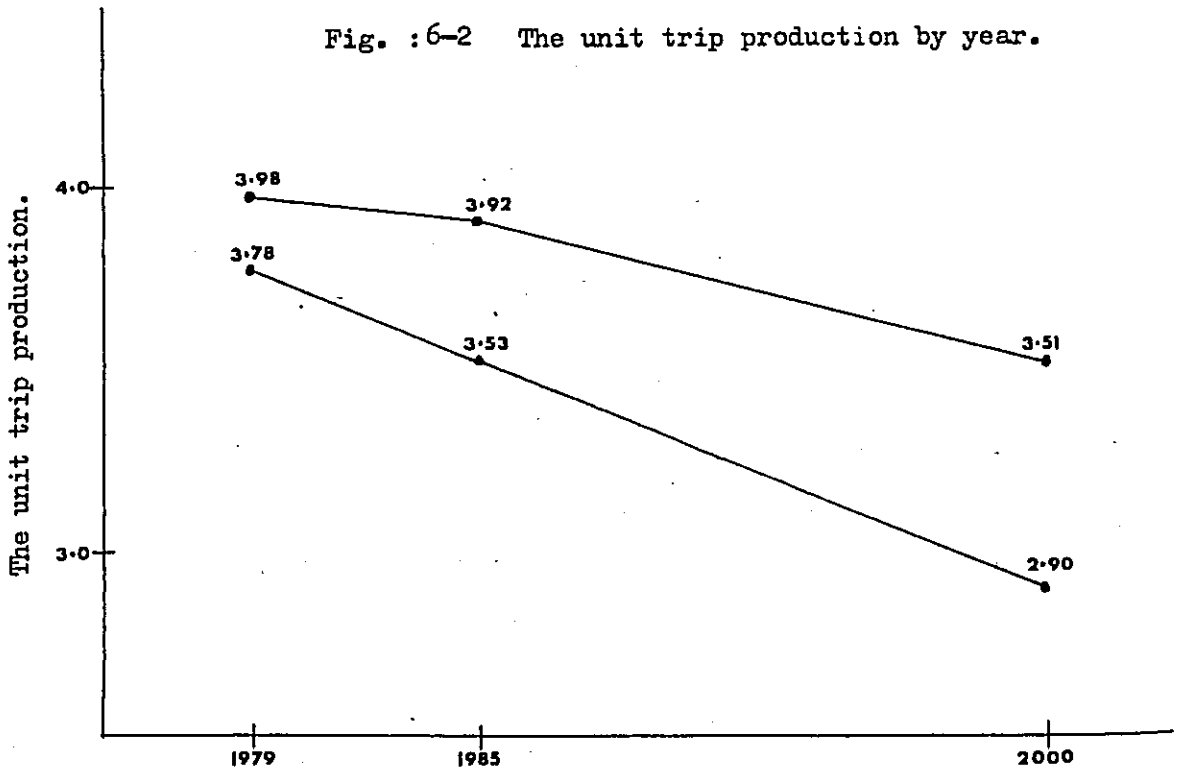
Concerning to other type of vehicle, the unit trip production are settled to be same figure in present.

Table 6-5 The Unit Trip Production

(Unit : trips per vehicle)

	1979	1985	2000
Private Car	3.98	3.92	3.51
Motor-cycle	3.78	3.53	2.90

Fig. :6-2 The unit trip production by year.



(2) Trip production from specific facilities.

The specific facilities in this section refer to the port and the airport.

The future cargo volume is estimated by using the relationship between the cargo volume and the Gross Domestic Product (G.D.P.).

Table 6-6 Cargo Tonnage in Penang Port (Unit : 1000 tons per year.)

	1979	1985	2000
Cargo Tonnage in Penang Port	5.12 (100)	7.94 (155)	12.5 (245)

The cargo volume by wharf for 1985 and 2000 estimated by using the data from the Penang Port Commission.

Table 6-7 Future cargo volume by cargo type and wharf. (Unit:1000 tons)

Location of Wharf \ year / cargo type		1985	2000
Penang Island	Commodity	535	550
	Fuel oil	85	150
	total	623	700
Butterworth	Commodity	2513	3090
	Fuel oil	-	-
	total	2513	3090
Prai River Area	Commodity	739	740
	Fuel oil	-	-
	total	739	740
Prai Marginal Area	Commodity	728	1130
	Fuel oil	650	1120
	total	1378	2250
New Development Area	Commodity	1296	3500
	Fuel oil	1391	-
	total	2687	3500
total	Commodity	5814	9230
	Fuel oil	2126	3270
	total	7940	12500

Trip production from these wharfs is estimated on the basis of their carrying capacity by each commodity type. The results are shown in the following table.

Table6-8 Trip production by wharf (Unit : 1000 trips per day)

Location of wharf \ year	1979	1985	2000
Penang Island	3.6	4.1	5.3
Butterworth	7.9	9.0	13.0
Prai River Area	1.7	1.9	3.9
Prai Marginal Area	2.3	2.6	2.9
New Development Area	-	4.0	15.9
Total	15.5 (100)	21.6 (140)	41.0 (213)

The Passengers bound for and departing from Penang Island are increasing at a rapid rate and in the time span of one decade, the growth rate shows a 5 times increase.

Table 6-9 No. of passengers (bound for/departing from Penang Island) Unit: 1000 persons per year)

Year	Passenger	Year	Passengers
1968	137.8	1974	497.0
'69	162.9	'75	560.6
'70	198.7	'76	588.6
'71	233.4	'77	635.6
'72	286.6	'78	685.5
'73	441.2		

The future volume of passengers is estimated by the regression equation.

Table 6-10 Future volume of passengers

(Unit : 1000 persons per year)

	1970	1975	1978	1979	1985	2000
Passengers	198.7 (100)	560.6 (282)	685.5 (345)	705.5 (355)	1129.5 (568)	4234.0 (2131)

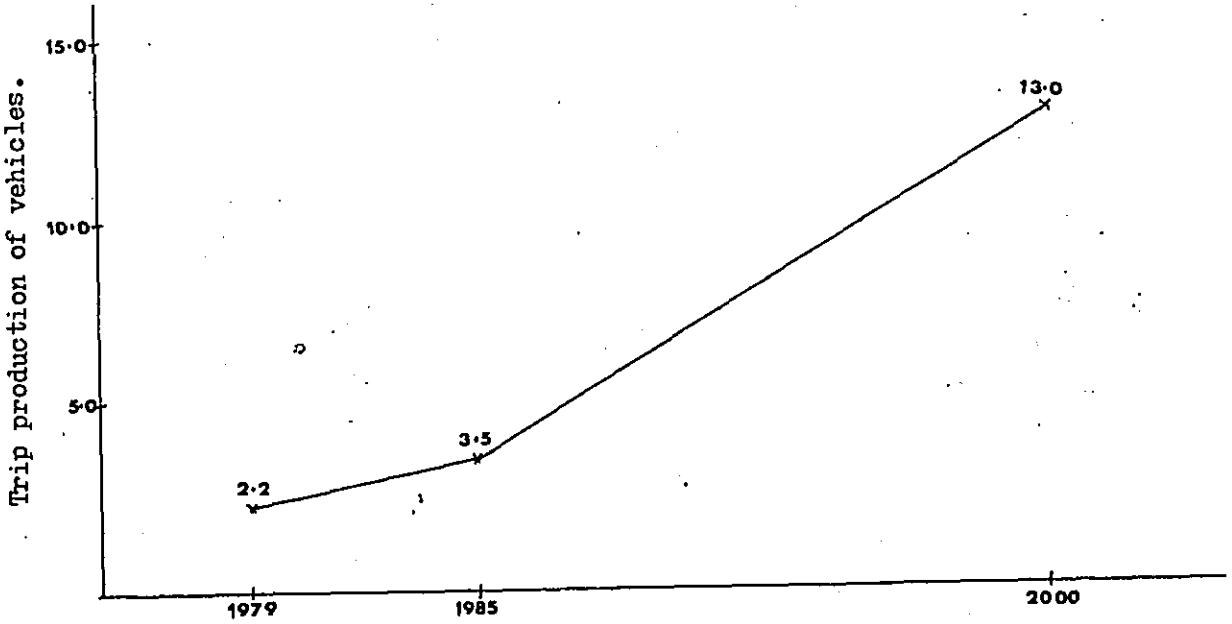
Trip prosuction from the airport is estimated from the growth rate of passengers as shown below:-

Table 6-11 Trip production (persons per day)

	1979	1985	2000
passengers per day	1930 (100)	3090 (160)	11600 (600)
trip production of vehicles	2165*	3460	13000

* From our Traffic Generation Survey (14.6.1979)

Fig : 6-3 Trip production from Air Port.



(3) External trips and through trips.

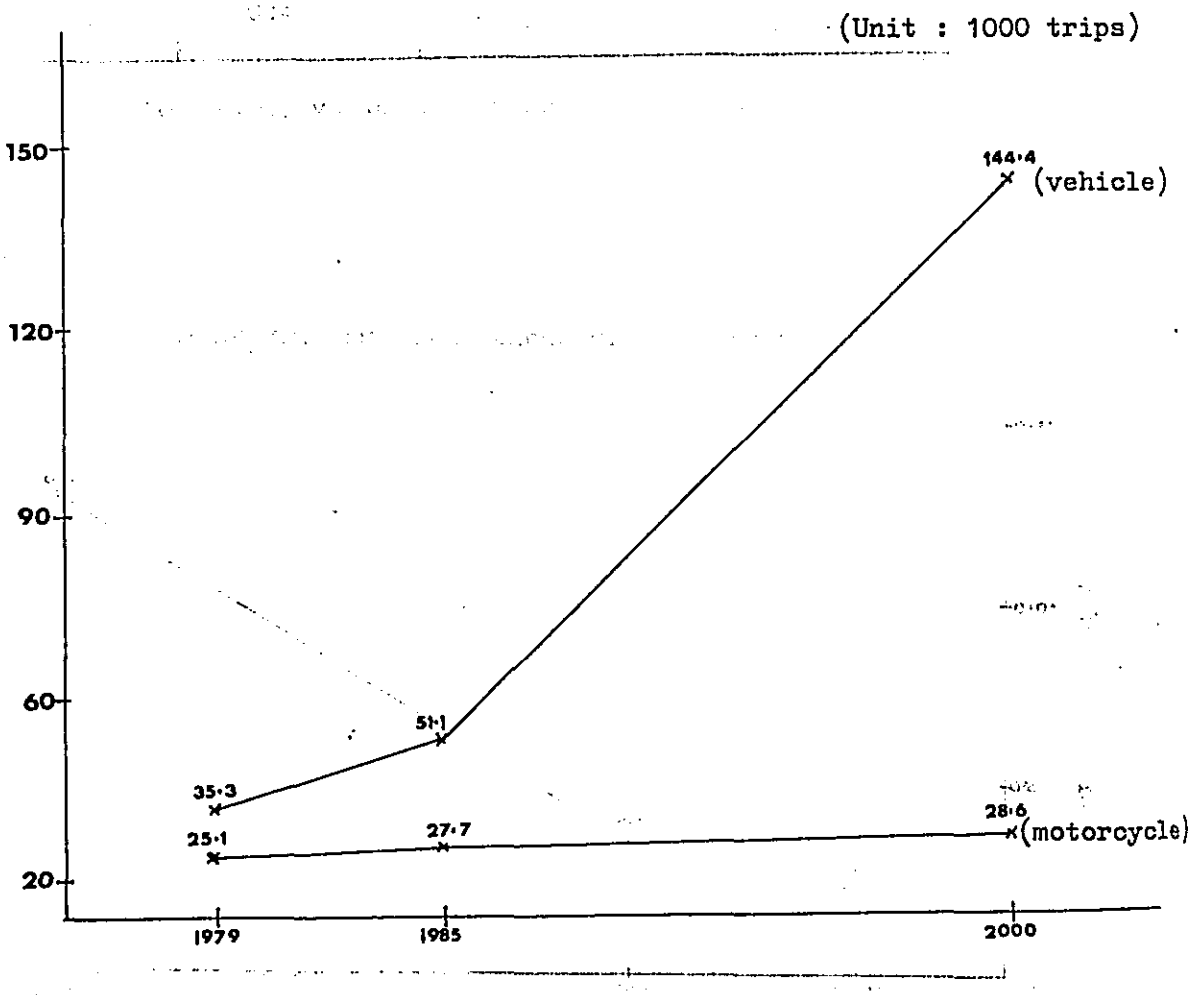
The rate of growth of external trips and through trips in the future is dependant upon the rate of growth of the external area.

With regards to Penang Island, the rate of growth of external trips is estimated by using the growth rate population in the external area of Penang Island.

In Province Wellesley on the other hand, the rate of growth of external trips is calculated by using the estimation from the 'Feasibility study of Federal Route 1' and the 'Feasibility study of the East-West Highway.'

The result of the estimation is as follows:-

Fig. : 6-4 External and Through trips.



(4) Total number of trip related to the study area.

The estimation for the number of trips was conducted separately according to the type of trips. The summary of these estimation are as follows :-

Table 6-12 Total number of trips (unit: 1000 trip perday)

		1979	1985	2000
vehicles	internal trip	286.1	381.5	864.2
	external and through trip	35.3	51.1	144.4
	trip production from specific facilities	—	(6.1) (1.3) 7.4	(25.5) (10.8) (36.3)
		321.5	440.0	1044.9
motorcycles	internal trip	397.3	437.7	449.3
	external and through trip	25.1	27.7	28.6
		422.4	465.3	477.9

6-2-2 Trip generation and attraction.

(1) Future trip generation and attraction.

Future volume of trip generation and attraction is calculated by the trip generation and attraction model which is derived from the present traffic and population data.

The results are as follows:-

Fig:6-5 The relationship with trip generation and population

(unit:1000 p.c.u, person)

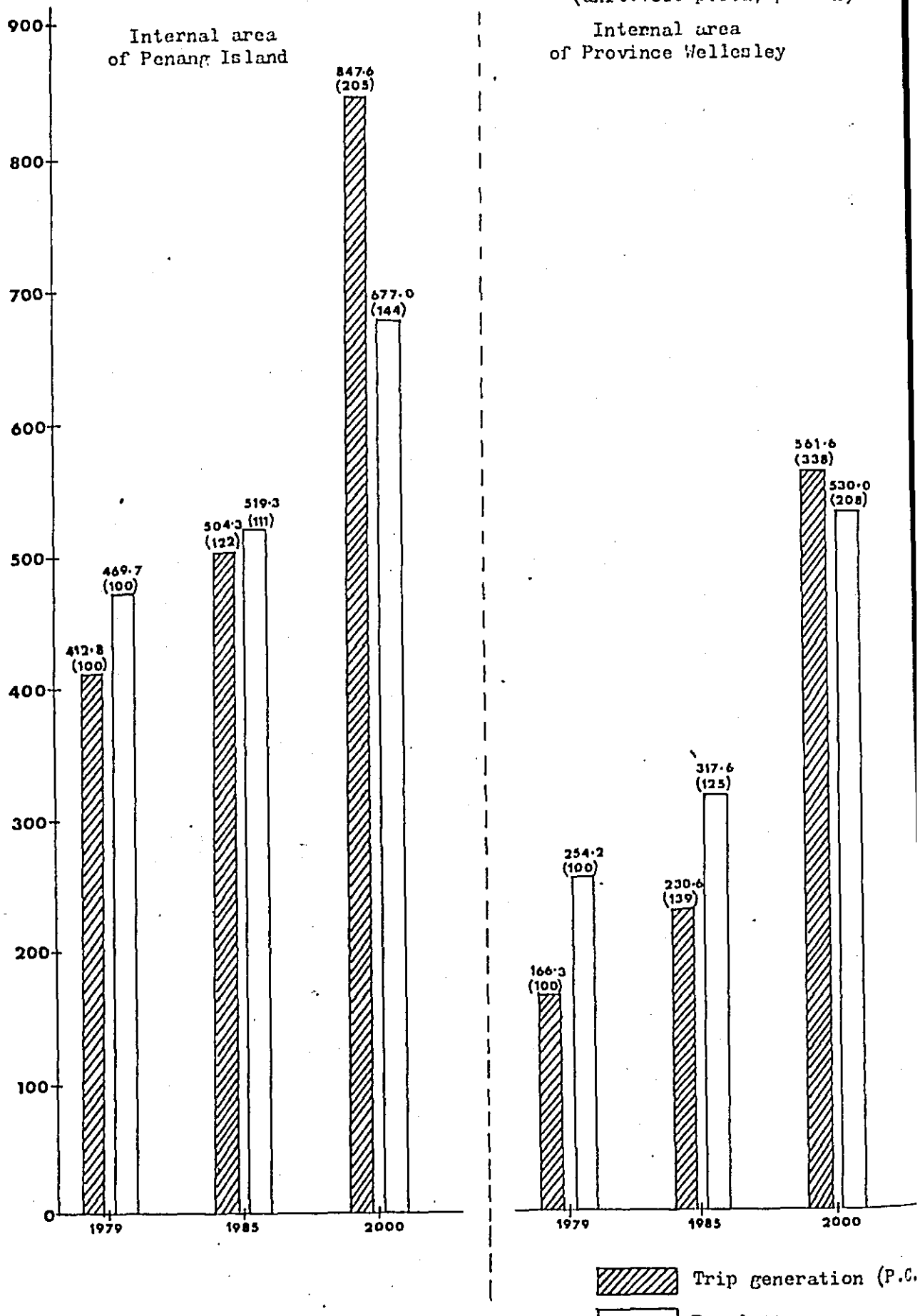


Fig: 6–6 Trip generation in Penang Island and Province Wellesley

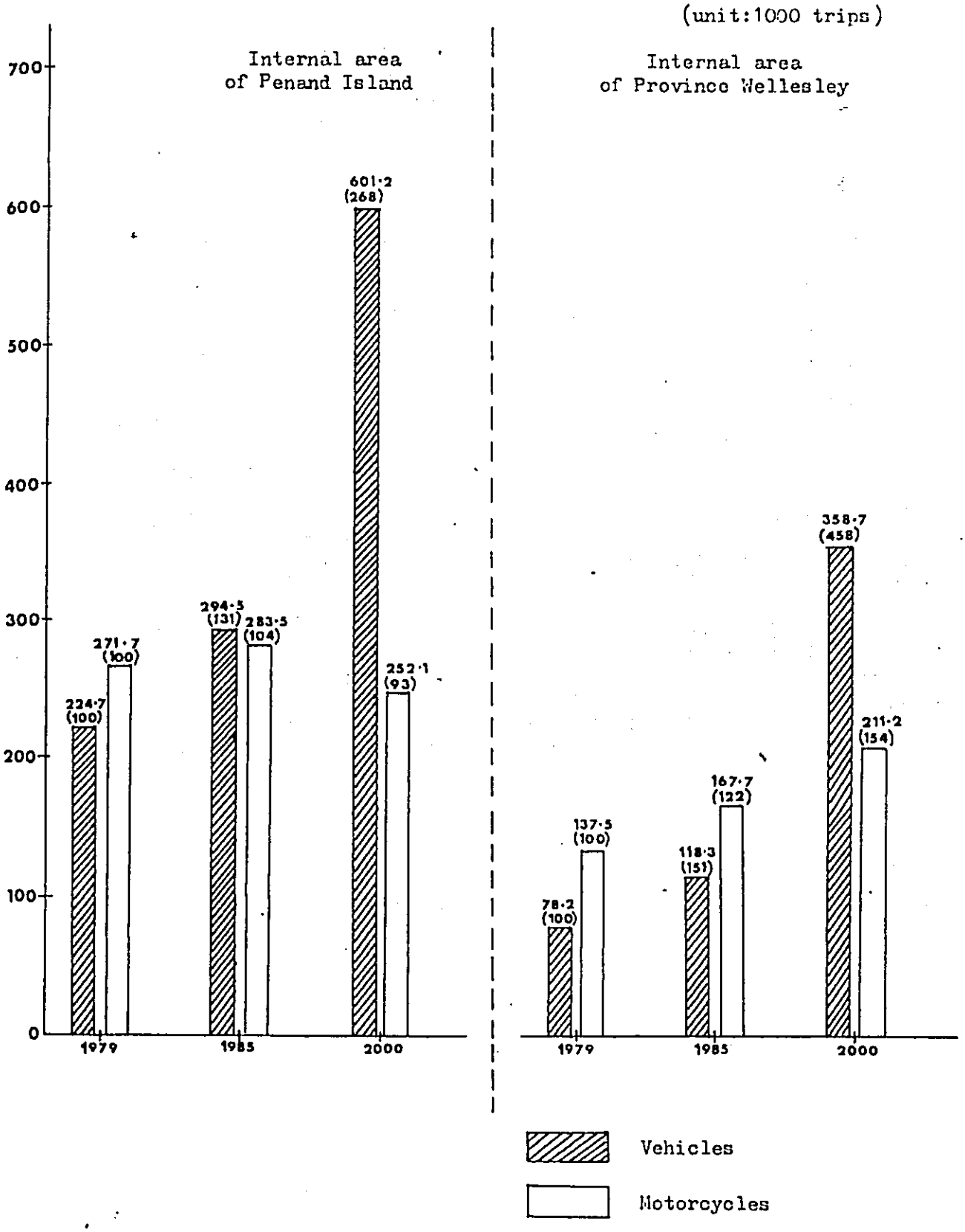


Table: 6-13 Number of trip generation (Unit : 1000 trips)

		Vehicle								
		Car								
		Going to Work	On Business	Private	Going Home	Sub-Total	Lorry	Taxi	Bus	Sub-Total
P	1979	53192	24579	42647	65347	185705	20440	2499	15937	224588
	1985	70067 (1.32)	31714 (1.29)	56627 (1.33)	81095 (1.24)	239503 (1.29)	29426 (1.44)	6000 (2.40)	19584 (1.23)	294513 (1.31)
	2000	156142 (2.94)	62911 (2.56)	119357 (2.80)	149717 (2.29)	488128 (2.63)	59736 (2.92)	22420 (8.97)	30907 (1.94)	601191 (2.68)
W	1979	15298	11174	13263	21343	61078	12701	1200	3275	78248
	1985	21619 (1.41)	15401 (1.38)	18955 (1.43)	34215 (1.60)	90190 (1.48)	20864 (1.64)	1800 (1.50)	5470 (1.67)	118324 (1.51)
	2000	67736 (4.43)	40749 (3.65)	59275 (4.47)	99322 (4.65)	267082 (4.37)	63667 (5.01)	6680 (5.57)	21293 (6.50)	358722 (4.58)
TOTAL	1979	68490	35753	55910	86690	246843	33141	3699	19212	302896
	1985	91282 (1.33)	47409 (1.33)	75381 (1.35)	115621 (1.33)	329693 (1.34)	50290 (1.52)	7800 (2.12)	25054 (1.30)	412837 (1.36)
	2000	223878 (3.27)	103660 (2.90)	178632 (3.19)	249039 (2.87)	755210 (3.06)	123403 (3.72)	29100 (7.87)	52200 (2.72)	959913 (3.17)

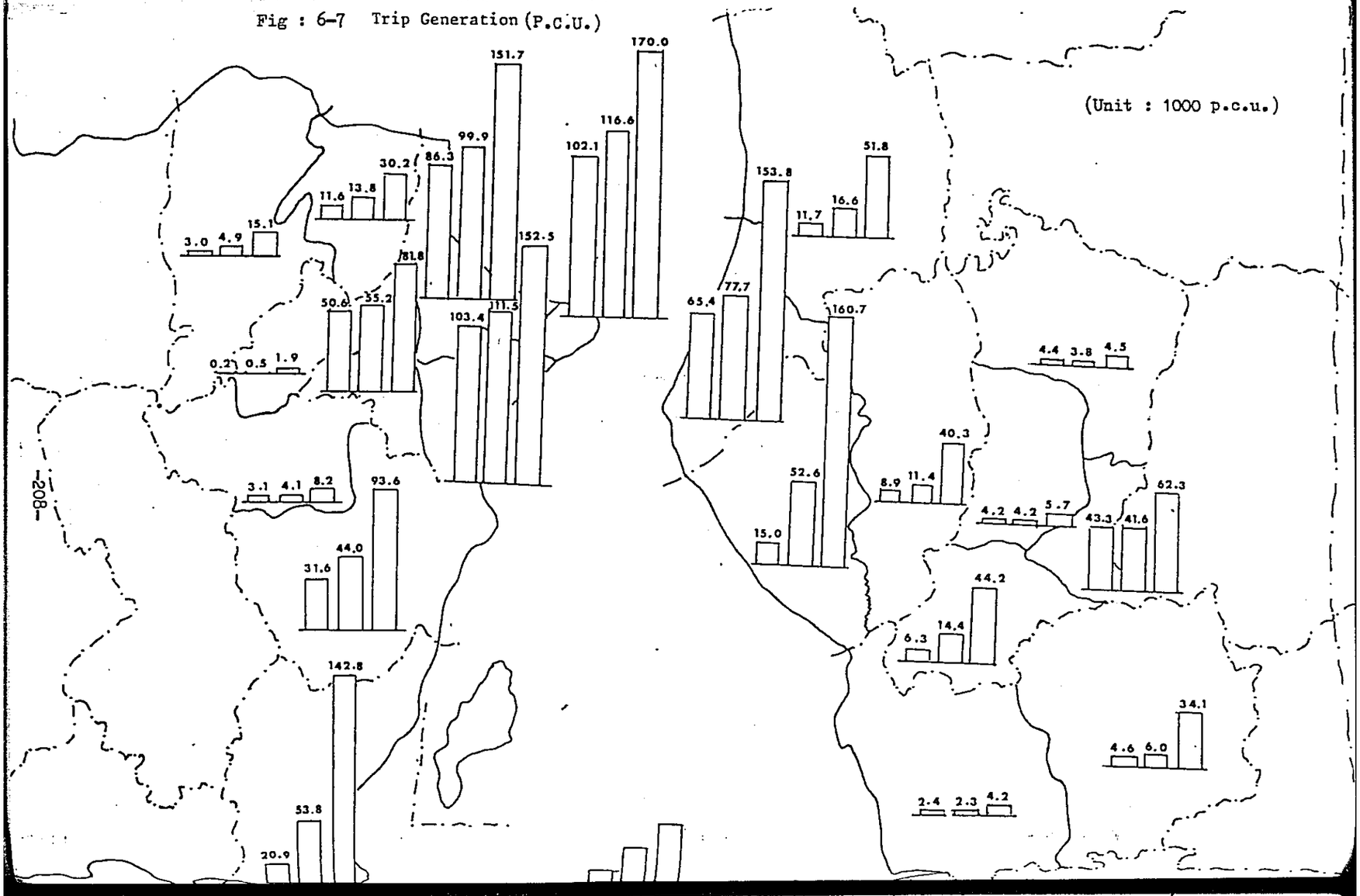
Table: 6-14 Number of trip Attraction

(Unit : 1000 trips)

	Vehicle									
	Car					Lorry	Taxi	Bus	Sub-Total	M/C
	Going to Work	On Business	Private	Going Home	Sub-Total					
1979	52518	24465	43594	65487	186149	20416	2513	15836	224974	271621
1985	65447 (1.25)	31274 (1.28)	56152 (1.29)	86630 (1.32)	239503 (1.29)	29426 (1.44)	6000 (2.39)	19584 (1.24)	294513 (1.3)	283458 (1.04)
2000	122261 (2.33)	61027 (2.49)	111133 (2.55)	193704 (2.96)	488125 (2.62)	59736 (2.93)	22420 (8.92)	30907 (1.95)	601188 (2.67)	252124 (0.93)
1979	15875	11234	12836	21171	61078	12544	1225	3151	78107	138098
1985	25189 (1.59)	15455 (1.38)	19769 (1.54)	29777 (1.41)	90190 (1.48)	20864 (1.66)	1800 (1.47)	5470 (1.74)	118324 (1.51)	167740 (1.21)
2000	74717 (4.71)	41537 (3.70)	61435 (4.79)	89391 (4.22)	267081 (4.37)	63667 (5.08)	6680 (5.45)	21294 (6.78)	358722 (4.59)	211275 (1.53)
1979	68393	35699	56430	86658	247227	20416	3738	18987	303054	409719
1985	90636 (1.33)	46729 (1.31)	75921 (1.35)	116407 (1.34)	329693 (1.33)	50290 (2.46)	7800 (2.09)	25954 (1.32)	412837 (1.36)	451199 (1.10)
2000	196978 (2.88)	102564 (2.87)	172568 (3.06)	283095 (3.27)	755206 (3.05)	123403 (6.04)	29100 (7.78)	52201 (2.75)	959910 (3.17)	463399 (1.13)

Fig : 6-7 Trip Generation (P.C.U.)

(Unit : 1000 p.c.u.)



MOTORCYCLE)

(Unit : 1000 trips)

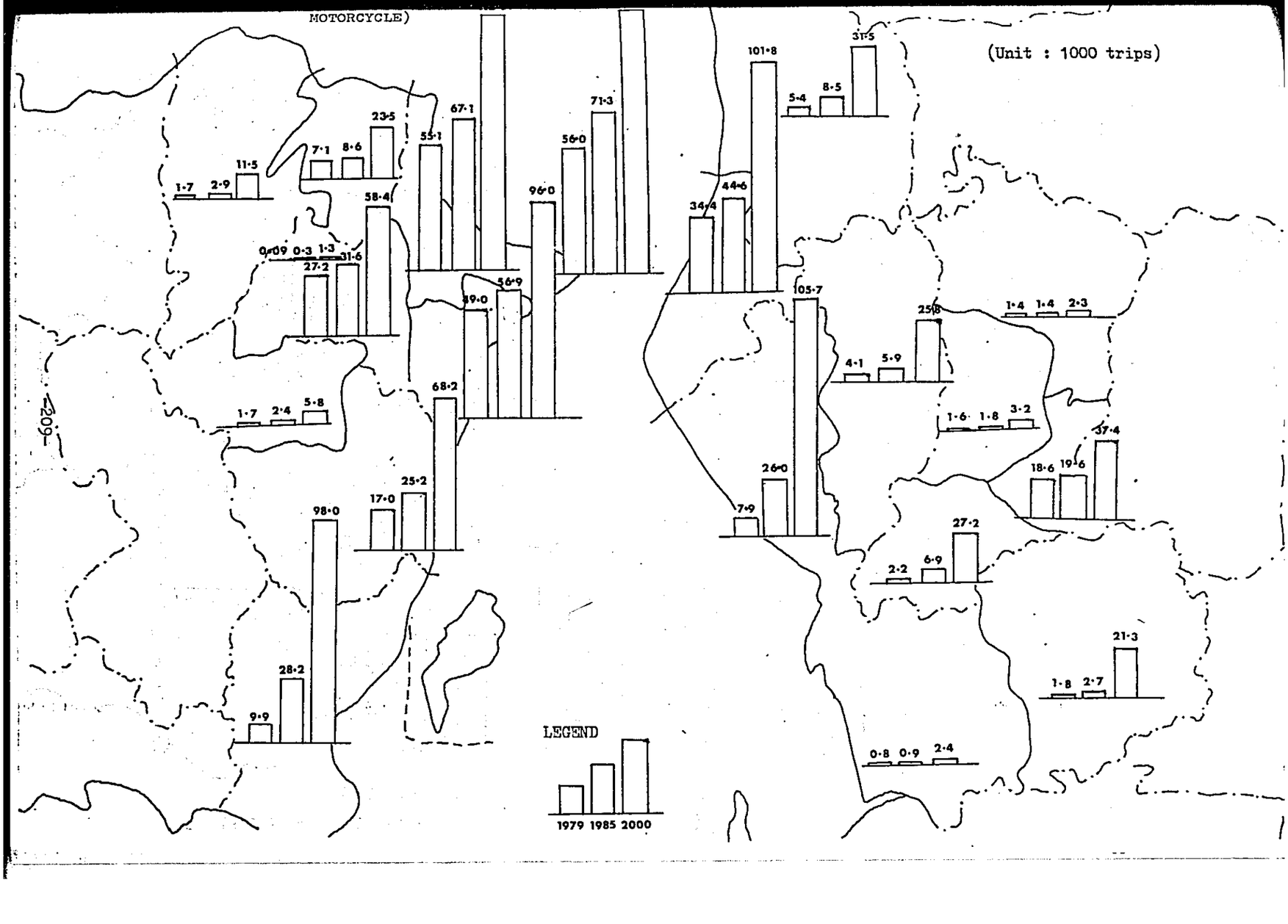
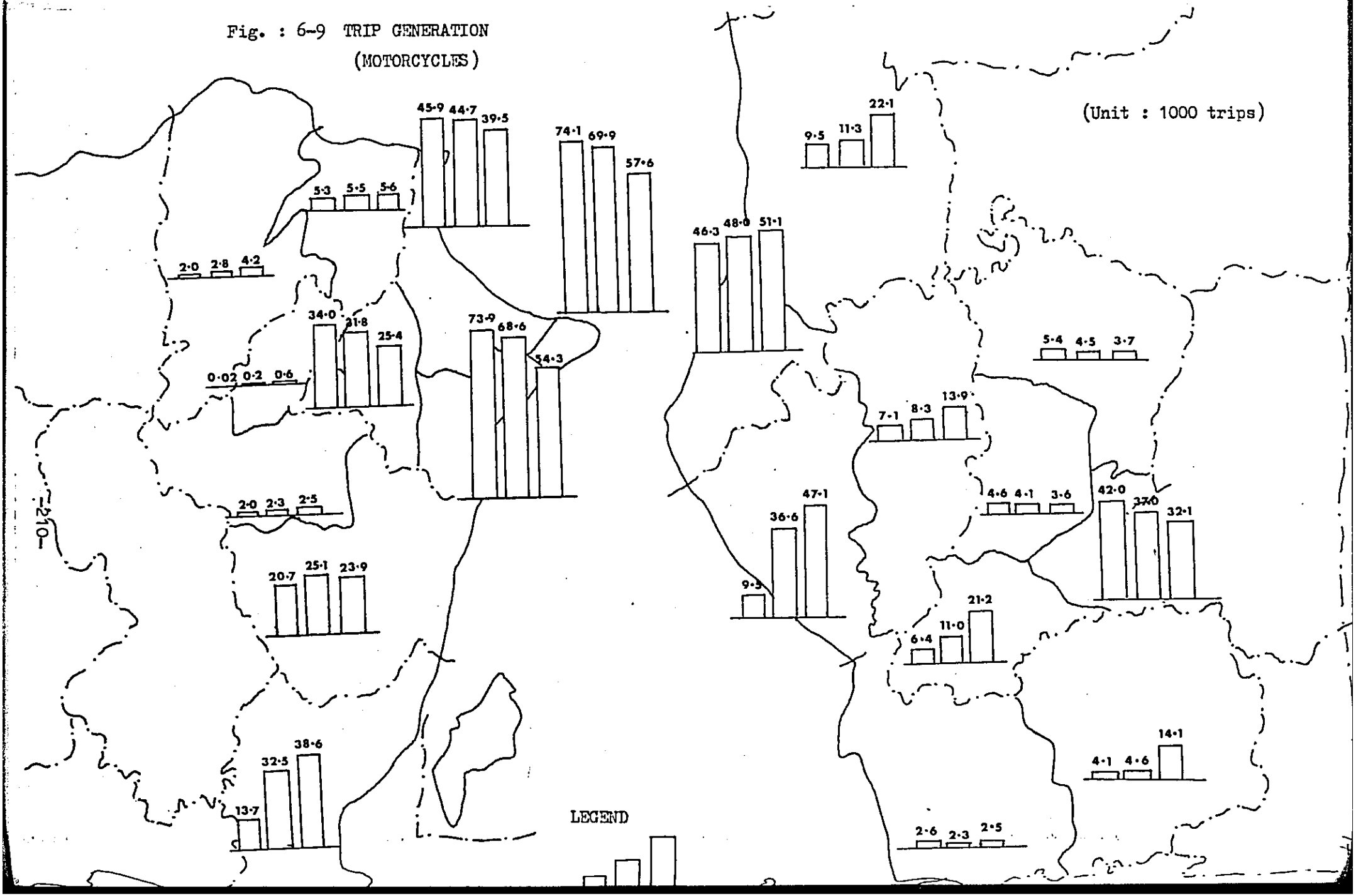


Fig. : 6-9 TRIP GENERATION
(MOTORCYCLES)

(Unit : 1000 trips)



6-2-3 Future O-D table

Number of trips in each traffic type.

O-D tables for the future are estimated by using the future trip generation, trip attraction, and distance between each zone pair together with gravity model which is derived from the present traffic data.

Table:6-15 Number of trip in each traffic type

(Unit:1000 trips)

	Year	Vehicle									
		Car					Lorry	Taxi	Bus	Sub-Total	M/C
		Going to Work	On Business	Private	Going Home	Sub-Total					
internal trip	1979	66.4	33.4	53.1	83.2	236.0	28.4	2.7	19.0	286.1	397
	1985	88.1	44.0	70.8	110.1	312.9	43.2	6.1	24.7	386.9	437
	2000	200.1	100.0	160.7	249.9	710.7	92.2	24.5	51.5	878.9	449
external and through trip	1979	4.3	4.8	6.4	7.5	23.2	9.8	2.1	0.4	35.3	25
	1985	6.0	7.2	9.8	10.3	33.3	15.8	3.4	0.6	53.1	27
	2000	14.4	21.6	27.3	25.5	89.0	66.4	9.2	1.4	166.0	28
TOTAL	1979	70.7	38.2	59.5	90.7	259.2	38.2	4.8	19.4	321.5	422
	1985	94.1	51.2	80.6	120.4	346.2	59.0	9.5	25.3	440.0	465
	2000	214.5	121.6	188.0	275.4	799.7	158.6	33.7	52.9	1044.9	477

Table : 6–16 Number of Trip production in each

Traffic Type (P.C.U.)

(unit: 1000 P.C.U.)

	1979	1985	2000
internal trip	551.2 (100)	692.2 (114)	1287.5 (211)
external and through trip	58.6 (100)	84.4 (144)	250.6 (428)
total	609.8 (100)	776.6 (127)	1538.1 (252)

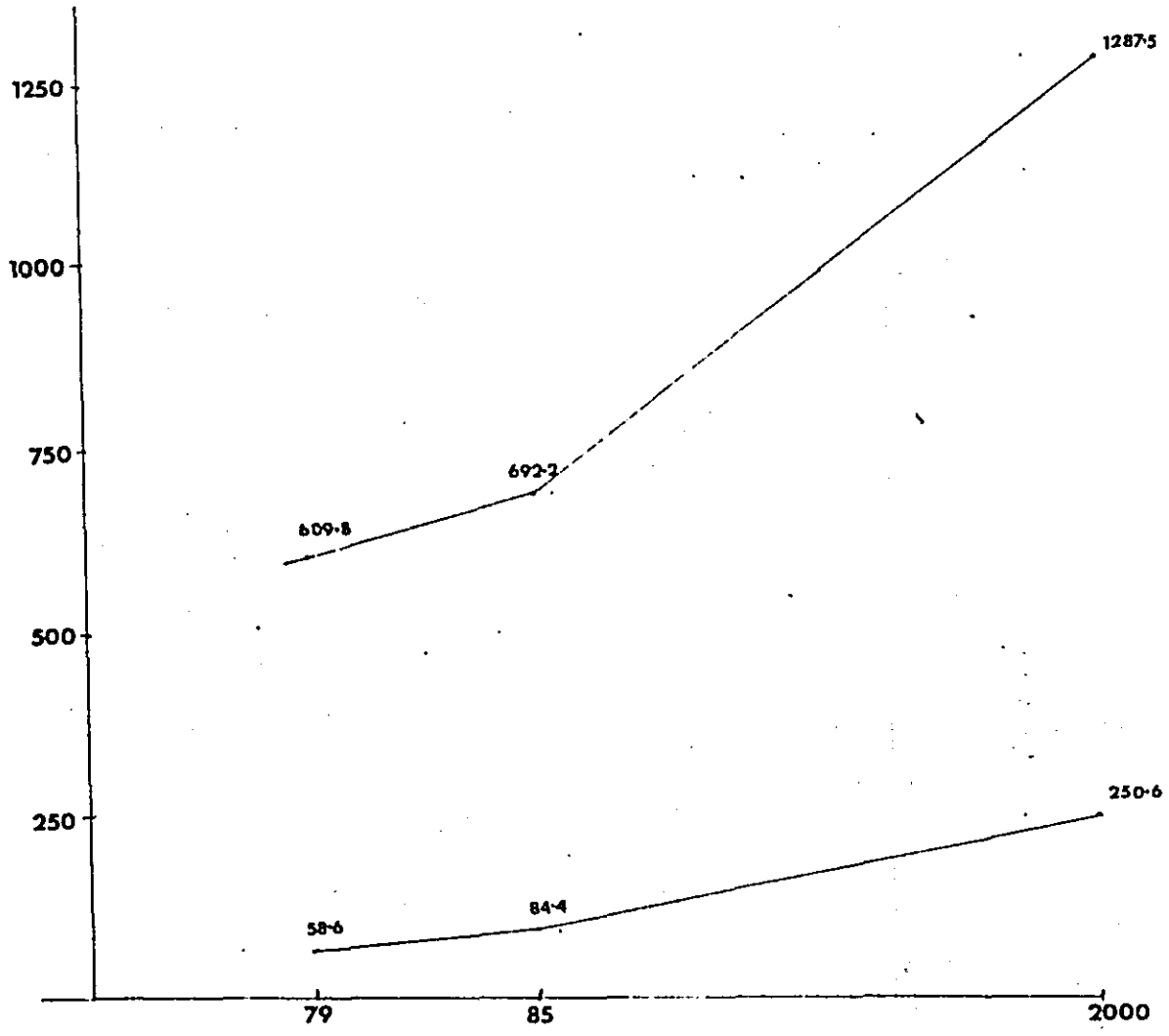


Table : 6- 17 Number of Trip Production
in each Traffic Type (Vehicles)

(unit: 1000 trips)

	1979	1985	2000
internal trip	286.1 (100)	386.9 (135)	878.9 (307)
external trip	33.9 (100)	51.7 (153)	161.7 (477)
Through Trip	1.4 (100)	1.4 (100)	4.3 (307)
Total	321.5 (100)	440.0 (140)	1044.9 (325)

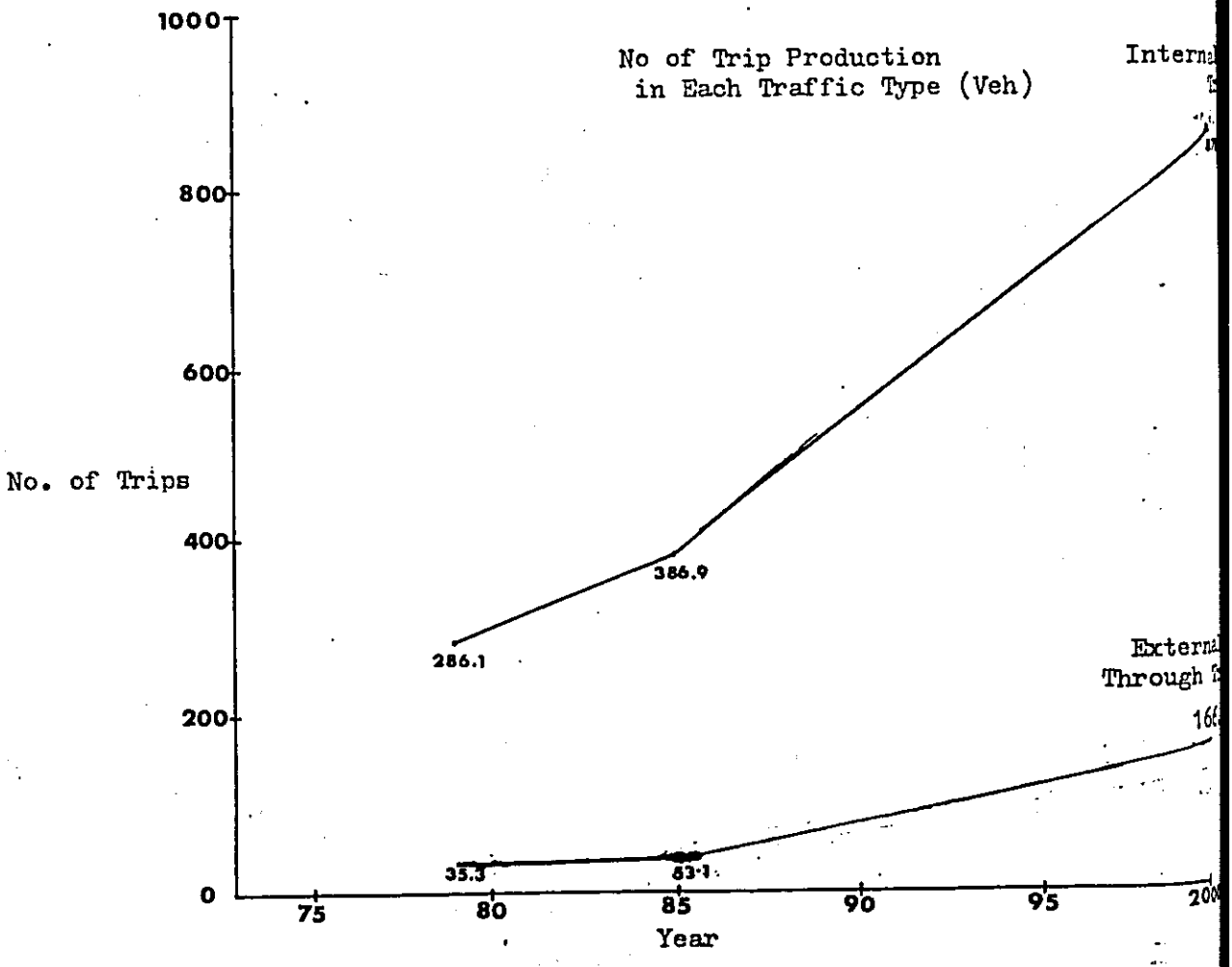
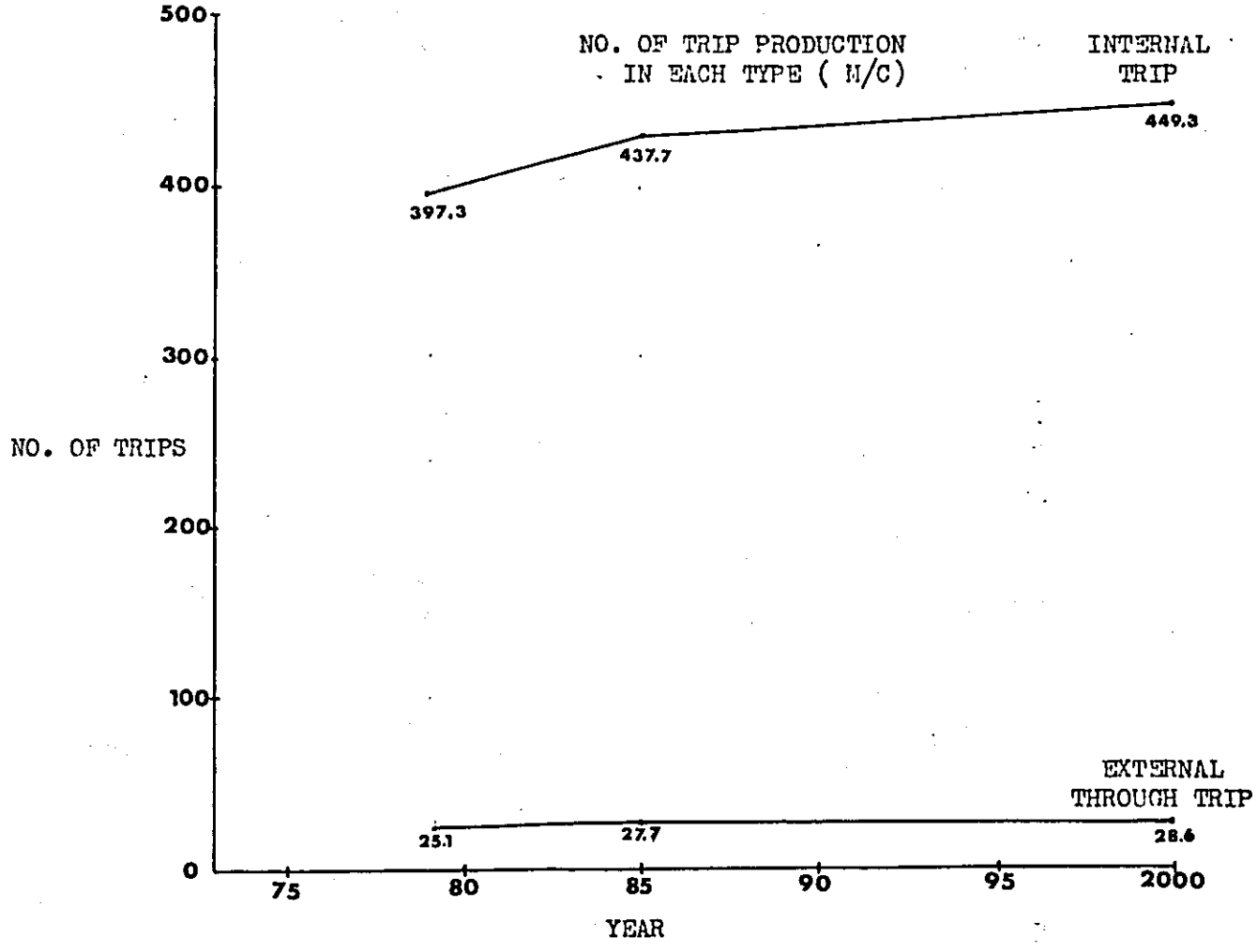


Table :6-18 Number of Trip Production in each Type (m/c)

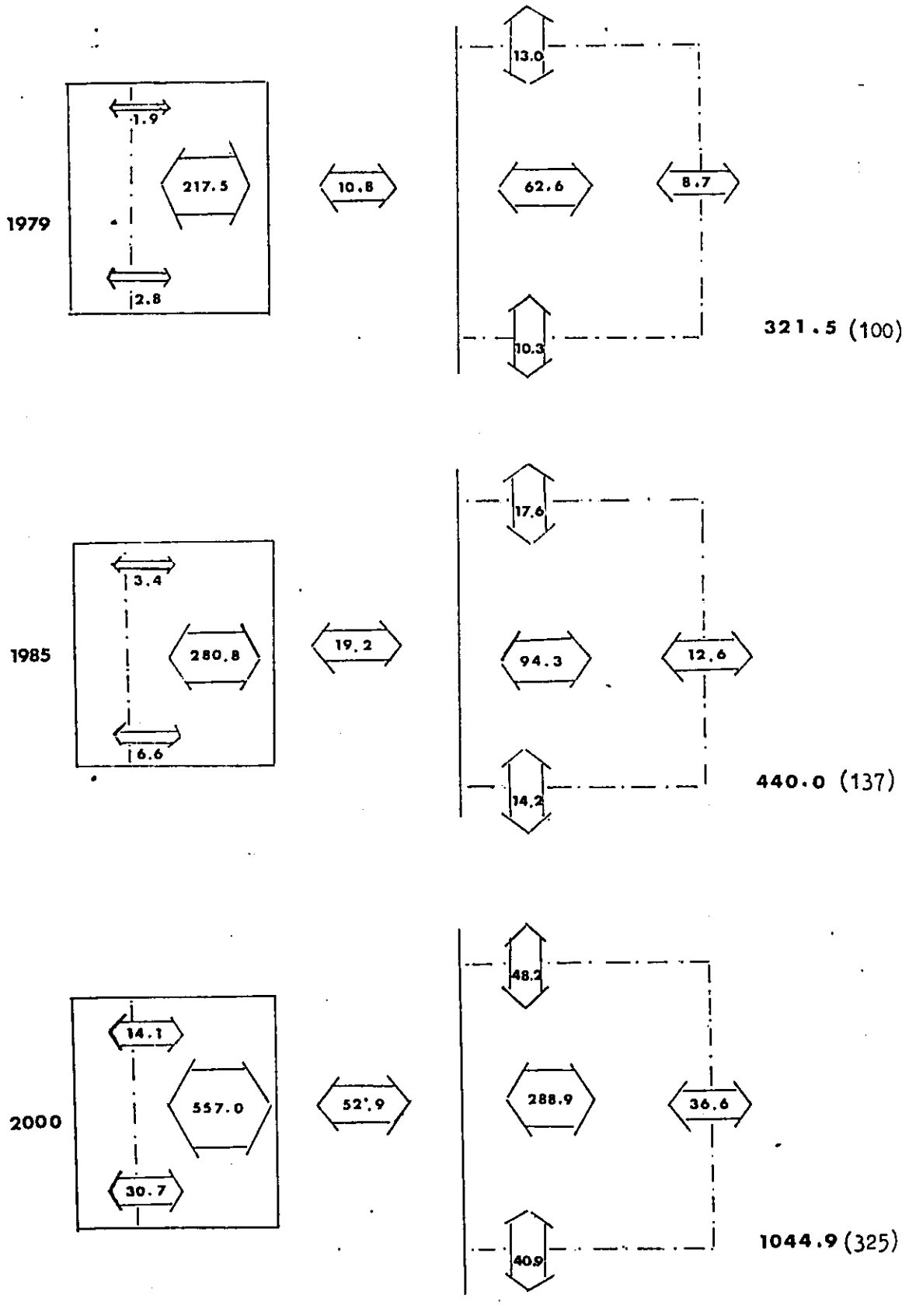
(unit: 1000 trips)

	1979	1985	2000
internal trip	397.3 (100)	437.7 (110)	449.3 (113)
external through trip	25.1 (100)	27.7 (110)	28.6 (113)
Total	422.4 (100)	465.3 (110)	477.9 (113)

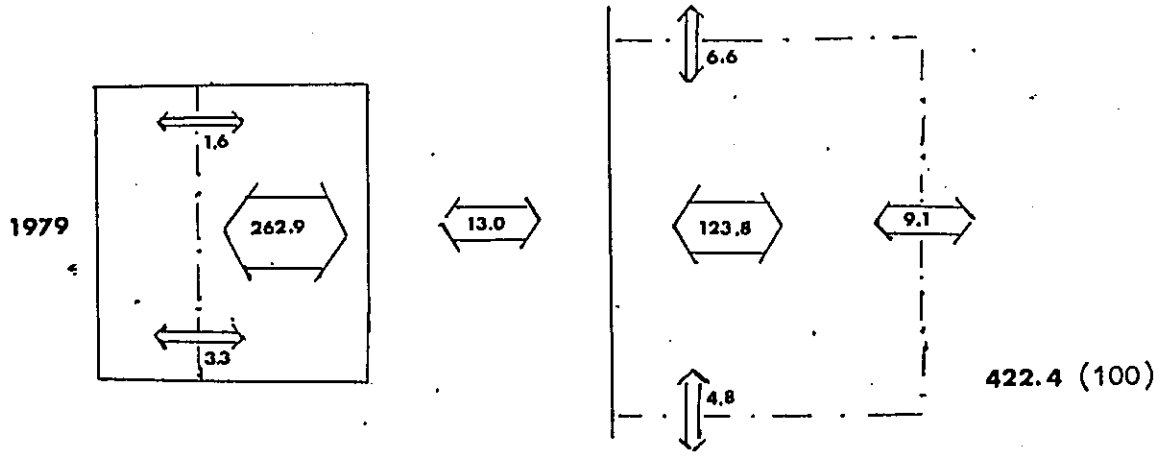


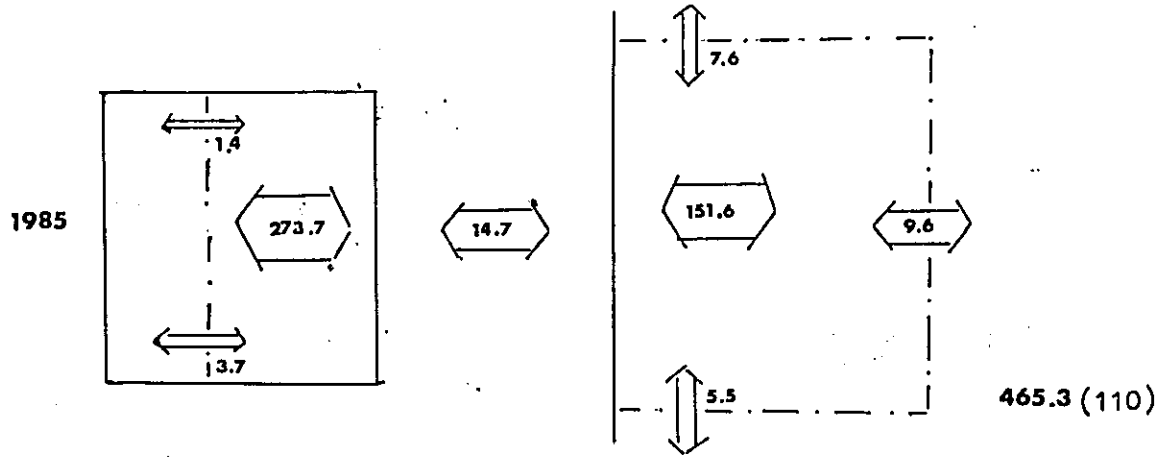
(2) Outline of movement

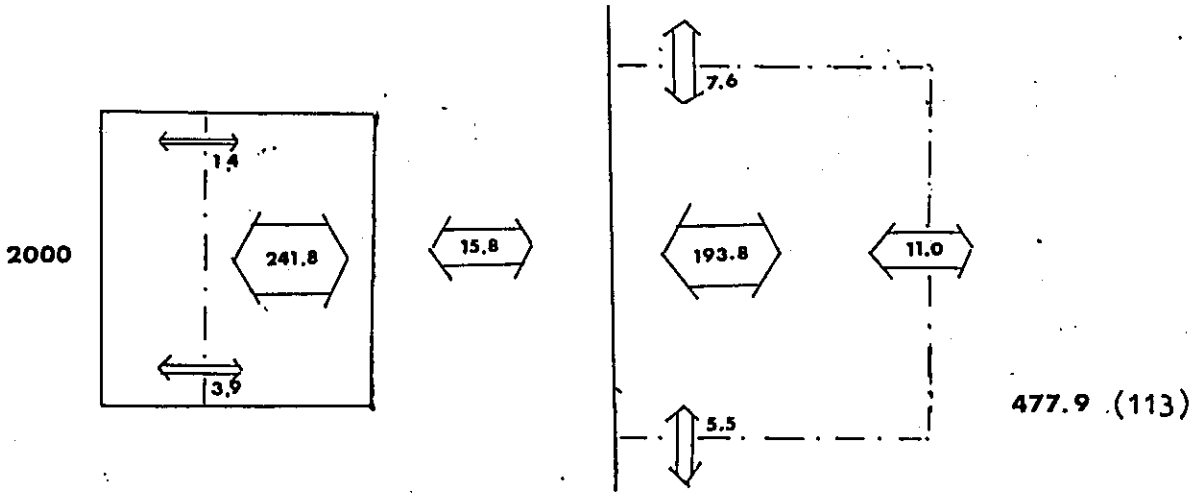
〈Vehicle〉 (unit: 1000 trips)



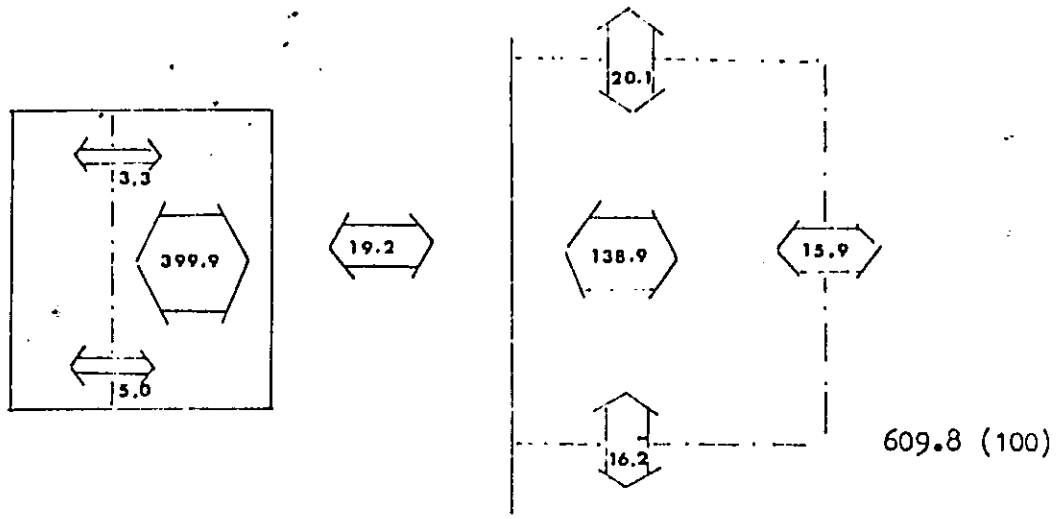
〈 Motorcycles 〉 (unit: 1000 trips)

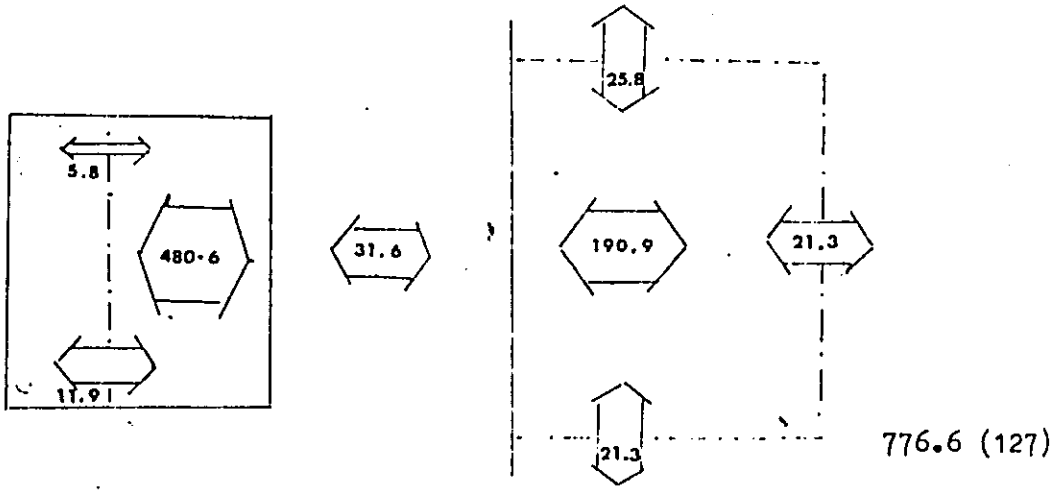


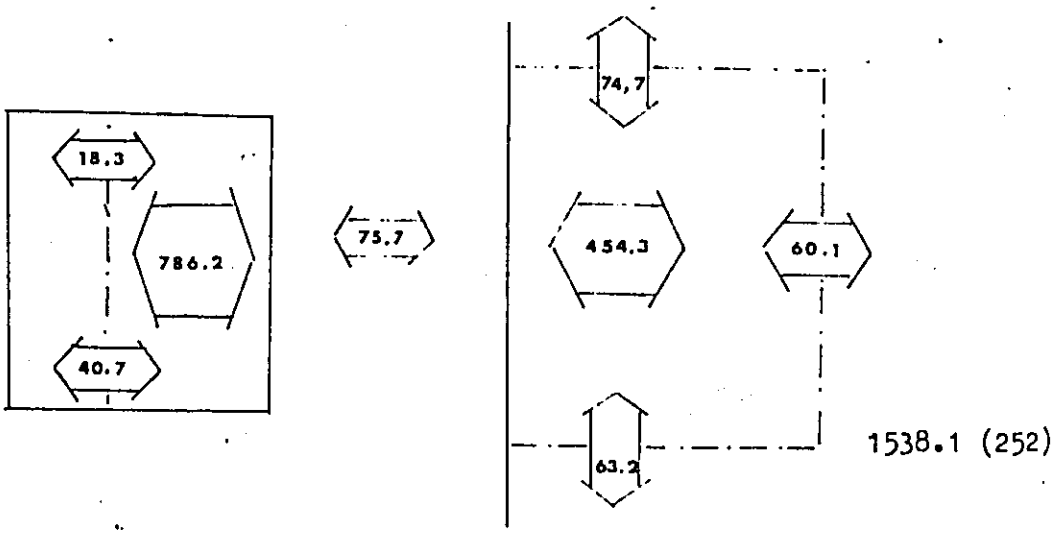




(P. C. U.)　　(unit: 1000 P.C.U.)







(3) Desired Assignment

For the purpose of grasping the traffic movement approximately, the desired assignment are conducted useing the method of simple assignment. This way is that the traffic demand of each O-D pair (in this case middle zone pair) is assigned to the shortest desired route according to the distance. The growth rate of traffic demand on major section estimated by the desired assingment are as follows;

From these figures, the following can be observed:

(1) In Penang Island, the traffic movement between George Town and Bayan Lepas will become greater. (Section C). The traffic movement in 1979, 1985 and 2000 are 63,000 106,000 and 239,000 respectively.

(2) In Province Wellesley, the traffic movement between Butterworth, Seberang Prai and Bukit Mertajam (Section F) will be increased remarkably from 41,000 to 73,000 in 1985, 20,400 in 2000.

Fig. : 6-10 Traffic demand on major section (Unit : 1000 p.c.u.)

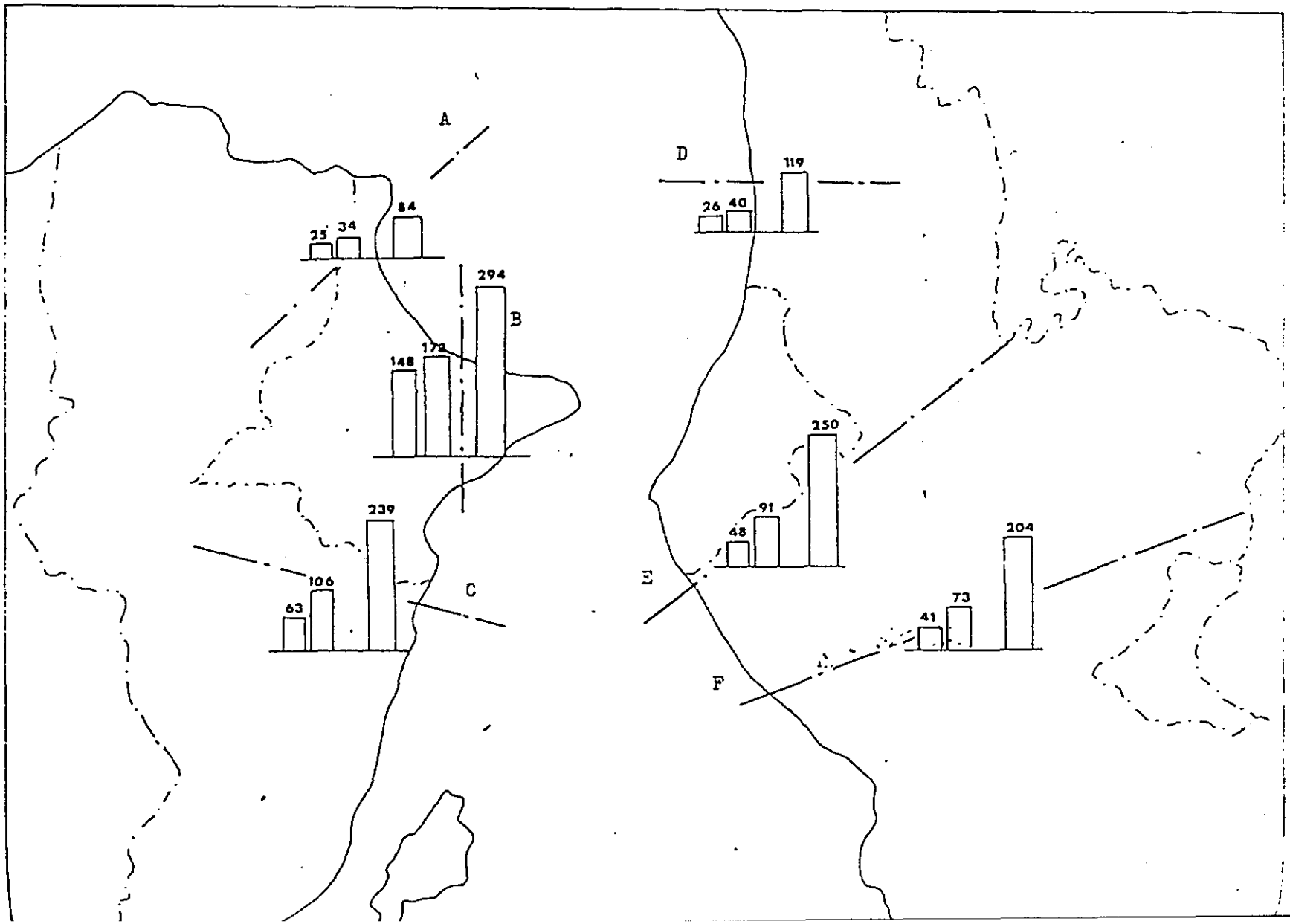


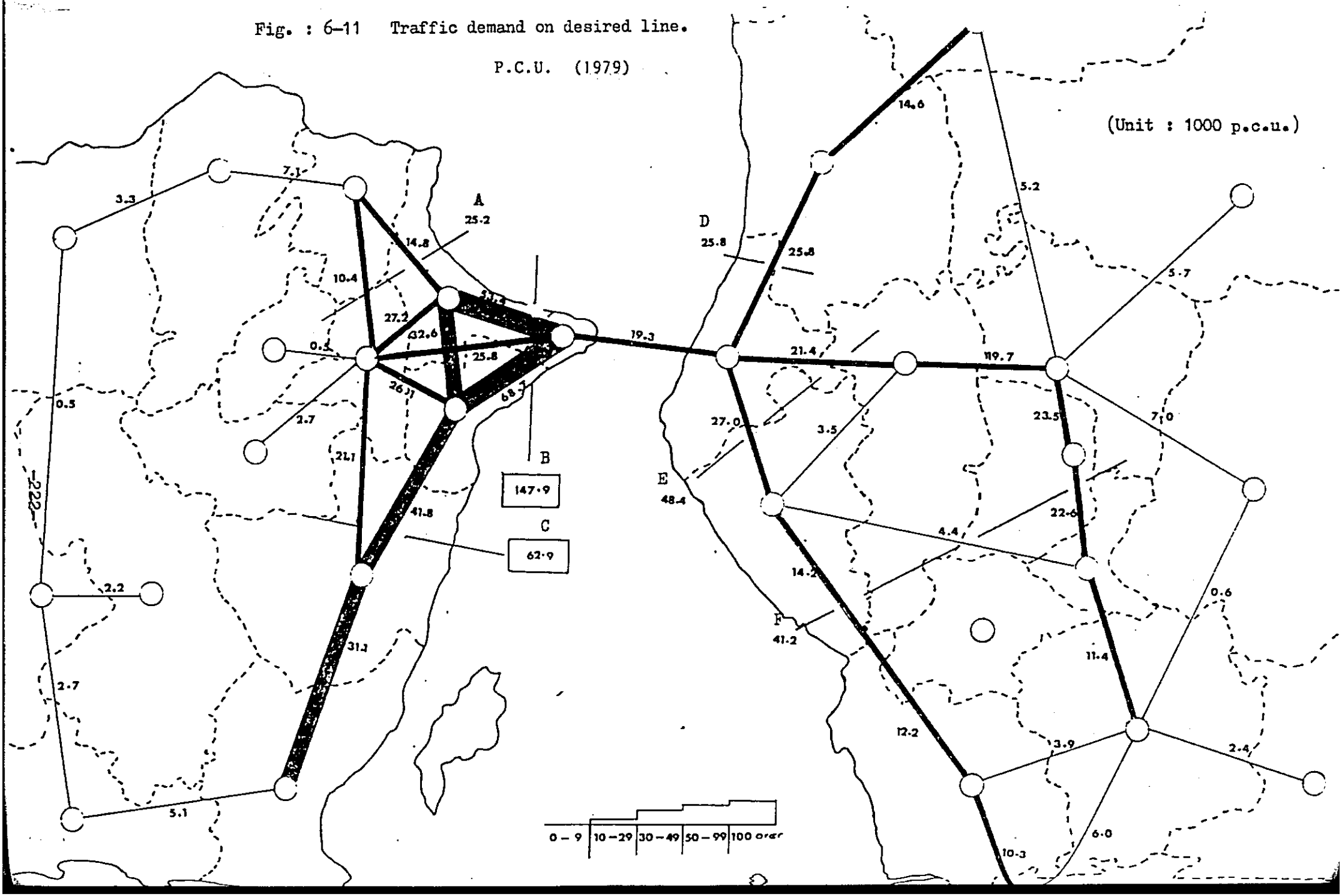
Table 6-19 Traffic Demand on Major Section

(Unit:1000 trip P.C.U)

Year \ Section		Penang Island			Province Wellesley		
		A	B	C	D	E	F
1979	Vehicles	15.7	85.7	35.9	14.6	27.2	20.4
	M/C	11.1	88.7	35.7	13.9	29.2	28.0
	P.C.U	25.2	147.9	62.9	25.8	48.4	41.2
1985	Vehicles	22.0	111.7	67.0	24.1	55.1	43.2
	M/C	11.8	80.6	40.8	18.6	42.6	36.5
	P.C.U	34.1 (1.35)	172.7 (1.17	105.7 (1.68)	39.7 (1.54)	90.6 (1.87)	72.8 (1.77)
2000	Vehicles	65.8	217.8	179.6	77.0	169.8	136.5
	M/C	12.9	70.2	39.1	29.1	56.4	48.9
	P.C.U	83.7 (3.32)	293.9 (1.99)	239.1 (3.80)	118.6 (4.60)	249.6 (5.16)	203.8 (4.95)

Fig. : 6-11 Traffic demand on desired line.

P.C.U. (1979)



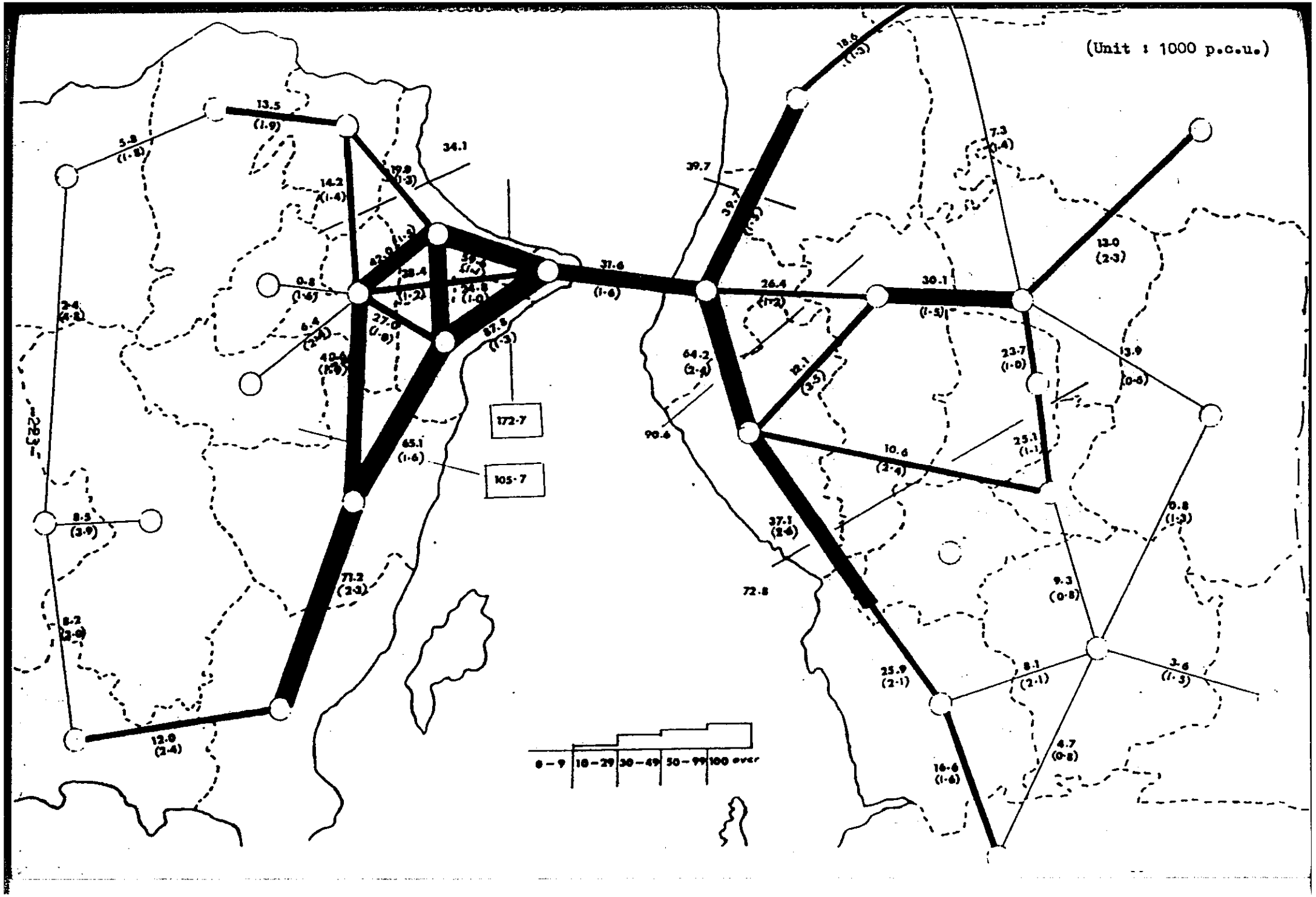
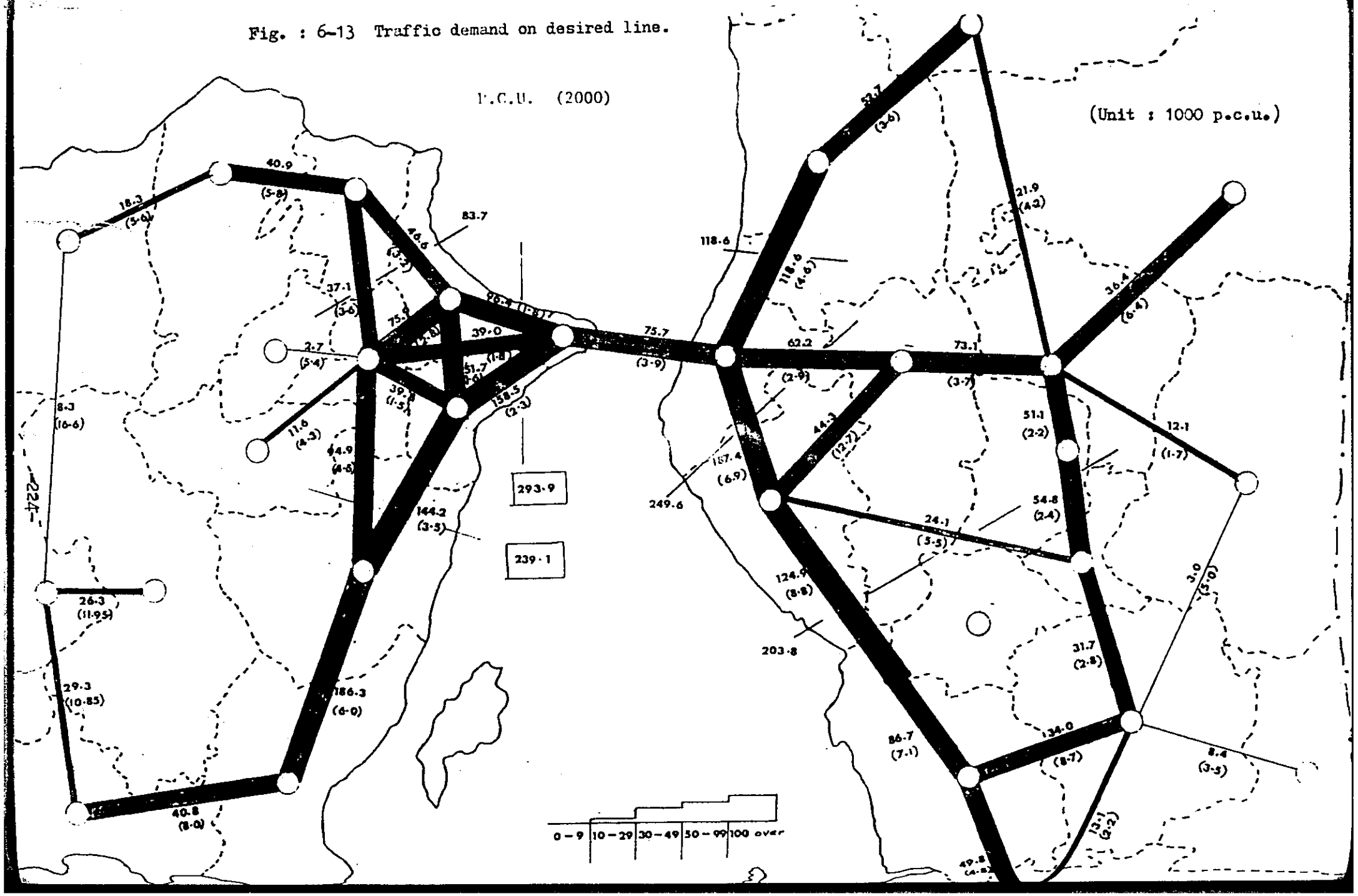

(Unit : 1000 p.c.u.)
13.5
(1.9)
5.8
(1.8)
34.1
14.2
(1.4)
19.9
(1.3)
42.0
38.4
(1.2)
0.8
(1.6)
6.4
(2.4)
27.0
(1.0)
40.6
(1.9)
87.5
(1.3)
172.7
105.7
65.1
(1.6)
71.2
(2.3)
12.0
(2.4)
8.5
(3.9)
8.2
(2.0)
31.6
(1.6)
39.7
26.4
(1.2)
64.2
(2.4)
90.6
12.1
(3.5)
10.6
(2.4)
37.1
(2.6)
72.8
25.9
(2.1)
16.6
(1.6)
30.1
(1.5)
23.7
(1.0)
25.1
(1.1)
13.0
(2.3)
13.9
(0.6)
7.3
(1.4)
0.8
(1.3)
9.3
(0.8)
8.1
(2.1)
3.6
(1.5)
4.7
(0.8)
0 – 9
10 – 29
30 – 49
50 – 99
100 over

Fig. : 6-13 Traffic demand on desired line.

P.C.U. (2000)



(4) The traffic volume across the Straits

The traffic volume over that unique section, viz cross the Straits is estimated as follows:-

Table 6-20 Traffic volume across the straits (unit: 1000 vehicles/motorcycles)

		1975	1979	1985	2000
vehicles	a	4.7	10.8 (100)	(14.6) (135)	(30.1) (278)
	b	-	-	(19.2) (178)	(52.9) (490)
motor-cycles	a	10.0	13.0 (100)	(14.4) (111)	(18.5) (142)
	b	-	-	(140.7) (113)	(15.8) (122)

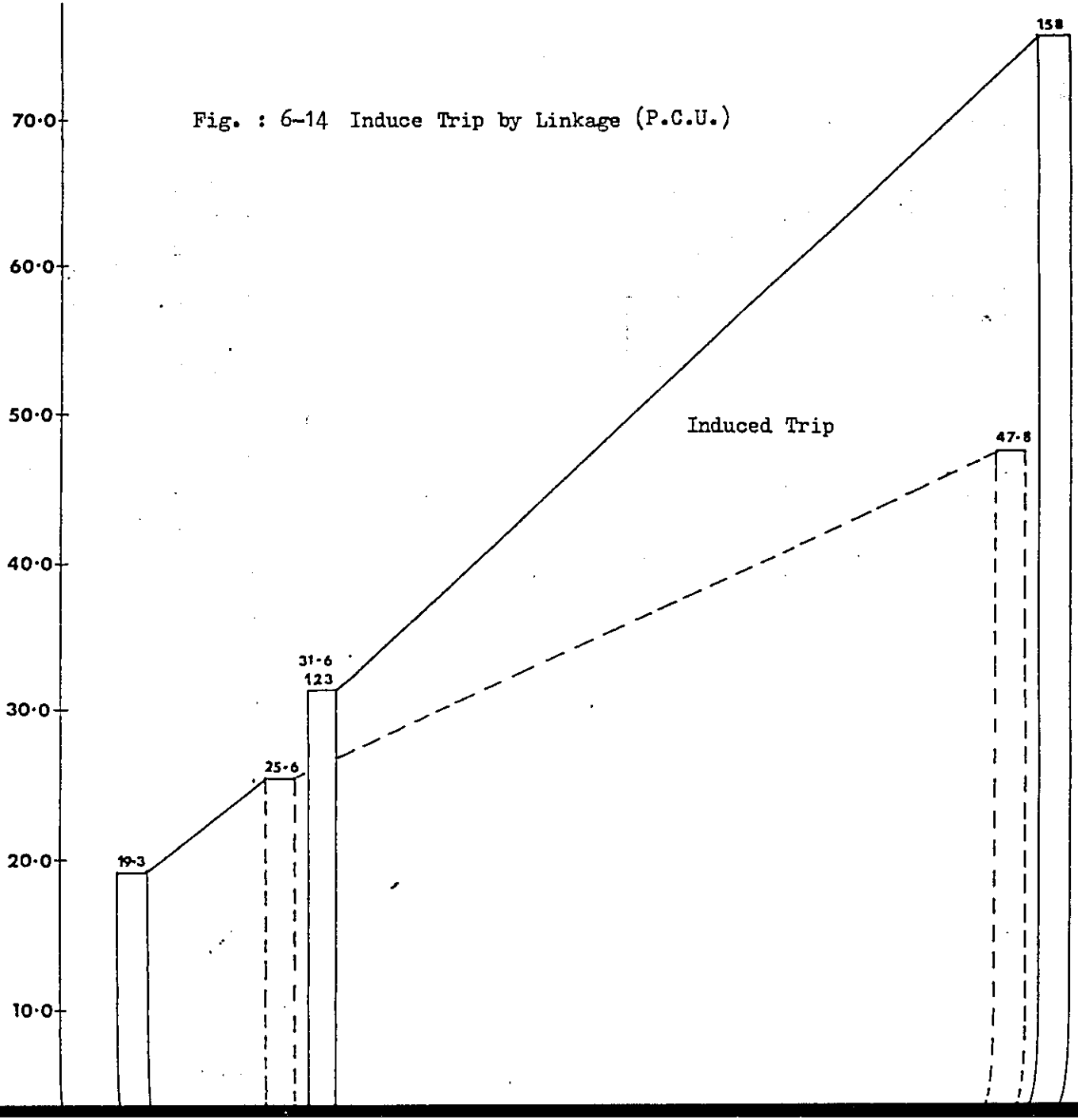
a: simple trend method

b: results from distribution estimation

From the results, the induced trips brought about at the completion of the linkage can be obtained. In 1985, these trips will total 6,000 p.c.u. but by the year 2000 they will total 28,000 p.c.u.

From this, we can deduce that the effects of the linkage will be quite large.

Fig. : 6-14 Induce Trip by Linkage (P.C.U.)

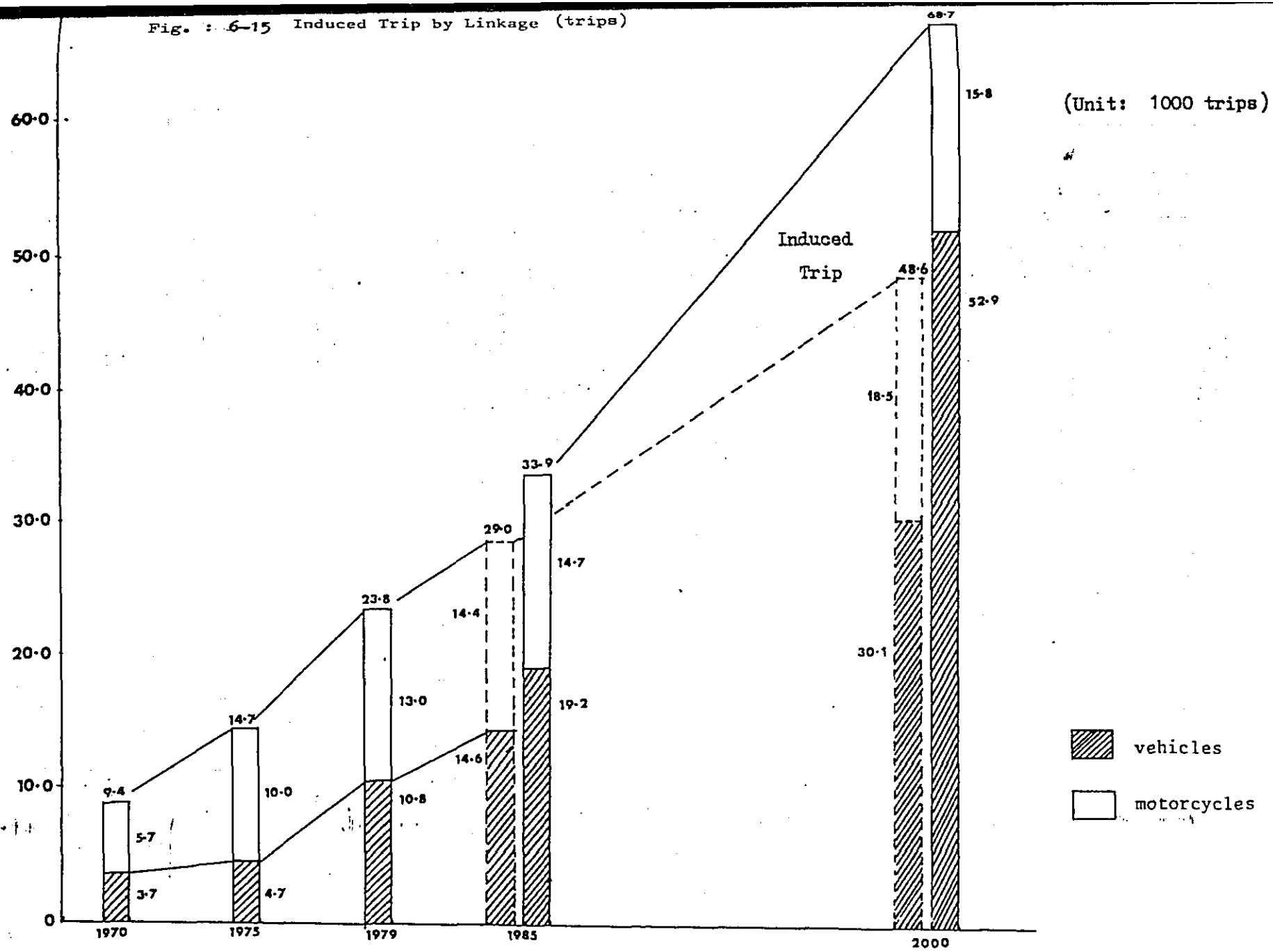


(Unit : 1000 p.c.u.)

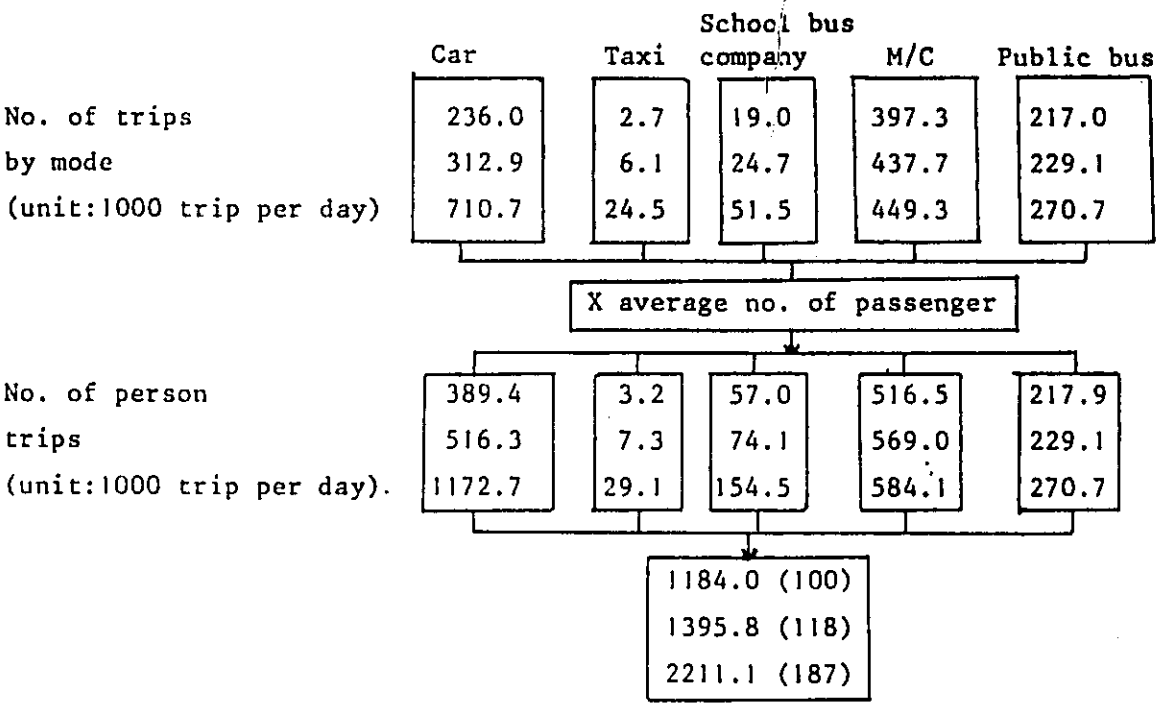
simple trend method

results from trip distribution.

Fig. : 6-15 Induced Trip by Linkage (trips)



-2-4 Varification by person trip



Population (unit:1000 person)

Population	above 15 years
723.0	458.2
837.0	537.3
1207.0	811.1

Unit of trip production per person (unit: no. of trip per person per day)

1.64 (100)	2.58 (100)
1.67 (102)	2.60 (101)
1.83 (112)	2.73 (106)

Upper : 1979
Middle : 1985
Lower : 2000

reference

Owner : 2.32
Non owner: 1.57
Average : 1.73
in Manila

7 Estimation of Future Traffic Demand by Transport Plan

7.1 Concept of the Transport Plan

The future O-D table which are described in chapter 6 are estimated according to the demand of vehicles. However, the actual appearance of the traffic are affected by many restriction and alternative transport, that is, if there are no parking area, vehicle traffic will decrease and if there are some superior transport which speed is faster than vehicles, some vehicle will divert to the new transport.

Therefore, we must consider some factors which are related to the traffic volume. In this chapter, some alternative transport plan are considered and some estimation are excuted by the transport plan.

(1) The transport plan

The transport plan are planned as following 3 (three) steps.

Plan B

In this plan, the restriction about parking demand and the alternative transport which are represented by bus exclusive lane are considered.

Plan C

In this plan, the new transport system which is imagined as the Lightway Rail System is considered on Penang Island in addition to Plan B.

Plan D

In this plan, the control of parking demand and the car pooling system are considered.

The calculation are executed as follows:-

Year	Plan - B	Plan - C	Plan - D
1985	execution		
2000	execution	execution	execution

Fig. :7.1 Alternative Plan – B

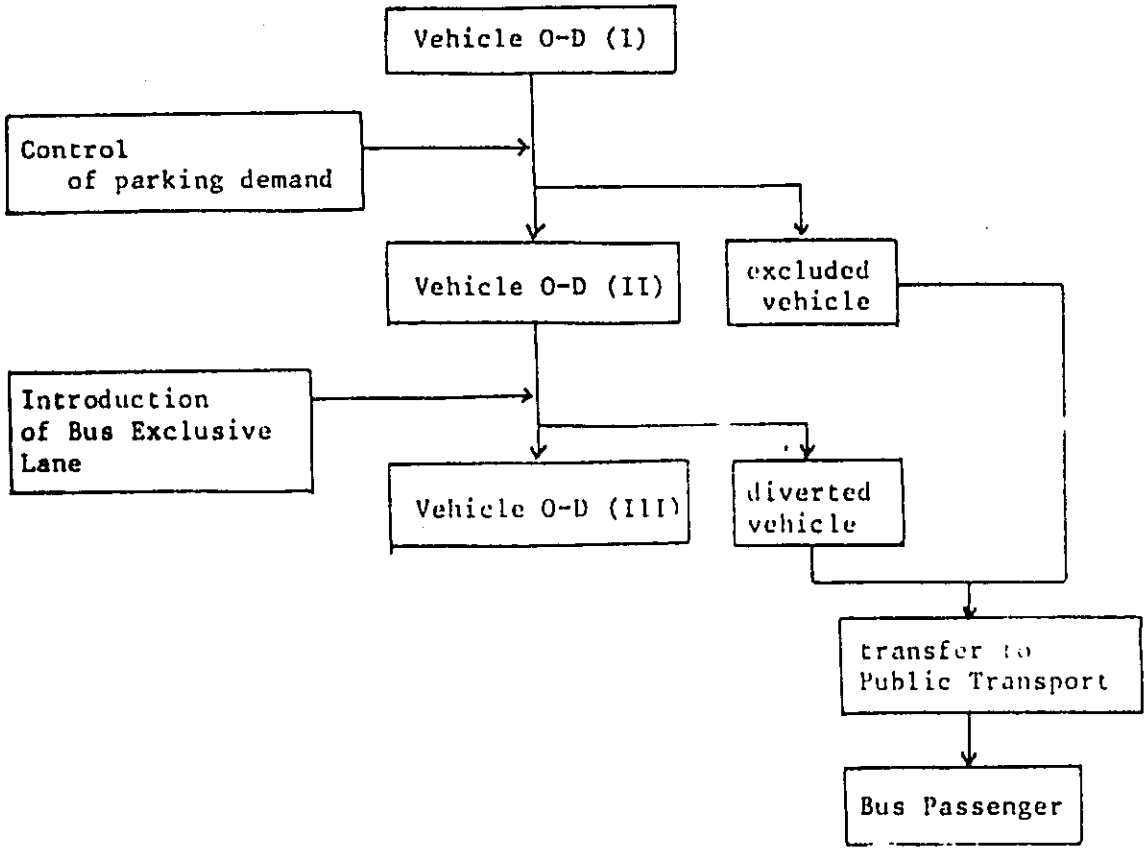


Fig. : 7.2 Alternative Plan – C

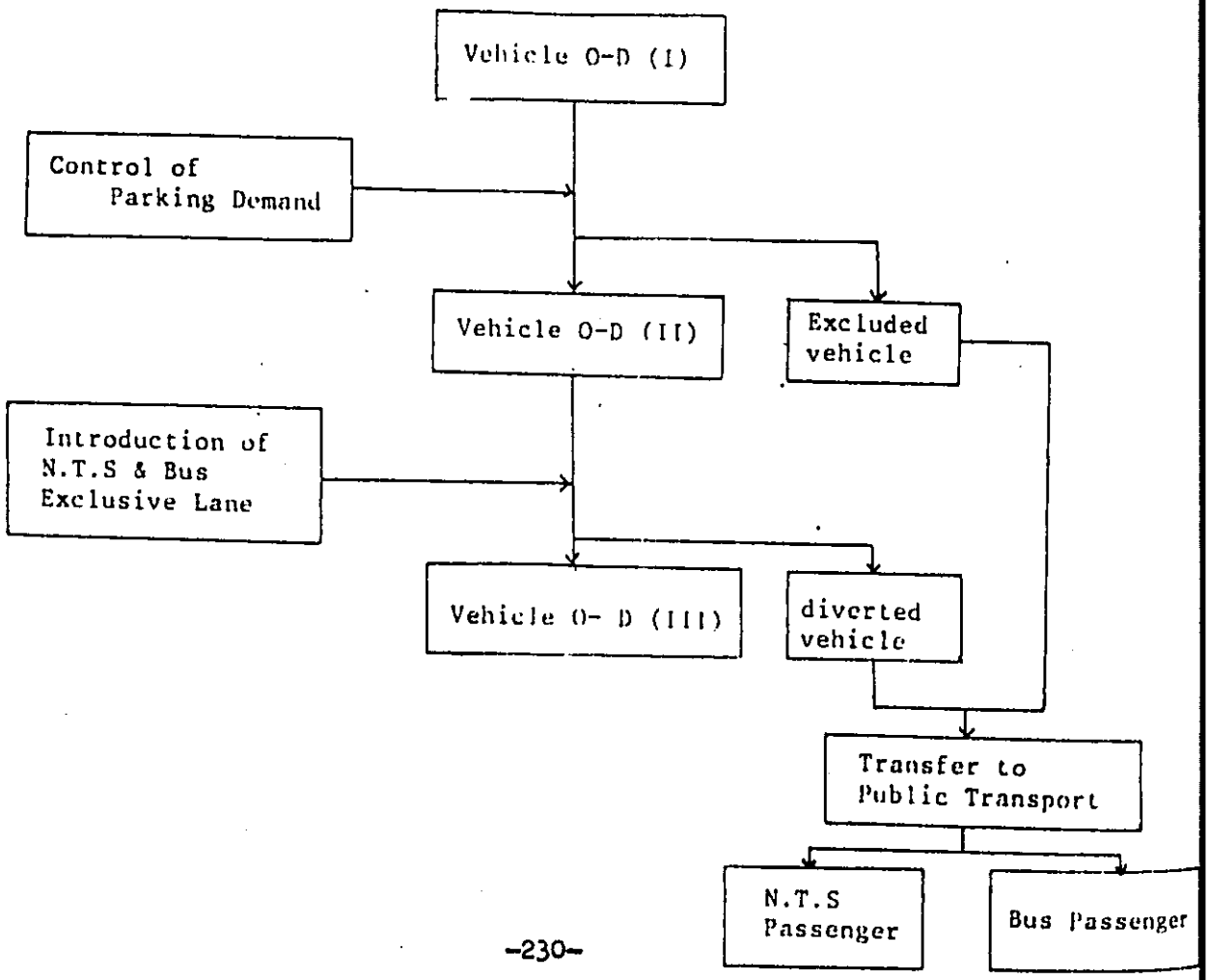
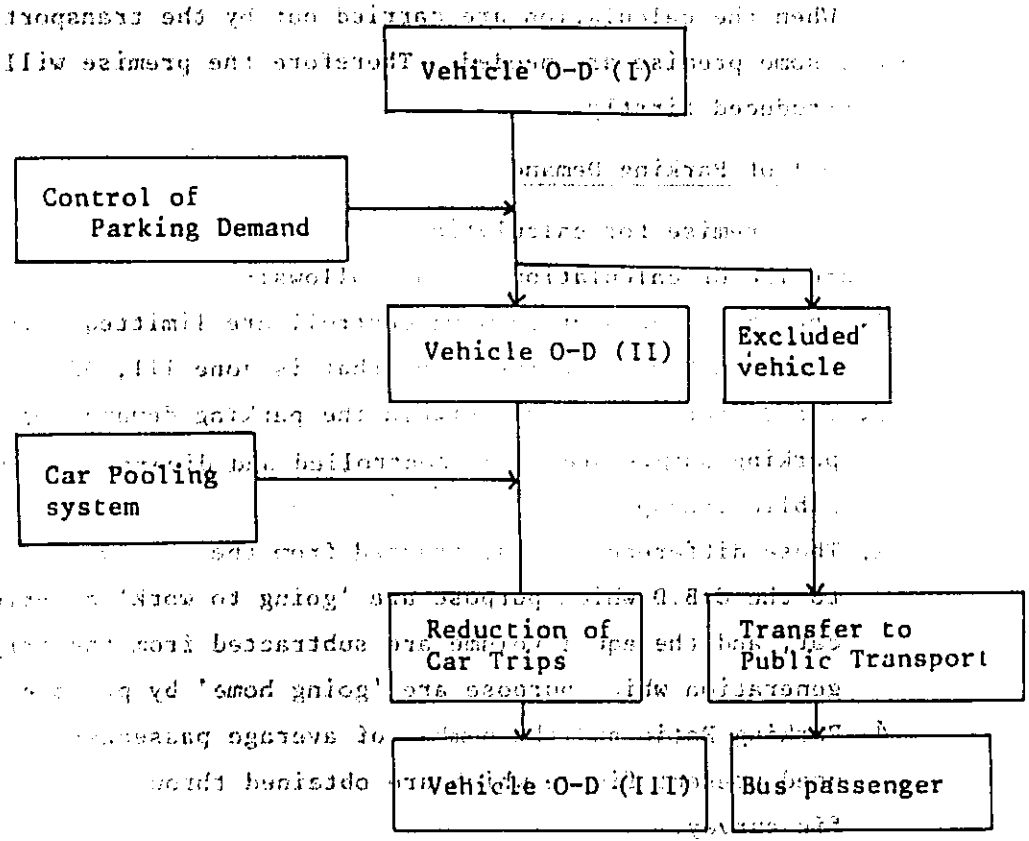


Fig. : 7.3 Alternative Plan - D



7.2 The way of the calculation

When the calculation are carried out by the transport plan, some premise are needed. Therefore the premise will be introduced firstly.

7.2.1 Controll of Parking Demand

(1) The premise for calculation

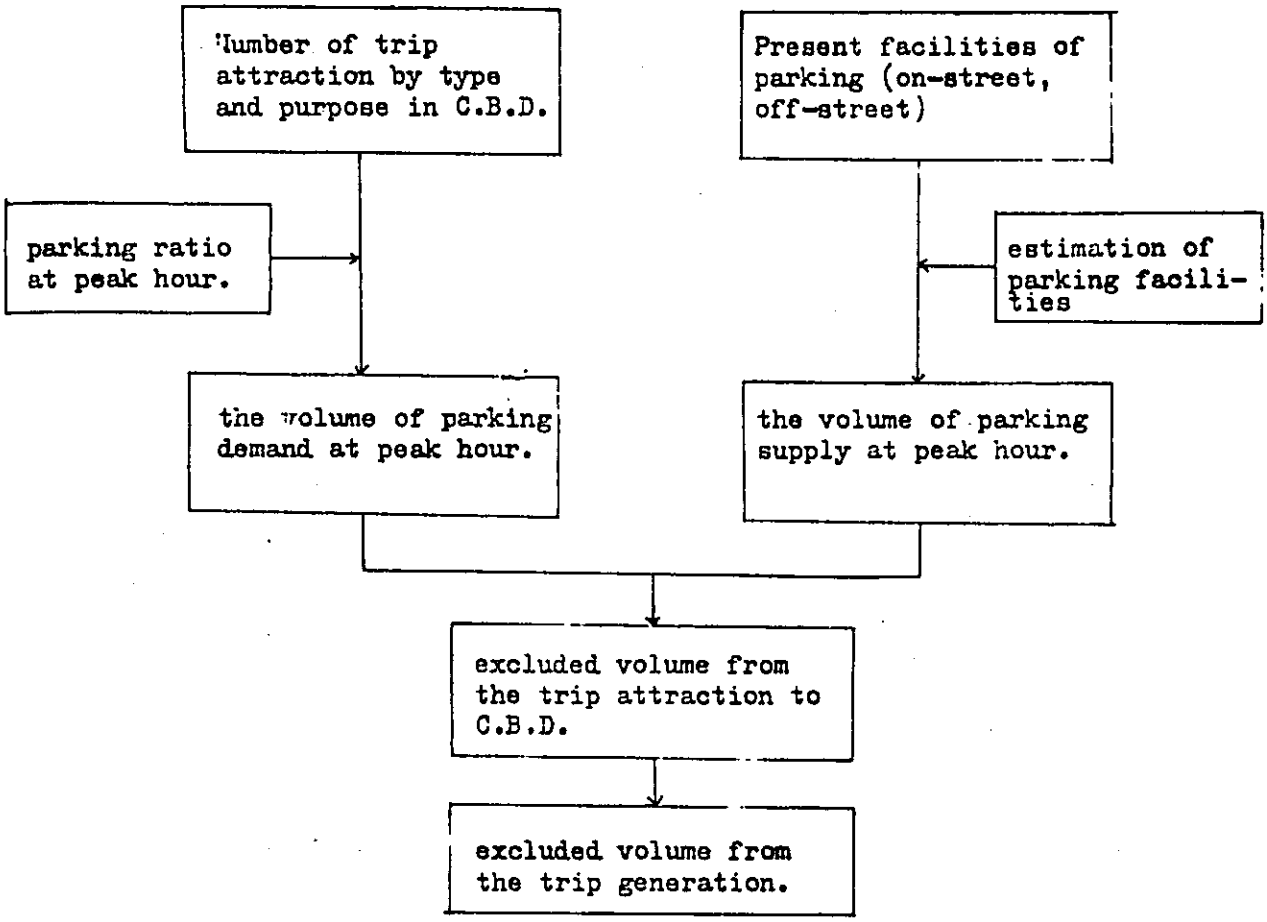
The premise of calculation are as follows:-

1. The object area of parking controll are limitted only within C.B.D in George Town (that is zone 111, 121, 131).
2. The difference volume between the parking demand and the parking supply are to be controlled and diverted to the public transport.
3. These difference are subtracted from the trip attraction to the C.B.D which purpose are 'going to work' by private car, and the equal volume are subtracted from the trip generation which purpose are 'going home' by private car.
4. Parking Ratio and the number of average passenger are used present figure which are obtained through the traffic survey.
5. There are no restriction concerning to motor-cycle because it is very difficult to estimate the future parking supply.
6. The average number of passengers is 1.4 in each private car.

(2) The result of calculation.

The calculations are executed as the following flow chart.

Fig. : 7.4 Flow chart of parking control.



The volume of parking demand at peak hour is calculated by multiplying the volume of trip attraction with the parking ratio. The parking ratio at peak hour are as follows:-

Table 7.1 The parking ratio at peak hour (10 - 12A.M.)

Car	To work	0.42
	On business	0.14
	Private	0.07
	Home	0.04
Lorry		0.14
Taxi		0.0
Bus		0.0

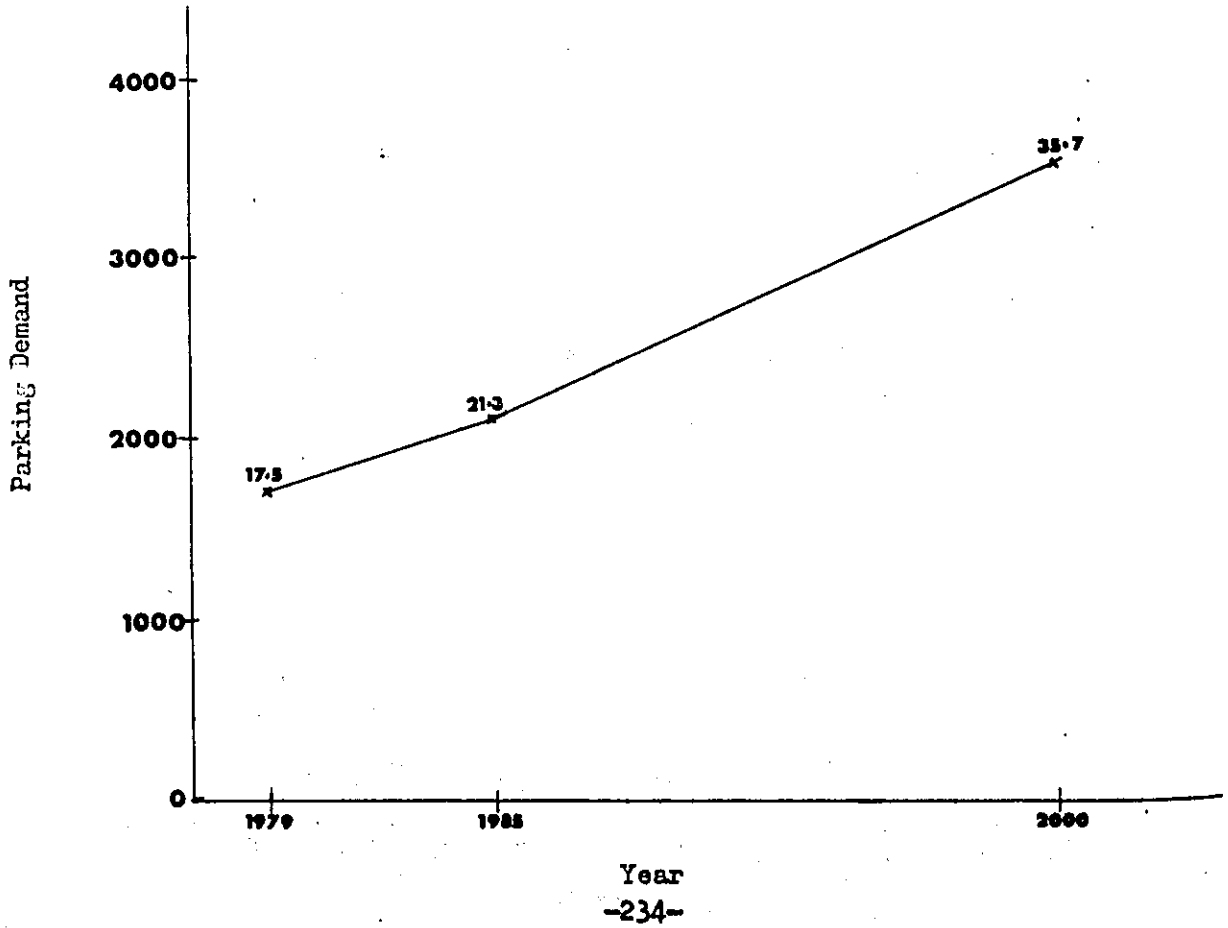
The parking demand at peak hours are as follows:-

Table 7.2 Parking demand at Peak Hour in C.B.D.

(Unit : trip end)

		1979	1935	2000
Car	To Work	12440	15010	24410
	On Business	1330	2320	3930
	Private	1290	1690	3030
	Home	540	680	930
Lorry		1300	1600	3300
Total		17450 (100)	21300 (122)	35650 (204)

Fig. : 7.5 Parking demand at peak hour.



The volume of parking supply are estimated by our parking survey as follows:-

Table 7.3 The volume of parking supply

(Unit:vehicles)

	1979	1985	2000
On-Street	14133	11500	10000
Off-Street	3491	6500	11000
Total	17624	18000	21000

From Table 7.2 and Table 7.3 , the excluded volume due to the shortage of parking supply are calculated as follows;

Table 7.4 The excluded volume

(Unit:1000 trip end)

	1979	1985	2000
demand volume	17.5	18.0	21.0
supply volume	17.6	21.3	35.7
difference	+0.1	-3.3	-14.7
excluded volume	-	-6.7	-29.3

7.2.2 Diverted volume to Public Transport

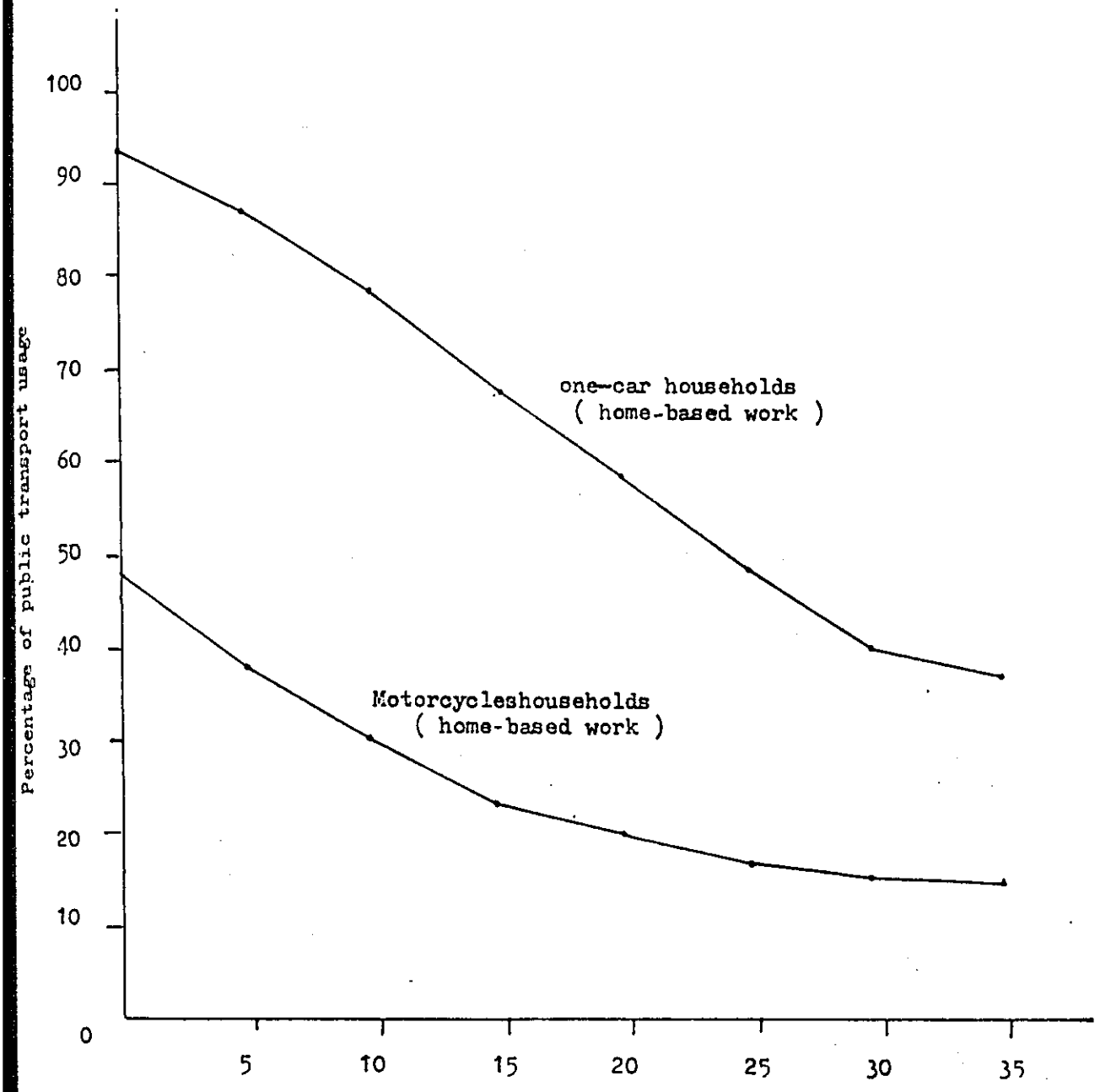
People who lived in urban area always chose their own mode among their available transport according to their judgement. The judgement are consist of varoius factors, but generally the factors are represented by concept of distance from origin place to destination. The distance includes, of course, actual distance, time distance and economic distance which includes the travel fare.

At 'Urban Transport Policy and Planning Study for Metropolitan Kuala Lumpur', the modal-choice model are applied the diversion curve and the factors of modal-choice are chosed time difference between alternative transport.

In Penang State, there are no modal-choice data, then the above-mentioned data in Kuala Lumpur are made use of the examination of diversion from traffic volume to public transport.

In above mentioned study in Kuala Lumpur, some diversion curve are verified by house-hold group and trip purpose. Among of them the representative curves are as follows;

Fig. : 7.6 Diversion Curve in K.L.



MODAL CHOICE MODEL

From these curve, following diversion ratio are obtained.

Table 7.5 Divertion ratio between car and public Transport

reduction of time difference (min)	increasing ratio of public transport usage (%)
5	10
10	18
15	24

(One Car Households - Home based Work)

Fig. : 7.7 Diversion ratio between car and public transport.

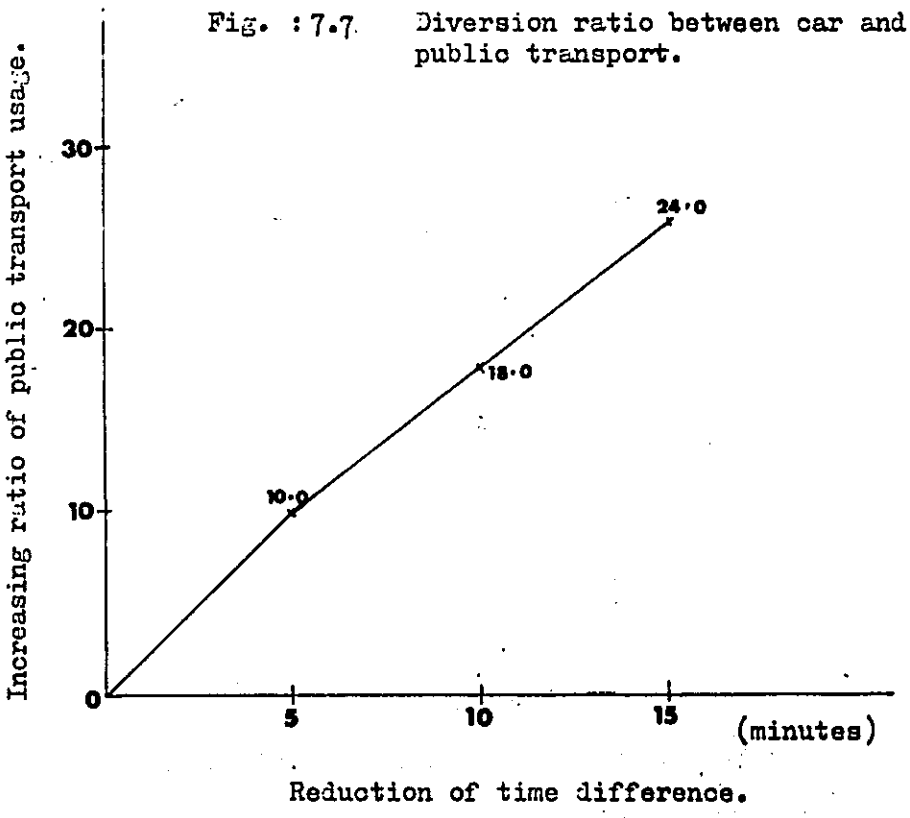
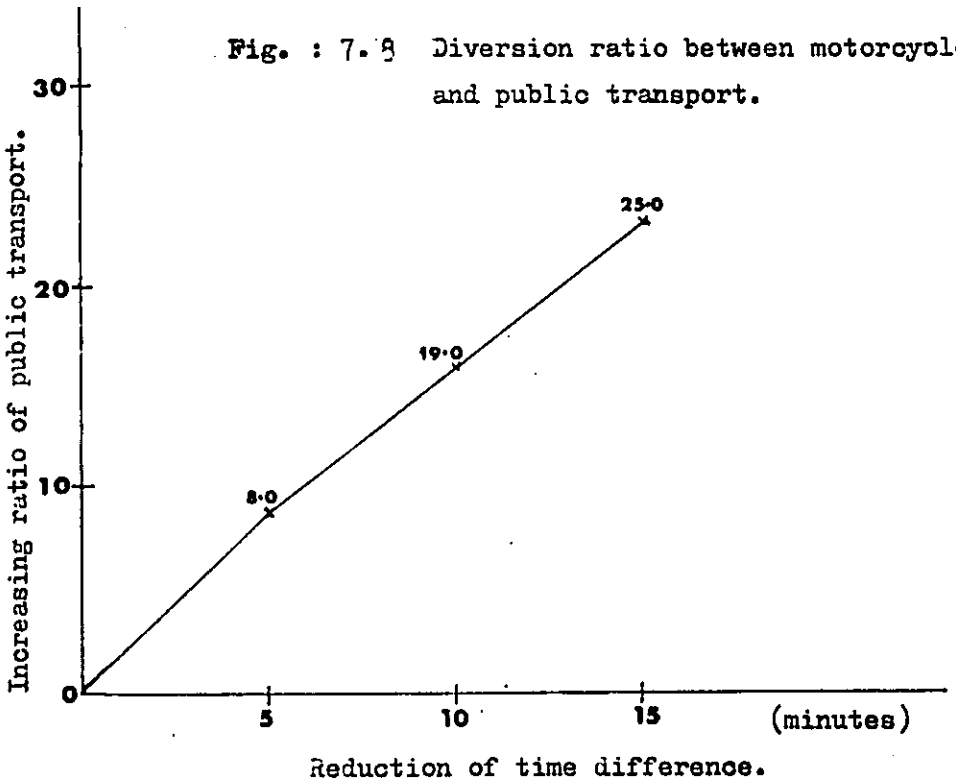


Table 7.6 Diversion ratio between M/C and public transport.

reduction of time difference (min)	increasing ratio of public transport usage (%)
5	8
10	19
15	25

(Motorcycle Households - Home-based Work)

Fig. : 7.8 Diversion ratio between motorcycle and public transport.



It is not accurate way to use the modal-choice modal of other city in severe examination, but it is equal to examine rough diversion from vehicle to public transport.

(1) The premise for calculation

This calculation are conducted in case of the execution of bus exclusive lane and the introduction of New Transport System.

Following premise are diceded to calculate.

1. The object area for diversion are limitted those area which are directly related to the new transport plan.

2. The object trip for diversion are only 'going to work' which made by private car and motor-cycle. And after calculation of diversion finished, the equal volume which are diverted to public transport from 'going to work' are subtracted from trip purpose 'going home'.

3. The schedule speed are determined as follows;

Bus :	On exclusive lane	25 km/h.
	On other lane (urbanized area)	15 km/h.
	On other lane	20 km/h.
	N.T.S.	30 km/h.

(2) The results of calculation

The volume of diversion from car and M/C to public transport are shown at followed Table.

Table 7.7 The volume of diversion by transport plans.

(Unit:1000 trips)

Year		In Penang Island		In Province Wellesley	
		Car	M/C	Car	M/C
1985 Caused by Bus Exclusive Lane	internal trip A	221.9	273.7	71.8	151.6
	object trip purpose for diversion B	124.9	156.0	40.2	86.4
	object trip related to the object area C	24.2	28.1	5.8	11.5
	Volume of diversion D	2.3	3.6	0.5	1.2
	ratio of diversion (D/C x 100)	9.5%	12.8%	8.6%	10.4%
2000 Caused by Bus Exclusive Lane	internal trip A	424.0	241.8	215.1	193.8
	object trip purpose for diversion B	237.4	137.8	120.5	110.5
	object trip related to the object area C	37.2	21.6	16.7	14.4
	volume of diversion D	3.5	3.6	1.7	2.1
	ratio of diversion (D/C x 100)	9.4%	16.7%	10.2%	14.6%

		In Penang Island		In Province Wellesley	
		Car	M/C	Car	M/C
2000	internal trip A	424.0	241.8	-	-
	object trip purpose for diversion B	237.4	137.8	-	-
N.T.S	object trip related to the object area C	75.0	56.9	-	-
	volume of diversion D	12.9	9.1	-	-
	ratio of diversion (D/C x 100)	17.2%	24.1%	-	-

NOTE : Object trip purpose for diversion (B) :

The traffic volume, the purpose of which is 'going to work' and 'going home'.

Object trip related to the object area (C) :

The traffic volume which generates or attracts from/to the object area.

Object area

The area in which the new transport plan is introduced.

These volume of diversion are not so large, that is, 2800 cars and 4800 M/C in 1985, 5200 cars and 5700 M/C in 2000 and after introduction of N.T.S, these figures are 12900 cars and 9100 motor-cycle.

Comparing with the total trips, these volume of diversion are only 1.2% of vehicles and 1.9% of motor-cycles even if after introduction of N.T.S.

It is because the object trip and limited by trip purpose and by area.

7.2.3 Execution of Car Pooling system

Car Pooling System is divised for the purpose of preventing from the traffic congestion which are caused by private car entering to C.B.D.

According to the rule, the number of passenger in each car are enforced to be more effective, that is, to be full of capacity. As a result of the restriction, the number of car which passengers are a few will be on the decrease and the traffic volume also will decrease.

(1) The premise for calculation

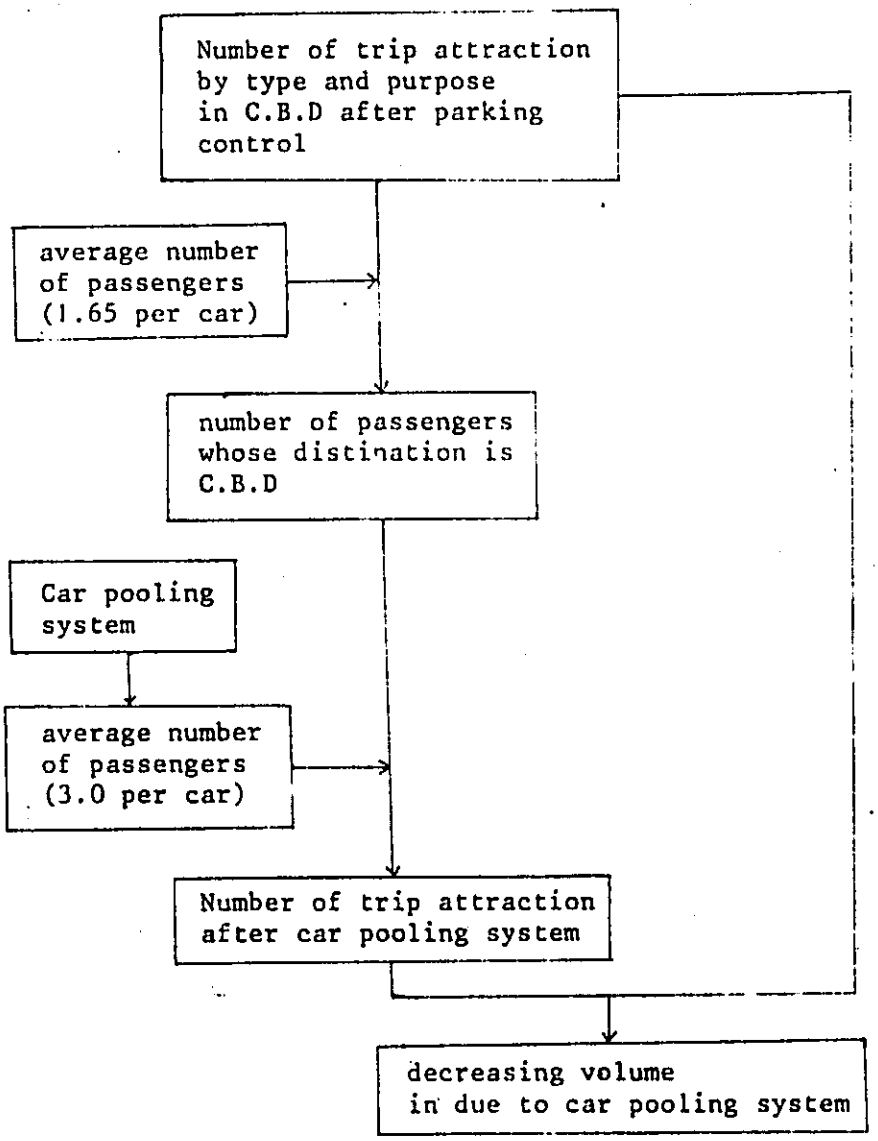
The premise are as follows;

1. The object area of car pooling system are limitted only within C.B.D in George Town.
2. The object trips are those which destination are C.B.D and also trip purpose is 'going to work' and 'private'.
3. Average number of passenger in each private car are enforced to be average 3.0 person includes the driver from 1.65 persons, therefore the decreasing ratio of traffic volume is 0.45 (3.0-1.65/3.0).
4. The equal volume with the decreasing number of intering volume into the C.B.D are subtracted from coming out volume from C.B.D.

(2) The results of calculation

The calculation are conducted as following flow-chart in 2000 year.

Fig. 7.9 Flow chart of calculation



The number of trip attraction in C.B.D after parking control are as follows;

Table 7.8 Number of trip attraction in C.B.D (Unit : 1000 trip ends)

Car	To work	43.4
	On Business	28.0
	Private	43.3
	Home	24.4
Lorry		23.6
Taxi		7.5
Bus		5.9
Sub-total		176.1
M/C		95.5

From this table, the number of passengers whose trip purpose are 'going to work' 'private' are as 143100 persons. (86700 cars x 1.65 persons).

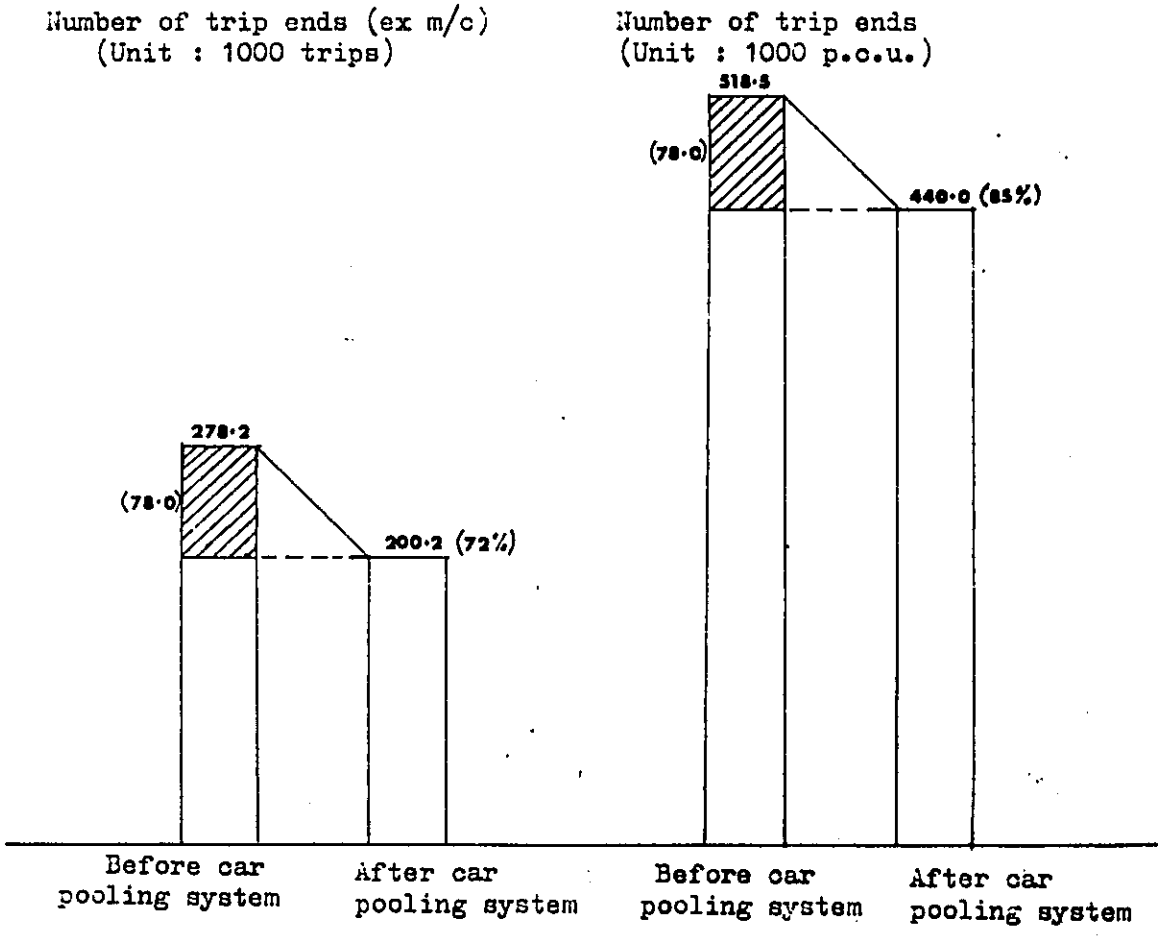
After excuting of car pooling system, following number of cars will be decreased.

Table 7.9 Decreasing volume due to car pooling system.

	number of trip attraction	number of passengers	average number of passengers
before car pooling system	86.7	141.3	1.65
after car pooling system	47.7	143.1	3.0
decreasing volume on one way direction	39.0		
decreasing volume on both way	78.0		

As a result of these restriction, number of trip attraction in C.B.D are decreased as followed figure.

Fig. 7.10 The effect of car pooling system in C.B.D.



7.3 Estimation of future traffic demand by transport plan.

7.3.1 Number of total trips by transport plan.

Estimation by transport plan are conducted according to the above-mentioned premise. Number of total trip (p.c.u) are changed as follows;

Fig. 7.11 Number of total trip by transport plan.

(Unit : 1000 p.c.u.)

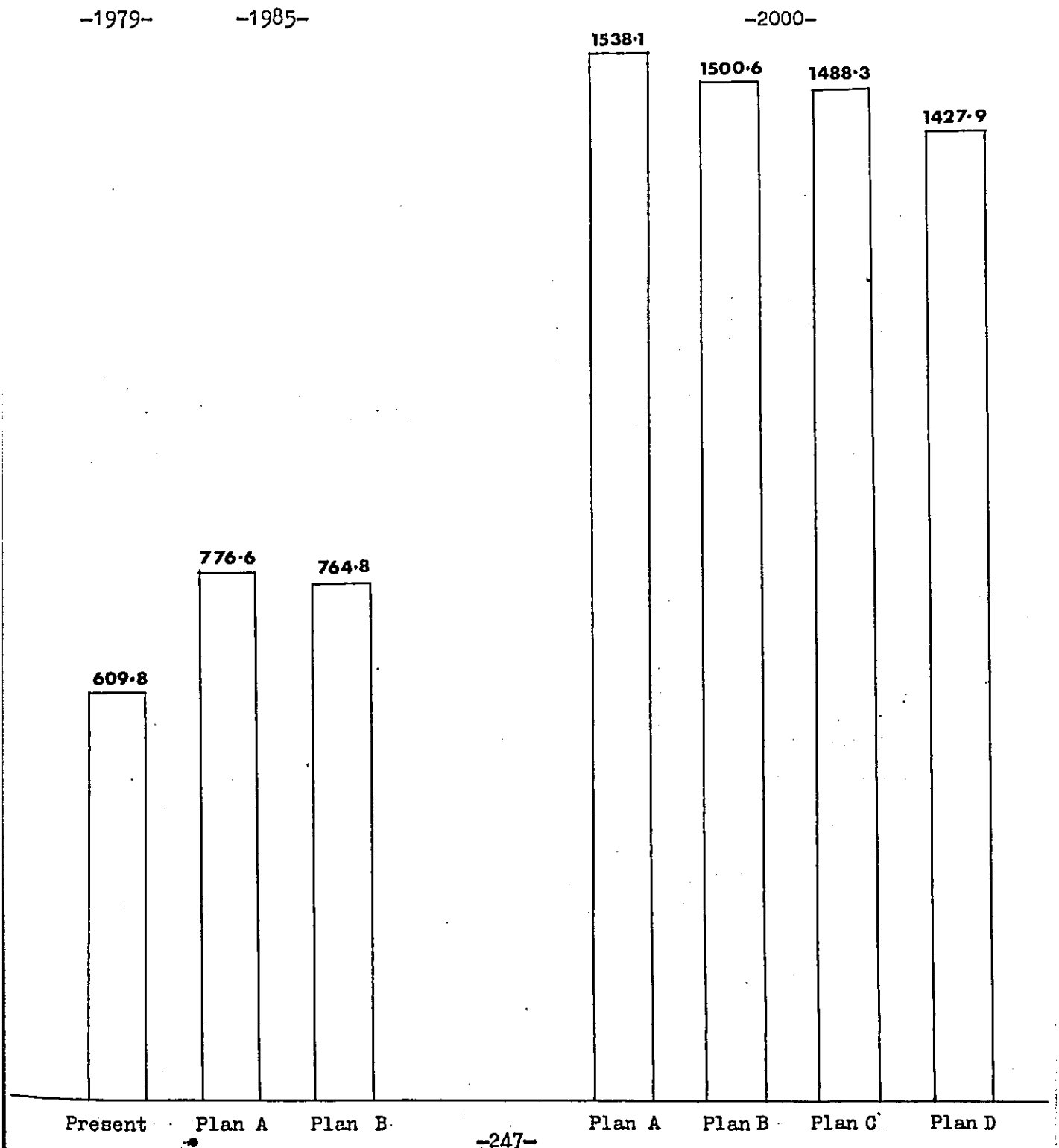
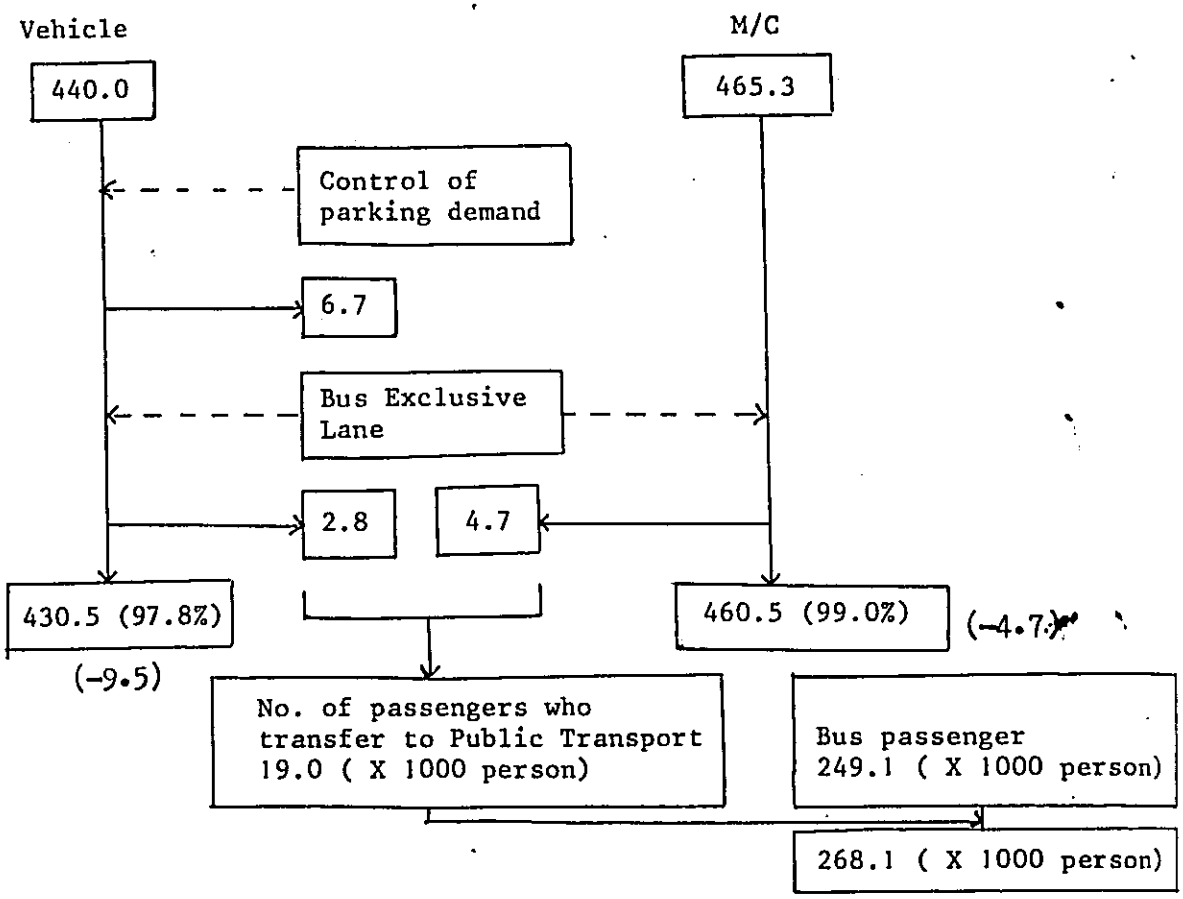


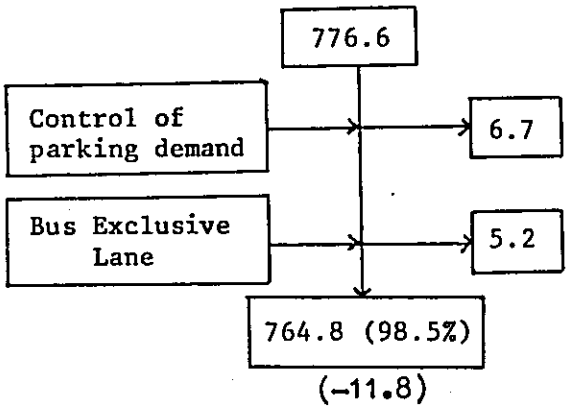
Fig. :7-12 Results of Estimation by Plan B (1985)

1985 - Plan B (unit: 1000 trip per day)



P.C.U.

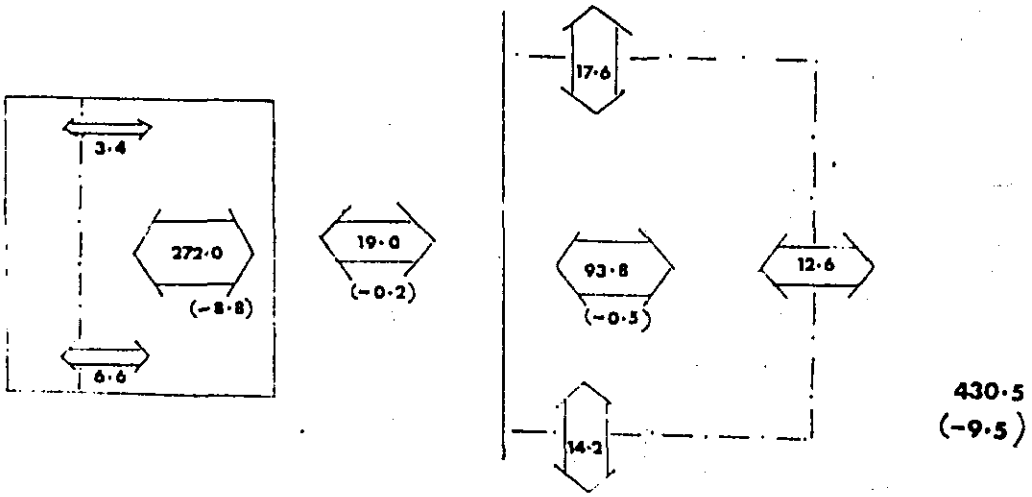
(Unit : 1000 p.c.u.)



1985 - Plan B

(unit : 1000 trips)

Vehicle



Motor-cycle

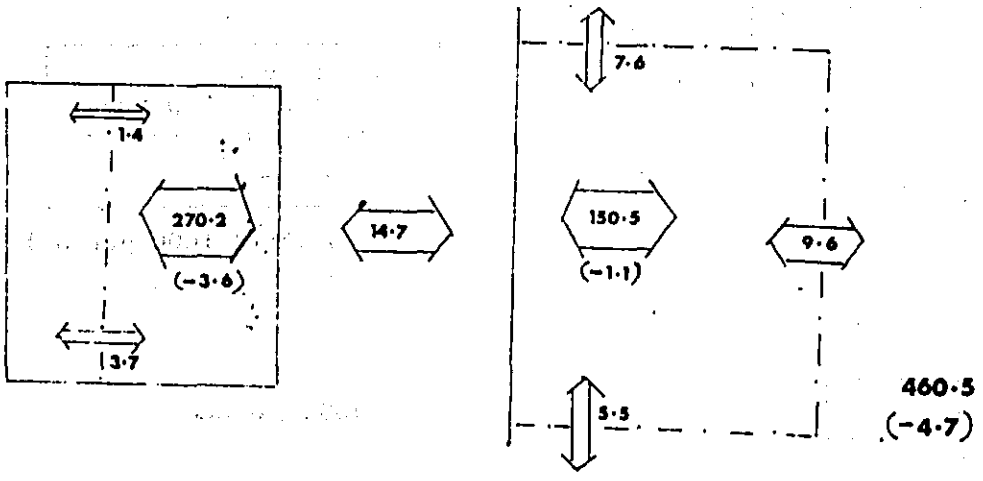
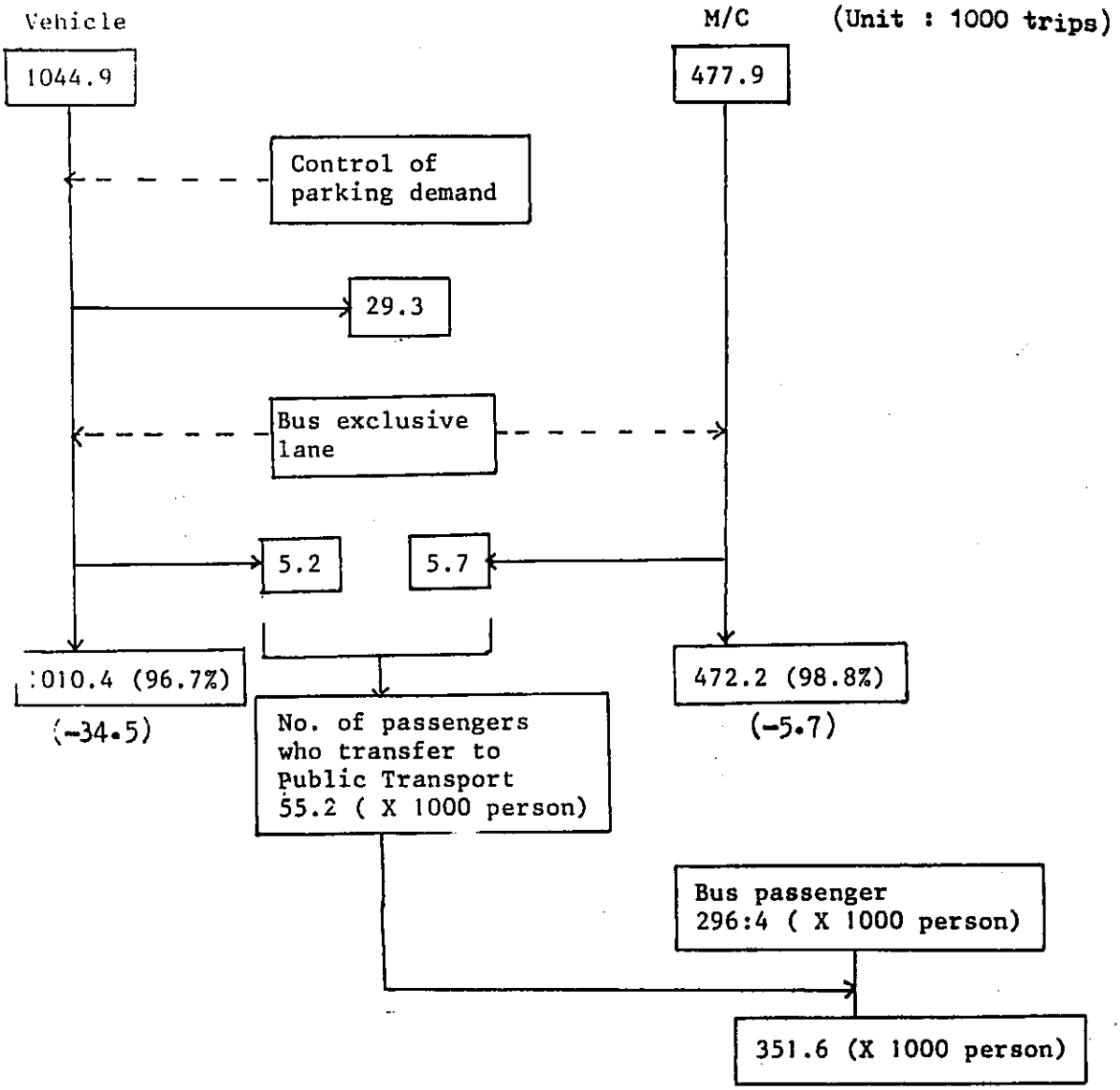
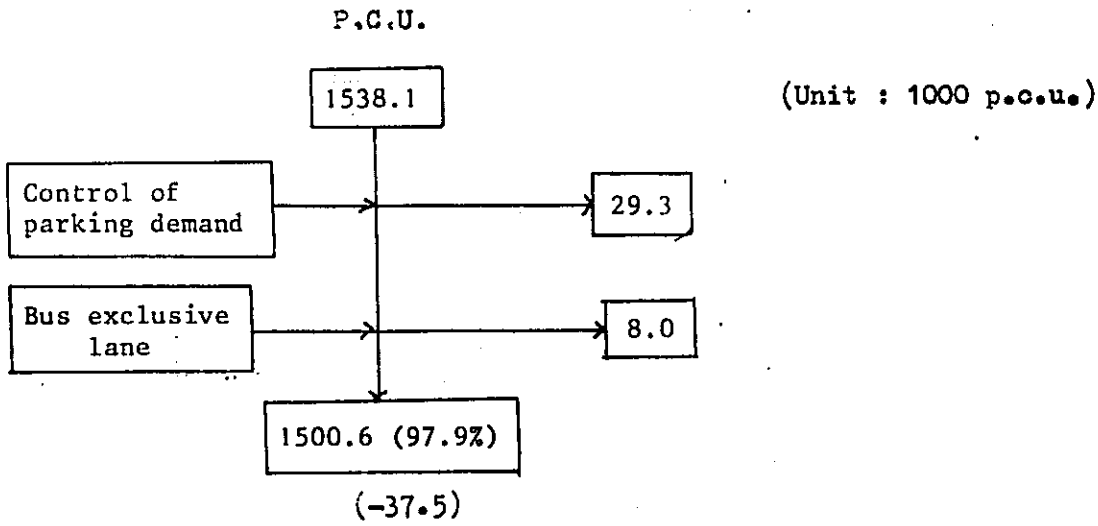


Fig. : 7.13 Results of Estimation by Plan B (2000)

2000 - Plan B





2000 - Plan B

(unit : 1000 trips)

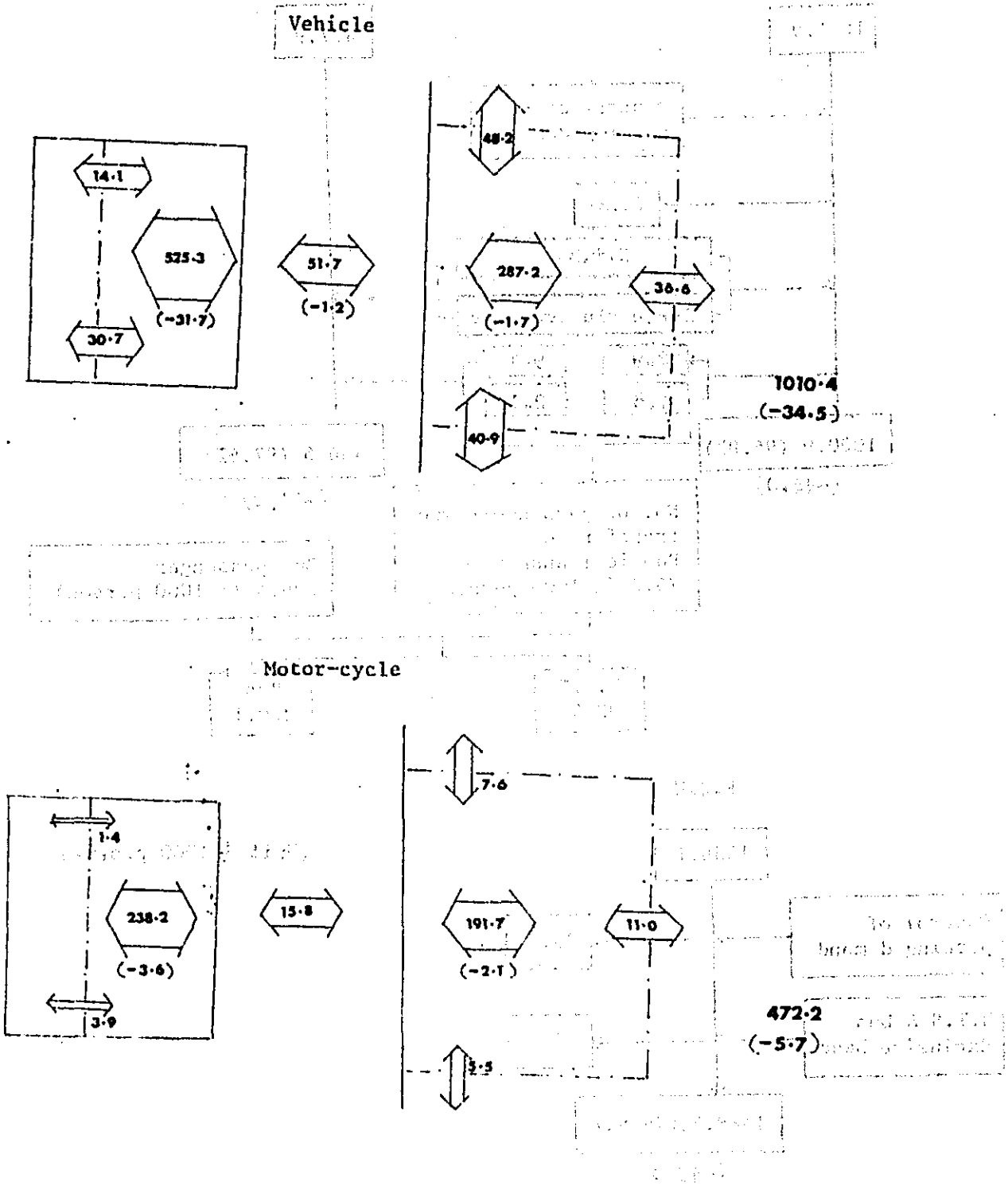
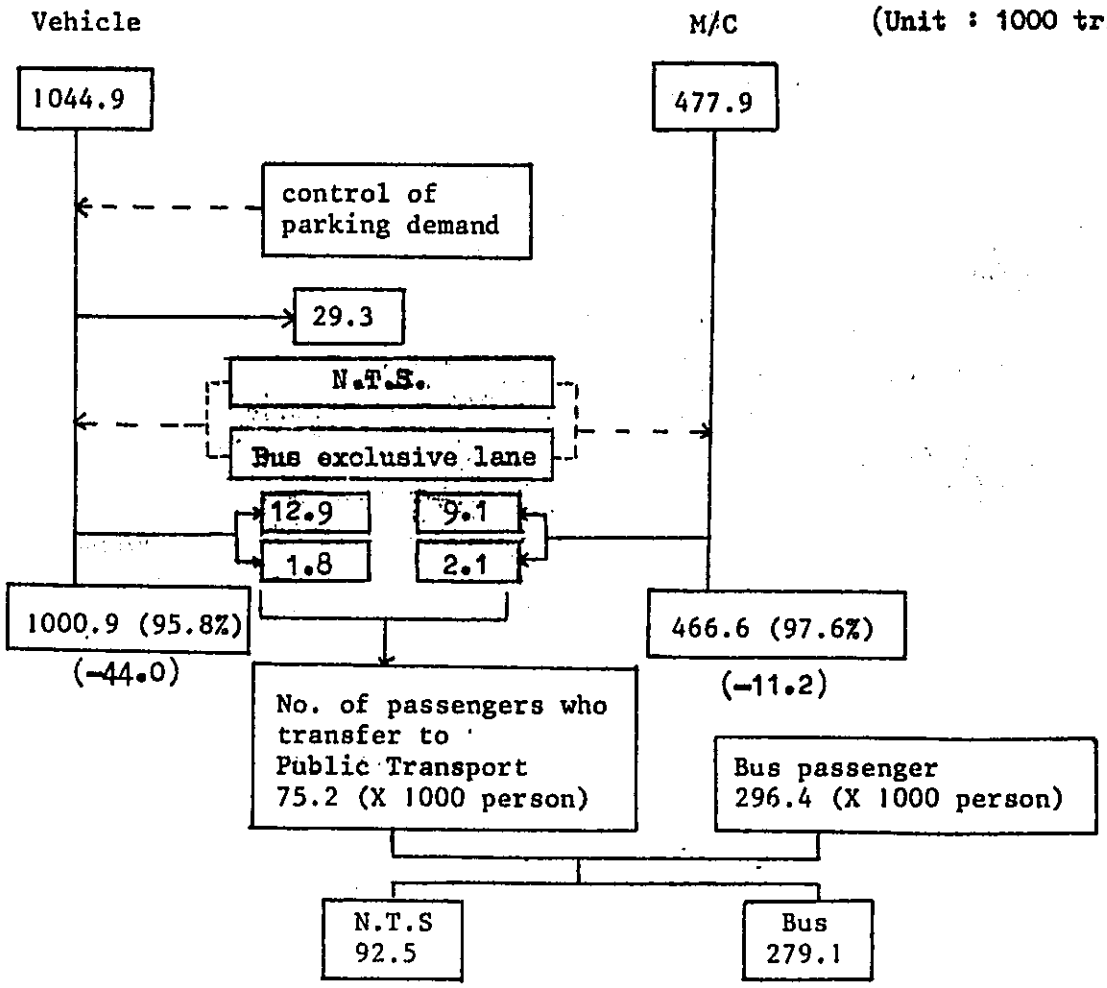
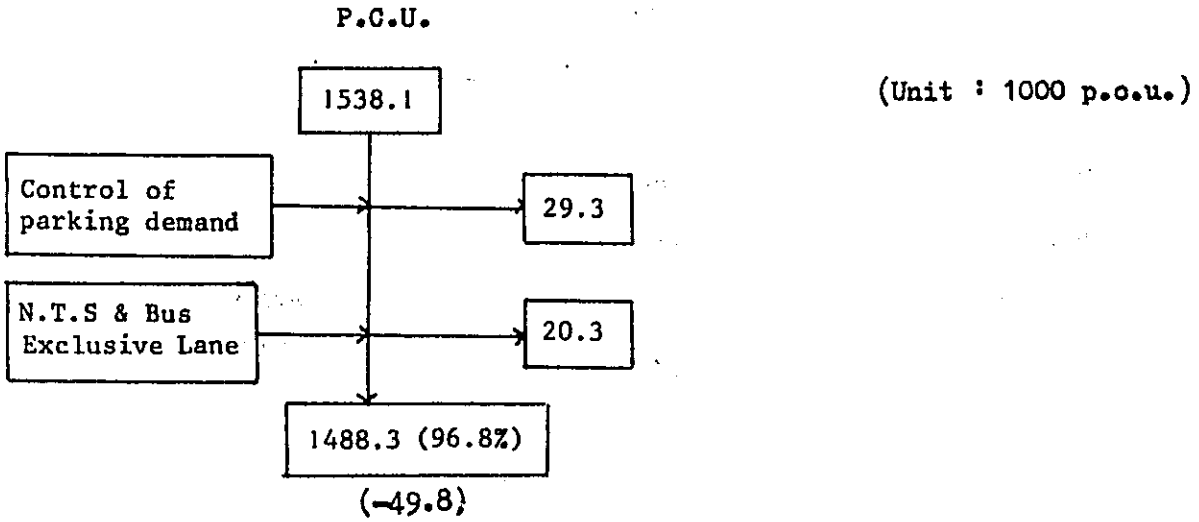


Fig. : 7.14 Results of Estimation by Plan C (2000)

2000 - Plan C

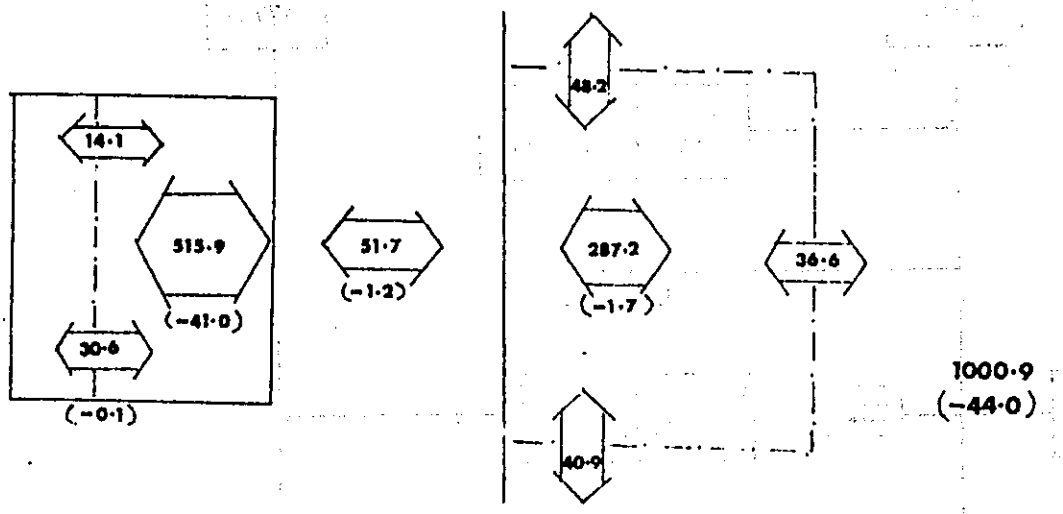




2000 - Plan C

(unit : 1000 trips)

Vehicle



Motor-cycle

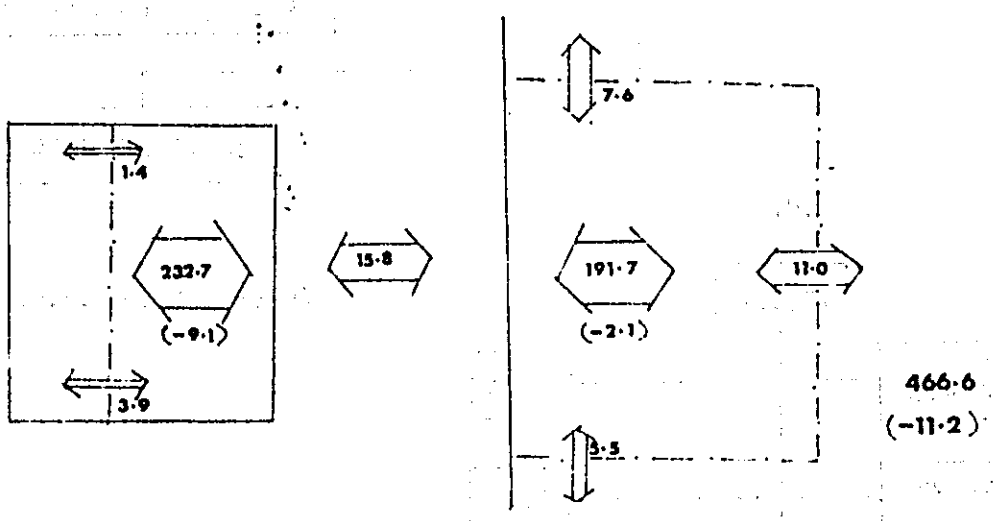
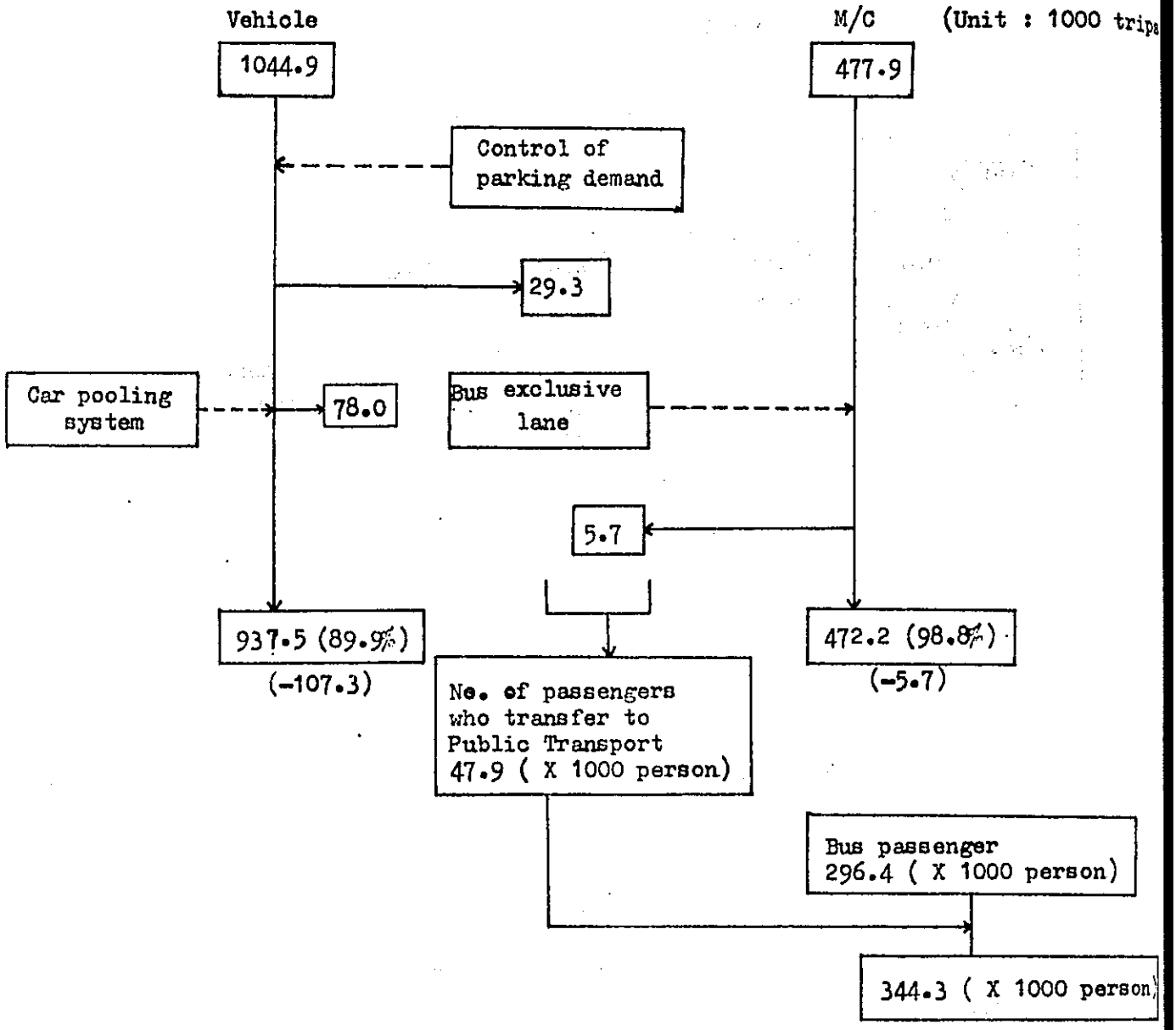
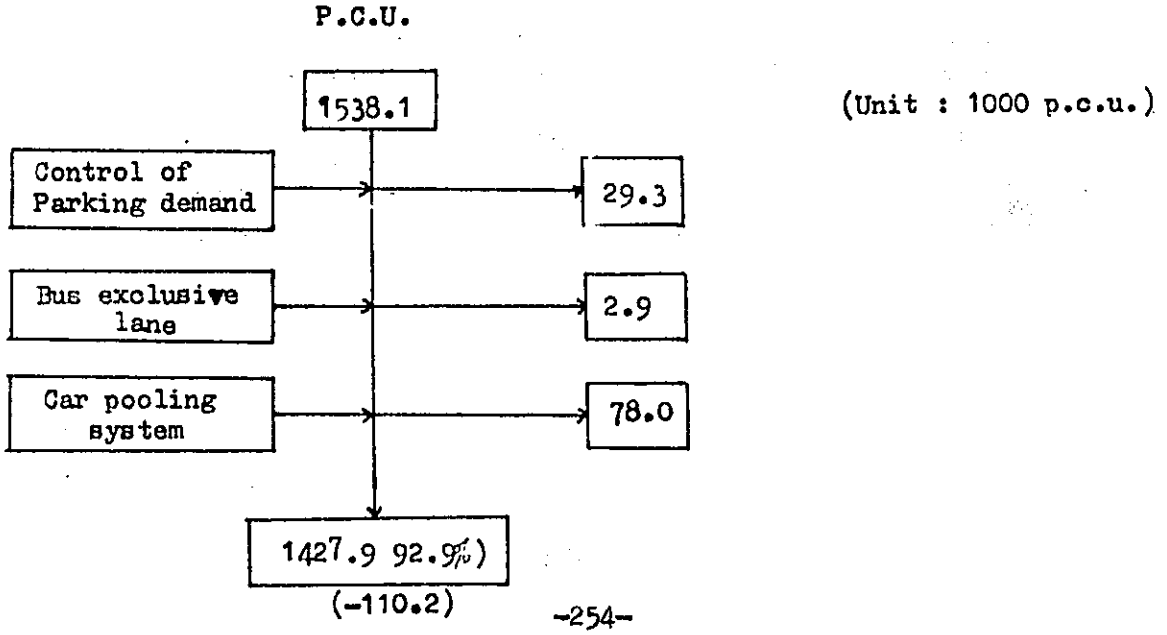


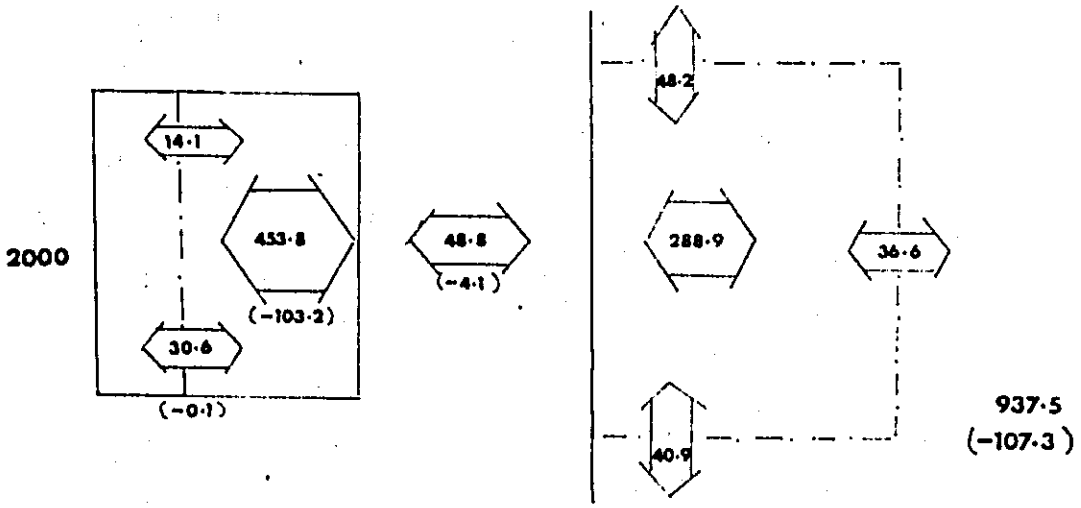
Fig. : 7. Results of Estimation by Plan D (2000)

2000 - Plan D

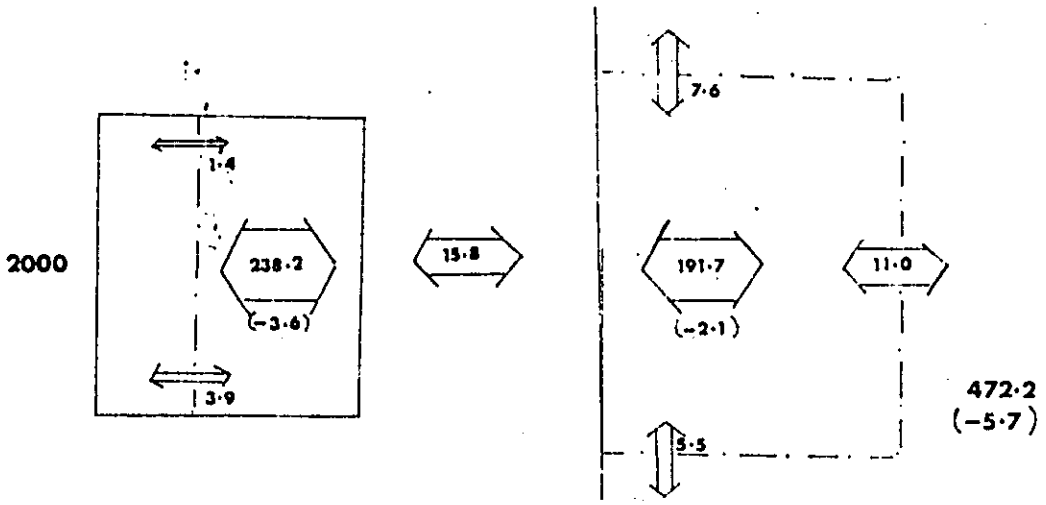




Vehicle



Motor-cycle



7.3.2 The comparizon of transport plan in George Town

(1) Number of trips related to George Town.

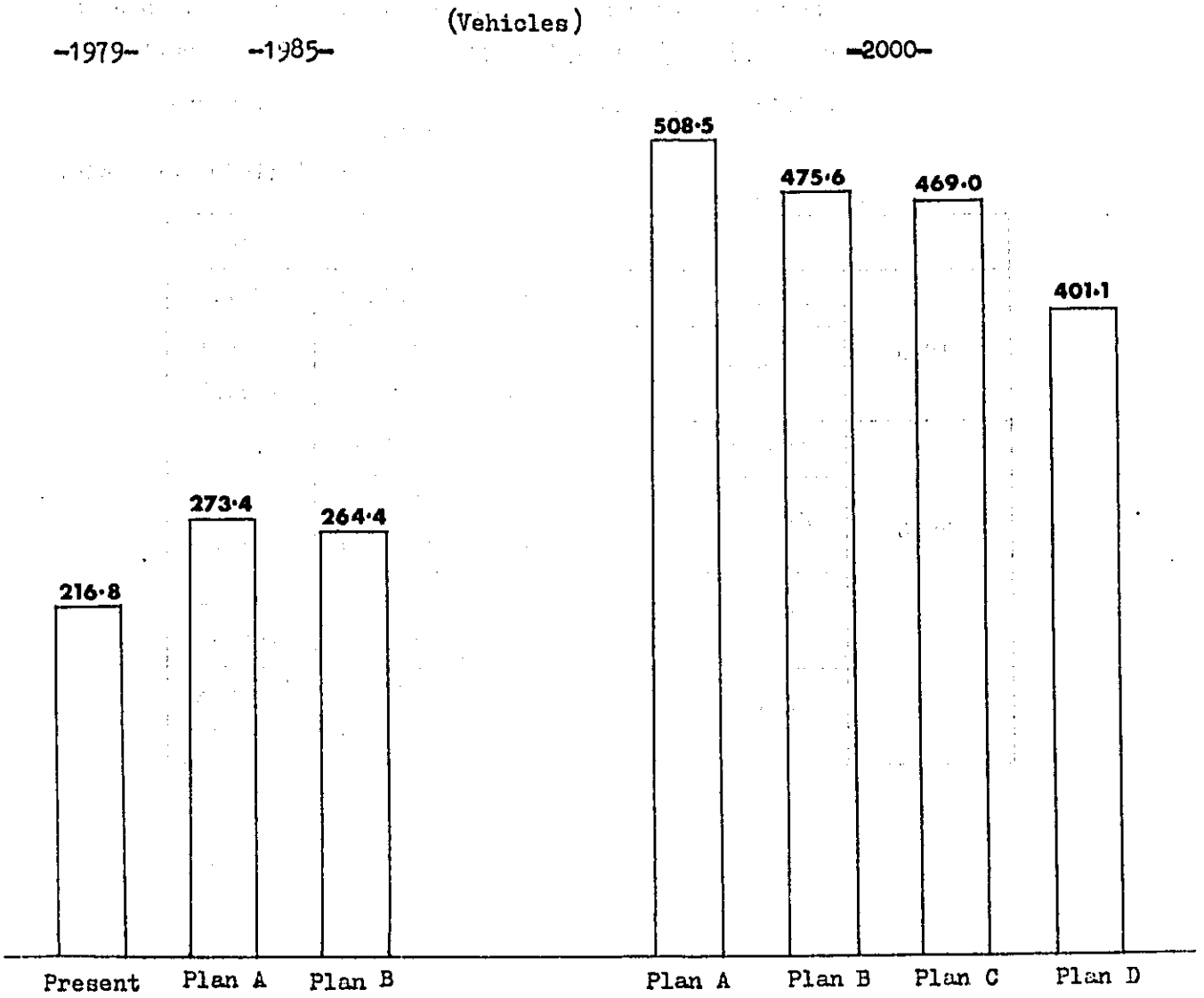
Number of trips by transport plans are as follows:-

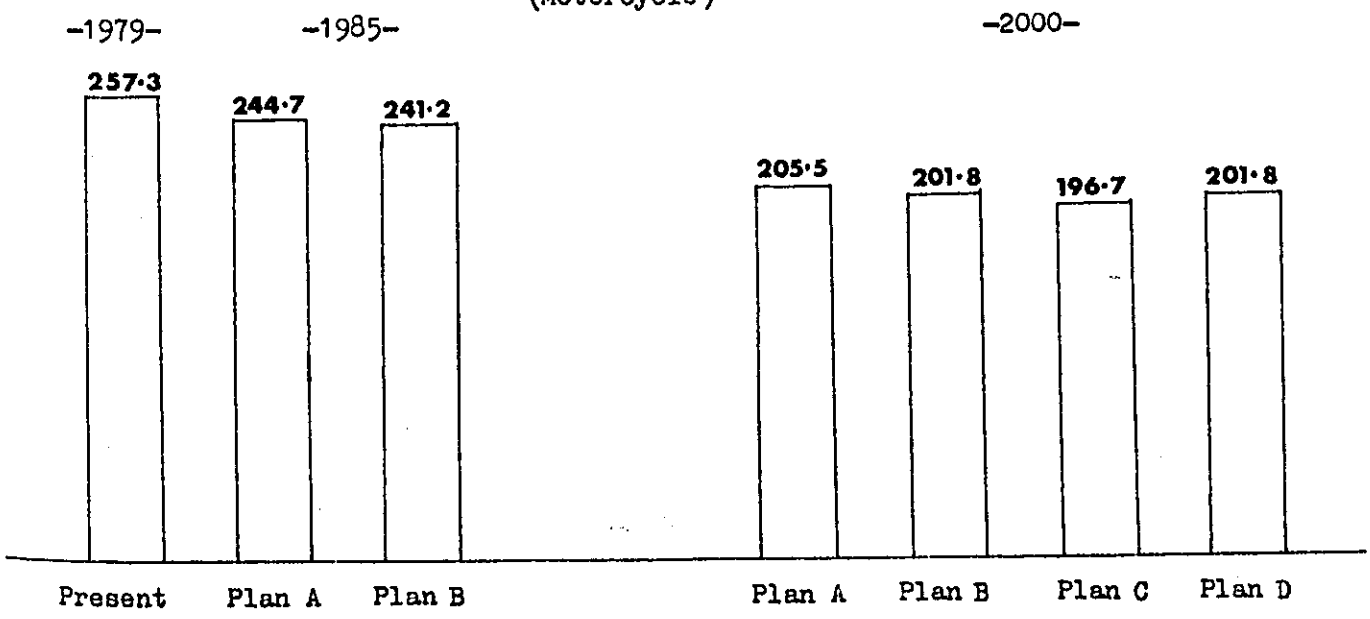
Table 7.10 The comparizon by transport plan in George Town.

(Unit:1000 trips)

		Vehicle			M/C		
		internal	external	total	internal	external	total
1985	Plan A	180.5	92.9	273.4	185.4	59.3	244.7
	Plan B	173.8 (-6.7)	90.6 (-2.3)	264.4 (-9.0)	182.5 (-2.9)	58.7 (-0.6)	241.2 (-3.5)
2000	Plan A	277.0	231.5	508.5	148.1	57.4	205.5
	Plan B	255.7 (-21.3)	219.9 (-11.6)	475.6 (-32.9)	145.2 (-0.8)	56.6 (-3.7)	201.8
	Plan C	252.8 (-24.2)	216.2 (-15.3)	469.0 (-39.5)	142.7 (-5.4)	54.1 (-3.3)	196.7 (-8.7)
	Plan D	208.3 (-68.7)	192.8 (-38.7)	401.1 (-107.4)	145.2 (-2.9)	56.6 (-0.8)	201.8 (-3.7)

Fig. 7.16 The camparizon of number of trips related to George Town.





Note : above figures include internal trip and external trip of George Town.

(2) Number of trip generation and attraction in C.B.D of George Town.

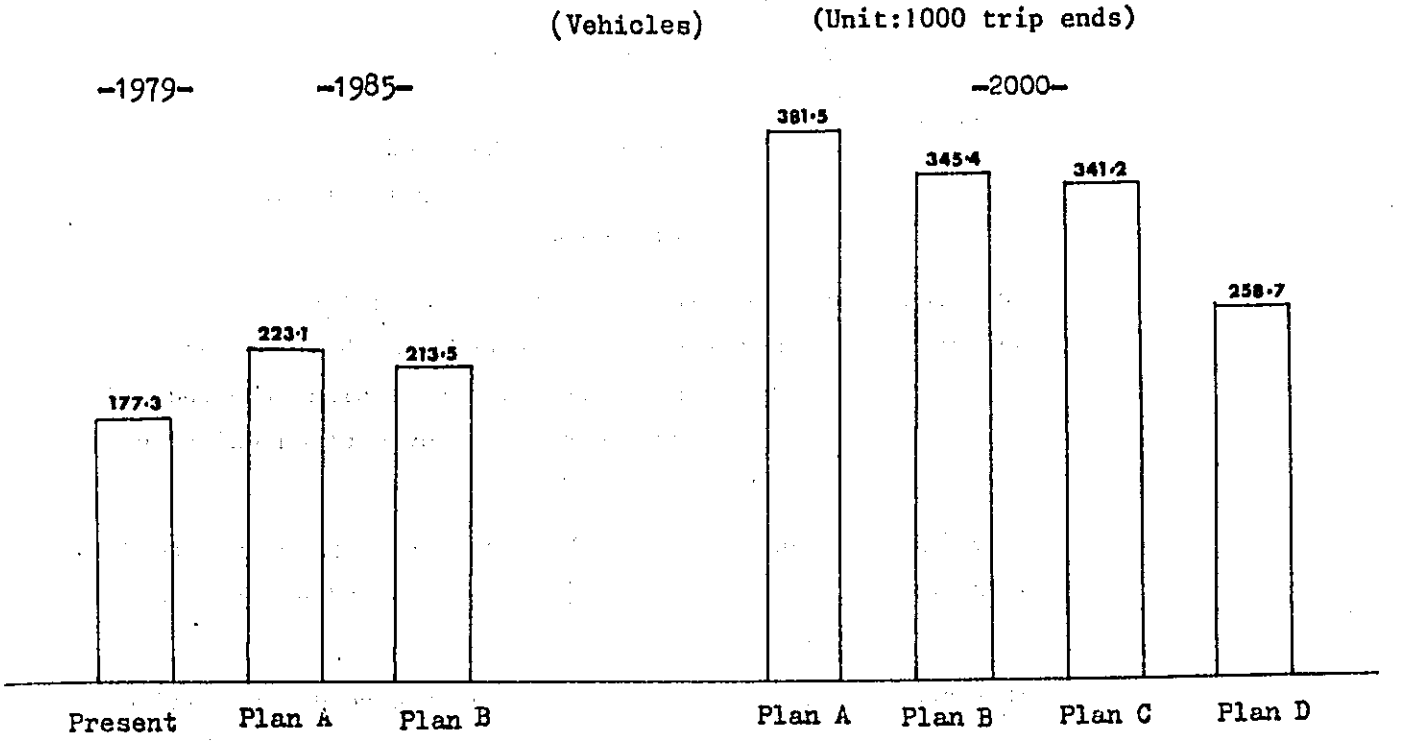
Number of trip generation and attraction in C.B.D area (zone 111, 121, 131) by transport plan are as follows;

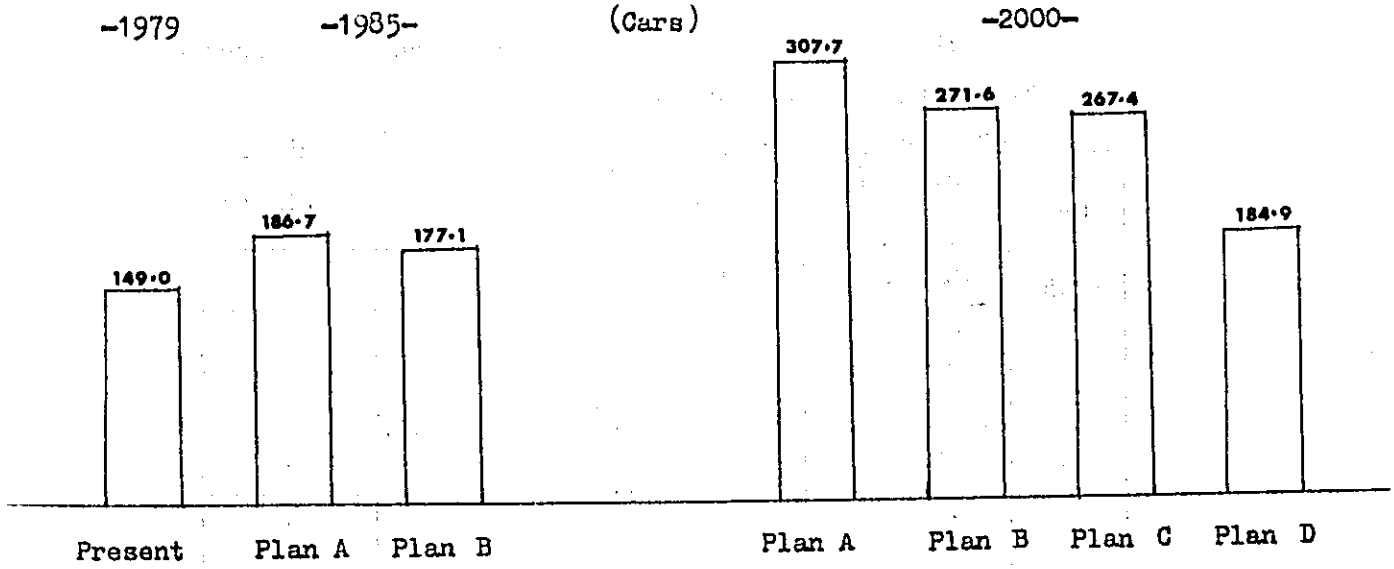
Table 7.11 The comparizon of trip generation and attraction in C.B.D

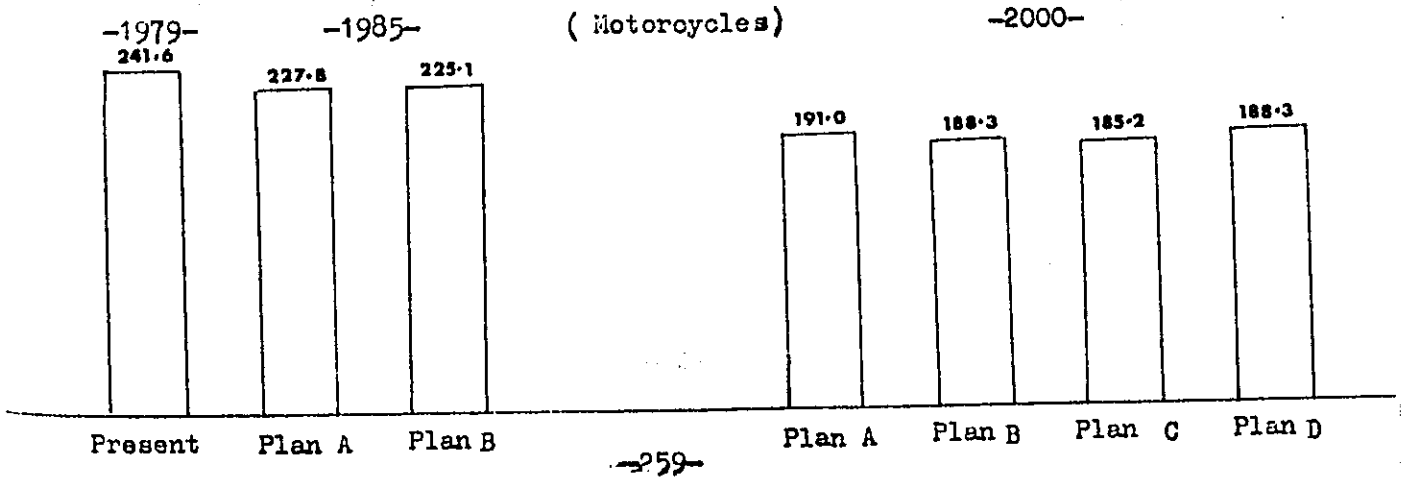
(Unit:1000 trip ends)

		Vehicle	(Car)	M/C
1985	Plan A	223.1	(186.7)	227.8
	Plan B	213.5 (-9.6)	177.1 (-9.6)	225.1 (-2.7)
2000	Plan A	381.5	(307.7)	191.0
	Plan B	345.4 (-36.1)	271.6 (-36.1)	188.3 (-2.7)
	Plan C	341.2 (-40.3)	267.4 (-40.3)	185.2 (-5.8)
	Plan D	258.7 (-122.8)	184.9 (-122.8)	188.3 (-2.7)

Fig. 7.17 The comparizon of trip generation and attraction in C.B.D.







8. Estimation of the future traffic demand on road network.

The road networks which are intended for traffic assignment are as follows:-

1979	Present network
1985	On going
	On going & Proposed
2000	On going & Proposal Ultimated
	Ultimated

The content of these road network are as follows:-

On going — The present road network to which is added the linkage plan, the dispersal plan, the federal route plan and some improvement on existing road.

On going & Proposed — The road network where our proposed new road plans (e.g. project 1, 2, 3 and 4) are added to 'On going'.

Ultimate — The road network where some road plans and plans to widen the roads are added to 'On going & Proposed'.

The simulation for traffic assignment are conducted according to following table:-

Table 8-1 Simulation for traffic assignment

O-D	Network	On going	On going & Proposed	Ultimate
1985	Plan A	0		
	Plan B		0	
2000	Plan A			
	Plan B		0	0
	Plan C			0
	Plan D			0

Regarding the toll charged, the following are taken in to consideration. In America, the toll rates which fall within the range of M$00.5 tc M$00.8 per mile is common. At the Slim River toll-gate, a toll of M$1.00 is imposed for the use of the new 18 mile section on Federal Route 1. Toll collection is only along one-way, hence, the charge is for 36 miles at a rate of M$0.028 per mile.

In the case of the Alor Star - Butterworth project, toll-gates are located at intervals of about 15 miles and the toll is expected to be M$0.50 per passenger car trip giving the rate of M$0.033 per mile. The toll rates on Federal Route 1 in this study area is M$0.033 per mile. On the other hand, the decision regarding the toll for the Linkage is influenced by the fare for the ferry, i.e. M$1.75 for one way.

This fare is converted in to time by dividing the fare by the time value. The time value used are as follows:-

Table 8-2 Time value

	1979	1985	2000
passenger car	3.70 M/Hour	4.50 M/Hour	7.30 M/Hour
motor-cycle	1.30 M/Hour	1.60 M/Hour	2.60 M/Hour

Fig. 8.1 Comparison of Travel Speed

(Unit : km/h)

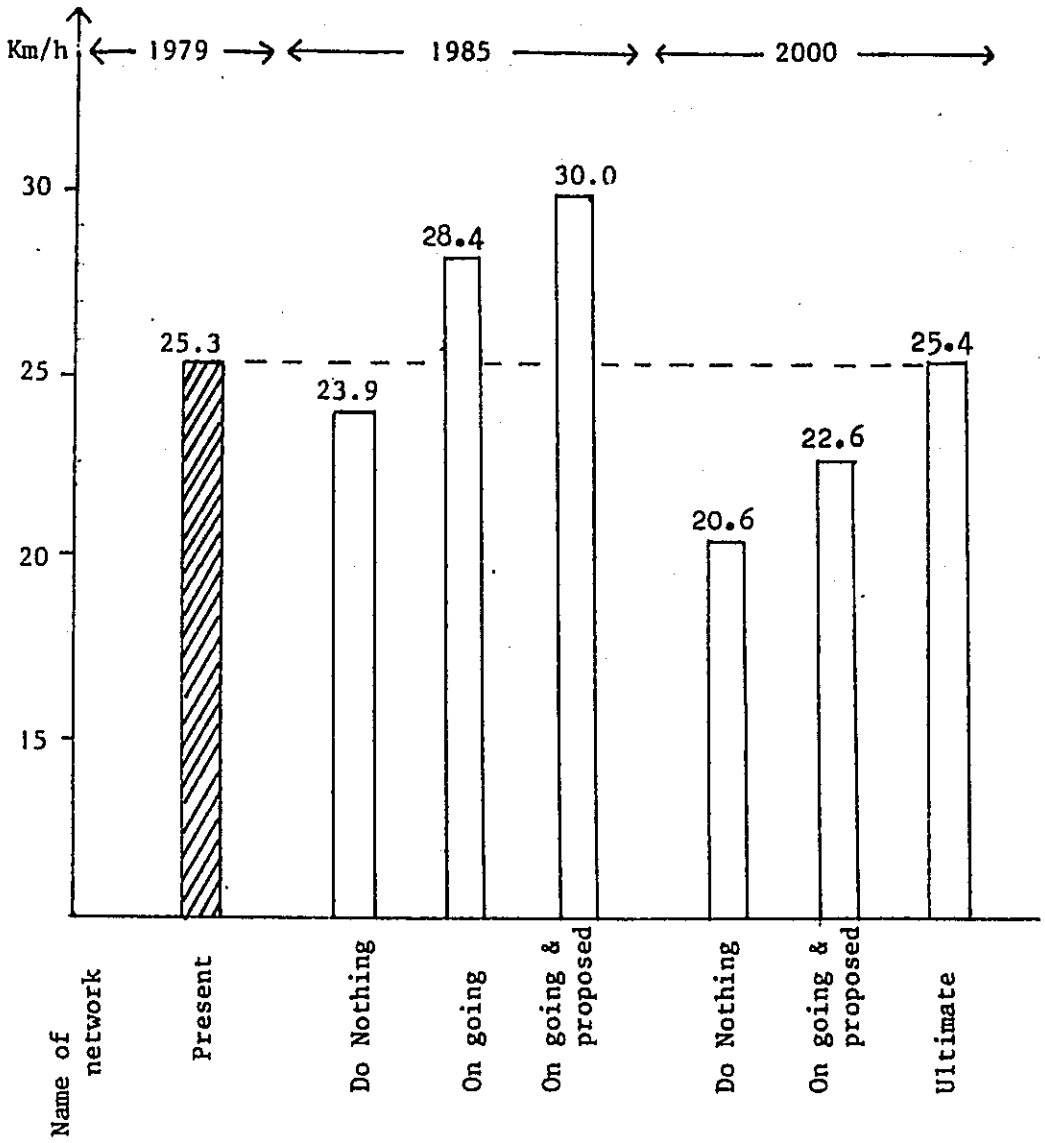
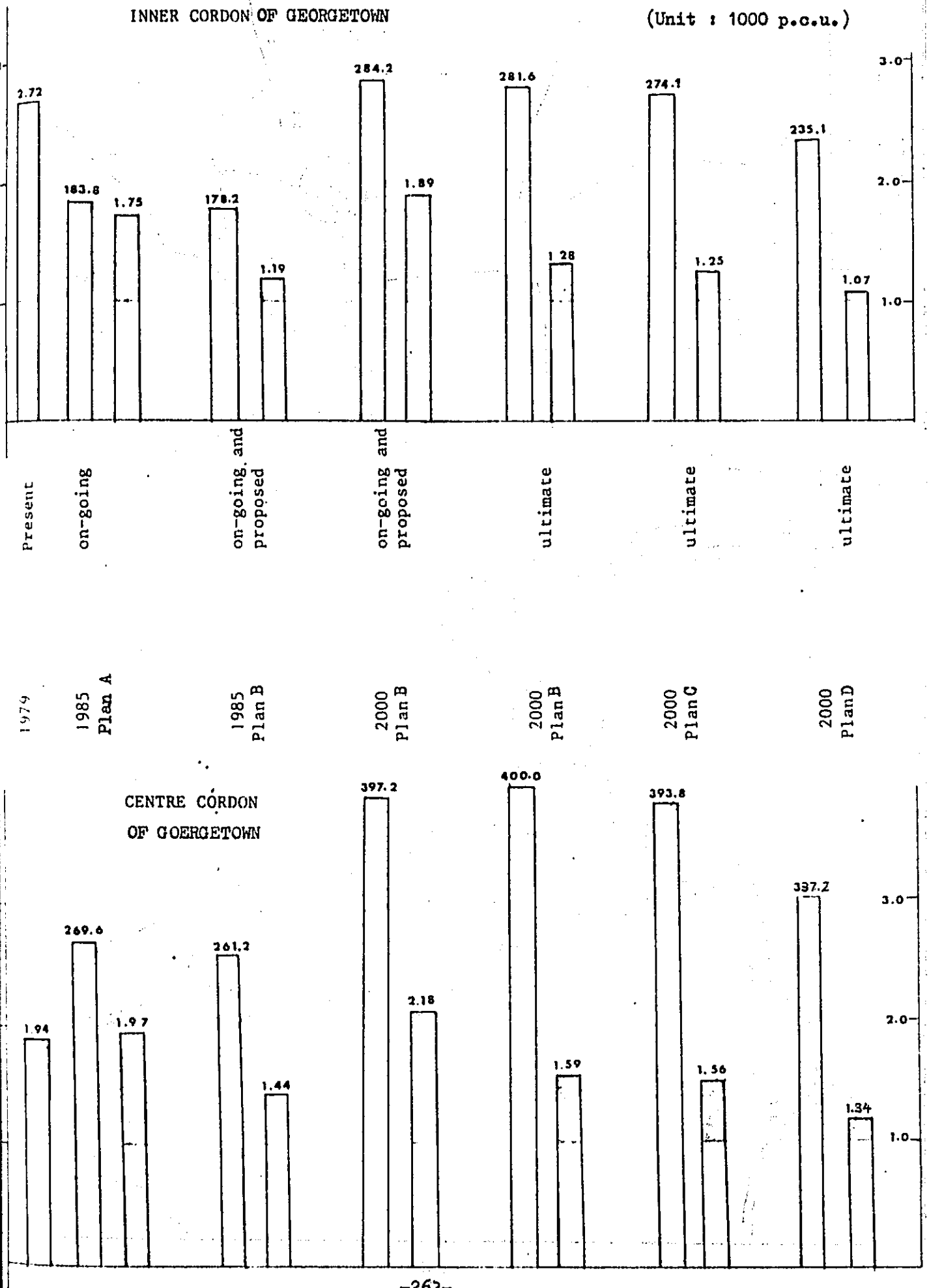
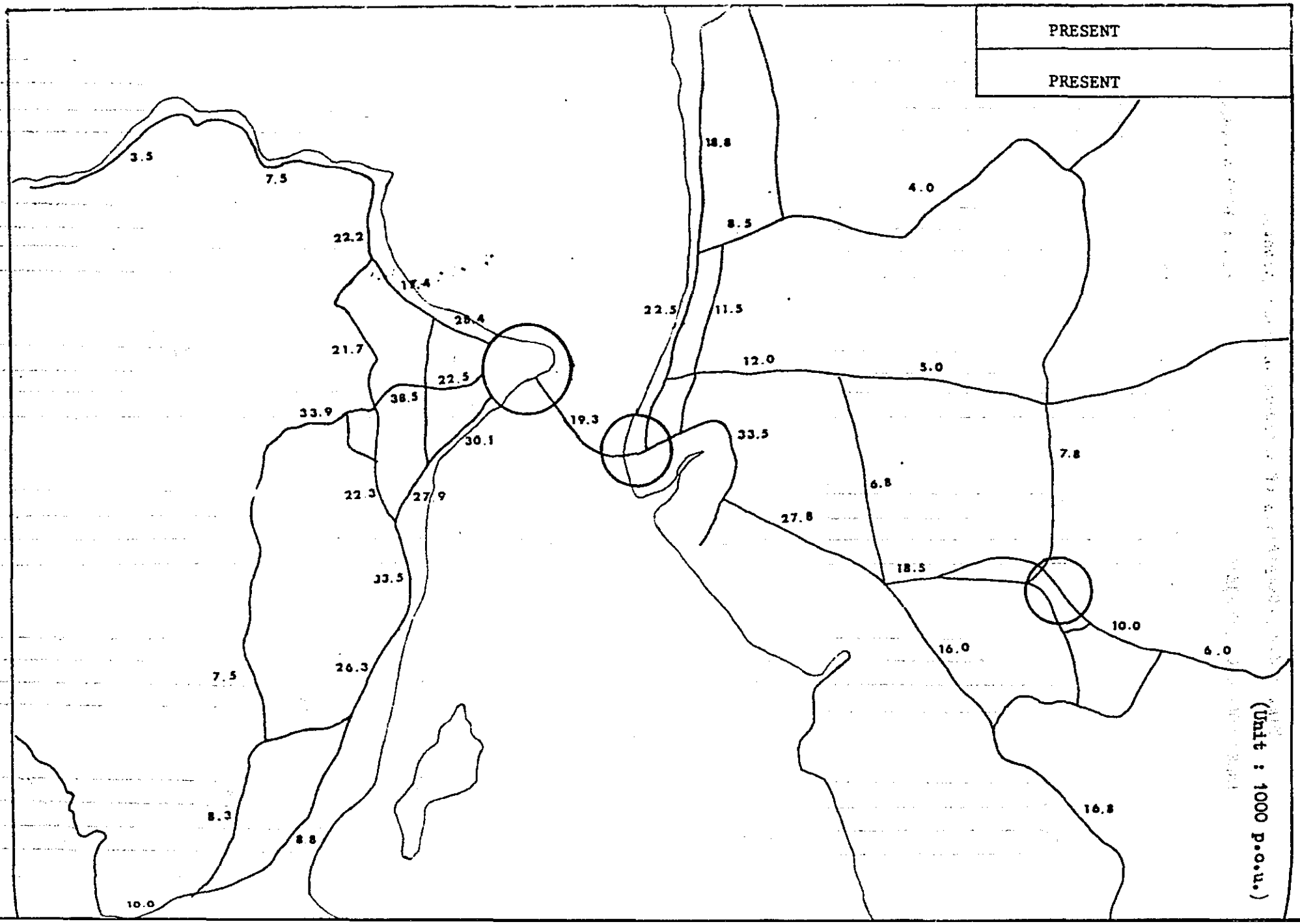
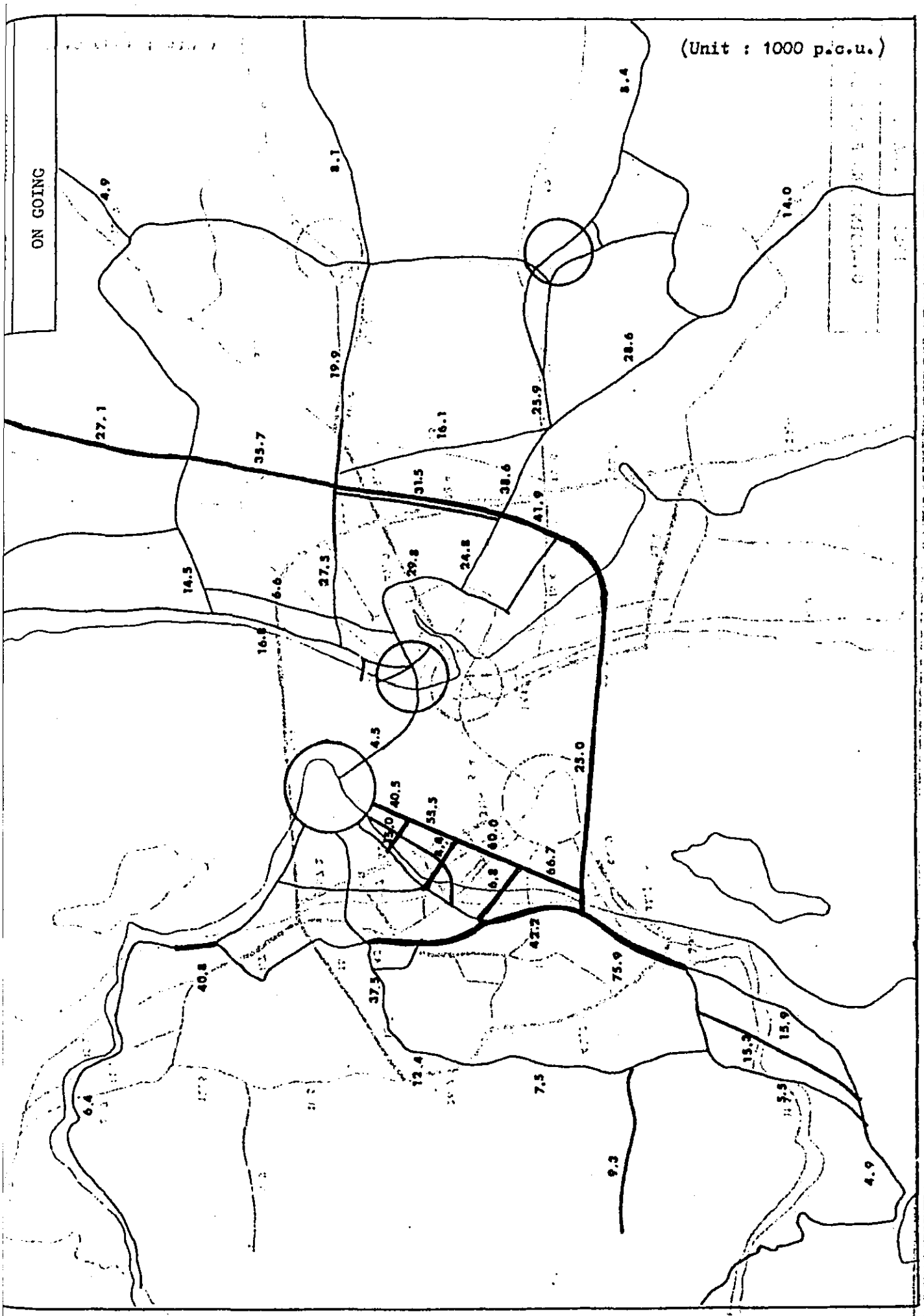


Fig. : 8.2 Comparison of the degree of congestion.




PRESENT
PRESENT
3.5
7.5
22.2
17.4
28.4
21.7
22.5
38.5
33.9
30.1
19.3
22.3
27.9
33.5
26.3
7.5
8.3
8.8
10.0
18.8
8.5
4.0
22.5
11.5
12.0
5.0
33.5
7.8
6.8
27.8
18.5
10.0
16.0
6.0
16.8
(Unit : 1000 p.o.u.)


ON GOING
(Unit : 1000 p.c.u.)
4.9
8.1
8.4
14.0
19.9
28.6
25.9
27.1
35.7
16.1
31.5
38.6
41.9
14.5
6.6
27.5
29.8
24.8
16.8
4.5
25.0
40.5
55.5
60.0
66.7
6.8
42.2
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37.5
15.9
15.3
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7.5
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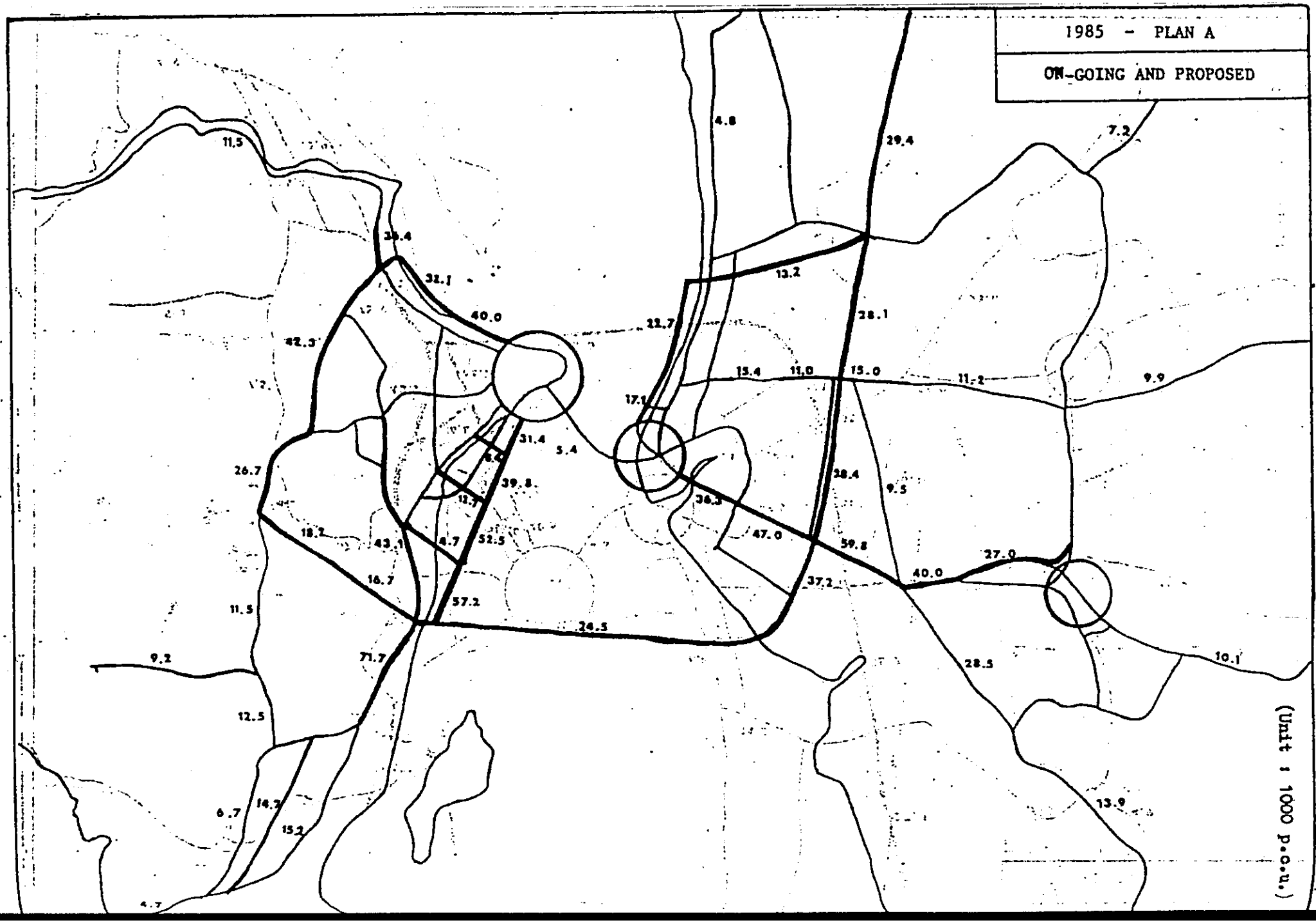
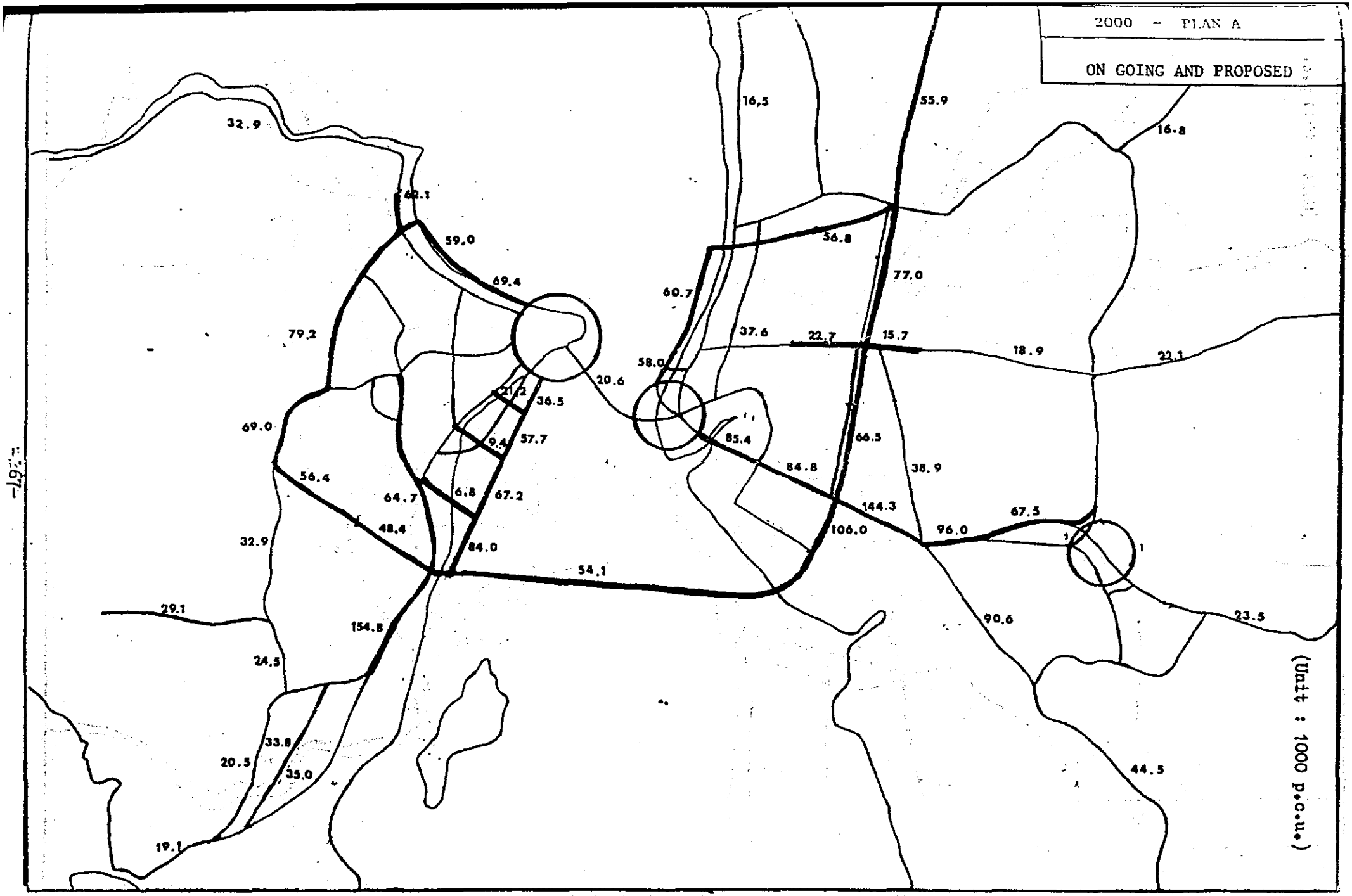
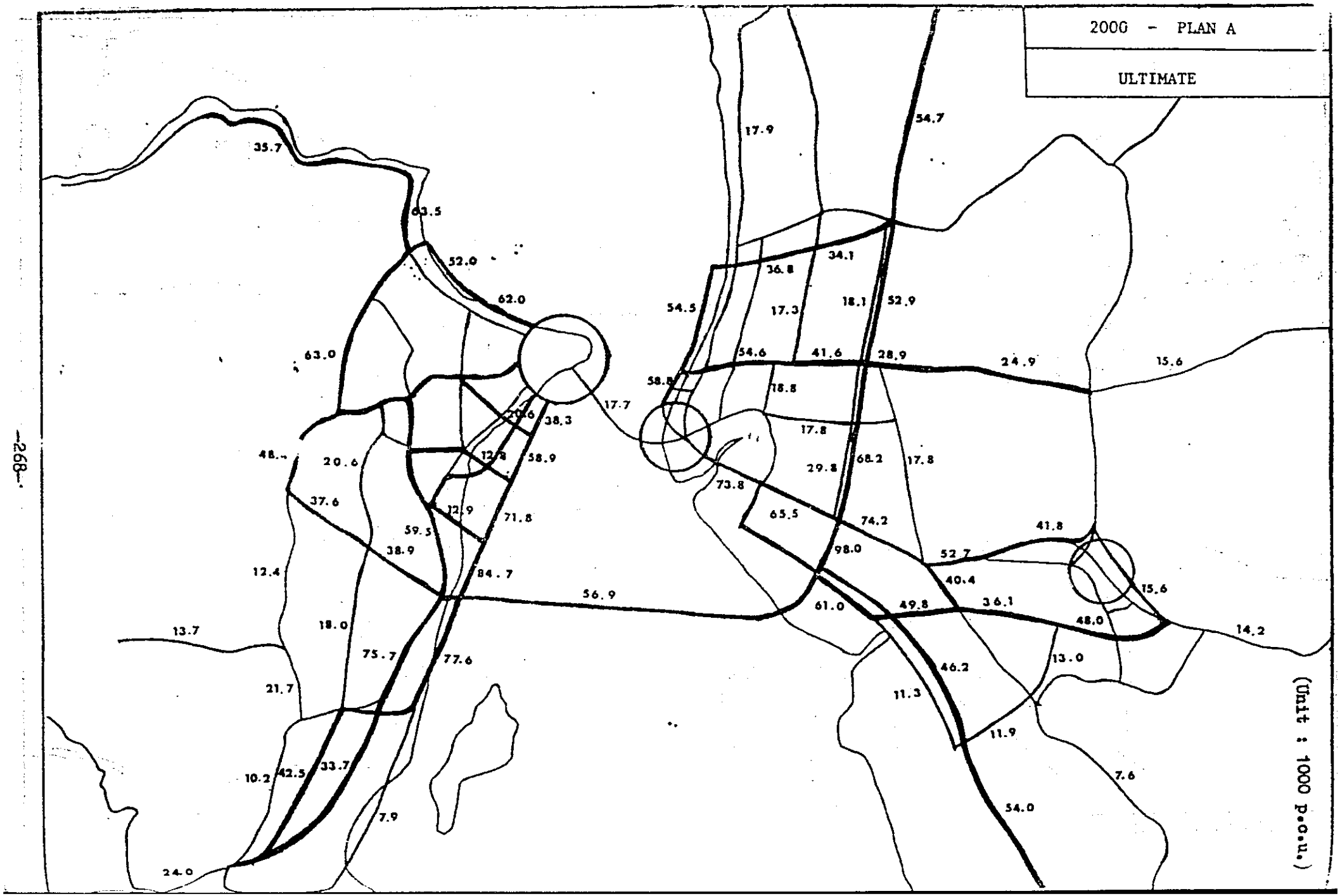
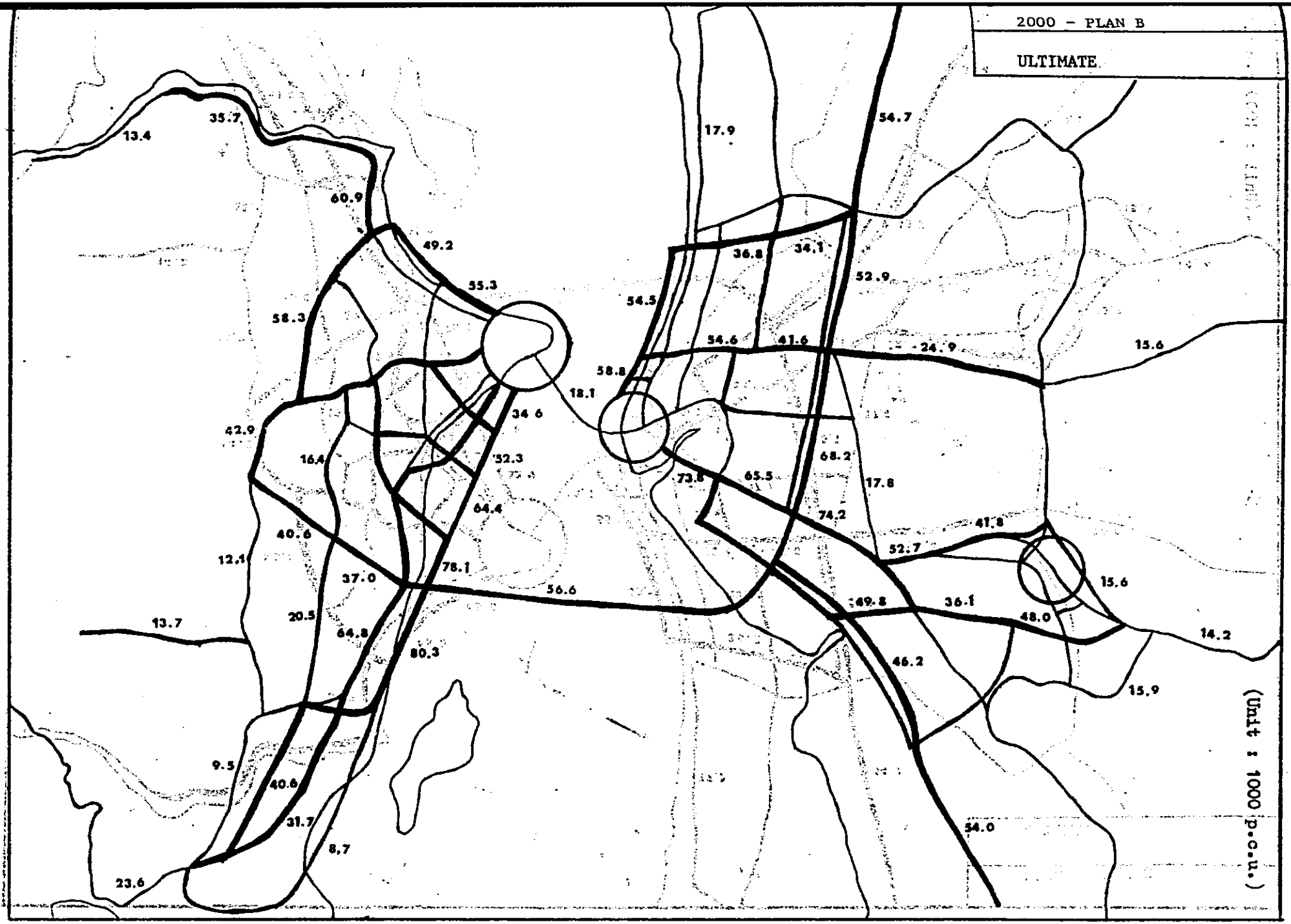
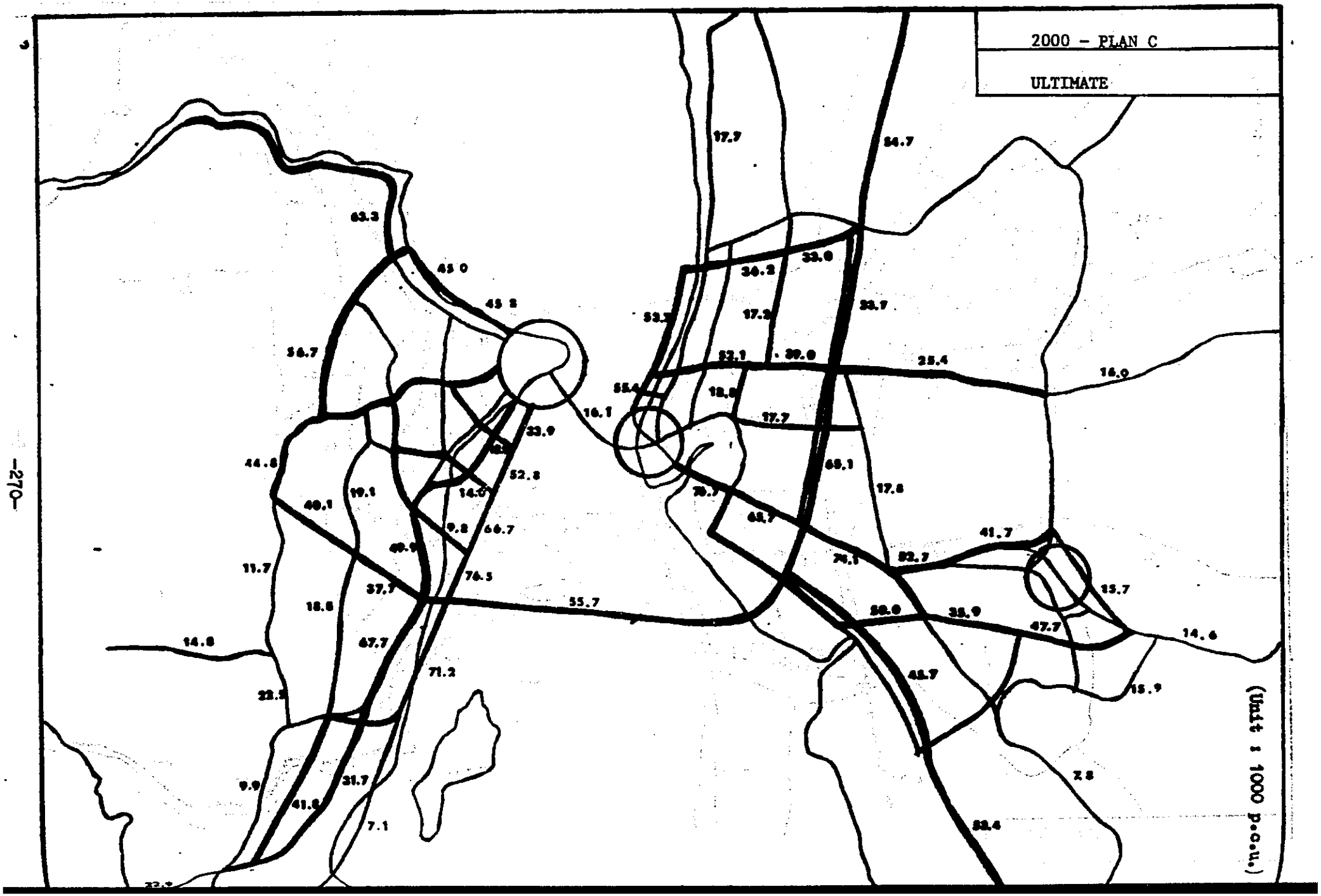
6.4
9.3
4.9


1985 - PLAN A
ON-GOING AND PROPOSED
(Unit : 1000 p.c.u.)


2000 - PLAN A
ON GOING AND PROPOSED
32.9
62.1
59.0
69.4
79.2
69.0
56.4
64.7
48.4
32.9
29.1
24.5
20.5
19.1
33.8
35.0
154.8
16.5
55.9
16.8
56.8
77.0
60.7
37.6
22.7
15.7
18.9
22.1
58.0
20.6
21.2
36.5
9.4
57.7
6.8
67.2
84.0
54.1
85.4
66.5
84.8
38.9
144.3
67.5
106.0
96.0
90.6
23.5
44.5
(Unit : 1000 p.c.u.)


2000 - PLAN A
ULTIMATE
(Unit : 1000 P.c.u.)


2000 - PLAN B
ULTIMATE
13.4
35.7
60.9
49.2
55.3
58.3
42.9
16.4
12.1
40.6
37.0
13.7
20.5
64.8
9.5
40.6
31.7
8.7
23.6
80.3
78.1
64.4
52.3
34.6
18.1
56.6
17.9
54.7
36.8
34.1
52.9
54.5
54.6
41.6
24.9
15.6
58.8
68.2
65.5
17.8
73.8
74.2
41.8
52.7
15.6
69.8
36.1
48.0
14.2
46.2
15.9
54.0
(Unit : 1000 p.c.u.)


2000 - PLAN C
ULTIMATE
(Unit : 1000 p.c.u.)

9. Assignment for the road network without Ferry

The traffic volume on the strait are obtained from traffic assignment as follows:-

Table 9.1 Traffic Volume on the strait

(Unit:1000 trip)

O-D		NETWORK	Ferry			Linkage		
			P.C.U (ex. m/c)	M/C	P.C.U	P.C.U (ex. m/c)	M/C	P.C.U
1979		Present	12.8	13.0	19.3	-	-	-
1985	- Plan A	On going	2.7	4.6	5.5	20.8	8.4	25.0
	- Plan B	On going & Proposed	2.1	6.5	5.4	21.2	7.5	25.0
2000	- Plan B	On going & Proposed	17.3	6.5	20.6	49.7	8.7	54.1
		Ultimate	14.6	6.2	17.7	52.4	8.9	56.9
	- Plan C	Ultimate	14.9	6.2	18.0	52.1	8.9	56.6
	-Plan D	Ultimate	13.0	6.2	16.1	51.2	8.9	55.7

For the purpose of measuring the effect of the ferry, the assignment are conducted on the road network without ferry (2000 - plan B, Ultimate)

Table 9.2

The Comparison between With Ferry and Without Ferry

(Unit: 1000 p.c.u)

		With Ferry	Without Ferry
Inner Cordon	P.C.U. (ex m/c)	247.8	262.4
	M/C	67.4	72.2
	P.C.U.	281.6	298.5
Center Cordon	P.C.U. (ex m/c)	357.9	372.5
	M/C	83.9	90.1
	P.C.U.	400.0	417.6

Therefore, if only the ferry service for vehicles (ex m/c) are stopped, the traffic volume will increase as follows:

Table 9.3

Traffic Volume Without Ferry for Vehicles (ex m/c)

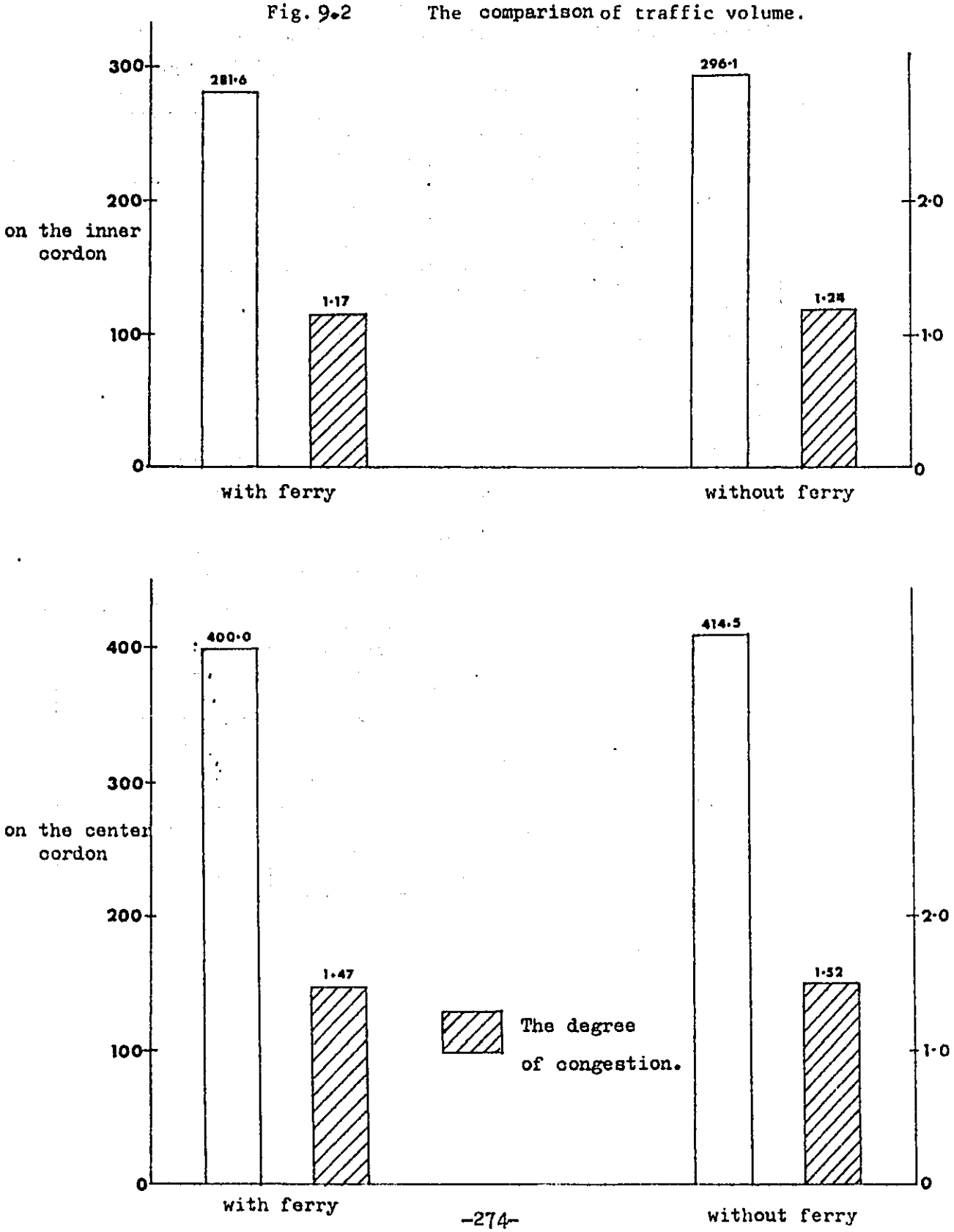
(Unit: 1000 p.c.u.)

Inner Cordon	P.C.U. (ex m/c)	262.4
	M/C	67.4
	P.C.U.	296.1
Center Cordon	P.C.U. (ex m/c)	372.5
	M/C	83.9
	P.C.U.	414.5

From this the traffic volume on the inner cordon line increase 12200 in traffic volume and on the center cordon line 14200 in traffic volume.

As a results of above-mentioned situation, the degree of congestion on each line are increased as follows;

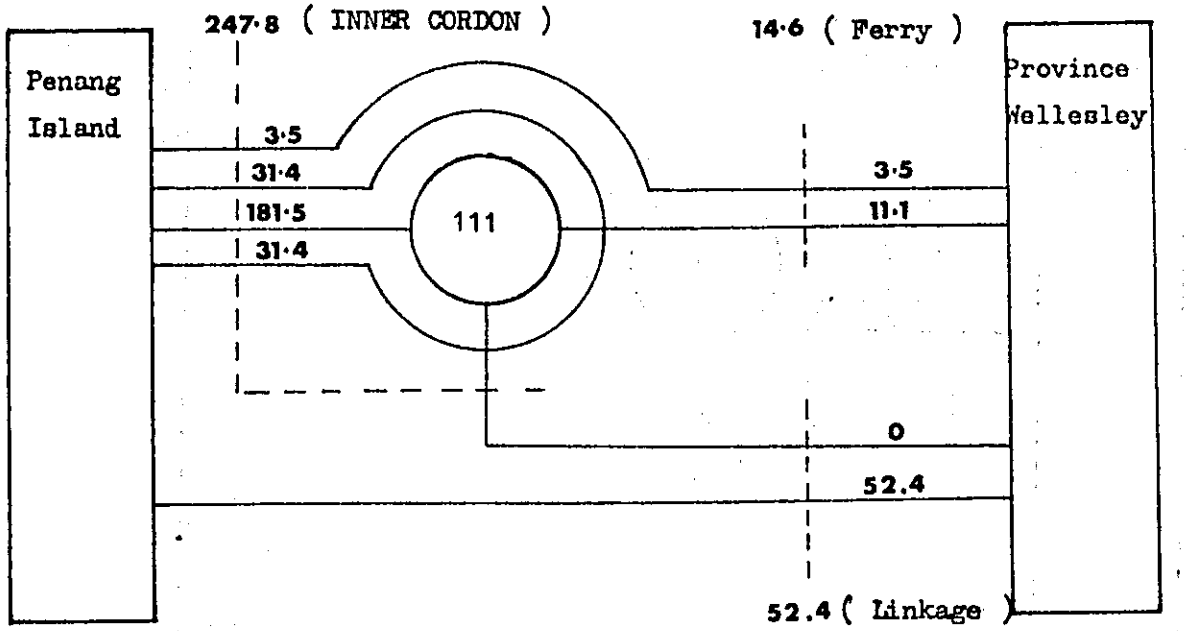
Fig. 9.2 The comparison of traffic volume.

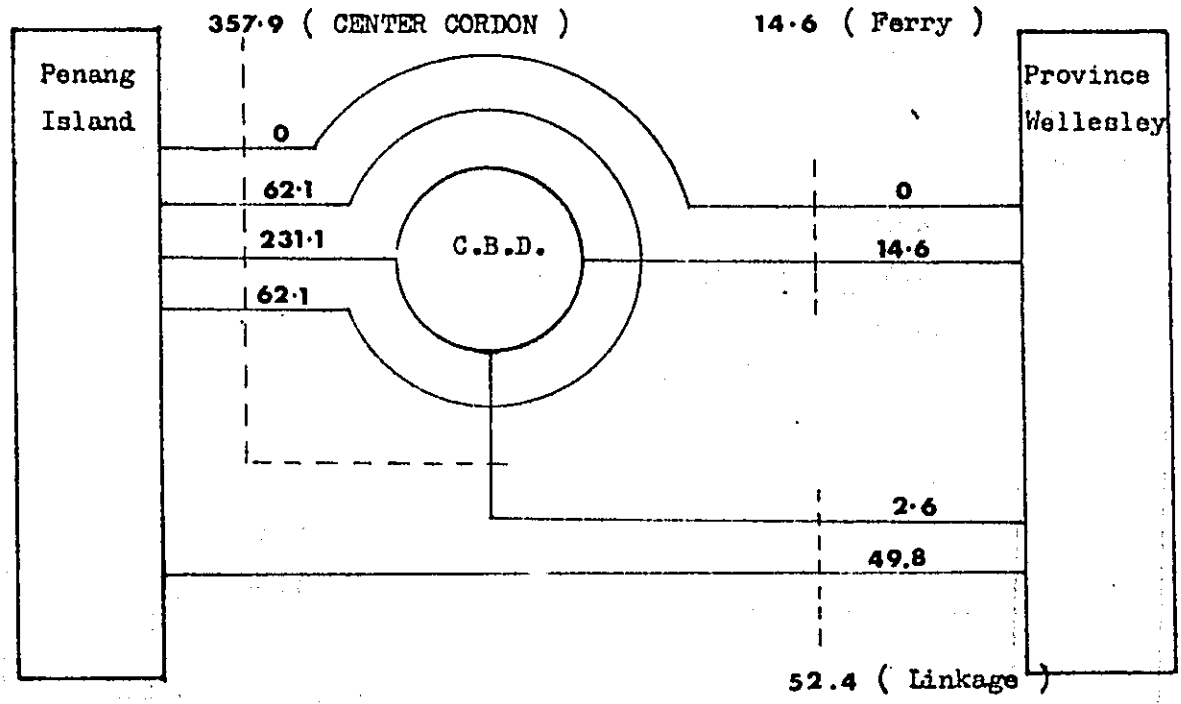


2000 - Plan B

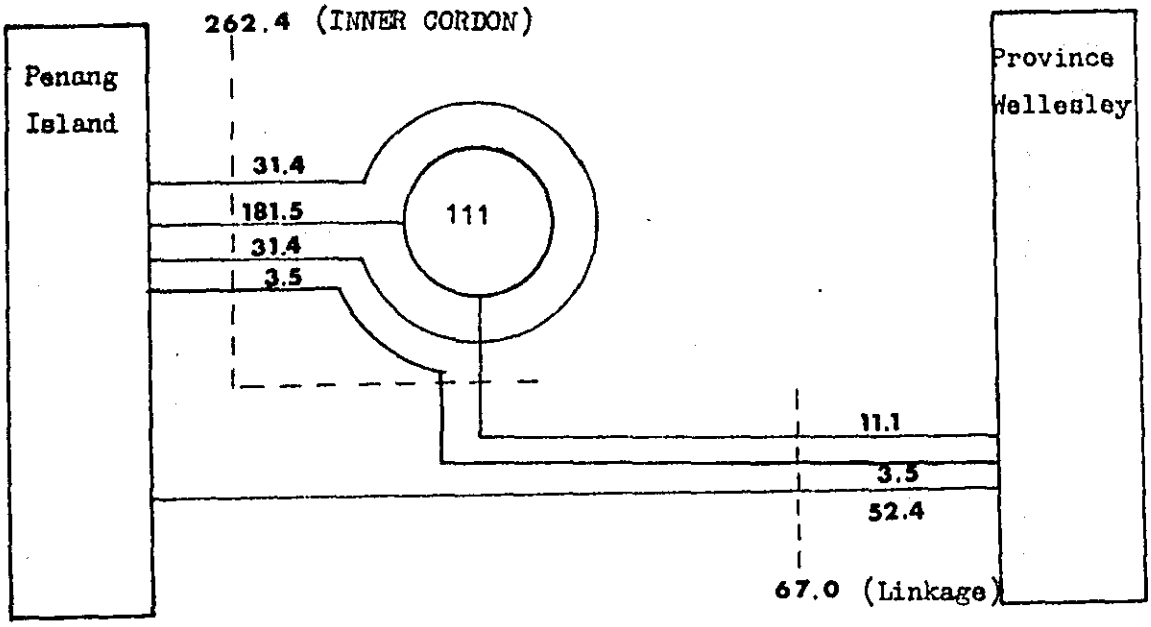
Ultimate

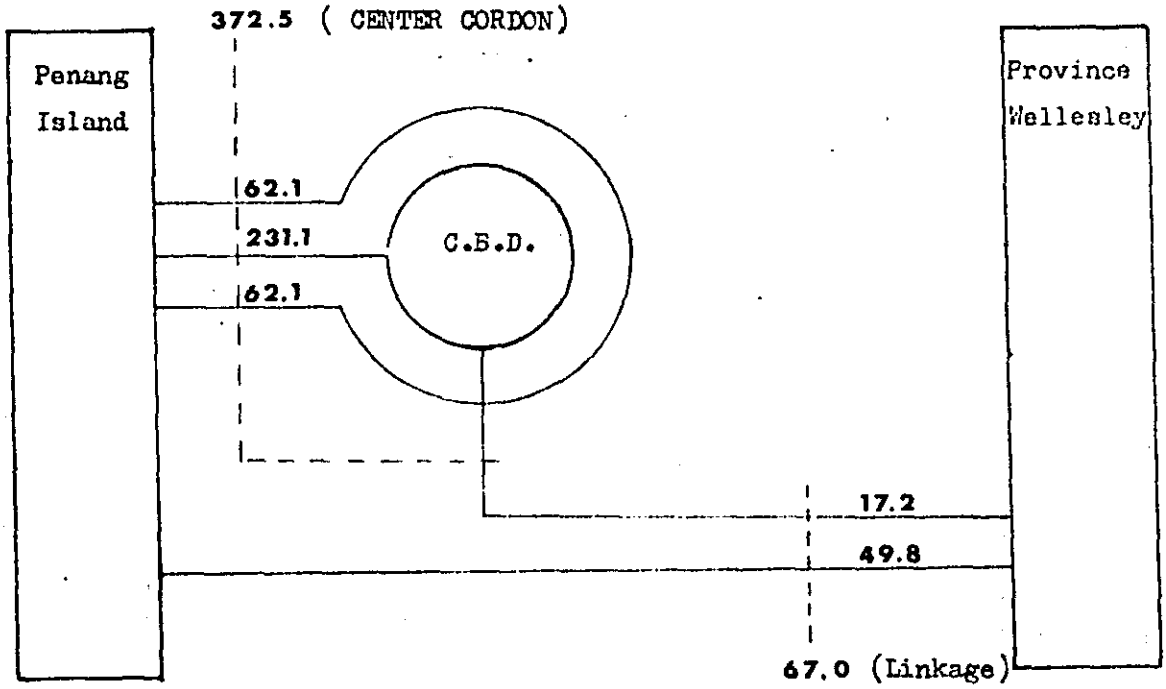
P.C.U (ex, M/C)



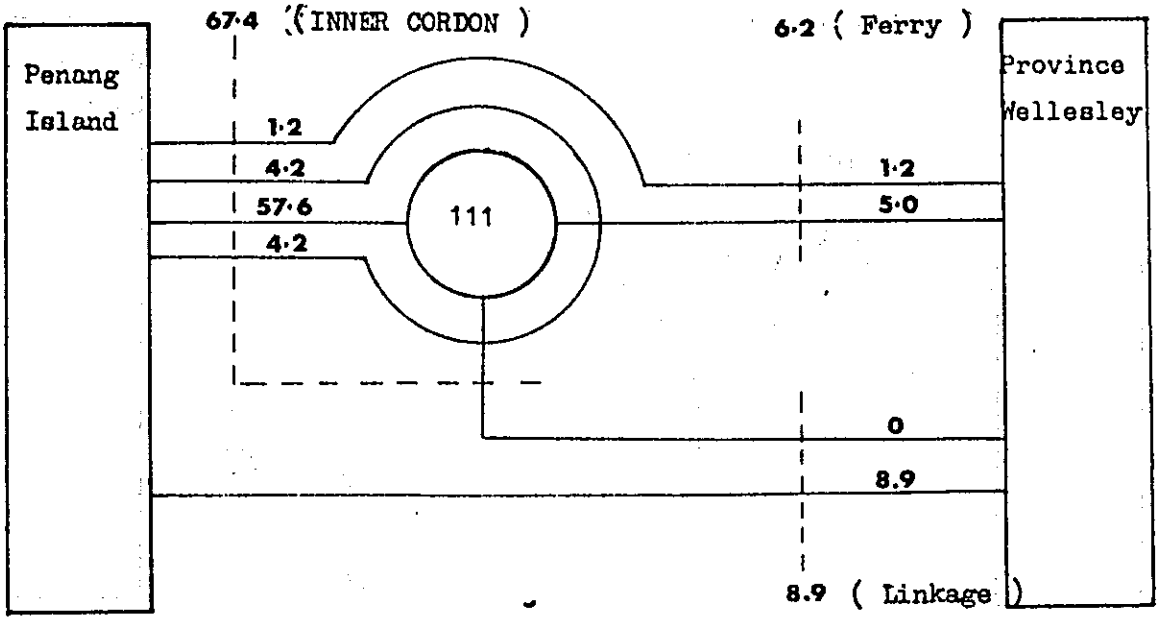


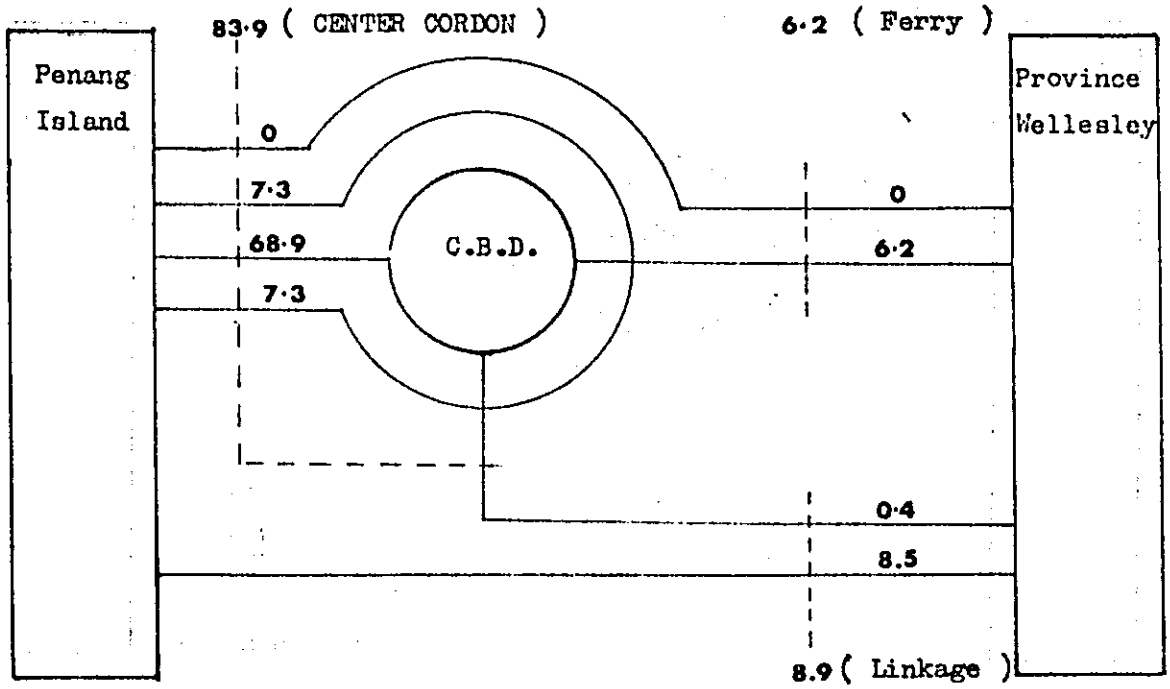
2000 - Plan B
Ultimate (without ferry)
P.C.U. (ex m/c)

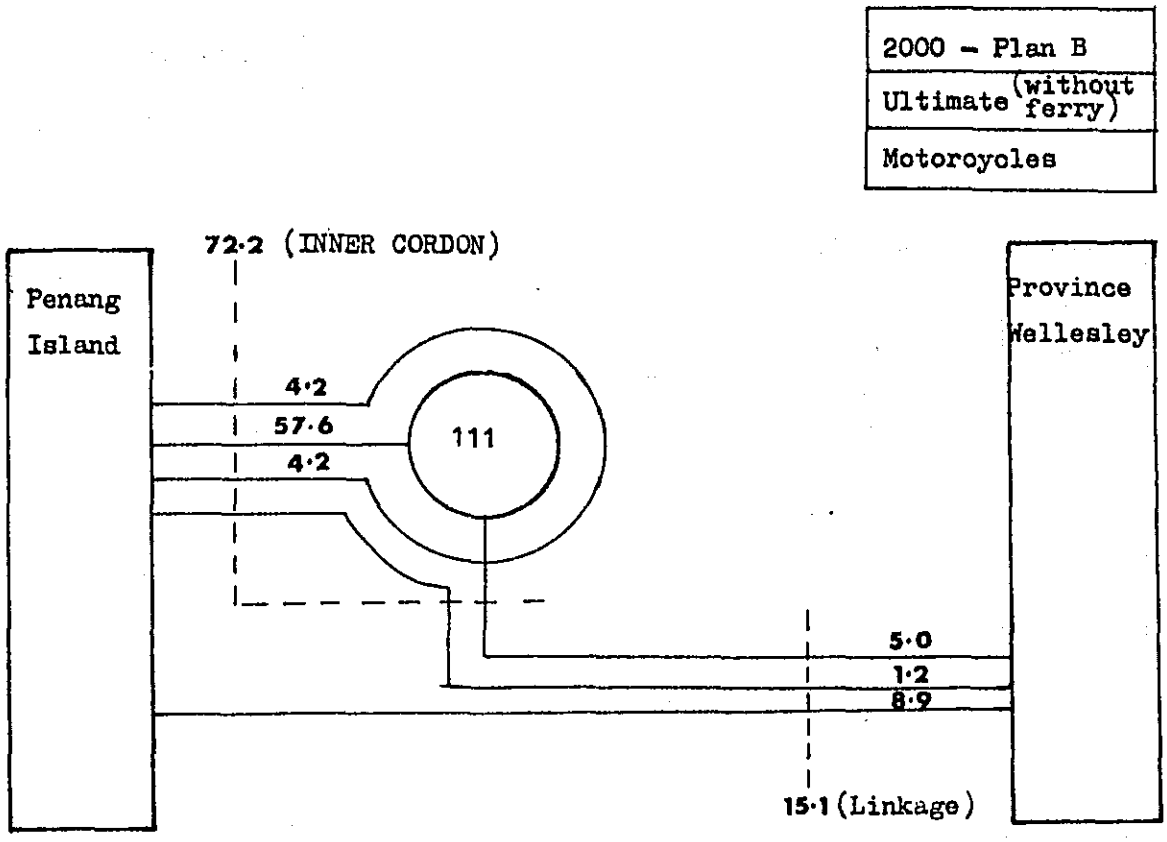


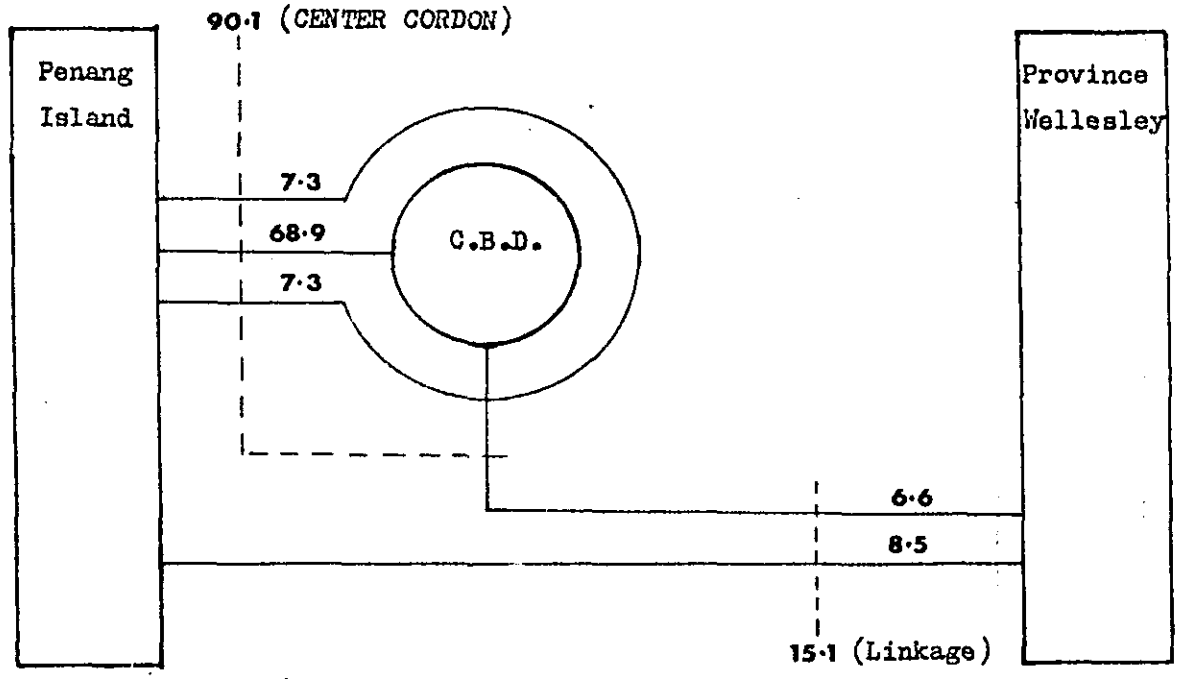


2000 — Plan B.
Ultimate
Motorcycles






2000 - Plan B
Ultimate (without ferry)
Motorcycles
72·2 (INNER CORDON)
Penang Island
Province Wellesley
4·2
57·6
4·2
111
5·0
1·2
8·9
15·1 (Linkage)


90·1 (CENTER CORDON)
Penang Island
Province Wellesley
7·3
68·9
7·3
C.B.D.
6·6
8·5
15·1 (Linkage)

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A - TABLES OF TRIP GENERATION AND ATTRACTION

1. 1985 - Plan A trip generation
2. 1985 - Plan A trip attraction
3. 2000 - Plan A trip generation
4. 2000 - Plan A trip attraction

(Unit : 1000 trip ends per day)

Trip Generation (1985)

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR-CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
111	9185	11058	10691	29388	60322	4865	1883	2227	69297	69904	139201
						2000			2000		2000
11	9185	11058	10691	29388	60322	6865	1883	2227	71297	69904	141201
121	3368	1976	3270	4295	12909	819	60	381	14169	9932	24101
122	4077	573	3232	3267	11149	127	31	424	11731	6386	18117
123	3319	1034	2737	4529	11619	1138	104	1151	14012	9593	23605
124	5938	1909	4699	6722	19268	669	262	1347	21546	14783	36329
125	2044	412	1776	663	4895	90	133	510	5628	4038	9666
12	18854	5792	15733	19461	59840	2843	590	3813	67086	44732	111818
131	5554	3723	5125	5727	20129	3654	79	2245	26107	34064	60171
132	5497	1533	3715	3641	14386	1960	107	2923	19376	17476	36852
133	3284	1149	1846	1788	8067	2184	144	1049	11444	17091	28535
13	14335	6405	10686	11156	42582	7798	330	6217	56927	68631	125558
141	2029	330	1517	403	4279	146	44	517	4986	3130	8116
142	4990	894	3362	3104	12350	960	105	1709	15124	12944	28068
143	4838	820	3112	1415	10185	591	29	729	11534	15747	27281
14	11857	2044	7991	4922	26814	1697	178	2955	31644	31821	63465
1	54866	25115	45364	64213	189558	19203	2981	15212	226954	215088	442042
211	1868	639	1412	1269	5188	1417	151	471	7227	4631	11858
212	238	101	331	589	1259	17	16	68	1360	829	2189
21	2106	740	1743	1858	6447	1434	167	539	8587	5460	14047
22	413	354	434	1017	2218	408	185	77	2888	2818	5706
2	2519	1094	2177	2875	8665	1842	352	616	11475	8278	19753
31	59	11	82	51	203	12	16	61	292	228	520
321	598	122	295	30	1045	314	16	31	1406	1267	2673
322	160	61	139	13	373	114	16	13	516	570	1086
323	254	29	119	10	412	41	16	13	482	478	960
32	1012	212	553	53	1830	469	48	57	2404	2315	4719
331	5767	980	3840	2551	13138	1564	61	820	15583	11342	26925
332	716	213	467	131	1527	280	16	41	1864	1515	3379
333	1428	476	784	1129	3817	1035	29	548	5479	9269	14748
334	685	162	384	400	1631	342	20	101	2094	2803	4897
335	36	11	24	20	91	12	16	13	132	128	260
33	8621	1827	5488	4268	20204	3283	142	1523	25152	25057	50209
3	9693	2051	6125	4368	22237	3764	206	1641	27848	27600	55443

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
411	1395	2261	1751	6231	11638	2914	380	1340	16272	18797	35069
412	1430	743	1149	2065	5387	1566	179	594	7726	11937	19663
413	633	285	332	768	2018	137	102	181	2438	1758	4196
							1800		1800		1800
4	3454	3282	3255	9052	19043	4617	2461	2115	28236	32492	60728
Sub-total	70067	31714	56627	81095	239503	29426	6000	19584	294513	283458	577972
511	4269	4093	3138	8008	19508	597	309	871	21285	27660	48945
						2100			2100		2100
						4500			4500		4500
512	1316	1036	1328	943	4623	398	16	263	5300	6117	11417
513	458	1013	754	2197	4422	457	112	201	5192	6606	11798
						900			900		900
514	1942	503	1009	916	4370	738	16	247	5371	7605	12976
51	7985	6645	6229	12064	32923	9690	453	1582	44648	47988	92636
521	729	359	264	989	2341	541	20	99	3001	3275	6276
522	492	80	298	216	1086	316	16	170	1588	2186	3774
523	516	179	356	550	1601	186	16	137	1940	3084	5024
524	163	69	104	65	401	138	16	21	576	821	1397
525	516	96	415	138	1165	88	16	131	1400	1964	3364
52	2416	783	1437	1958	6594	1269	84	558	8505	11330	19835
5	10401	7428	7666	14022	39517	10959	537	2140	53153	59318	112471
611	2834	992	2040	2572	8438	882	149	1010	10479	15133	25612
612	561	2364	1614	5740	10279	3172	534	264	14249	21486	35735
						1300			1300		1300
61	3340	3379	3637	8361	18717	5354	683	1274	26028	36619	62647
621	29	11	31	24	95	12	16	13	136	247	383
622	821	735	701	470	2727	466	16	119	3328	5163	8491
623	424	225	405	839	1893	266	57	183	2399	2845	5244
62	1274	971	1137	1333	4715	744	89	315	5863	8255	14118
6	4494	4314	4708	9926	23432	6098	772	1589	31891	44874	76765
711	120	11	41	24	196	20	16	13	245	437	682
712	150	20	142	27	339	27	16	13	395	1216	1611
713	139	11	212	215	577	96	23	15	711	2883	3594
71	409	42	395	266	1112	143	55	41	1351	4536	5887

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
721	164	105	282	56	607	102	16	13	738	1622	2360
722	56	52	76	10	194	21	16	13	244	644	888
723	203	80	214	116	613	155	19	13	800	1820	2620
72	423	237	572	182	1414	278	51	39	1782	4086	5868
731	299	253	413	425	1390	216	16	103	1725	3985	5710
732	1610	1091	1470	4359	8530	1403	191	340	10464	21642	32106
733	1104	398	840	684	3026	256	16	52	3350	5160	8510
734	931	475	972	1155	3533	411	17	113	4074	6219	10293
73	3929	2217	3663	6670	16479	2286	240	608	19613	37006	56619
741	587	107	436	358	1488	35	16	306	1845	4379	6224
742	1085	507	921	1475	3988	556	65	424	5033	6595	11628
74	1672	614	1357	1833	5476	591	81	730	6878	10974	17852
7	6448	3105	6001	8927	24481	3298	427	1418	29624	56602	86226
811	173	107	197	298	775	241	16	140	1172	2013	3185
812	355	131	333	434	1253	152	16	151	1572	2589	4161
81	530	237	530	731	2028	393	32	291	2744	4602	7346
821	37	11	26	51	125	12	16	17	170	644	814
822	214	152	132	109	607	104	16	15	742	1700	2442
82	251	163	158	160	732	116	32	32	912	2344	3256
8	779	397	690	894	2760	509	64	323	3656	6946	10602
Sub-total	21619	15401	18955	34215	90190	20864	1800	5470	118324	167740	286064
Total	91282	47409	75381	115621	329693	50290	7800	25054	412837	451199	864036

Trip Attraction (1985)

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
111	25650	12527	17396	4749	60322	4865 2000	1883	2227	69297 2000	69904	139201 2000
11	25650	12527	17396	4749	60322	6865	1883	2227	71297	69904	141201
121	4451	1370	2912	4176	12909	819	60	381	14169	9932	24101
122	844	393	3909	6003	11149	127	31	424	11731	6386	18117
123	3490	869	3461	3799	11619	1138	104	1151	14012	9593	23605
124	4811	1856	5583	7018	19268	669	262	1347	21546	14783	36329
125	253	385	883	3374	4895	90	133	510	5628	4038	9666
12	13849	4873	16748	24370	59840	2843	590	3813	67086	44732	111818
131	5635	2685	3876	7933	20129	3654	79	2245	26107	34064	60171
132	2803	1129	2729	7725	14386	1960	107	2923	19376	17476	36852
133	1332	915	1460	4360	8067	2184	144	1049	11444	17091	28535
13	9770	4729	8065	20018	42582	7798	330	6217	56927	68631	125558
141	254	293	564	3168	4279	146	44	517	4986	3130	8116
142	2322	899	2266	6863	12350	960	105	1709	15124	12944	28068
143	704	626	1846	7009	10185	591	29	729	11534	15747	27281
14	3280	1818	4676	17040	26814	1697	178	2955	31644	31821	63465
1	52549	23947	46885	66177	189558	19203	2981	15212	226954	215088	442042
211	619	842	1136	2591	5188	1417	151	471	7227	4631	11858
212	59	94	791	315	1259	17	16	68	1360	829	2189
21	678	936	1927	2906	6447	1434	167	539	8587	5460	14047
22	798	512	553	355	2218	408	185	77	2888	2818	5706
2	1476	1448	2480	3261	8665	1842	352	616	11475	8278	19753
31	21	22	33	127	203	12	16	61	292	228	520
321	84	64	39	858	1045	314	16	31	1406	1267	2673
322	39	16	11	307	373	114	16	13	516	570	1086
323	66	11	13	322	412	41	16	13	482	478	960
32	189	91	63	1487	1830	469	48	57	2404	2315	4719
331	2435	792	1687	8224	13138	1564	61	820	15583	11342	26925
332	434	30	47	1016	1527	280	16	41	1864	1515	3379
333	629	585	407	2196	3817	1085	29	548	5479	9269	14748
334	229	139	160	1103	1631	342	20	101	2094	2803	4897
335	12	11	11	57	91	12	16	13	132	128	260
33	3739	1557	2312	12596	20204	3283	142	1523	25152	25057	50209
3	3949	1670	2408	14210	22237	3764	206	1641	27848	27600	55448

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
411	5528	2754	2998	358	11638	2914	380	1340	16272	18797	35069
412	1490	863	983	2051	5387	1566	179	594	7726	11937	19663
413	455	592	398	573	2018	137	102	181	2438	1758	4196
							1800		1800		1800
4	7473	4209	4379	2982	19043	4617	2461	2115	28236	32492	60728
Sub-total	65447	31274	56152	86630	239503	29426	6000	19584	294513	283458	577972
511	6218	4539	6518	2233	19508	597	309	871	21285	27660	48945
						2100			2100		2100
						4500			4500		4500
512	732	715	679	2497	4623	398	16	263	5300	6117	11417
513	2066	1207	1090	59	4422	457	112	201	5192	6606	11798
						900			900		900
514	730	448	603	2589	4370	738	16	247	5371	7605	12976
51	9746	6909	8890	7378	32923	9690	453	1582	44648	47988	92636
521	991	338	128	884	2341	541	20	99	3001	3275	6276
522	92	50	50	894	1086	316	16	170	1588	2186	3774
523	344	176	218	863	1601	186	16	137	1940	3084	5024
524	37	11	22	331	401	138	16	21	576	821	1397
525	81	72	127	885	1165	88	16	131	1400	1964	3364
52	1545	647	545	3857	6594	1269	84	558	8505	11330	19835
5	11291	7556	9435	11235	39517	10959	537	2140	53153	59318	112471
611	1821	1023	1944	3650	8438	882	149	1010	10479	15133	25612
612	5104	2636	1911	628	10279	3172	534	264	14249	21486	35735
						1300			1300		1300
61	6925	3659	3855	4278	18717	5354	683	1274	26028	36619	62647
621	16	11	11	57	95	12	16	13	136	247	383
622	673	493	290	1271	2727	466	16	119	3328	5163	8491
623	615	296	361	621	1893	266	57	183	2399	2845	5244
62	1304	800	662	1949	4715	744	99	315	5863	8255	14118
6	8229	4459	4517	6227	23432	6098	772	1589	31891	44874	76765
711	96	11	13	76	196	20	16	13	245	437	682
712	83	11	11	234	339	27	16	13	395	1216	1611
713	140	61	158	218	577	96	23	15	711	2883	3594
71	319	83	182	528	1112	143	55	41	1351	4536	5887

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
721	61	76	26	444	607	102	16	13	738	1622	2360
722	10	11	13	160	194	21	16	13	244	644	888
723	87	40	74	412	613	155	19	13	800	1820	2620
72	158	127	113	1016	1414	278	51	39	1782	4086	5868
731	242	168	230	750	1390	216	16	103	1725	3985	5710
732	1922	1397	3123	2088	8530	1403	191	340	10464	21642	32106
733	405	288	396	1937	3026	256	16	52	3350	5160	8510
734	755	421	564	1793	3533	411	17	113	4074	6219	10293
73	3324	2274	4313	6568	16479	2286	240	608	19613	37006	56619
741	165	98	132	1093	1488	35	16	306	1845	4379	6224
742	1105	562	755	1566	3988	556	65	424	5033	6595	11628
74	1270	660	887	2659	5476	591	81	730	6878	10974	17852
7	5071	3144	5495	10771	24481	3298	427	1418	29624	56602	86226
811	202	104	94	375	775	241	16	140	1172	2013	3185
812	309	104	183	657	1253	152	16	151	1572	2589	4161
81	511	208	277	1032	2028	393	32	291	2744	4602	7346
821	33	17	11	64	125	12	16	17	170	644	814
822	54	71	34	448	607	104	16	15	742	1700	2442
82	87	88	45	512	732	116	32	32	912	2344	3256
8	598	296	322	1544	2760	509	64	323	3656	6946	10602
Sub-total	25189	15455	19769	29777	90190	20864	1800	5470	118324	167740	286064
Total	90636	46729	75921	116407	329693	50290	7800	25054	412837	451199	864036

Trip Generation (2000)

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB - TOTAL	MOTOR-CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB - TOTAL						
111	11439	19455	16717	50802	98412	12853	6480	2269	120014	57601	177615
						2500			2500		2500
11	11439	19455	16717	50802	98412	15353	6480	2269	122514	57601	180115
121	5606	3148	5236	6407	20397	1418	260	484	22559	8001	30560
122	10783	1223	7481	5138	24625	369	103	1000	26097	7837	33934
123	8022	1821	5820	7093	22756	1653	265	1673	26347	8528	34875
124	10242	2499	7252	7688	27681	1013	645	1916	31255	12161	43416
125	4082	706	3246	507	8541	151	332	636	9660	2974	12634
12	38735	9397	29035	26833	104000	4604	1605	5710	115919	39501	155420
131	9792	6183	8762	10282	35019	6788	764	3112	45683	29898	75581
132	11019	2472	6788	4392	24661	2946	307	3621	31535	12431	43966
133	6556	1808	3338	1910	13612	3490	398	1300	18800	11953	30753
13	27367	10463	18878	16584	73292	13224	1469	8033	96018	54283	150301
141	4664	597	3127	217	8606	243	300	750	9899	2991	12890
142	11801	1652	7235	4318	25006	1445	735	2443	29629	11463	41092
143	9668	1234	5613	562	17077	754	128	913	18872	10956	29828
14	26133	3483	15975	5097	50689	2442	1163	4106	58400	25410	83810
1	103674	42798	80605	99316	326393	35623	10717	20118	392851	176795	569646
211	5560	1440	3781	2352	13133	1989	1142	690	16954	4064	21018
212	1518	345	1345	1610	4818	91	1419	209	6537	1512	8049
21	7077	1785	5126	3962	17951	2080	2561	898	23490	5576	29066
22	2018	1589	2037	4383	10027	984	225	249	11485	4209	15694
2	9095	3374	7163	8345	27978	3064	2786	1147	34975	9785	44760
31	461	67	365	236	1128	44	17	138	1327	573	1900
321	1744	278	892	153	3068	456	15	145	3714	1531	5245
322	453	117	336	46	952	170	15	39	1176	544	1720
323	420	57	254	112	844	63	15	20	942	391	1333
32	2619	452	1482	311	4864	719	45	204	5832	2466	8298
331	14147	1988	8662	3801	28599	2430	79	1563	32671	8470	41141
332	1972	396	1204	415	3987	477	15	207	4686	2024	6710
333	7366	1435	4302	3703	16806	1932	61	1514	20313	9067	29380
334	3450	575	2026	1506	7557	678	34	512	8781	3576	12357
335	57	337	230	885	1509	223	32	27	1791	758	2549
33	26992	4731	16424	10310	58456	5740	221	3819	68236	23895	92131
3	30070	5250	18271	10857	64448	6503	283	4162	75396	26934	102330

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB - TOTAL	MOTOR-CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
411	4218	7254	6220	19643	37335	8971	1038	2582	49526	20401	70327
412	7627	3855	6291	10544	28317	5274	555	2460	36612	15413	52025
413	1458	180	807	1012	3457	301	541	433	4732	2797	7529
							6500		6500		6500
4	13303	11489	13318	31199	69309	14546	8634	5481	97970	38611	136581
SUB-TOTAL	156142	62911	119357	149717	488128	59736	22420	30907	601191	252124	853315
511	7076	6716	9489	13960	37242	6343	2483	1732	47800	26663	74463
						9800			9800		9800
						5000			5000		5000
512	2240	1595	2155	1779	7769	820	351	530	9470	5897	15367
513	1244	3407	2612	8447	15710	3134	359	637	19840	12392	32232
						1800			1800		1800
514	3207	658	1564	853	6281	1040	316	492	8129	6135	14264
51	13767	12376	15820	25039	67002	27937	3509	3391	101839	51087	152926
521	1342	461	508	1204	3516	755	19	239	4529	2821	7350
522	1854	240	1100	641	3834	550	15	621	5020	3570	8590
523	6682	781	4043	2658	14165	727	33	2028	16953	12052	29005
524	480	107	284	130	1001	206	15	106	1328	998	2326
525	1511	187	1012	301	3011	180	15	438	3644	2669	6313
52	11869	1776	6947	4934	25527	2418	97	3431	31473	22109	53582
5	25636	14152	22767	29973	92528	30355	3606	6822	133311	73196	206509
611	9831	3901	7371	10008	31111	4138	465	3695	39409	19783	59192
612	1428	11115	4902	28792	46237	16136	1014	1533	64920	27293	92213
						1400			1400		1400
61	11259	15016	12273	38800	77348	21674	1479	5228	105729	47076	152805
621	316	1513	1072	3971	6872	1628	230	247	8977	4569	13546
622	928	707	732	334	2701	637	15	178	3531	2697	6228
623	3857	916	2690	2938	10419	1116	124	1643	13302	6644	19946
62	5119	3136	4494	7243	19992	3381	369	2068	25810	13911	39721
6	16378	18152	16767	46043	97340	25055	1848	7296	131539	60987	192526
711	237	16	88	24	365	30	15	21	431	396	827
712	267	28	209	15	520	39	15	21	595	941	1536
713	343	24	382	290	1040	141	22	60	1263	2319	3582
71	847	68	679	329	1923	210	52	101	2286	3656	5942
721	407	149	496	69	1120	147	15	48	1330	1420	2750
722	168	73	105	38	384	33	15	20	452	567	1019
723	472	119	401	151	1143	221	17	65	1446	1567	3013
72	1047	341	1002	258	2647	401	47	133	3228	3553	6781

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR-CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
731	829	362	812	619	2622	320	15	269	3226	3491	6717
732	3248	2276	3072	8035	16632	2378	739	1679	21428	18097	39525
733	2007	553	1377	756	4693	377	15	158	5243	4232	9475
734	1763	860	1666	2051	6340	837	15	357	7549	6290	13839
73	7847	4051	6927	11461	30286	3912	784	2463	37444	32111	69555
741	1918	234	1225	673	4050	123	15	784	4972	4768	9740
742	6993	1774	4867	5191	18825	1795	160	1467	22247	16396	38643
74	8911	2008	6092	5864	22875	1918	175	2251	27219	21164	48383
7	18652	6468	14700	17912	57732	6441	1058	4948	70179	60485	130664
811	1167	227	823	677	2893	396	15	483	3787	2860	6647
812	5023	1492	3702	4392	14609	1234	123	1555	17521	11287	28809
81	6190	1719	4525	5069	17502	1630	138	2039	21309	14147	35456
821	292	37	177	142	648	26	15	94	783	835	1618
822	588	221	339	183	1331	160	15	94	1600	1626	3226
82	880	258	516	325	1979	186	30	188	2383	2461	4844
8	7070	1977	5041	5394	19481	1816	168	2228	23693	16608	40301
SUB-TOTAL	67736	40749	59275	99322	267082	63667	6680	21293	358722	211276	569998
TOTAL	223878	103660	178632	249039	755210	123403	29100	52200	959913	463400	1423313

Trip Attraction (2000)

ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
111	41728	20941	31114	4629	98412	12853	6480	2269	120014	57601	177615
						2500			2500		2500
11	41728	20941	31114	4629	98412	15353	6480	2269	122514	57601	180115
121	6625	2275	4788	6710	20398	1418	260	484	22560	8001	30561
122	1893	923	6917	14891	24624	369	103	1000	26096	7837	33933
123	5587	1505	5965	9698	22755	1653	265	1673	26346	8528	34874
124	5870	2338	7342	12130	27680	1013	645	1916	31254	12161	43415
125	473	637	1527	5904	8541	151	332	636	9660	2974	12634
12	20448	7678	26539	49333	103998	4604	1605	5709	115916	39501	155417
131	9755	4831	7349	13085	35020	6788	764	3112	45684	29898	75582
132	4251	1749	4532	14128	24660	2946	307	3621	31534	12431	43965
133	1935	1366	2358	7952	13611	3490	398	1300	18799	11953	30752
13	15941	7946	14239	35165	73291	13224	1469	8033	96017	54282	150299
141	523	523	1037	6522	8605	243	300	750	9898	2991	12889
142	3942	1611	4077	15376	25006	1445	735	2443	29629	11463	41092
143	898	875	2925	12379	17077	754	128	913	18872	10956	29828
14	5363	3009	8039	34277	50688	2442	1163	4106	58399	25410	83809
1	83480	39574	79931	123404	326389	35623	10717	20117	392846	176794	569640
211	1447	1789	2602	7295	13133	1989	1142	690	16954	4064	21018
212	394	328	1890	2205	4817	91	1419	209	6536	1512	8048
21	1841	2117	4492	9500	17950	2080	2561	899	23490	5576	29066
22	3305	1917	2497	2309	10028	984	225	249	11486	4209	15695
2	5146	4034	6989	11809	27978	3064	2786	1148	34976	9785	44761
31	138	88	133	768	1127	44	17	138	1326	573	1899
321	303	189	197	2379	3068	486	15	145	3714	1531	5245
322	104	49	46	753	952	170	15	39	1176	544	1720
323	121	16	39	668	844	63	15	20	942	391	1333
32	528	254	282	3800	4864	719	45	204	5832	2466	8298
331	4835	1668	3744	18352	28599	2430	79	1563	32671	8470	41141
332	461	181	274	3072	3988	477	15	207	4687	2024	6711
333	2340	1604	1718	11144	16806	1932	61	1514	20313	9067	29380
334	997	549	754	5257	7557	678	34	512	8781	3576	12357
335	626	357	453	73	1509	223	32	23	1787	758	2545
33	9259	4359	6943	37898	58459	5740	221	3819	68239	23895	92134
3	9925	4701	7358	42466	64450	6503	283	4161	75397	26934	102331

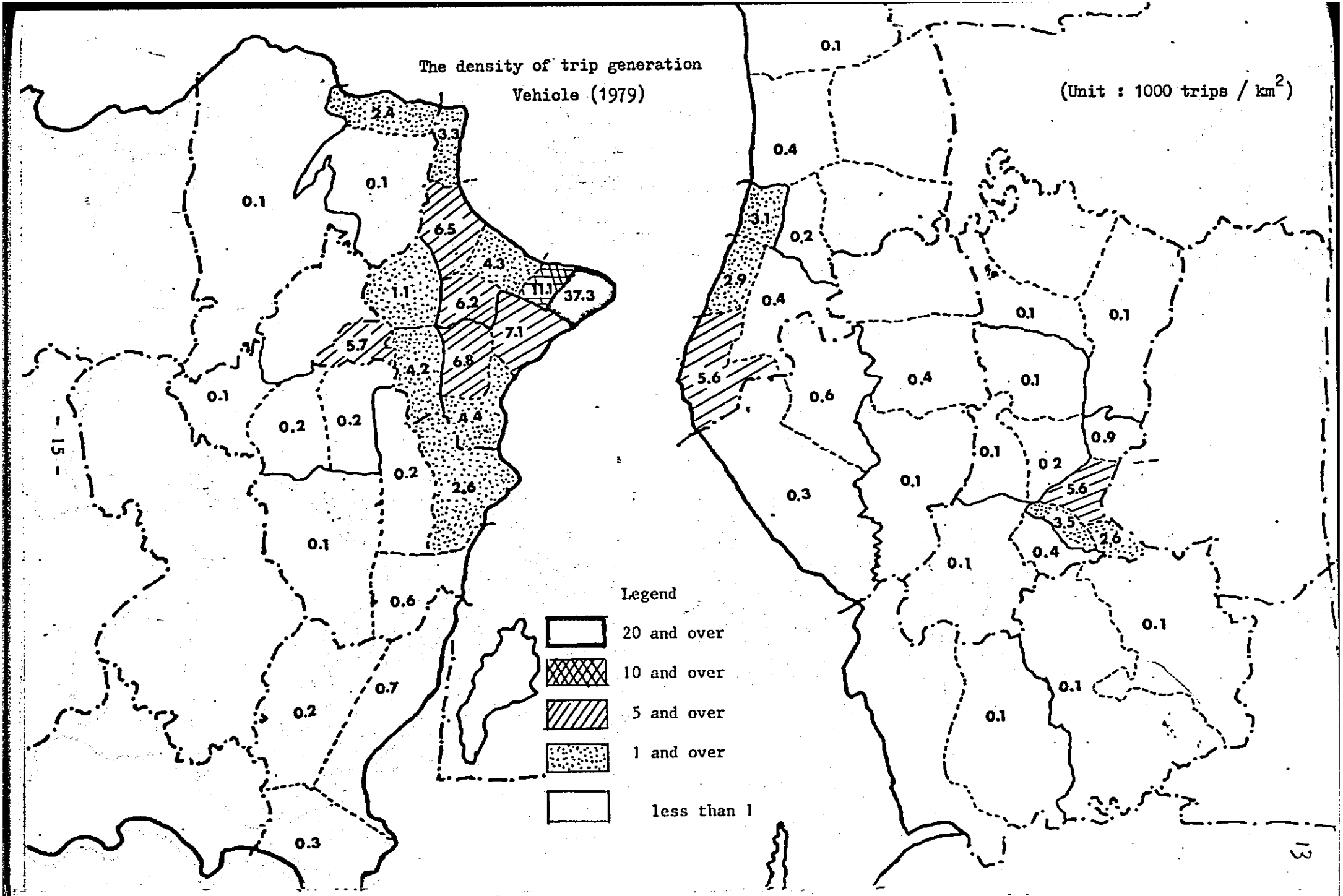
ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
411	15502	7943	10700	3190	37335	8971	1038	2582	49926	20401	70327
412	7581	4121	5599	11015	28316	5274	555	2466	36611	15413	52024
413	627	654	556	1820	3657	301	541	433	4932	2797	7729
							6500		6500		6500
4	23710	12718	16855	16025	69308	14546	8634	5481	97969	38611	136580
Sub-total	122261	61027	111133	193704	488125	59736	22420	30907	601188	252124	853312
511	11353	7115	15955	2819	37242	6343	2483	1732	47800	26663	74463
						9800			9800		9800
						5000			5000		5000
512	1516	1184	1362	3707	7769	820	351	530	9470	5897	15367
513	6813	3700	4829	367	15709	3134	359	637	19839	12392	32231
						1800			1800		1800
514	925	568	826	3962	6281	1040	316	492	8129	6135	14264
51	20607	12567	22972	10855	67001	27937	3509	3391	101838	51087	152925
521	1183	419	196	1718	3516	755	19	239	4529	2821	7350
522	398	209	282	2946	3835	550	15	621	5021	3570	8591
523	1547	800	1139	10679	14165	727	33	2028	16953	12052	29005
524	89	32	62	818	1001	206	15	106	1328	998	2326
525	238	159	269	2345	3011	180	15	438	3644	2669	6313
52	3455	1619	1948	18506	25528	2418	97	3432	31475	22110	53585
5	24062	14186	24920	29361	92529	30355	3606	6823	133313	73197	206510
611	8530	4021	6594	11966	31111	4138	465	3695	39409	19783	59192
612	21429	11767	11711	1329	46236	16136	1014	1533	64919	27293	92212
						1400			1400		1400
61	29959	15788	18305	13295	77347	21674	1479	5228	105728	47076	152804
621	2898	1597	2022	355	6872	1628	230	247	8977	4569	13546
622	612	456	292	1341	2701	637	15	178	3531	2697	6228
623	2189	1012	1733	5485	10419	1116	124	1643	13302	6644	19946
62	5699	3065	4047	7181	19992	3381	369	2068	25810	13910	39720
6	35658	18853	22352	20476	97339	25055	1848	7296	131538	60986	192524
711	127	14	26	199	366	30	15	21	432	396	828
712	105	14	16	385	520	39	15	21	595	941	1536
713	194	89	228	528	1039	141	22	60	1262	2319	3581
71	426	117	270	1112	1925	210	52	102	2289	3656	5945

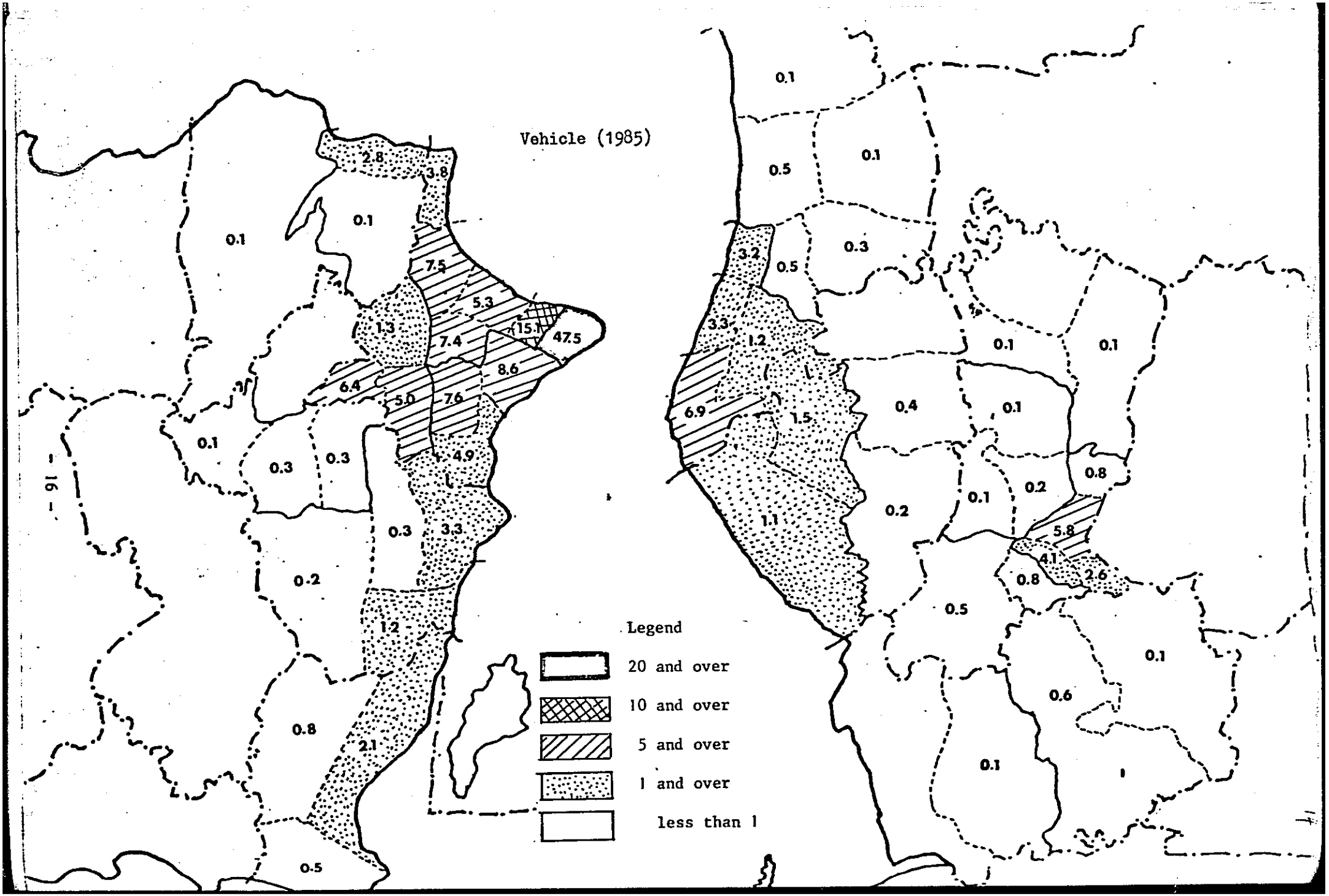
ZONE CODE	CAR					LORRY	TAXI	BUS	SUB-TOTAL	MOTOR CYCLE	GRAND TOTAL
	GOING TO WORK	ON BUSINESS	PRIVATE	GOING HOME	SUB-TOTAL						
721	99	107	53	862	1121	147	15	48	1331	1420	2751
722	15	14	24	331	384	33	15	20	452	567	1019
723	136	65	122	820	1143	221	17	65	1446	1567	3013
72	250	186	199	2013	2648	401	47	133	3229	3554	6783
731	363	243	359	1656	2621	320	15	269	3225	3491	6716
732	4033	2673	5765	4160	16632	2378	739	1679	21428	18097	39525
733	566	396	584	3148	4694	377	15	158	5244	4232	9476
734	1629	889	1288	2532	6338	837	15	357	7547	6290	13837
73	6591	4201	7996	11496	30285	3912	784	2463	37444	32110	69554
741	394	222	322	3112	4050	123	15	784	4972	4768	9740
742	3631	1875	2721	10598	18825	1795	160	1467	22244	16396	38643
74	4025	2097	3043	13710	22875	1918	175	2251	27219	21164	48383
7	11292	6601	11508	28331	57733	6441	1058	4949	70181	60484	130665
811	424	221	259	1988	2892	396	15	483	3786	2860	6646
812	3083	1519	2270	7736	14608	1234	123	1555	17520	11287	28807
81	3507	1740	2529	9724	17500	1630	138	2038	21306	14147	35453
821	86	45	45	472	648	26	15	94	783	835	1618
822	112	112	81	1027	1332	160	15	94	1601	1626	3227
82	198	157	126	1499	1980	186	30	188	2384	2461	4845
8	3705	1897	2655	11223	19480	1816	168	2226	23690	16608	40298
Sub-total	74717	41537	61435	89391	267081	63667	6680	21294	358722	211275	569997
Total	196978	102564	172518	283095	755206	123403	29100	52201	959910	463399	1423309

B - FIGURES OF THE DENSITY OF TRIP GENERATION

1.	Vehicles ex. M/C	1979
		1985 - Plan A
		2000 - Plan A
2.	Motor-cycles	1979
		1985 - Plan A
		2000 - Plan A

(Unit : 1000 trips/Km^2)


The density of trip generation
Vehiole (1979)
(Unit : 1000 trips / km²)
Legend
20 and over
10 and over
5 and over
1 and over
less than 1
0.1
0.4
3.1
0.2
2.9
0.4
0.1
0.1
5.6
0.6
0.4
0.1
0.1
0.9
0.3
0.1
0.2
5.6
3.5
2.6
0.4
0.1
0.1
0.1
0.1
2.4
3.3
0.1
0.1
6.5
4.3
11.1
37.3
1.1
6.2
7.1
5.7
6.8
4.2
0.1
0.2
0.2
4.4
0.2
2.6
0.1
0.6
0.7
0.2
0.3


Vehicle (1985)
Legend
20 and over
10 and over
5 and over
1 and over
less than 1
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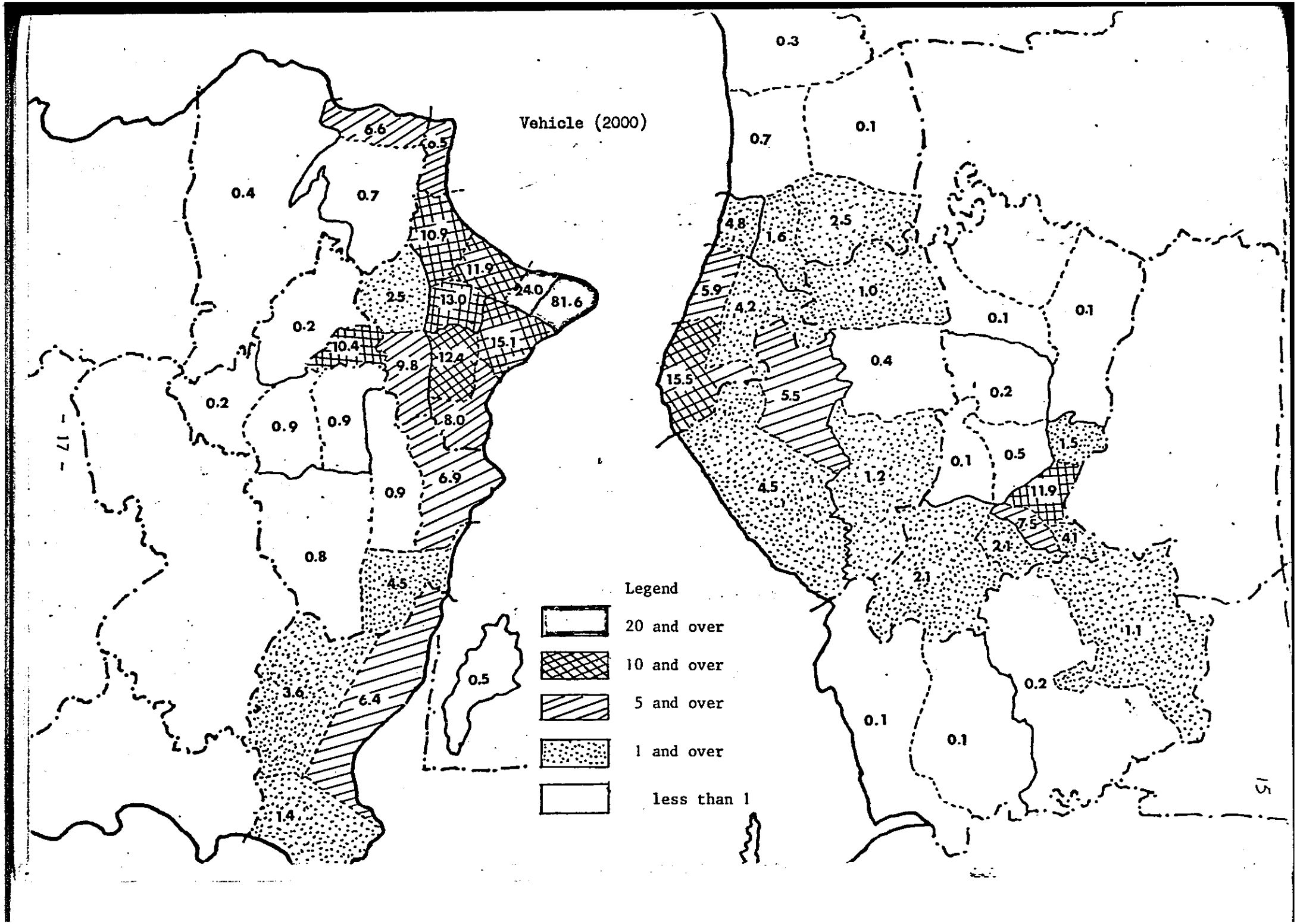
0.5
0.1
0.3
3.2
0.5
3.3
1.2
0.1
0.1
6.9
1.5
0.4
0.1
0.2
0.1
0.2
0.8
1.1
5.8
4.1
2.6
0.8
0.5
0.1
0.6
0.1
2.8
3.8
0.1
0.1
7.5
5.3
1.3
15.1
47.5
7.4
8.6
6.4
5.0
7.6
0.1
0.3
0.3
4.9
0.3
3.3
0.2
1.2
0.8
2.1
0.5
- 16 -


Vehicle (2000)
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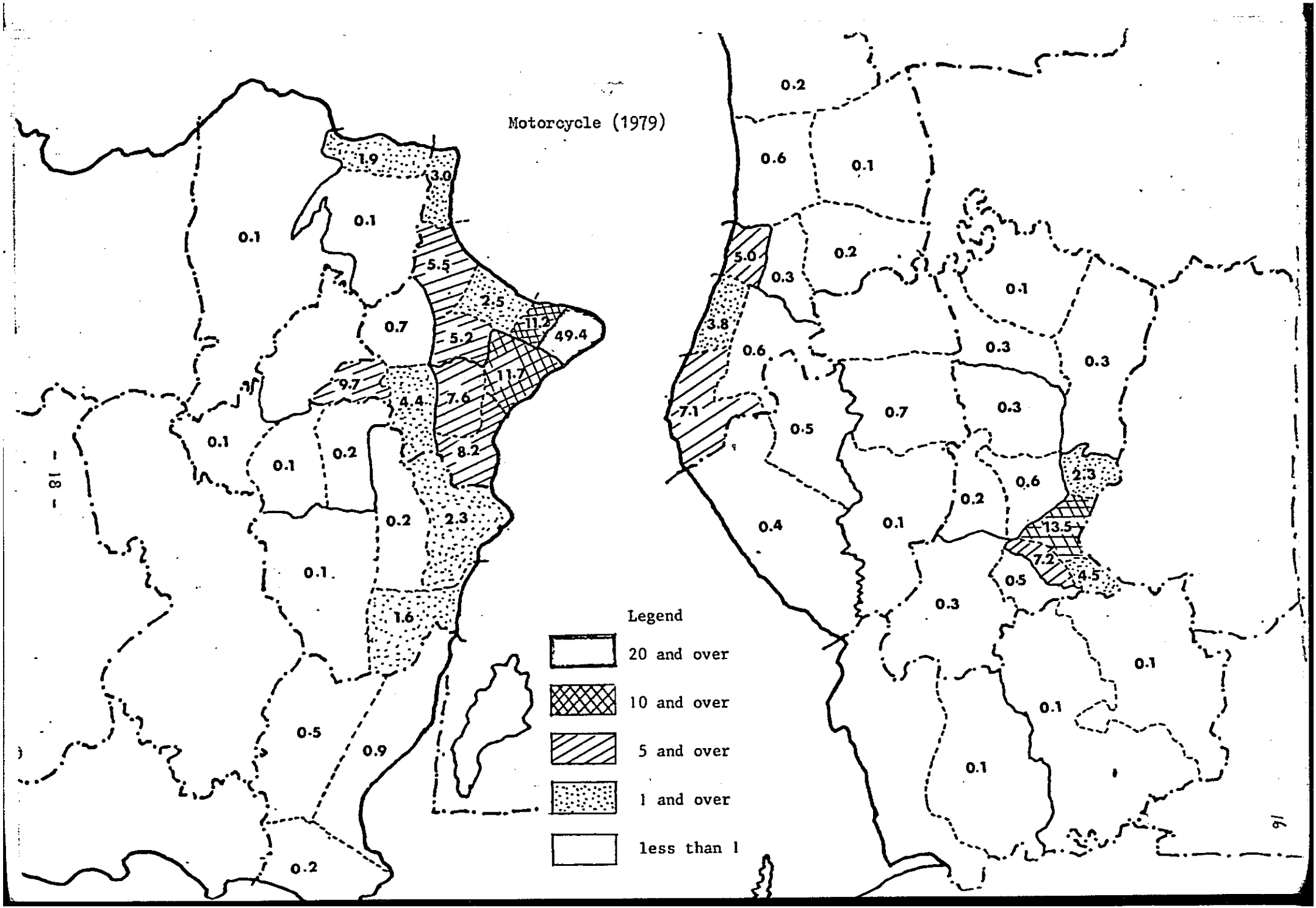
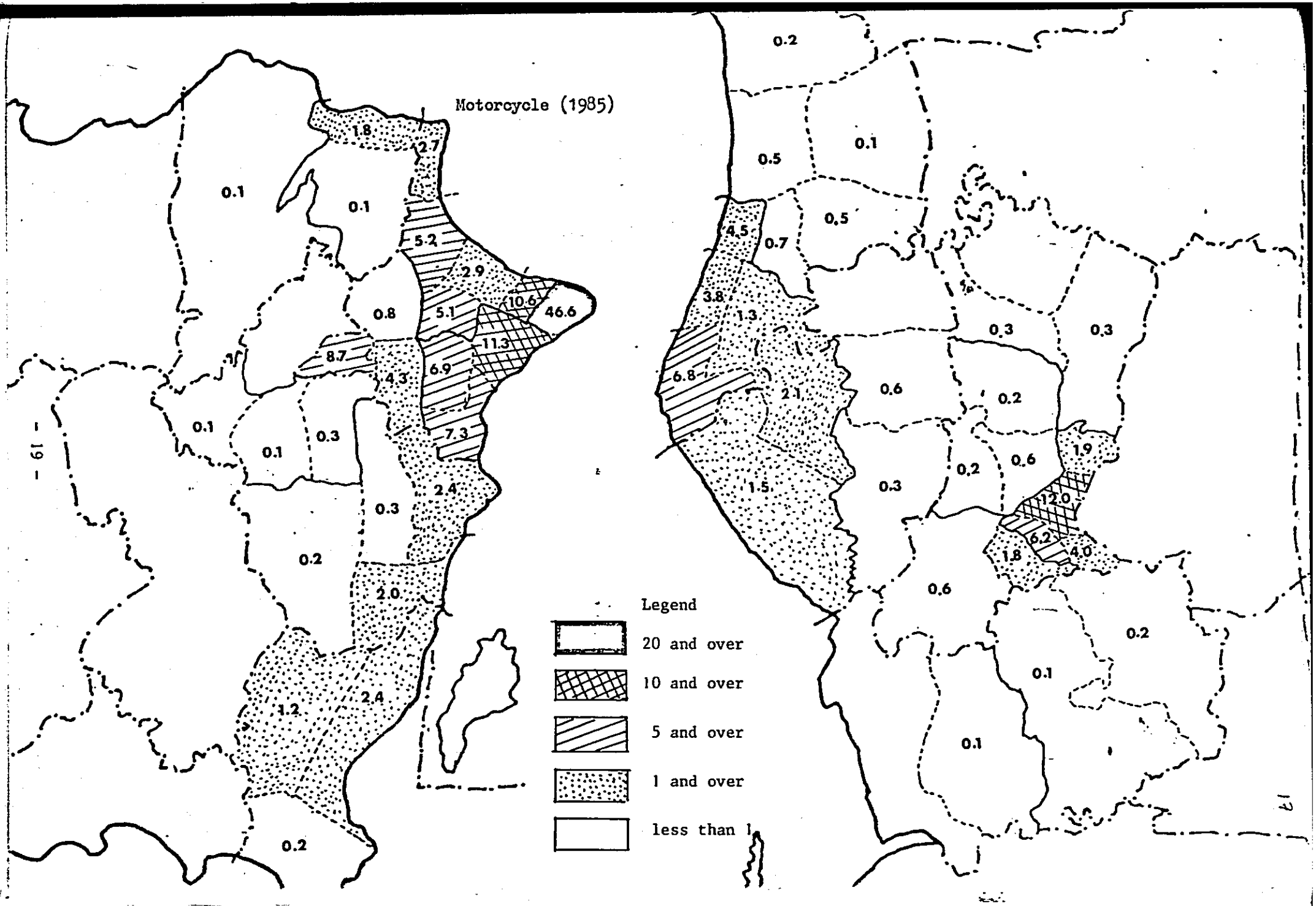
0.4
0.7
6.6
0.5
10.9
11.9
24.0
81.6
13.0
2.5
0.2
10.4
9.8
12.4
15.1
0.2
0.9
0.9
8.0
6.9
0.9
0.8
4.5
3.6
6.4
1.4
0.5
4.8
1.6
2.5
5.9
4.2
1.0
0.1
0.1
0.4
15.5
5.5
0.2
0.1
0.5
1.5
4.5
1.2
11.9
7.5
4.1
2.1
2.1
1.1
0.2
0.1
0.1
Legend
20 and over
10 and over
5 and over
1 and over
less than 1
- 17 -
15


Motorcycle (1979)
Legend
20 and over
10 and over
5 and over
1 and over
less than 1
1.9
3.0
0.1
0.1
5.5
2.5
11.2
49.4
0.7
5.2
9.7
4.4
7.6
11.7
8.2
0.1
0.1
0.2
0.2
2.3
0.1
1.6
0.5
0.9
0.2
0.2
0.6
0.1
5.0
0.3
0.2
3.8
0.6
0.1
0.3
0.3
7.1
0.5
0.7
0.3
0.6
2.3
0.2
0.4
0.1
13.5
7.2
4.5
0.5
0.3
0.1
0.1
0.1
- 18 -
- 19 -


Motorcycle (1985)
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0.5
0.1
0.5
4.5
0.7
3.8
1.3
6.8
2.1
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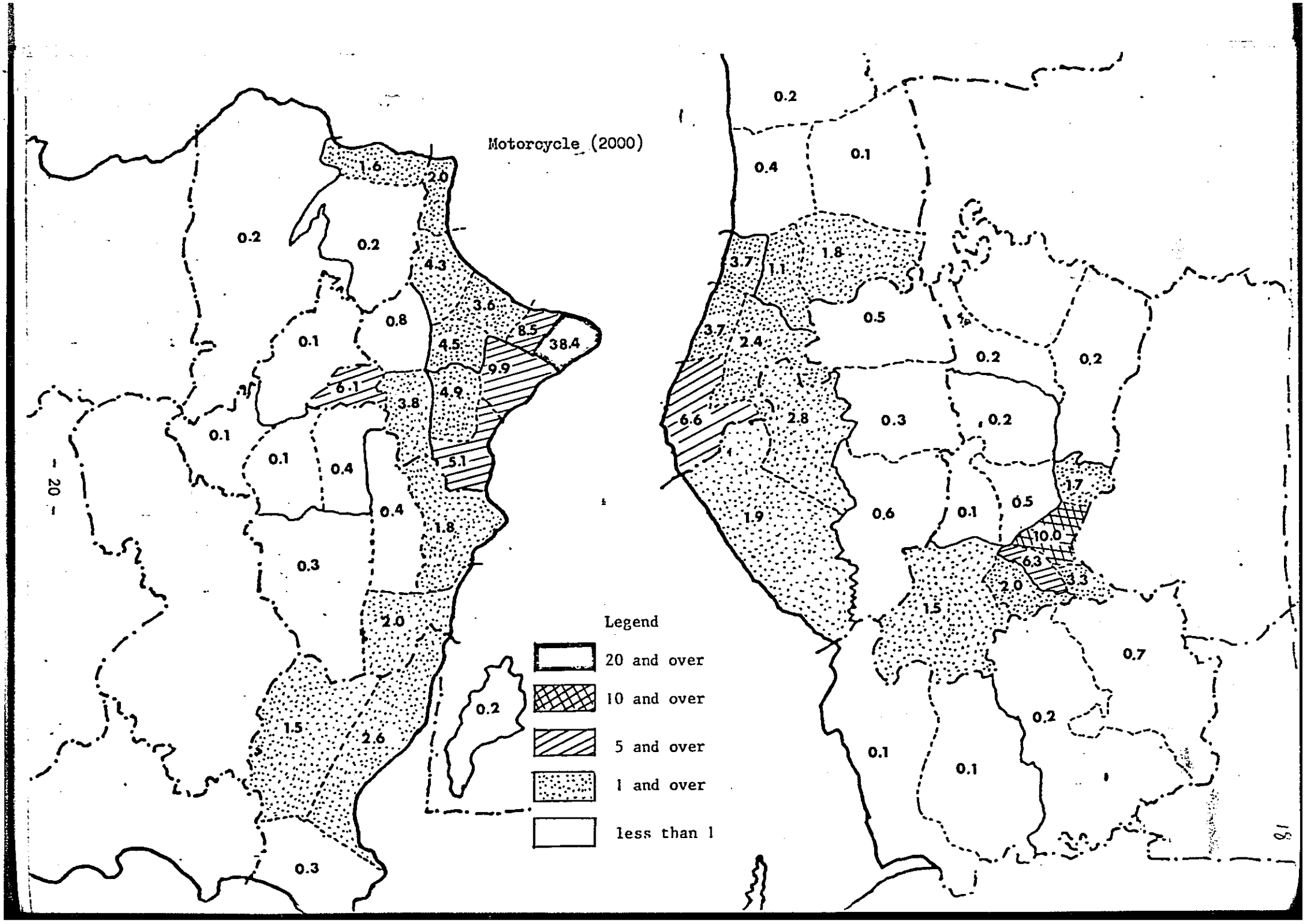
0.6
0.3
0.3
0.2
0.2
0.6
1.9
12.0
6.2
1.8
4.0
0.6
0.2
0.1
0.1
1.8
2.7
0.1
0.1
5.2
2.9
0.8
5.1
10.6
46.6
8.7
4.3
6.9
11.3
7.3
0.1
0.1
0.3
2.4
0.3
0.2
2.0
1.2
2.4
0.2
Legend
20 and over
10 and over
5 and over
1 and over
less than 1


Motorcycle (2000)
Legend
20 and over
10 and over
5 and over
1 and over
less than 1
1.6
2.0
0.2
0.2
4.3
3.6
0.8
8.5
38.4
0.1
4.5
9.9
6.1
4.9
3.8
0.1
0.1
0.4
5.1
0.4
1.8
0.3
2.0
0.2
1.5
2.6
0.3
0.2
0.4
0.1
3.7
1.1
1.8
0.5
3.7
2.4
0.2
0.2
6.6
2.8
0.3
0.2
1.9
0.6
0.1
0.5
1.7
10.0
6.3
3.3
2.0
1.5
0.7
0.2
0.1
0.1
- 20 -
18

C.- O-D TABLES

1.	1985 - Plan A	Vehicles (Unit : trips) (ex. M/C)
		Vehicles (Unit : p.c.u) (ex. M/C)
		Motor-cycles (Unit : trips)
2.	2000 - Plan A	Vehicles (Unit : trips) (ex. M/C)
		Vehicles (Unit : p.c.u) (ex. M/C)
		Motor-cycles (Unit : trips)

VEHICLE (1985)

O \ D	1	2	3	4	SUB-TOTAL	5	6	7	8	SUB-TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB-TOTAL	01	02	03	04	05	SUB-TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	180465	7549	15994	13605	217613	1814	1269	929	168	4180	221793	769	1473	119	547	2908	836	409	105	95	774	2219	5127	226920
2	7542	1633	794	821	10790	108	79	60	9	256	11046	306	101	8	38	253	61	30	8	7	58	164	417	11463
3	15968	794	5861	3576	26199	273	233	155	25	636	26885	99	349	23	107	578	142	67	17	15	129	370	948	27833
4	13622	818	3564	8210	26214	316	256	136	34	792	27006	113	440	31	211	795	170	82	22	18	158	450	1245	28251
SUB-TOTAL	217597	10794	26213	26212	280316	2511	1837	1330	236	5914	286730	1037	2363	181	903	4534	1209	588	152	135	1119	3203	7737	294467
5	1811	108	272	316	2507	27121	9687	5286	866	42960	45467	27	60	4	22	113	3238	1492	314	282	2193	7569	7632	53149
6	1270	79	233	255	1837	9697	9762	4562	727	24738	26575	19	45	3	18	85	2176	983	234	214	1627	5231	5324	31899
7	929	59	154	186	1328	5248	4565	13360	760	23934	25262	14	33	2	12	61	1568	892	256	239	1337	4232	4333	29605
8	166	9	25	34	234	857	725	768	273	2623	2857	3	6	0	3	12	266	128	50	50	285	779	791	3648
SUB-TOTAL	4176	255	684	791	5906	42913	24740	23976	2626	94255	100161	63	144	9	55	271	7298	3450	854	785	5442	17369	18140	118301
TOTAL IN INTERNAL AREA	221773	11049	26897	27003	286722	45424	26577	25306	2862	100169	386891	1150	2507	190	958	4805	8507	4078	1006	920	6561	21072	25877	412768
91	771	106	99	114	1090	24	18	16	3	61	1151	0	0	0	4	4	16	8	2	2	16	44	48	1199
92	1474	101	349	442	2366	59	44	33	6	142	2508	0	0	0	0	0	34	17	4	4	33	92	92	2600
93	118	8	23	31	180	4	3	2	0	9	189	0	0	0	0	0	3	1	0	0	3	7	7	196
94	543	39	107	213	902	22	18	12	3	55	957	4	0	0	0	4	14	7	2	2	13	38	42	999
SUB-TOTAL	2906	254	578	800	4538	109	83	63	12	267	4805	4	0	0	4	8	67	33	8	8	65	181	189	4994
01	840	59	140	169	1208	3252	2146	1524	260	7182	8390	16	34	3	14	67	0	0	26	20	268	314	381	8771
02	414	30	67	82	593	1499	991	876	128	3494	4087	8	17	1	7	33	0	0	21	15	110	146	179	4266
03	106	8	17	22	153	314	234	258	50	856	1009	2	4	0	2	8	27	21	0	5	33	86	94	1103
04	94	7	15	18	134	281	214	240	50	785	919	2	4	0	2	8	20	15	5	0	34	74	82	1001
05	800	58	129	160	1147	2220	1638	1329	285	5472	6619	16	33	3	14	66	168	135	38	35	0	376	442	7061
SUB-TOTAL	2254	162	368	451	3235	7566	5223	4227	773	17789	21024	44	92	7	39	182	215	171	90	75	445	996	1178	22202
TOTAL IN EXTERNAL AREA	5160	416	946	1251	7773	7675	5306	4290	785	18056	25829	48	92	7	43	190	282	204	98	83	510	1177	1367	27196
GRAND TOTAL	226933	11465	27843	28254	294495	53099	31883	29596	3647	118225	412720	1198	2599	197	1001	4995	8789	4282	1104	1003	7071	22249	27244	439964

VEHICLE (P.C.U1985)

O \ D	1	2	3	4	SUB-TOTAL	5	6	7	8	SUB-TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB-TOTAL	01	02	03	04	05	SUB-TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	216900	9349	19648	17272	263169	2186	1558	1112	218	5074	268243	1194	2109	116	910	4329	1024	493	148	138	992	2795	7124	275367
2	9359	2154	1015	1077	13605	143	102	79	16	340	13945	170	150	8	67	395	76	37	11	11	78	213	608	14553
3	19696	1015	7270	4715	32696	337	294	192	35	858	33554	161	516	22	183	882	178	85	24	22	168	477	1359	34913
4	17402	1081	4716	11103	34302	407	335	235	45	1022	35324	186	672	33	369	1260	220	105	32	30	212	599	1859	37183
SUB-TOTAL	263357	13599	32649	34167	343772	3073	2289	1618	314	7294	351066	1711	3447	179	1529	6866	1498	720	215	201	1450	4084	10950	362016
5	2187	141	333	405	3066	32142	12131	6373	1114	51760	54826	46	85	3	40	174	4067	1819	448	420	2841	9595	9769	64595
6	1573	102	292	334	2301	12171	12539	5641	957	31308	33609	30	66	3	30	129	2754	1235	344	324	2156	6813	6942	40551
7	1104	75	190	230	1599	6317	5610	15686	969	28582	30181	23	49	2	23	97	1911	1057	363	350	1711	5392	5489	35670
8	214	15	35	45	209	1110	958	982	376	3426	3735	5	10	0	5	20	349	165	77	78	393	1062	1082	4817
SUB-TOTAL	5078	333	850	1014	7275	51740	31238	28682	3416	115076	122351	104	210	8	98	420	9081	4276	1232	1172	7101	22862	23282	145633
TOTAL IN INTERNAL AREA	268435	13932	33499	35181	351047	54813	33527	30300	3730	122370	473417	1815	3657	187	1627	7286	10579	4996	1447	1373	8551	26946	34232	507649
91	1205	171	163	187	1726	38	29	24	5	96	1822	0	0	0	10	10	26	13	4	3	27	73	83	1905
92	2121	150	513	671	3455	85	66	50	10	211	3666	0	0	0	0	0	50	24	7	7	50	138	138	3804
93	115	8	22	33	178	4	3	2	0	9	187	0	0	0	0	0	3	1	0	0	3	7	7	194
94	911	67	183	370	1531	41	30	23	5	99	1630	10	0	0	0	10	24	11	3	3	24	65	75	1705
SUB-TOTAL	4352	396	881	1261	6890	168	128	99	20	415	7305	10	0	0	10	20	103	49	14	13	104	283	303	7608
01	1039	76	176	219	1510	4039	2723	1874	342	8978	10488	26	50	3	23	102	0	0	39	30	354	423	525	11013
02	504	37	85	106	732	1839	1244	1062	166	4311	5043	13	25	1	12	51	0	0	30	22	144	196	247	5290
03	149	11	24	32	216	450	347	369	77	1243	1459	4	7	0	3	14	39	30	0	9	51	129	143	1602
04	139	11	22	30	202	420	325	354	78	1177	1379	3	7	0	3	13	31	22	9	0	55	117	130	1509
05	1031	79	170	217	1497	2887	2179	1711	395	7172	8669	28	51	3	24	106	223	176	58	55	0	512	618	9287
SUB-TOTAL	2862	214	477	604	4157	9635	6818	5370	1058	22881	27038	74	140	7	65	286	293	228	136	116	604	1377	1663	28701
TOTAL IN EXTERNAL AREA	7214	610	1358	1865	11047	9803	6946	5469	1078	23296	34343	84	140	7	75	306	396	277	150	129	708	1660	1966	36309
GRAND TOTAL	275649	14542	34857	37046	362094	64616	40473	35769	4808	145666	507760	1899	3797	194	1702	7592	10975	5273	1597	1502	9259	28606	36198	543958

MOTOR-CYCLE (1985)

O \ D	1	2	3	4	SUB-TOTAL	5	6	7	8	SUB-TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB-TOTAL	01	02	03	04	05	SUB-TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	185432	4409	11078	7775	208694	2182	1380	809	225	4596	213290	359	376	194	288	1217	173	134	51	35	179	572	1789	215079
2	4413	2741	363	366	7883	65	71	46	13	195	8078	102	23	13	19	157	12	10	3	2	13	40	197	8275
3	11115	361	10206	4635	26317	191	335	167	46	739	27056	47	226	68	86	427	35	26	9	6	35	111	538	27594
4	7784	365	4662	18040	30851	239	361	218	61	879	31730	53	230	93	263	639	44	34	13	9	45	145	784	32514
SUB-TOTAL	199744	7876	26309	30816	273745	2677	2147	1240	345	6409	280154	561	855	368	656	2440	264	204	76	52	272	868	3308	283462
5	2058	57	177	211	1503	39425	9568	3714	812	53519	56022	1	1	1	1	4	1337	889	205	147	639	3217	3221	59243
6	1246	67	302	326	1941	9740	22233	6373	1363	39709	41650	2	3	2	3	10	1199	824	270	196	810	3299	3309	44959
7	702	39	137	193	1071	3555	6320	41073	1571	52519	53590	0	1	0	1	2	775	854	366	262	678	2935	2937	56527
8	206	12	40	53	311	807	1352	1608	2118	5885	6196	0	0	0	0	0	176	136	116	95	242	765	765	6961
SUB-TOTAL	4212	175	656	783	5826	53527	39473	52768	5864	151632	157458	3	5	3	5	16	3487	2703	957	700	2369	10216	10232	167690
TOTAL IN INTERNAL AREA	212956	8051	26965	31599	279571	56204	41620	54008	6209	158041	437612	564	860	371	657	2456	3751	2907	1033	752	2641	11084	13540	451152
91	366	105	48	55	574	6	7	4	1	18	592	0	0	0	2	2	0	0	0	0	0	0	2	594
92	387	23	230	234	874	7	11	7	2	27	901	0	0	0	0	0	0	0	0	0	0	0	0	901
93	202	13	72	97	384	5	6	2	0	13	397	0	0	0	0	0	0	0	0	0	0	0	0	397
94	297	20	88	268	673	7	10	5	2	24	697	2	0	0	0	2	0	0	0	0	0	0	2	699
SUB-TOTAL	1252	161	438	654	2505	25	34	18	5	82	2587	2	0	0	2	4	0	0	0	0	0	0	4	2591
01	269	17	54	70	410	1281	1145	680	164	3270	3680	8	10	6	9	33	0	0	12	6	74	92	125	3805
02	215	15	41	56	327	873	813	761	129	2576	2903	7	8	5	8	28	0	0	23	10	42	75	103	3006
03	78	5	16	21	120	200	261	339	110	910	1030	3	3	2	3	11	12	23	0	7	22	64	75	1105
04	53	4	10	14	81	140	187	248	91	666	747	2	2	1	2	7	6	10	7	0	20	43	50	797
05	278	19	55	72	424	622	781	577	224	2204	2628	10	11	7	10	38	30	60	27	20	0	137	175	2803
SUB-TOTAL	893	60	176	233	1362	3116	3187	2605	718	9626	10988	30	34	21	32	117	48	93	69	43	158	411	528	11516
TOTAL IN EXTERNAL AREA	2145	221	614	887	3867	3141	3221	2623	723	9708	13575	32	34	21	34	121	48	93	69	43	158	411	532	14107
GRAND TOTAL	215101	8272	27579	32486	283438	59345	44841	56631	6932	167749	451187	596	894	392	691	2577	3799	3000	1102	795	2799	11495	14072	465259

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VEHICLE (2000)

O \ D	2	2	3	4	SUB-TOTAL	5	6	7	8	SUB-TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB-TOTAL	01	02	03	04	05	SUB-TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	276964	19233	34969	36441	367607	3527	3818	1795	730	9870	377477	2758	4891	947	1958	10554	1641	761	306	201	1530	4489	15043	392520
2	19269	5991	2998	3647	31905	370	399	196	80	1045	32950	621	552	111	225	1510	193	90	36	24	192	535	2045	34995
3	35092	3010	16593	14128	68813	784	1005	452	182	2423	71236	533	1764	236	569	3152	401	183	72	50	378	1084	4236	75472
4	36659	3661	14166	34148	88634	1053	1292	607	246	3203	91837	699	2484	431	1235	4849	551	256	103	69	530	1509	6358	98195
SUB-TOTAL	367984	31895	68716	88364	556959	5739	6514	3050	1238	16541	573500	4611	9691	1775	3988	20065	2786	1290	517	344	2680	7617	27682	601182
5	3511	366	777	1046	5700	57431	34045	12417	4648	108541	114241	124	242	52	105	523	7371	3388	1095	725	5307	18386	18909	133150
6	3818	397	1002	1285	6502	34151	49142	16315	5344	105452	111954	131	282	58	120	591	7597	3319	1250	833	5998	18997	19538	131542
7	1780	194	444	600	3018	12354	16285	24070	4145	56854	59372	68	136	27	56	287	3523	1819	838	565	3157	9902	10189	70061
8	726	80	182	245	1233	4647	5835	4154	3439	18075	19308	28	57	11	25	121	1339	647	429	303	1471	4239	4360	23668
SUB-TOTAL	9835	1037	2405	3176	16453	108583	105307	56956	18076	288922	305375	351	717	148	306	1522	20380	9173	3612	2426	15933	51524	53046	358421
TOTAL IN INTERNAL AREA	377819	32932	71121	91540	573412	114322	111821	60006	19314	305463	878875	4962	10408	1923	4294	21587	23166	10463	4129	2770	18613	59141	80728	959603
91	2774	623	536	698	4631	110	130	68	28	336	4967	0	0	0	36	36	71	34	14	9	73	201	237	5204
92	4915	552	1761	2482	9710	242	281	135	57	715	10425	0	0	0	0	0	137	64	26	17	137	381	381	10806
93	947	111	287	429	1774	51	58	29	11	149	1923	0	0	0	0	0	29	14	5	4	29	81	81	2004
94	1965	227	569	1232	3993	104	120	57	25	306	4299	36	0	0	0	36	60	28	11	7	60	166	202	4501
SUB-TOTAL	10601	1513	3153	4841	20108	507	589	289	121	1506	21614	36	0	0	36	72	297	140	56	37	299	829	901	22515
01	1633	190	394	548	2765	7843	7575	3475	1373	20271	23036	70	137	29	60	296	0	0	93	52	637	782	1078	24114
02	766	90	182	258	1296	3423	3356	1828	652	9259	10555	34	65	14	28	141	0	0	68	35	252	355	496	11051
03	306	36	72	103	517	1103	1256	849	431	3639	4156	14	26	5	11	56	94	68	0	20	119	301	357	4513
04	200	24	50	67	341	728	834	572	304	2438	2779	9	17	4	7	37	53	35	20	0	90	198	235	3014
05	1605	193	379	536	2713	5385	6083	3166	1487	16121	18834	74	139	30	61	304	409	305	135	90	0	939	1243	20077
SUB-TOTAL	4510	533	1077	1512	7632	18482	19104	9890	4252	51728	59360	201	384	82	167	834	556	408	316	197	1098	2575	3409	62769
TOTAL IN EXTERNAL AREA	15111	2046	4230	6353	27740	18909	19693	10179	4373	53234	80974	237	384	82	203	906	853	548	372	234	1397	3404	4310	85284
GRAND TOTAL	392930	34978	75351	97893	601152	133311	131514	70185	23687	353697	959849	5199	10792	2005	4497	22493	24019	11011	4501	3004	20010	62545	85038	1044887

VEHICLE (P.G.U 2000)

D / O	1	2	3	4	SUB-TOTAL	5	6	7	8	SUB-TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB-TOTAL	01	02	03	04	05	SUB-TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	327370	21970	41426	45077	435843	4262	4705	2103	875	11945	447788	3559	5619	1300	2610	13088	2375	1160	429	260	2323	6547	19635	467423
2	21969	6747	3438	4368	36522	438	475	224	95	1232	37554	778	615	148	292	1833	271	133	49	30	275	758	2591	40345
3	41437	3443	19509	17489	81878	955	1237	528	215	2935	84813	689	2016	393	755	3853	578	279	103	62	554	1576	5429	90242
4	45071	4369	17520	44075	111035	1331	1646	738	306	4021	115056	938	2964	615	1694	6211	825	404	148	91	805	2273	8484	123540
SUB-TOTAL	435847	36529	81893	111009	665278	6986	8063	3593	1491	20133	685411	5964	11214	2456	5351	24985	4049	1976	729	443	3957	11154	36139	721550
5	4236	436	953	1323	6948	70425	42945	14911	5715	133996	140944	165	286	71	143	665	11610	5284	1569	960	7967	27390	28055	168999
6	4687	474	1231	1645	8037	43010	62851	19875	7282	133018	141055	177	337	81	167	762	11358	5246	1817	1119	9130	28670	29432	170487
7	2088	223	522	734	3567	14831	19875	28629	4930	68265	71832	87	155	38	80	360	5045	2760	1166	727	4601	14299	14659	86491
8	872	95	215	306	1488	5709	7278	4945	4155	22087	23575	37	68	17	32	154	2034	1002	608	397	2196	6237	6391	29966
SUB-TOTAL	11883	1228	2921	4008	20040	133975	132949	68360	22082	357366	377406	466	846	207	422	1941	30047	14292	5160	3203	23894	76596	78537	455943
TOTAL IN INTERNAL AREA	447730	37757	84814	115017	685318	140961	141012	71953	23573	377499	1062817	6430	12060	2663	5773	26926	34096	16268	5889	3646	27851	87750	114676	1177493
91	3577	783	693	941	5994	141	175	87	37	440	6434	0	0	0	53	53	112	56	21	12	118	319	372	6806
92	5626	616	2018	2967	11227	285	335	154	68	842	12069	0	0	0	0	0	192	95	35	21	194	537	537	12606
93	1300	149	393	614	2456	71	81	37	17	206	2662	0	0	0	0	0	49	24	9	5	50	137	137	2799
94	2613	294	759	1692	5358	143	166	80	32	421	5779	52	0	0	0	52	98	49	18	11	99	275	327	6106
SUB-TOTAL	13116	1842	3863	6214	25035	640	757	358	154	1909	26944	52	0	0	53	105	451	224	83	49	461	1268	1373	28317
01	2329	264	562	815	3970	11446	11239	4923	1999	29607	33577	110	190	48	96	444	0	0	157	81	1131	1369	1813	35390
02	1160	133	277	406	1976	5301	5286	2747	1003	14337	16313	57	96	24	49	226	0	0	121	58	475	654	880	17193
03	423	49	102	148	722	1571	1818	1175	609	5173	5895	21	35	9	18	83	160	121	0	30	206	517	600	6495
04	256	30	62	89	437	955	1115	731	396	3197	3634	12	21	5	11	49	82	58	30	0	143	313	362	3996
05	2335	275	552	815	3977	8041	9237	4580	2207	24065	28042	119	197	51	101	468	729	576	233	144	0	1682	2150	30192
SUB-TOTAL	6503	751	1555	2273	11082	27314	28695	14156	6214	76379	87461	319	539	137	275	1270	971	755	541	313	1955	4535	5805	932666
TOTAL IN EXTERNAL AREA	19619	2593	5418	8487	36117	27954	29452	14514	6368	78288	114405	371	539	137	328	1375	1422	979	624	362	2416	5803	7178	121583
GRAND TOTAL	467349	40350	90232	123504	721435	168915	170464	86467	29941	455787	1177222	6801	12599	2800	6101	28301	35518	17247	6513	4088	30267	93553	121854	1299076

MOTOR-CYCLE (2600)

O \ D	1	2	3	4	SUB-TOTAL	5	6	7	8	SUB-TOTAL	TOTAL IN INTERNAL AREA	91	92	93	94	SUB-TOTAL	01	02	03	04	05	SUB-TOTAL	TOTAL IN EXTERNAL AREA	GRAND TOTAL
1	148100	4661	9892	7934	170437	2188	1455	805	343	4796	175283	322	393	151	226	1097	121	118	45	29	129	442	1539	176822
2	4667	3660	452	496	9275	89	102	59	28	278	9553	128	32	14	19	193	10	10	4	2	12	38	231	9784
3	9957	453	9521	5502	25433	237	396	195	86	914	26347	51	302	67	84	504	30	28	10	5	31	104	608	26955
4	7823	497	5539	22696	36555	321	430	274	116	1191	37746	62	317	95	281	755	40	33	15	10	41	144	899	38645
SUB-TOTAL	170547	9271	25404	36528	241750	2835	2433	1333	578	7179	248929	563	1049	327	610	2549	201	194	74	46	213	728	3277	252206
5	2072	78	216	289	2655	46615	13600	5033	1724	66977	69632	1	3	1	2	7	1361	1093	240	164	603	3466	3473	73105
6	1307	91	360	435	2193	13761	30157	8752	2772	55452	57645	2	6	2	3	13	1113	960	316	218	766	3378	3391	61036
7	710	52	167	243	1172	4918	8693	39322	3580	56513	57685	1	1	1	1	4	649	837	375	257	591	2709	2713	60398
8	310	25	78	106	519	1733	2781	3592	6770	14876	15395	1	1	0	1	3	242	236	237	133	316	1214	1217	16612
SUB-TOTAL	4399	246	821	1073	6539	67027	55231	56704	14856	193818	200357	5	11	4	7	27	3370	3131	1168	822	2276	10767	10794	211151
TOTAL IN INTERNAL AREA	174946	9517	26225	37601	248289	69862	57664	58037	15434	200997	449286	568	1060	331	617	2576	3571	3325	1242	868	2489	11495	14071	463357
91	327	131	52	63	573	7	8	3	3	21	594	0	0	0	2	2	0	0	0	0	0	0	2	596
92	402	33	305	320	1061	11	16	9	3	39	1100	0	0	0	0	0	0	0	0	0	0	0	0	1100
93	154	15	68	96	333	3	7	3	1	14	347	0	0	0	0	0	0	0	0	0	0	0	0	347
94	232	20	85	284	621	6	10	3	3	22	643	2	0	0	0	2	0	0	0	0	0	0	2	645
SUB-TOTAL	1115	199	511	763	2588	27	41	18	10	96	2684	2	0	0	2	4	0	0	0	0	0	0	4	2688
01	189	17	44	63	313	1303	1075	592	230	3200	3513	7	10	4	7	28	0	0	9	4	46	59	87	3600
02	186	17	44	62	309	1071	943	757	230	3001	3310	7	10	5	7	29	0	0	22	9	33	64	93	3403
03	70	7	17	23	117	233	306	352	229	1120	1237	3	4	2	3	12	9	22	0	7	17	55	67	1304
04	47	4	10	16	77	156	208	245	174	783	860	2	2	1	2	7	5	9	7	0	15	36	43	903
05	199	19	46	66	330	581	737	521	301	2140	2470	8	11	5	8	32	18	47	21	15	0	101	133	2603
SUB-TOTAL	691	64	161	230	1146	3344	3269	2467	1164	10244	11390	27	37	17	27	108	32	78	59	35	111	315	423	11813
TOTAL IN EXTERNAL AREA	1806	263	672	993	3734	3371	3310	2485	1174	10340	14074	29	37	17	29	112	33	78	59	35	111	315	427	14501
GRAND TOTAL	176752	9780	26897	38594	252023	73233	60974	60522	16608	211337	463360	597	1097	348	646	2688	3603	3403	1301	903	2600	11810	14498	477858

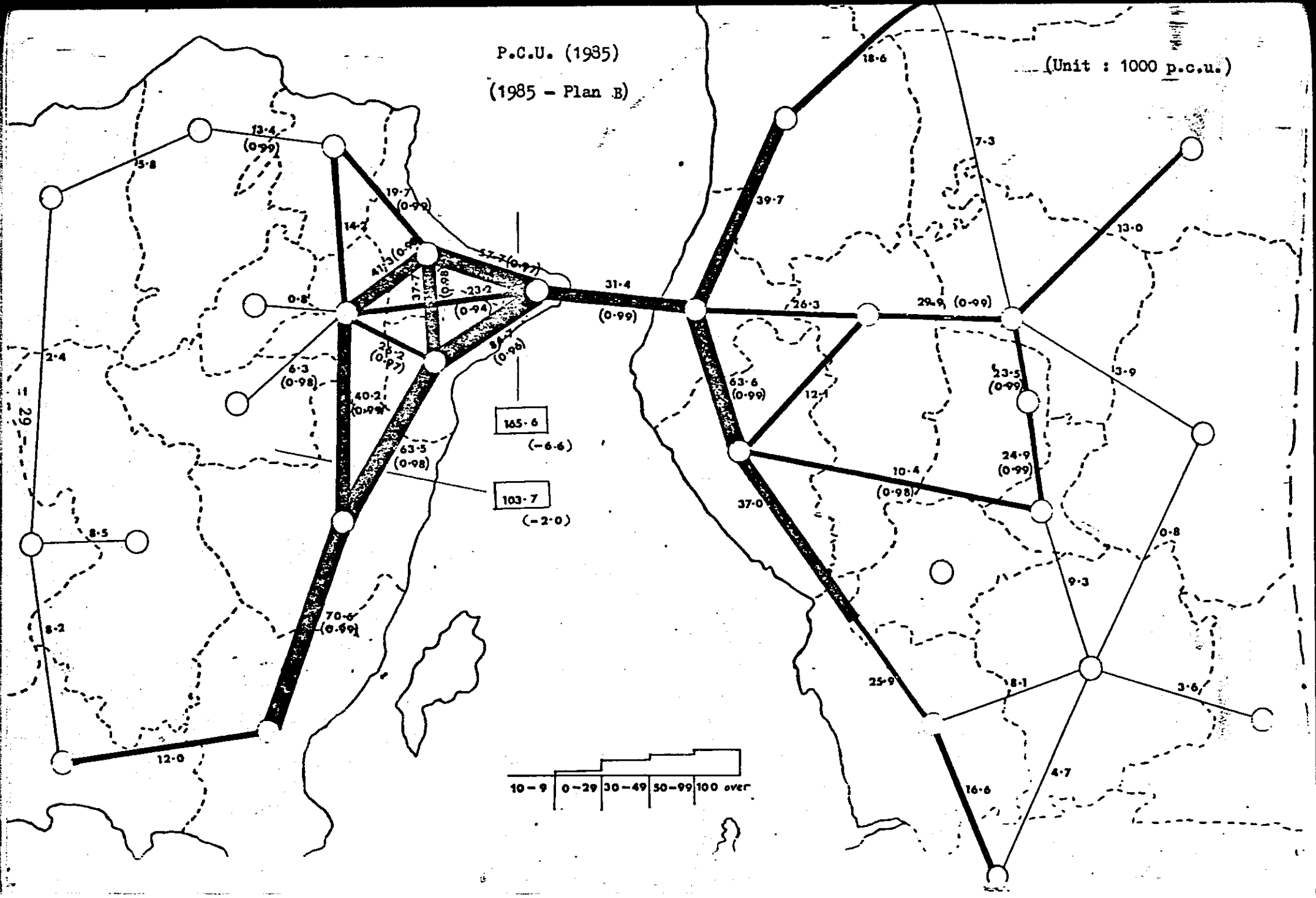
D - FIGURES OF THE DESIRED ASSIGNMENT

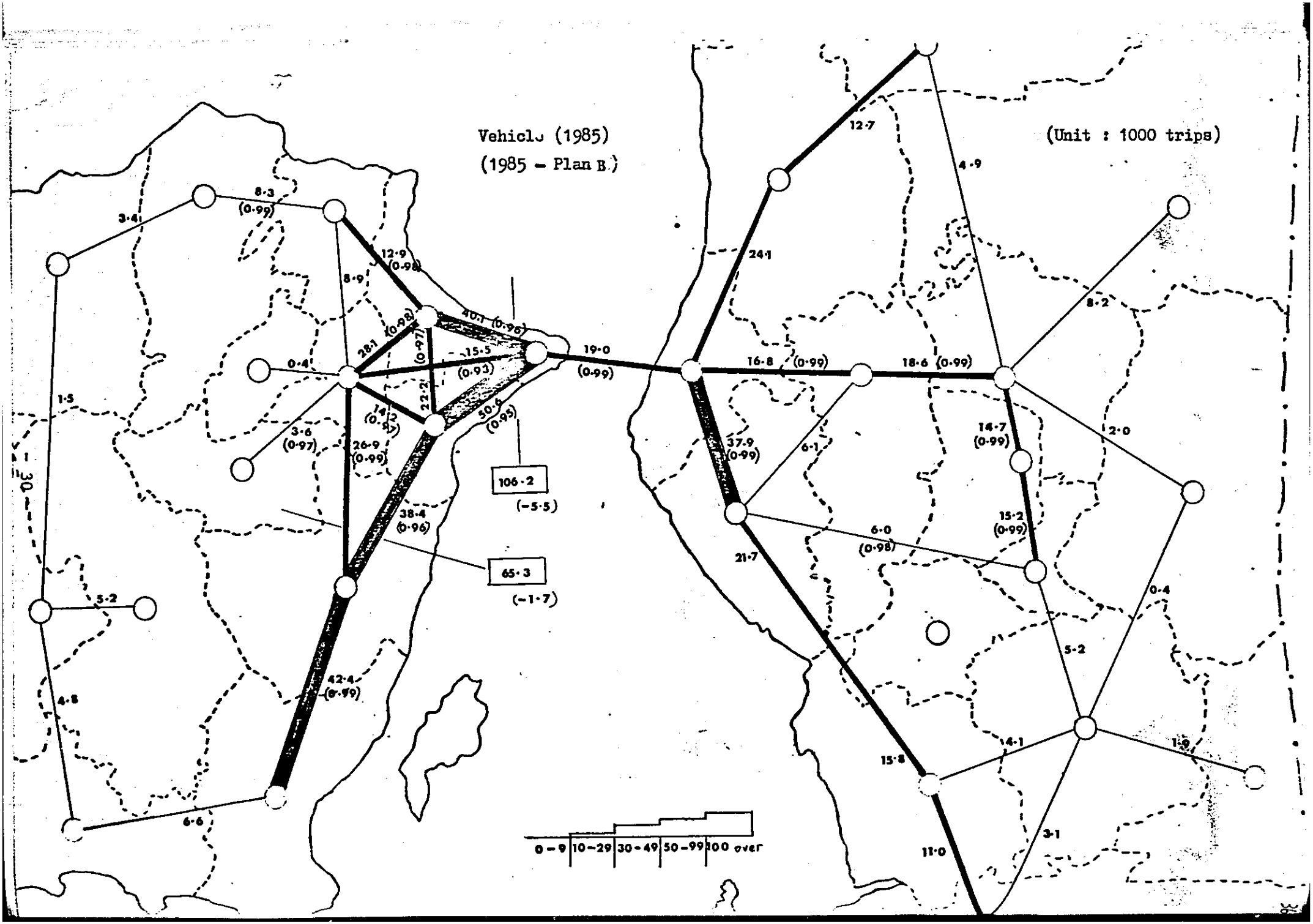
1.	1985 - Plan B	P.C.U (Unit : 1000 p.c.u) Vehicles (Unit : 1000 trips) (ex. M/C)
2.	2000 - Plan B	P.C.U (Unit : 1000 p.c.u) Vehicles (Unit : 1000 trips) (ex. M/C)
3.	2000 - Plan C	P.C.U (Unit : 1000 p.c.u) Vehicles (Unit : 1000 trips) (ex. M/C)
4.	2000 - Plan D	P.C.U (Unit : 1000 p.c.u) Vehicles (Unit : 1000 trips) (ex. M/C)
5	1979	Bicycles (Unit : 1000 trips) M/C (Unit : 1000 trips)
6	1985 - Plan A	Vehicles (Unit : 1000 trips) M/C (Unit : 1000 trips)
7	2000 - Plan A	Vehicles (Unit : 1000 trips) M/C (Unit : 1000 trips)

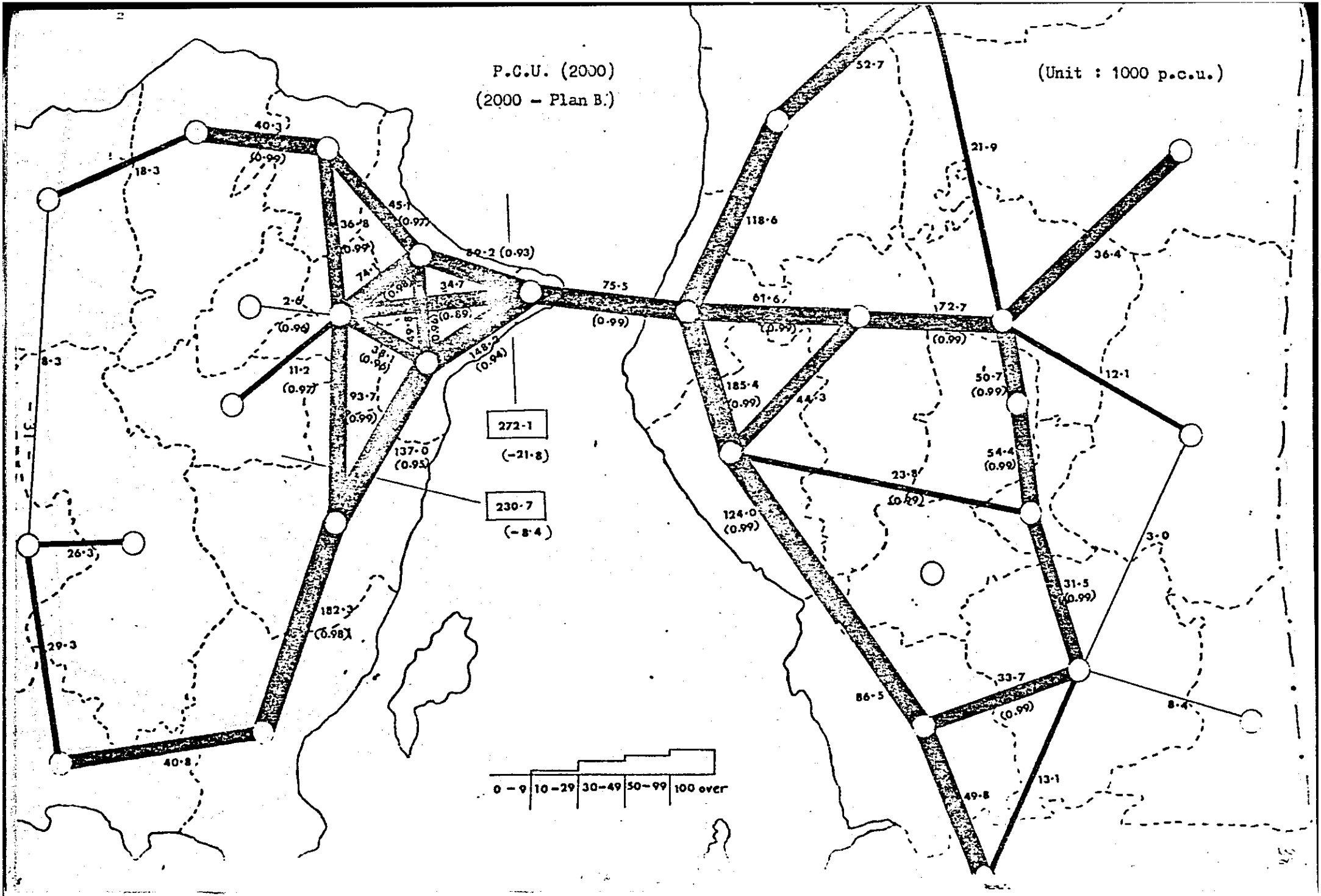
P.C.U. (1985)

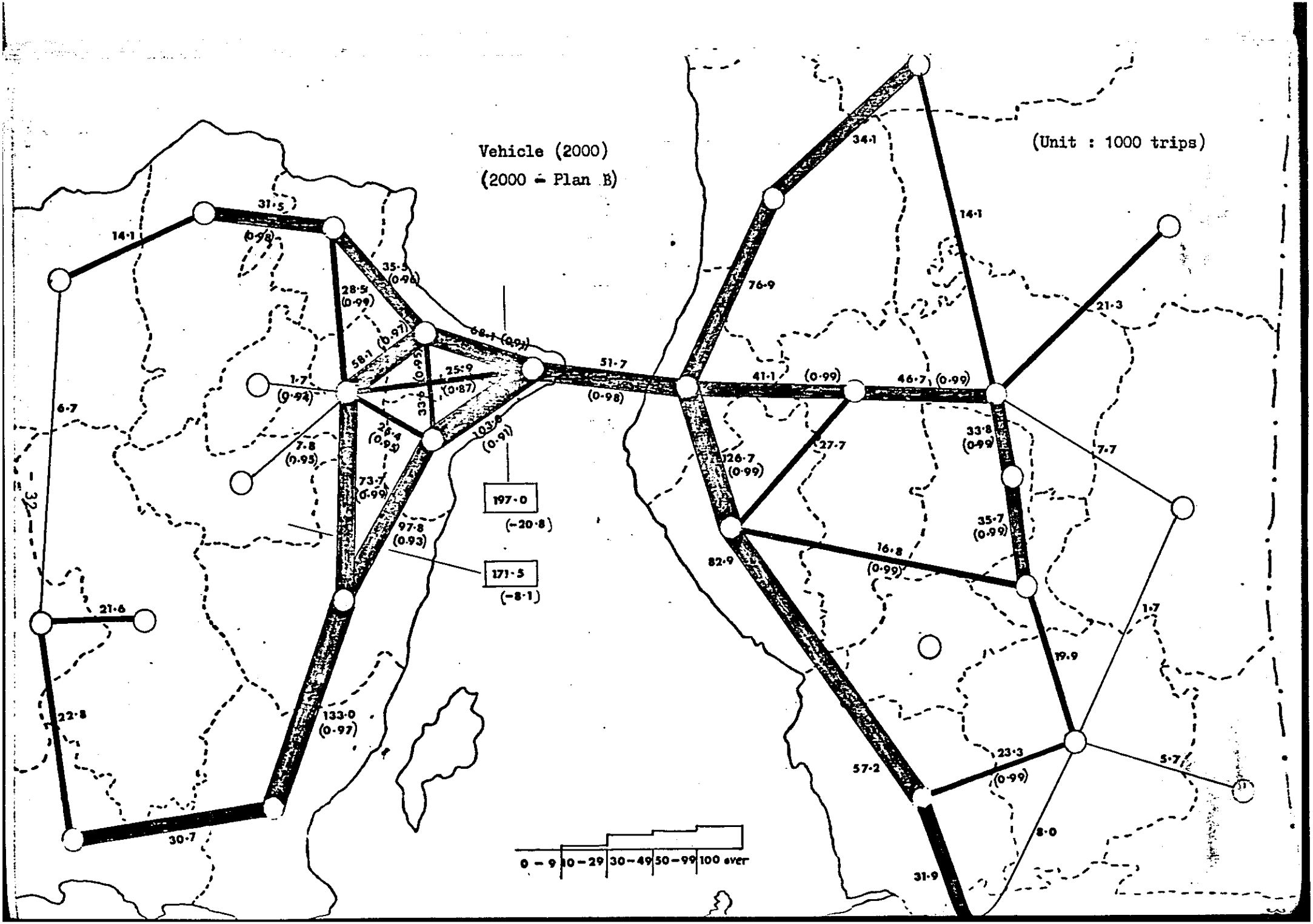
(1985 - Plan B)

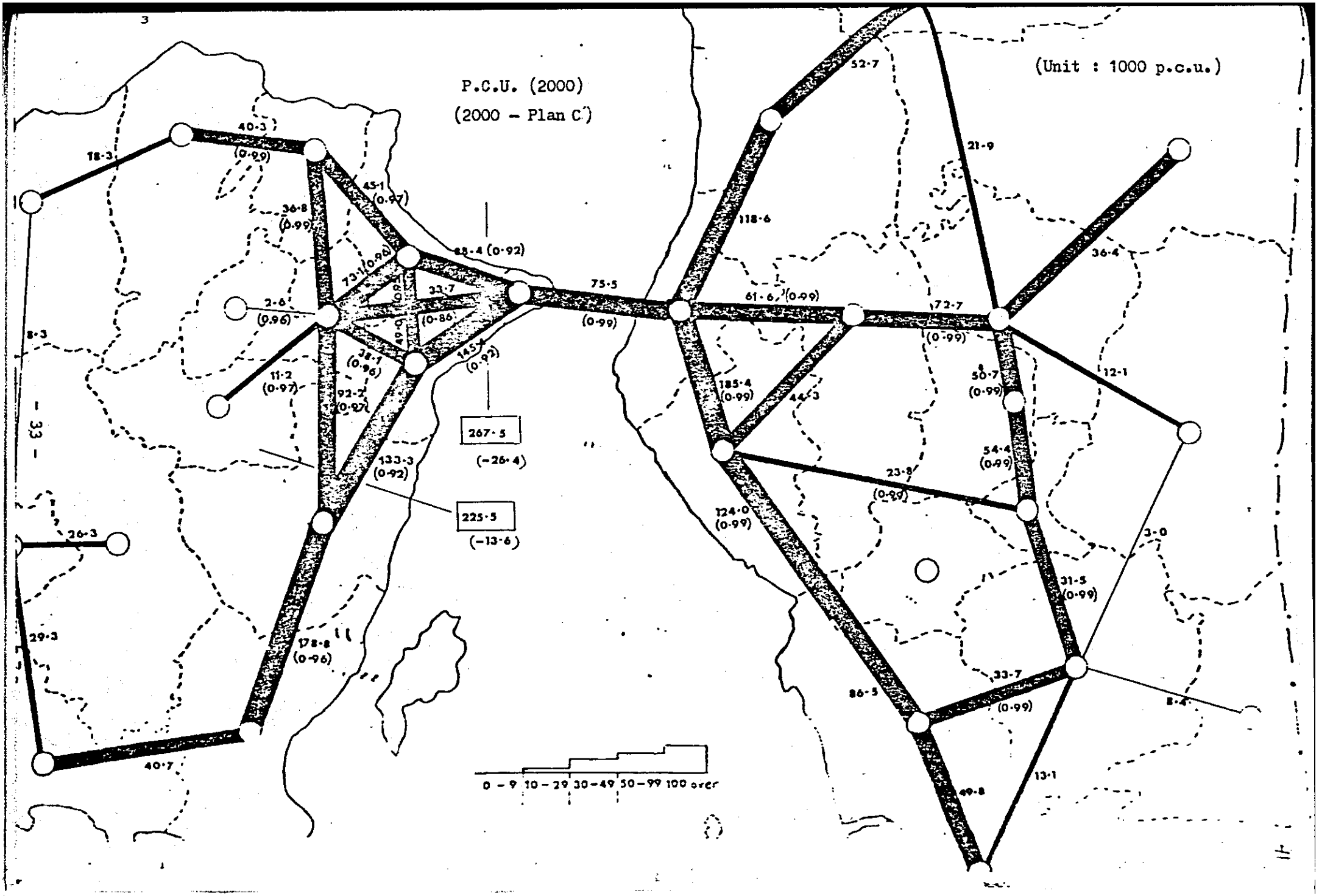
(Unit : 1000 p.c.u.)

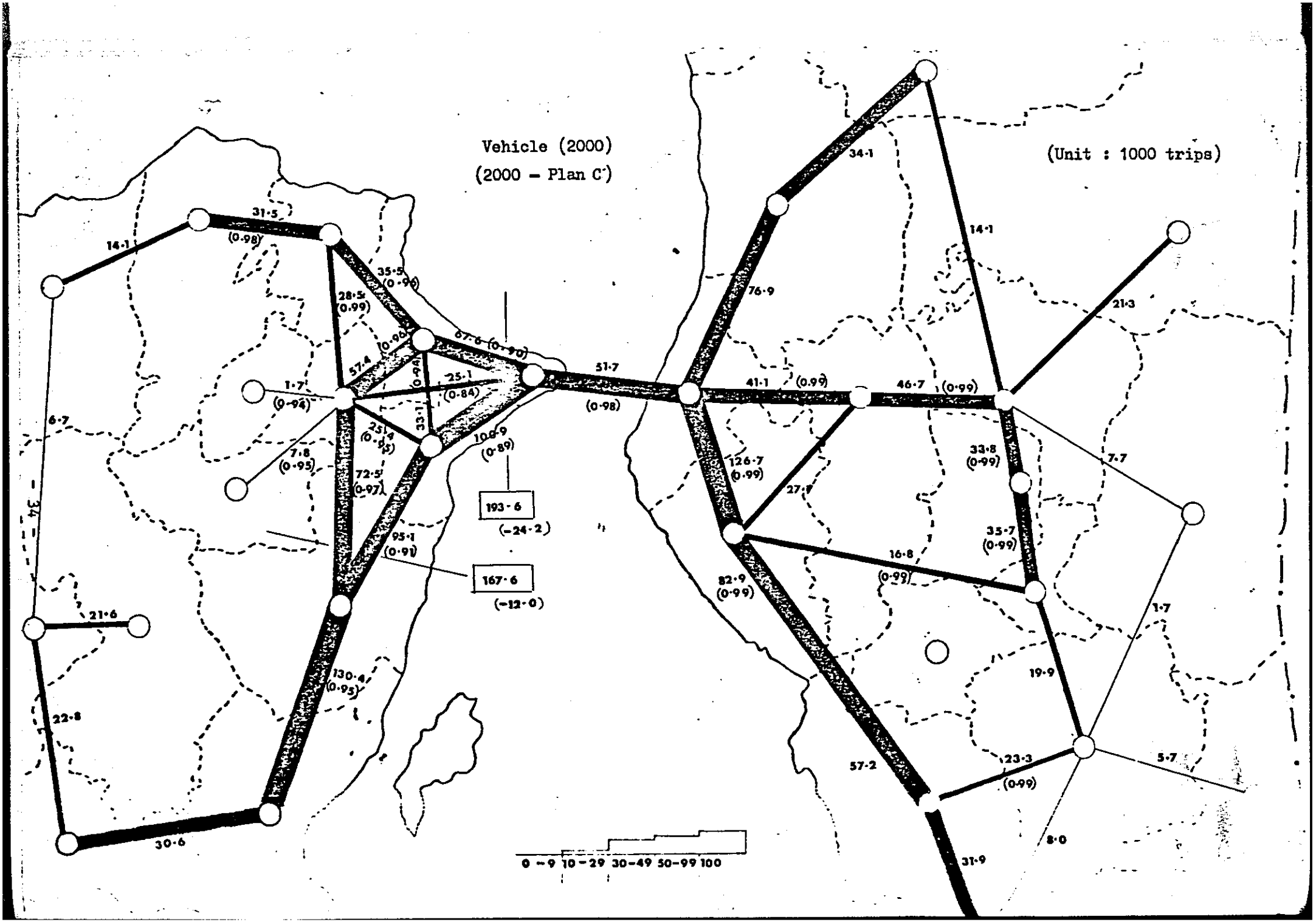


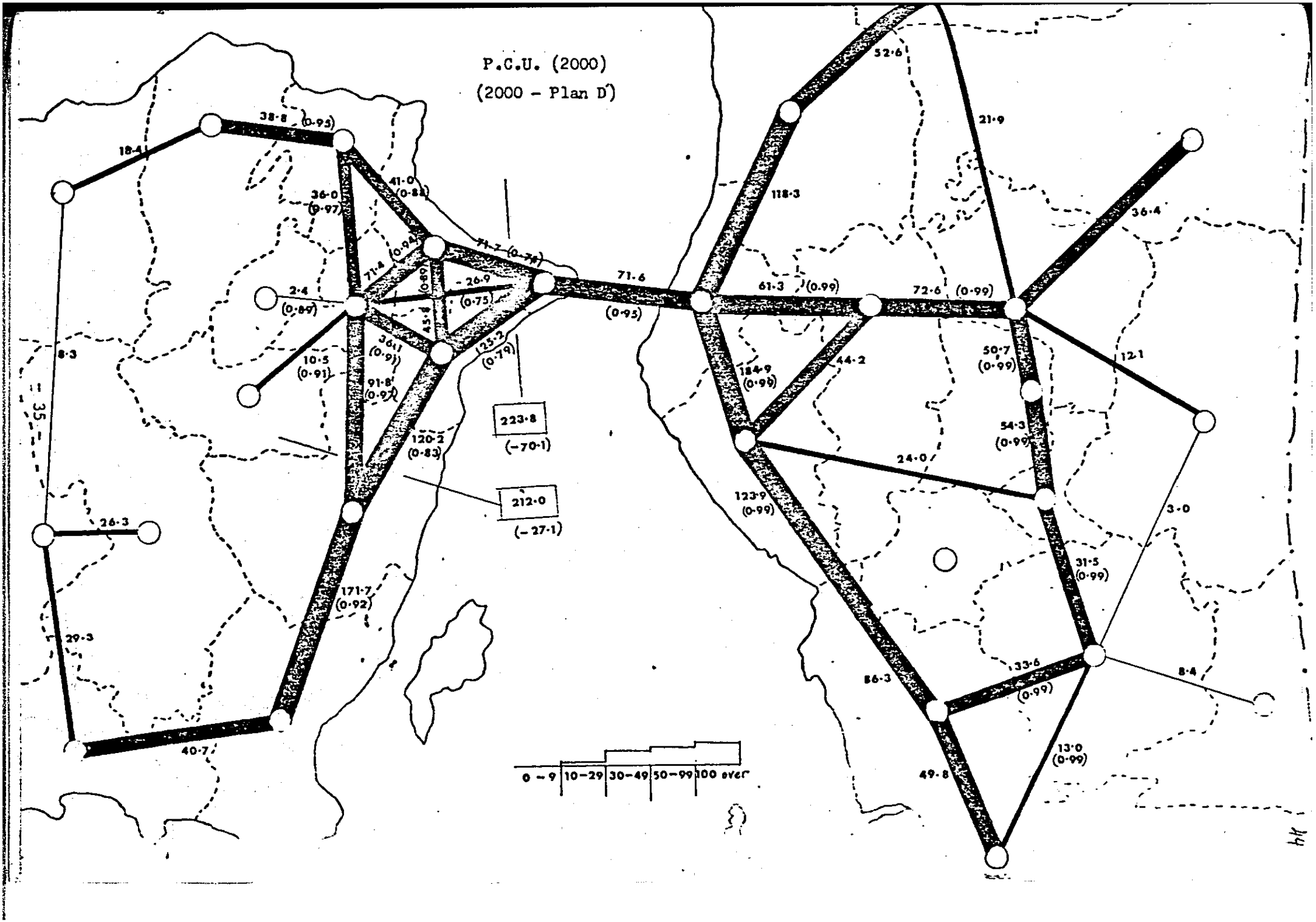

Vehicle (1985)
(1985 - Plan B)
(Unit : 1000 trips)
8·3 (0·99)
3·4
12·9 (0·98)
8·9
40·1 (0·96)
28·1 (0·98)
15·5 (0·93)
22·2 (0·97)
0·4
1·5
3·6 (0·97)
14·2 (0·97)
26·9 (0·99)
50·6 (0·95)
106·2
(-5·5)
38·4 (0·96)
65·3
(-1·7)
42·4 (0·99)
5·2
4·8
6·6
19·0 (0·99)
12·7
24·1
4·9
8·2
16·8 (0·99)
18·6 (0·99)
37·9 (0·99)
6·1
16·7 (0·99)
2·0
6·0 (0·98)
15·2 (0·99)
21·7
0·4
5·2
4·1
1·9
15·8
3·1
11·0
0 - 9
10 - 29
30 - 49
50 - 99
100 over
- 30 -


P.C.U. (2000)
(2000 – Plan B.)
(Unit : 1000 p.c.u.)
40·3
(0·99)
18·3
45·1
(0·97)
36·8
(0·99)
74·1
(0·98)
80·2 (0·93)
34·7
(0·89)
75·5
(0·99)
52·7
21·9
118·6
36·4
2·6
(0·99)
61·6
(0·99)
172·7
(0·99)
8·3
11·2
(0·97)
93·7
(0·99)
148·2
(0·94)
185·4
(0·99)
44·3
50·7
(0·99)
12·1
272·1
(-21·8)
137·0
(0·95)
54·4
(0·99)
23·8
(0·99)
230·7
(-8·4)
124·0
(0·99)
3·0
26·3
31·5
(0·99)
182·3
(0·98)
29·3
33·7
(0·99)
86·5
8·4
40·8
13·1
49·8
0 – 9
10 – 29
30 – 49
50 – 99
100 over

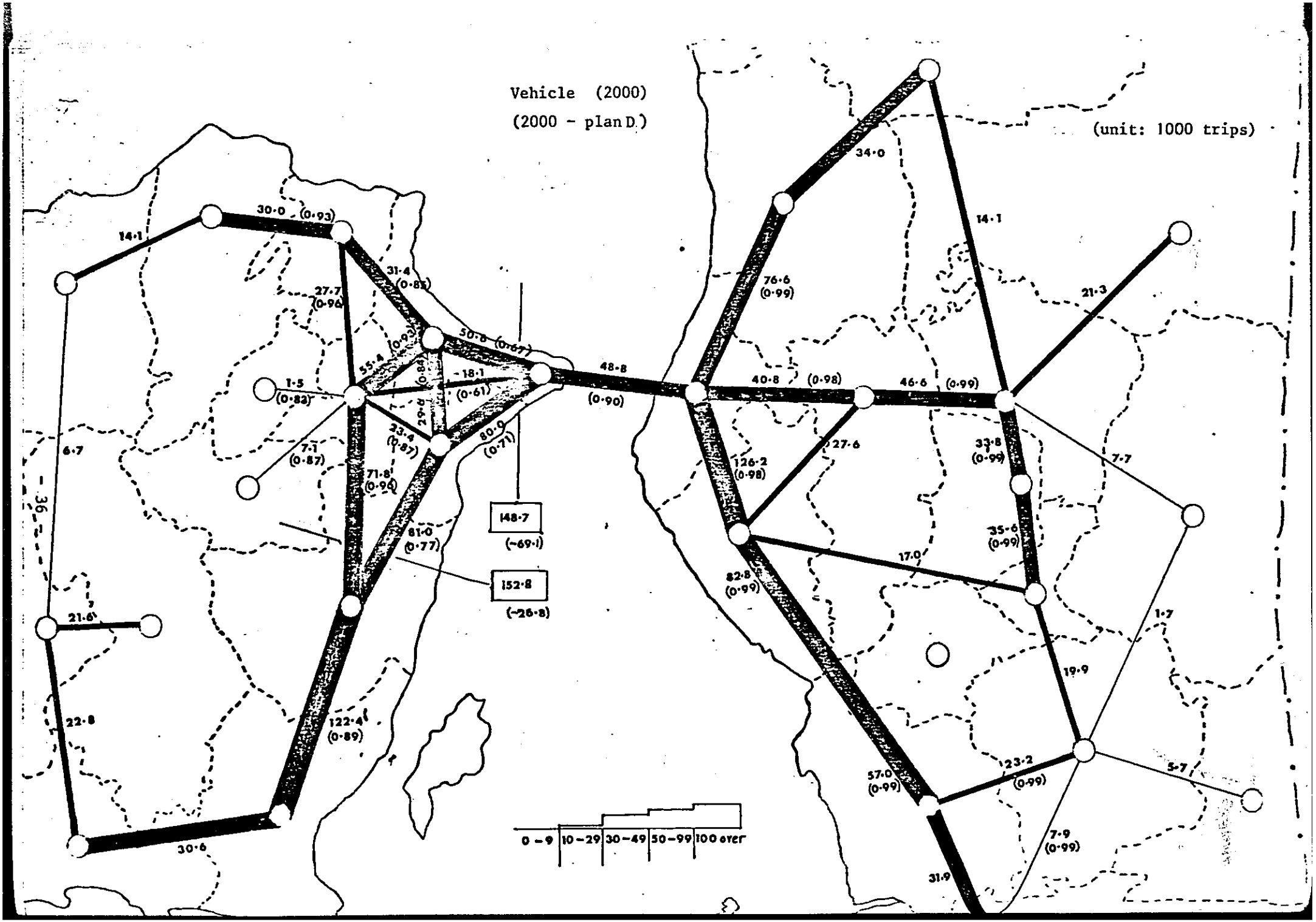

Vehicle (2000)
(2000 – Plan B)
(Unit : 1000 trips)
31·5
(0·98)
14·1
35·5
(0·98)
28·5
(0·99)
58·1
(0·97)
68·1 (0·99)
51·7
(0·98)
1·7
(0·94)
25·9
(0·87)
33·6
(0·95)
6·7
7·8
(0·95)
26·4
(0·95)
73·7
(0·99)
103·6
(0·91)
197·0
(–20·8)
97·8
(0·93)
171·5
(–8·1)
21·6
22·8
30·7
133·0
(0·97)
34·1
14·1
76·9
21·3
41·1
(0·99)
46·7
(0·99)
33·8
(0·99)
7·7
27·7
126·7
(0·99)
35·7
(0·99)
16·8
(0·99)
82·9
1·7
19·9
23·3
(0·99)
5·7
57·2
8·0
31·9
0 – 9
10 – 29
30 – 49
50 – 99
100 over
– 32 –

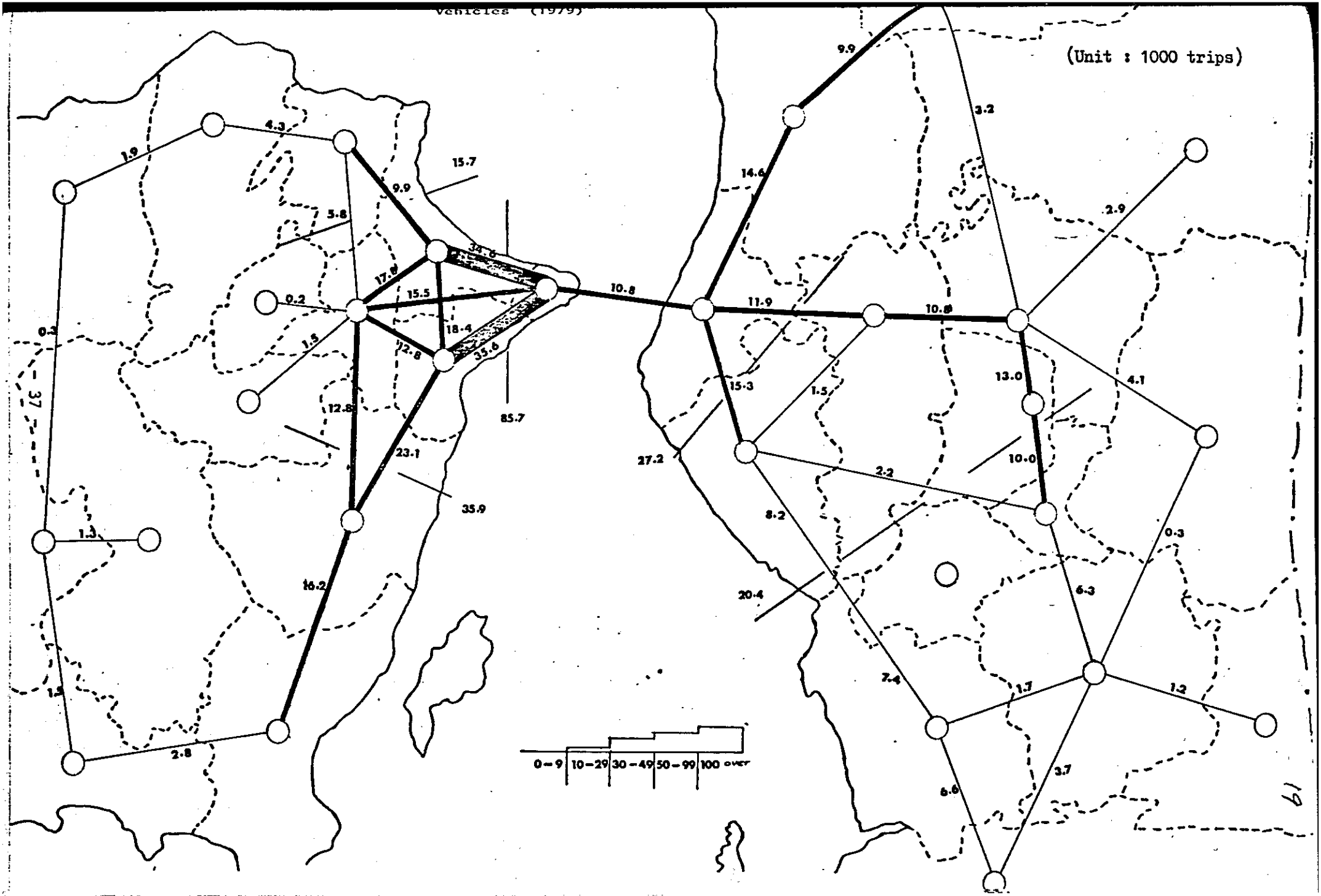

P.C.U. (2000)
(2000 - Plan C)
(Unit : 1000 p.c.u.)
40·3 (0·99)
18·3
45·1 (0·97)
36·8 (0·99)
73·1 (0·96)
88·4 (0·92)
33·7 (0·86)
2·6 (0·96)
8·3
11·2 (0·97)
38·1 (0·96)
92·2 (0·97)
145·4 (0·92)
267·5
(-26·4)
133·3 (0·92)
225·5
(-13·6)
26·3
29·3
178·8 (0·96)
40·7
75·5 (0·99)
52·7
118·6
21·9
36·4
61·6 (0·99)
172·7 (0·99)
185·4 (0·99)
44·3
50·7 (0·99)
12·1
54·4 (0·99)
23·8 (0·99)
124·0 (0·99)
3·0
31·5 (0·99)
33·7 (0·99)
86·5
8·4
13·1
49·8
0 - 9 10 - 29 30 - 49 50 - 99 100 over

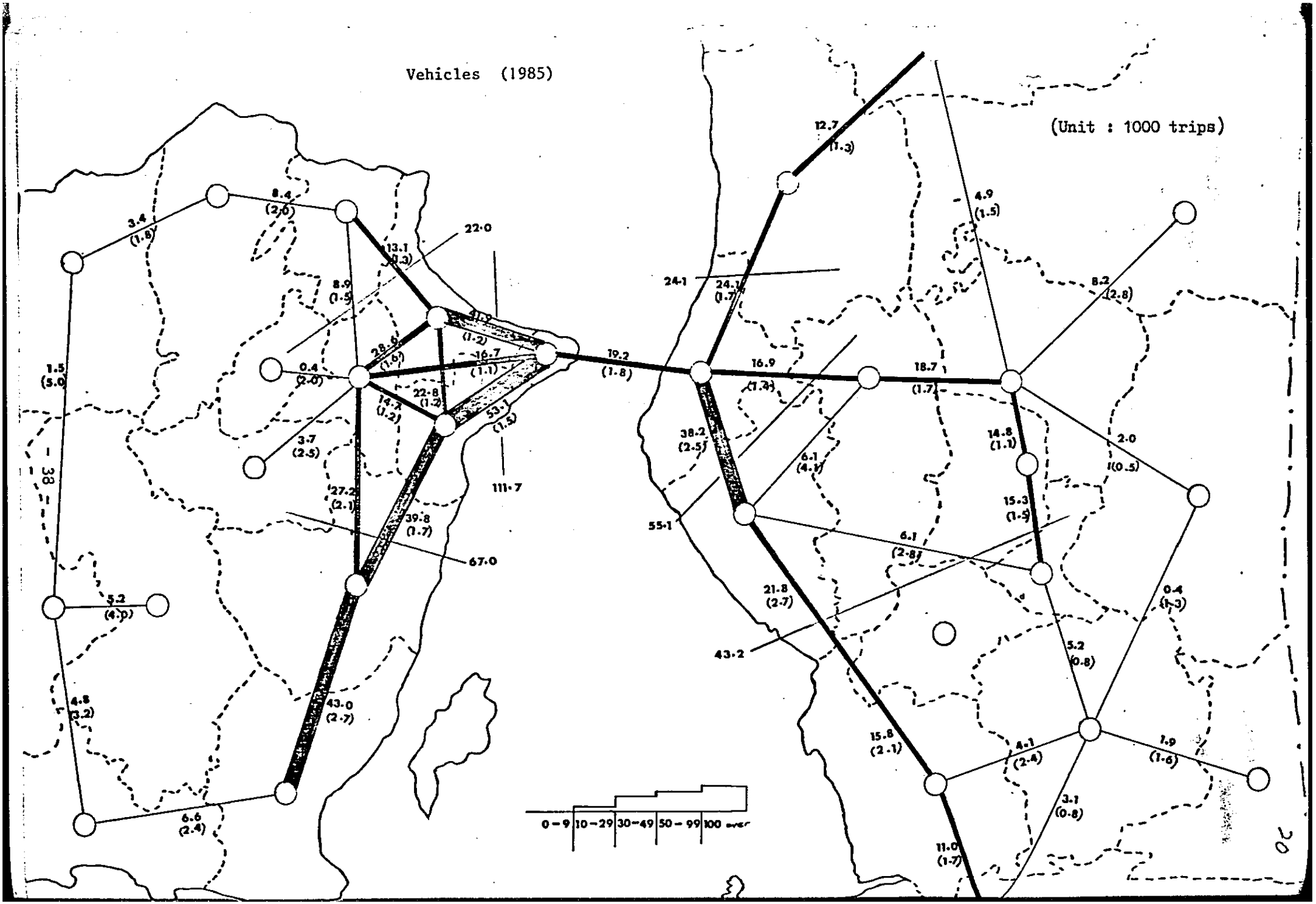

Vehicle (2000)
(2000 – Plan C')
(Unit : 1000 trips)
34·1
14·1
76·9
21·3
31·5
(0·98)
14·1
35·5
(0·99)
28·5
(0·99)
67·6 (0·90)
51·7
(0·98)
41·1 (0·99)
46·7 (0·99)
57·4
(0·96)
0·94
25·1
(0·84)
1·7
(0·94)
6·7
33·1
25·4
(0·85)
10·9
(0·89)
7·8
(0·95)
72·5
(0·97)
193·6
(–24·2)
126·7
(0·99)
33·8
(0·99)
7·7
27·1
95·1
(0·91)
167·6
(–12·0)
35·7
(0·99)
16·8
(0·99)
82·9
(0·99)
21·6
1·7
19·9
130·4
(0·95)
22·8
57·2
23·3
(0·99)
5·7
8·0
30·6
31·9
0 – 9 10 – 29 30–49 50–99 100

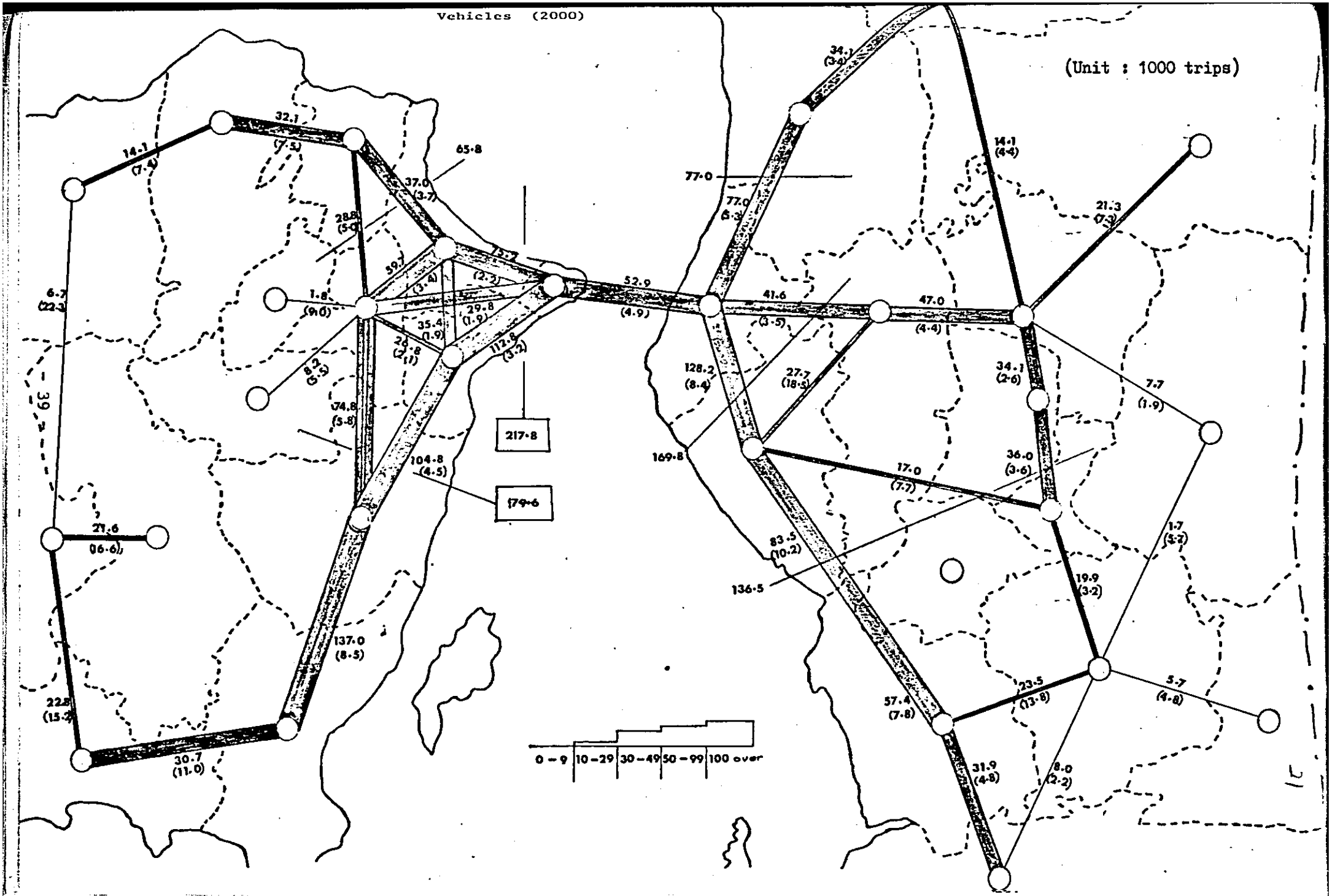

P.C.U. (2000)
(2000 - Plan D)
18·4
38·8 (0·95)
36·0 (0·97)
41·0 (0·88)
71·4 (0·94)
71·7 (0·74)
26·9 (0·75)
2·4 (0·89)
45·8 (0·89)
36·1 (0·91)
10·5 (0·91)
91·8 (0·97)
125·2 (0·79)
120·2 (0·83)
223·8 (-70·1)
212·0 (-27·1)
171·7 (0·92)
40·7
29·3
26·3
8·3
71·6 (0·95)
118·3
52·6
21·9
36·4
61·3 (0·99)
72·6 (0·99)
184·9 (0·99)
44·2
50·7 (0·99)
12·1
54·3 (0·99)
24·0
123·9 (0·99)
3·0
31·5 (0·99)
33·6 (0·99)
8·4
86·3
13·0 (0·99)
49·8
0 - 9
10-29
30-49
50-99
100 over

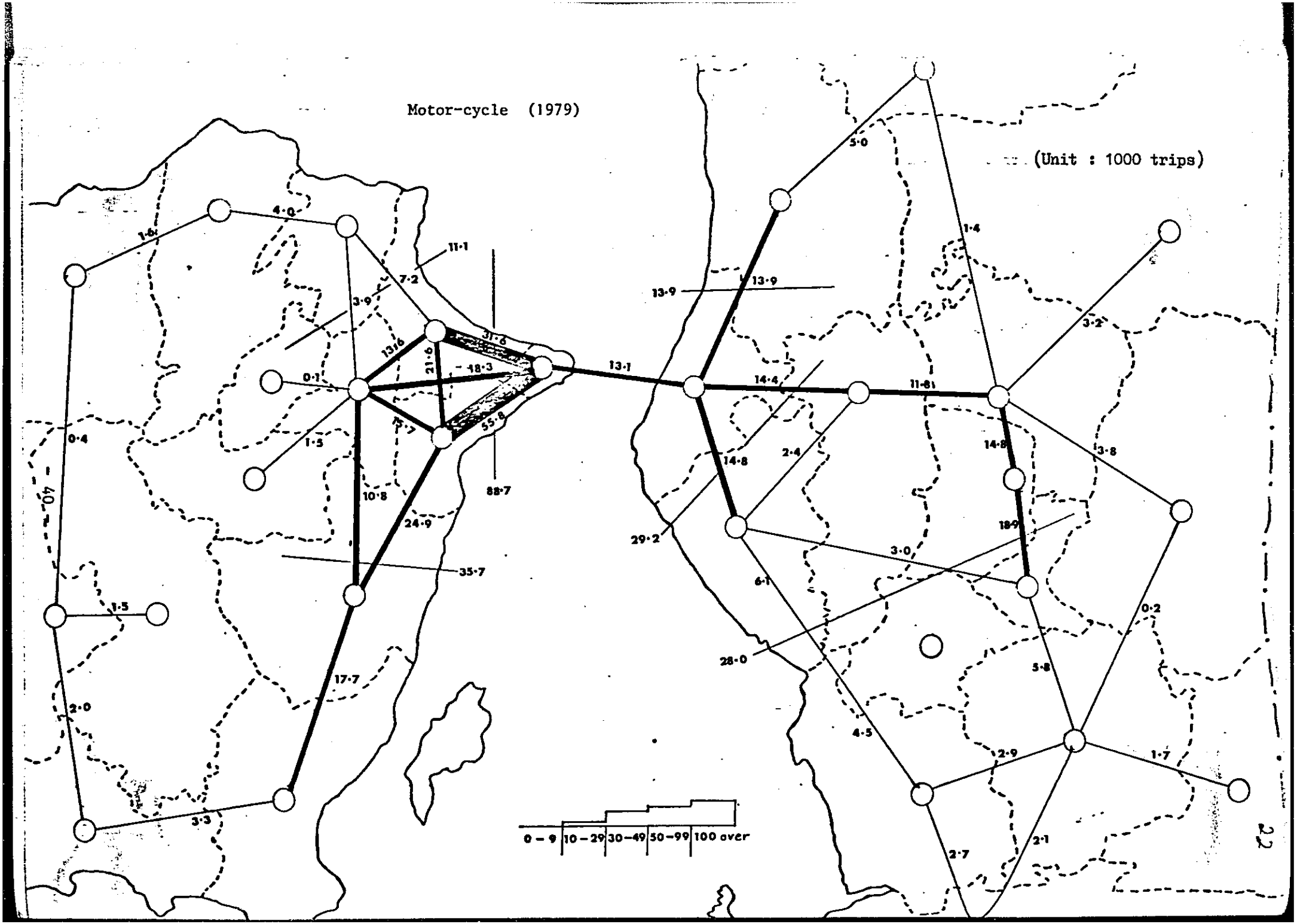
44

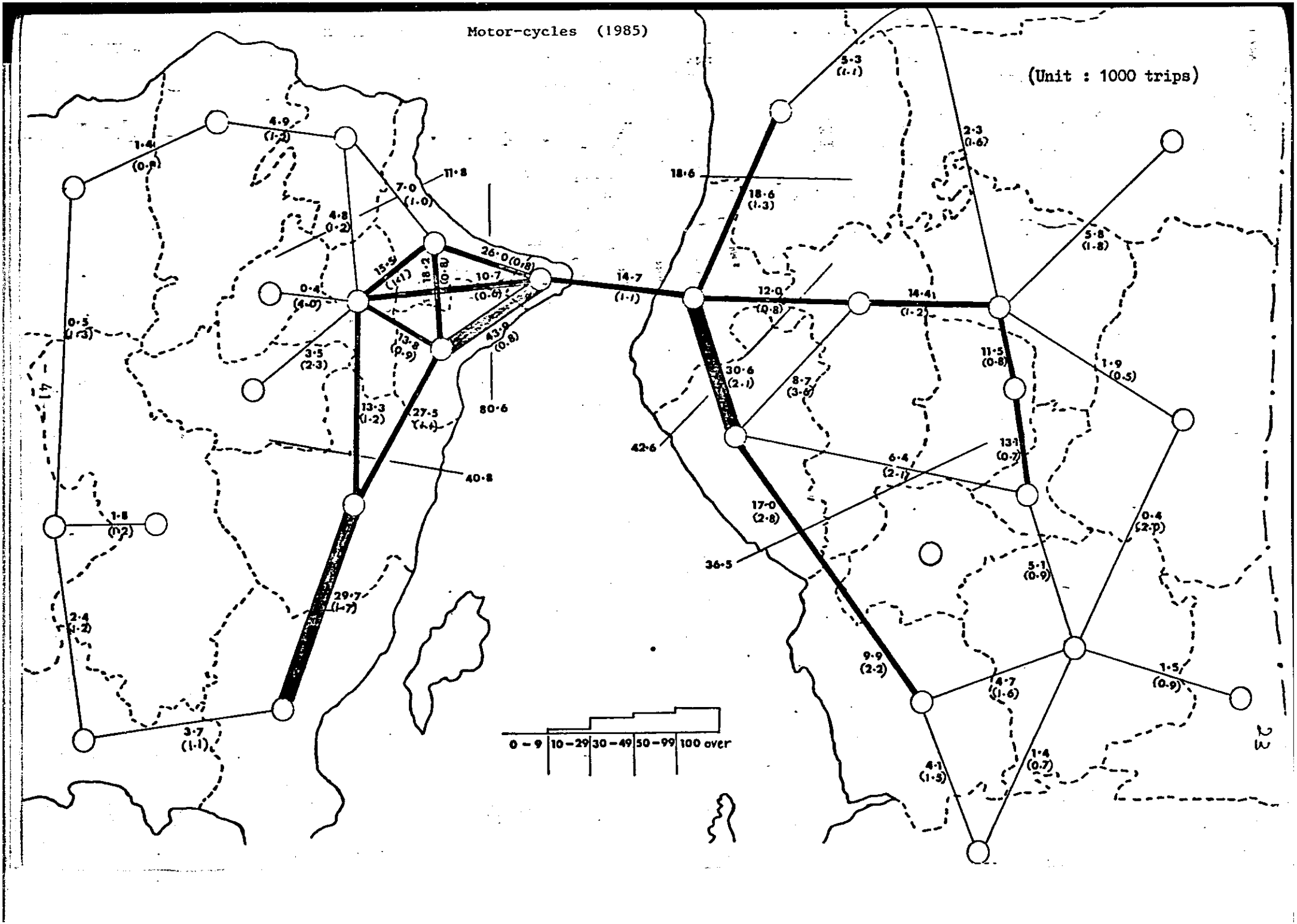

Vehicle (2000)
(2000 - plan D)
(unit: 1000 trips)
14·1
30·0 (0·93)
31·4 (0·85)
27·7 (0·96)
55·4 (0·93)
50·6 (0·67)
18·1 (0·61)
29·6 (0·84)
1·5 (0·82)
23·4 (0·87)
7·1 (0·87)
71·8 (0·96)
80·0 (0·71)
81·0 (0·77)
122·4 (0·89)
6·7
21·6
22·8
30·6
148·7 (-69·1)
152·8 (-26·8)
48·8 (0·90)
34·0
76·6 (0·99)
40·8 (0·98)
46·6 (0·99)
14·1
21·3
126·2 (0·98)
27·6
33·8 (0·99)
7·7
35·6 (0·99)
17·0
82·8 (0·99)
1·7
19·9
57·0 (0·99)
23·2 (0·99)
5·7
7·9 (0·99)
31·9
0 - 9
10 - 29
30 - 49
50 - 99
100 over

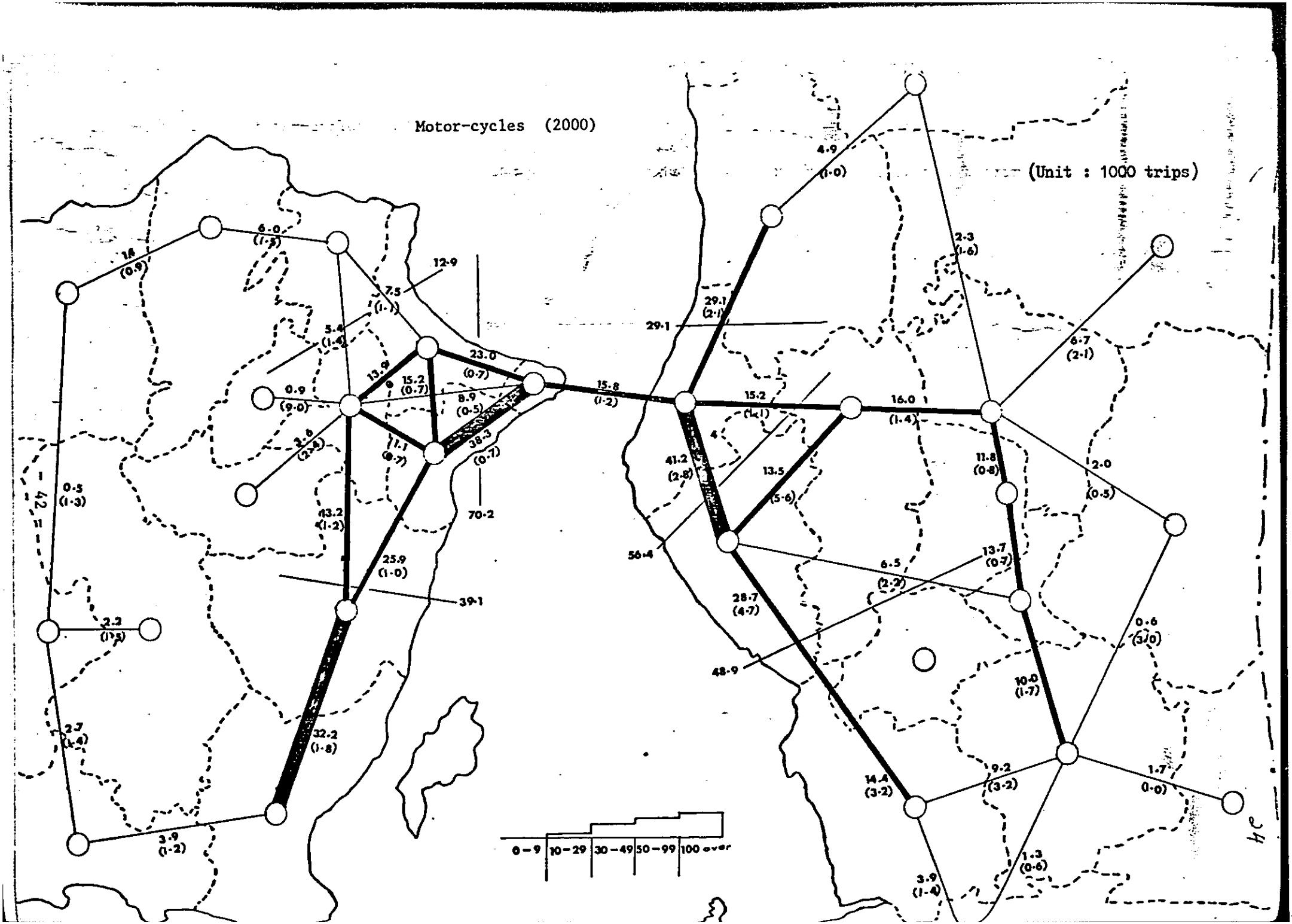

Vehicles (1979)
(Unit : 1000 trips)
9.9
3.2
4.3
1.9
15.7
14.4
9.9
5.8
2.9
34.6
17.8
10.8
0.2
15.5
11.9
10.8
0.3
1.5
18.4
12.8
35.6
13.0
4.1
15.3
1.5
12.8
85.7
23.1
27.2
10.0
2.2
35.9
8.2
1.3
0.3
16.2
20.4
6.3
1.5
7.4
1.7
1.2
2.8
3.7
6.6
0-9
10-29
30-49
50-99
100 over
37
61

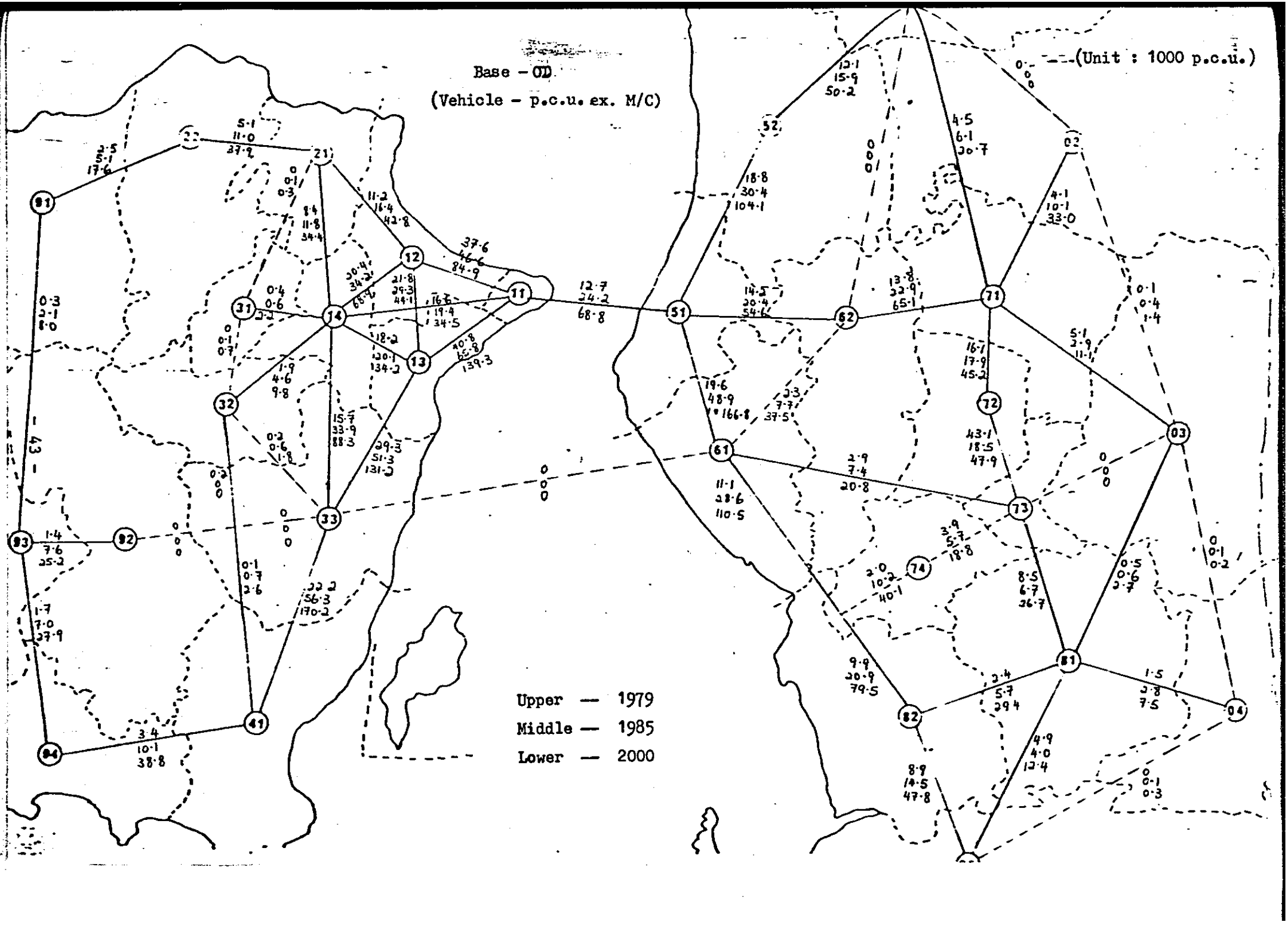

Vehicles (1985)
(Unit : 1000 trips)
12.7
(1.3)
4.9
(1.5)
8.4
(2.6)
3.4
(1.8)
22.0
13.1
(1.3)
24.1
24.1
(1.7)
8.9
(1.5)
8.2
(2.8)
31.8
(1.2)
28.6
(1.6)
16.7
(1.1)
19.2
(1.8)
1.5
(5.0)
0.4
(2.0)
16.9
(1.7)
18.7
(1.7)
22.8
(1.2)
14.7
(1.2)
53.1
(1.5)
38.2
(2.5)
14.8
(1.1)
2.0
(0.5)
3.7
(2.5)
6.1
(4.1)
111.7
27.2
(2.1)
15.3
(1.5)
39.8
(1.7)
55.1
6.1
(2.8)
67.0
21.8
(2.7)
0.4
(1.3)
5.2
(4.0)
43.2
5.2
(0.8)
4.8
(3.2)
43.0
(2.7)
15.8
(2.1)
4.1
(2.4)
1.9
(1.6)
3.1
(0.8)
6.6
(2.4)
11.0
(1.7)
0 - 9
10 - 29
30 - 49
50 - 99
100 over
- 38 -
20

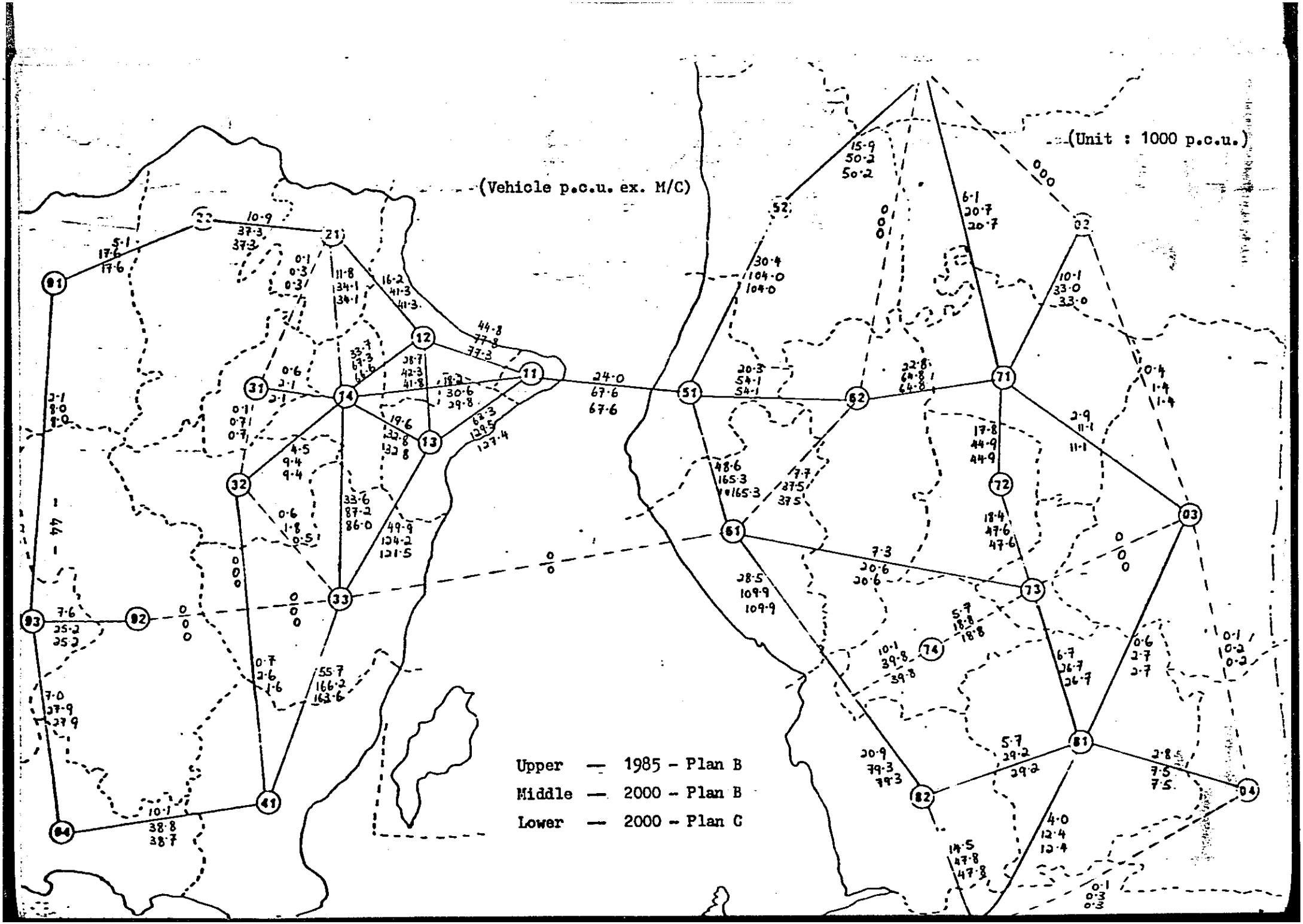

Vehicles (2000)
(Unit : 1000 trips)
0 - 9
10 - 29
30 - 49
50 - 99
100 over

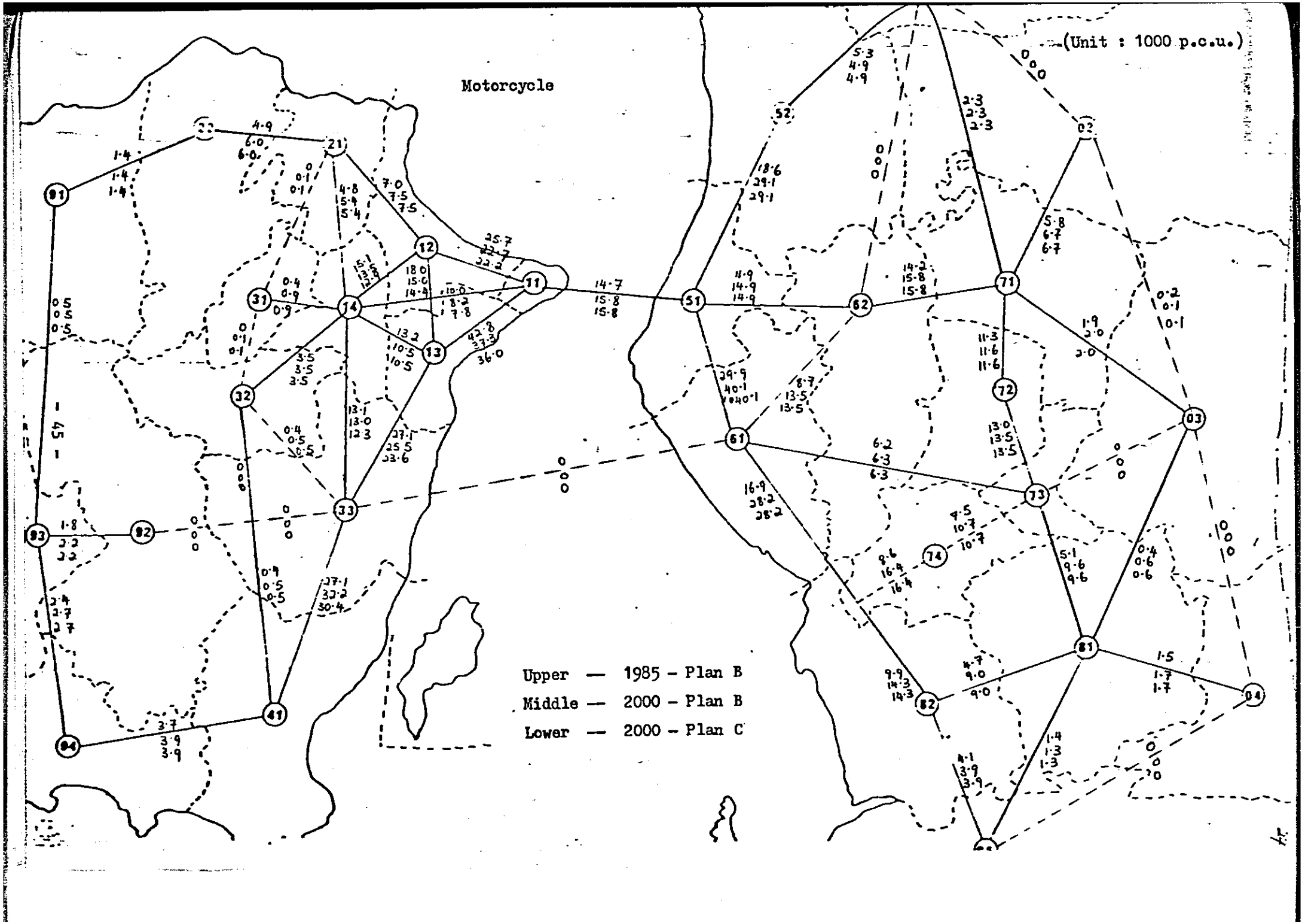

Motor-cycle (1979)
(Unit : 1000 trips)
0 – 9
10 – 29
30 – 49
50 – 99
100 over


Motor-cycles (1985)
(Unit : 1000 trips)
0 - 9
10 - 29
30 - 49
50 - 99
100 over


Motor-cycles (2000)
(Unit : 1000 trips)
0 - 9
10 - 29
30 - 49
50 - 99
100 over


Base - OD
(Vehicle - p.c.u. ex. M/C)
(Unit : 1000 p.c.u.)
Upper — 1979
Middle — 1985
Lower — 2000


(Vehicle p.c.u. ex. M/C)
(Unit : 1000 p.c.u.)
Upper — 1985 - Plan B
Middle — 2000 - Plan B
Lower — 2000 - Plan C


Motorcycle
(Unit : 1000 p.c.u.)
Upper — 1985 - Plan B
Middle — 2000 - Plan B
Lower — 2000 - Plan C

E - THE DEGREE OF CONGESTION ON MAJOR SECTION

1. 1979 - Present
2. 1985 Plan A - On Going
3. 1985 Plan B - On Going & Proposed
4. 2000 Plan B - On Going & Proposed
5. 2000 Plan B - Ultimate
6. 2000 Plan C - Ultimate
7. 2000 Plan D - Ultimate

1. The degree of congestion on major section.

1979
PRESENT

Network

Item / Name of section		traffic characteristic					P.C.U	No. of Road			Capa-city	degree of congestion
		Vehicle	rate of large veh.	Vehicle	M/C	rate of M/C		2	4	6		
George Town	Inner Cordon	89.3	7%	99.0	63.1	41.4%	130.5	06	00		48.0	2.72
	Center Cordon	118.4	7%	131.3	79.2	40.1%	170.9	011	00		88.0	1.94
	Outer Cordon	40.9	16%	51.3	48.2	54.1%	75.4	05	00		50.0	1.51
Penang Island	Section 1	27.2	16%	34.1	24.0	46.9%	46.1	03	00		30.0	1.53
	Section 2	34.1	16%	42.8	24.8	42.1%	33.8	02	00		20.0	1.69
	Section 3	5.5	23%	17.5	19.3	77.8%	17.1	02	00		20.0	0.86
Province Wellesley	Section 4	19.2	18%	24.7	18.6	49.2%	34.0	02	00		20.0	1.70
	Section 5	3.8	18%	4.9	7.2	65.5%	8.5	01	00		10.0	0.85
	Section 6	26.2	16%	32.5	26.0	49.8%	45.5	02	00		20.0	2.28
	Section 7	16.8	23%	22.6	24.1	58.9%	34.6	02	00		20.0	1.73
	Section 8	9.3	23%	12.5	12.1	56.5%	18.5	01	00		10.0	1.85
Channel	Ferry	10.8	12%	12.8	13.0	54.6%	19.3					
	Lincage						0					

2. The degree of congestion on major section.

1985 -- Plan A
On Going

Network

Name of section \ Item		traffic characteristic					P.C.U	No. of Road			Capacity	Degree of congestion
		Vehicle	rate of large veh.	Vehicle	M/C			2	4	6		
George Town	Inner Cordon	122.3	13%	144.3	79.0	39.2	183.8	16	10		105.0	1.75
	Center Cordon	185.8	13%	219.2	100.7	35.1	269.6	11	10		145.0	1.86
	Outer Cordon	109.6	18%	139.2	59.3	35.1	168.9	03	30		204.0	0.83
Penang Island	Section 1	82.2	18%	104.4	45.1	35.4	127.0	02	00		136.0	0.93
	Section 2	52.7	18%	66.9	33.0	38.5	83.4	01	10		68.0	1.23
	Section 3	21.8	21%	28.6	16.3	42.8	36.7	12	00		35.0	1.05
Province Wellesley	Section 4	12.9	17%	16.3	14.0	52.0	23.3	02	00		20.0	1.17
	Section 5	8.6	17%	10.8	7.3	45.9	14.5	01	00		10.0	1.45
	Section 6	35.2	17%	44.3	26.0	42.5	57.3	02	00		20.0	2.87
	Section 7	31.2	19%	40.3	28.9	48.1	54.8	02	00		20.0	2.74
	Section 8	14.6	19%	18.9	14.0	49.0	25.9	01	00		10.0	2.59
Channel	Ferry	2.1	17%	2.7	5.6	72.7	4.5					
	Lincage	16.5	17%	20.8	8.4	33.7	25.0					

3. The degree of congestion on major section.

Network: 1985 - Plan B, On Going & Proposer

Item		Traffic Characteristic					P.C.U	No. of Road			Capacity	Degree of congestion
		Vehicle	rate of large veh.	Vehicle	M/C			2	4	6		
George Town	Inner Cordon	117.3	13%	139.3	77.8	39.9	178.2	16	20		150.0	1.19
	Center Cordon	179.1	13%	212.5	97.4	35.2	261.2	110	20		182.0	1.44
	Outer Cordon	110.0	18%	140.7	58.7	34.8	170.1	02	40		252.0	0.68
Penang Island	Section 1	83.1	18%	106.3	44.3	34.8	128.4	01	30		184.0	0.70
	Section 2	52.1	18%	66.6	33.1	38.8	83.2	01	10		68.0	1.22
	Section 3	21.2	21%	27.9	17.3	44.9	36.6	12	00		35.0	1.05
Province Wellesley	Section 4	17.8	17%	22.5	15.1	45.9	30.1	02	10		78.0	0.39
	Section 5	91.2	17%	11.5	10.3	10.1	16.7	01	10		68.0	0.25
	Section 6	37.6	17%	47.4	26.7	41.5	60.8	02	10		78.0	0.78
	Section 7	42.5	19%	54.9	28.6	40.2	69.2	01	10		68.0	1.02
	Section 8	25.5	19%	33.0	14.0	35.4	40.0	00	10		58.0	0.69
Channel	Ferry	1.7	17%	2.1	6.5	79.3	5.4					
	Lincage	16.8	17%	21.2	7.5	30.9	25.0					

4. The degree of congestion on major section.

Network: 2000 - Plan B (On Going & Proposal)

Item / Name of section		traffic characteristic: Vehicle	rate of large veh.	Vehicle	M/C		P.C.U	No. of Road: 2	4	6	Capacity	P.C.U/ Capacity
George Town	Inner Cordon	207.5	13%	250.5	67.4	24.5	284.2	16	20		150.0	1.89
	Center Cordon	294.4	13%	355.4	83.6	22.1	397.2	110	20		182.0	2.18
	Outer Cordon	214.8	15%	264.8	56.2	20.7	292.9	02	40		252.0	1.16
Penang Island	Section 1	165.8	15%	204.4	42.7	20.5	225.8	01	30		184.0	1.23
	Section 2	138.4	15%	170.6	34.1	19.8	187.7	01	10		68.0	2.76
	Section 3	63.1	16%	78.8	20.9	24.9	89.3	12	00		35.0	2.55
Province Wellesley	Section 4	68.6	23%	92.9	18.0	20.8	101.9	02	10		78.0	1.31
	Section 5	53.8	23%	72.8	14.4	21.1	80.1	01	10		68.0	1.18
	Section 6	103.6	21%	135.5	33.1	24.2	152.1	02	10		78.0	1.95
	Section 7	124.6	21%	163.1	40.2	24.4	183.2	01	10		68.0	2.69
	Section 8	66.7	21%	87.3	17.4	20.7	96.0	00	10		58.0	1.66
Channel	Ferry	13.2	21%	17.3	6.5	33.0	20.6					
	Lincage	38.0	21%	49.7	8.7	18.6	54.1					

5. The degree of congestion on major section.

Network
2000 - Plan B
Ultimate

Name of section \ Item		traffic characteristic					P.C.U	No. of Road			Capacity	Degree of congestion
		Vehicle	rate of large veh.	Vehicle	M/C			2	4	6		
George Town	Inner Cordon	204.8	13%	247.8	67.4	24.8	281.6	05	40		220.0	1.28
	Center Cordon	295.8	13%	357.9	83.9	22.1	400.0	09	40		252.0	1.59
	Outer Cordon	217.9	15%	268.0	53.9	80.2	294.9	12	40		267.0	1.10
Penang Island	Section 1	159.5	15%	196.2	40.4	20.2	216.6	11	30		199.0	1.09
	Section 2	135.3	15%	166.4	34.2	20.2	183.5	11	20		141.0	1.30
	Section 3	67.0	16%	83.8	21.0	23.9	94.3	11	20		141.0	0.67
Province Wellesley	Section 4	45.3	23%	61.1	14.2	23.9	68.2	01	10		78.0	0.87
	Section 5	29.5	23%	39.8	10.3	25.9	44.9	01	10		68.0	0.66
	Section 6	99.8	21%	130.8	28.0	21.9	144.8	01	20		126.0	1.15
	Section 7	137.6	21%	180.3	37.5	21.4	199.2	00	20		190.0	1.05
	Section 8	60.1	21%	78.7	20.0	25.0	88.7	00	20		116.0	0.76
Channel	Ferry	11.1	21%	14.6	6.2	35.8	17.7					
	Lincage	40.0	21%	52.4	8.9	18.2	56.9					

6. The degree of congestion on major section.

Network: 2000 - Plan C / Ultimate

Name of section		traffic characteristic: Vehicle	rate of large veh.	Vehicle	M/C		P.C.U	No. of Road: 2	4	6	Capacity	P.C.U/ Capacity
George Town	Inner Cordon	201.4	13%	244.4	59.4	22.8	274.1	05	40		220.0	1.25
	Center Cordon	291.3	13%	353.4	80.8	21.7	393.8	09	40		252.0	1.56
	Outer Cordon	211.1	16%	261.4	51.4	19.6	287.1	12	40		267.0	1.08
Penang Island	Section 1	152.5	16%	188.8	37.9	19.9	207.8	11	30		199.0	1.04
	Section 2	130.6	16%	161.7	31.7	19.5	177.5	11	20		141.0	1.26
	Section 3	64.2	16%	80.6	19.7	23.5	90.5	11	20		141.0	0.64
Province Wellesley	Section 4	45.2	23%	61.1	14.2	23.9	68.2	02	10		78.0	0.87
	Section 5	29.5	23%	39.8	10.3	25.9	45.0	01	10		68.0	0.66
	Section 6	99.8	21%	130.8	28.0	21.9	144.8	01	20		126.0	1.15
	Section 7	137.6	21%	180.3	37.5	21.4	199.0	01	20	1	190.0	1.05
	Section 8	60.1	21%	78.7	20.0	25.0	88.7	00	20		116.0	0.76
Channel	Ferry	11.4	21%	14.9	6.2	35.2	18.0					
	Lincage	39.8	21%	52.1	8.9	18.3	56.6					

67.0 15.1

7. The degree of congestion on major section.

Network: 2000 - Plan D, Ultimate

Item / Name of section		traffic characteristic					P.C.U	No. of Road			Capacity	Degree of congestion
		Vehicle	rate of large veh.	Vehicle	M/C			2	4	6		
George Town	Inner Cordon	158.4	18%	201.4	67.4	29.8	235.1	05	40		220.0	1.07
	Center Cordon	224.6	20%	295.2	83.9	29.8	337.2	09	40		252.0	1.34
	Outer Cordon	193.1	17%	241.4	53.9	21.8	268.4	12	40		267.0	1.01
Penang Island	Section 1	141.1	17%	176.4	40.4	22.3	196.8	11	30		199.0	0.99
	Section 2	121.7	17%	152.1	34.2	21.9	169.2	11	20		141.0	1.20
	Section 3	64.0	17%	80.0	21.0	24.7	90.5	11	20		141.0	0.64
Province Wellesley	Section 4	44.7	23%	60.3	14.2	24.1	67.4	02	10		78.0	0.86
	Section 5	28.8	23%	38.9	10.3	26.3	44.1	01	10		68.0	0.65
	Section 6	100.3	21%	131.4	28.0	21.8	145.4	01	20		126.5	1.15
	Section 7	136.9	21%	179.4	37.5	21.5	198.2	01	20		190.0	1.04
	Section 8	59.9	21%	78.5	20.0	25.0	88.5	00	20		116.0	0.76
Channel	Ferry	10.0	20%	13.0	6.2	38.3	16.1					
	Lincage	39.4	20%	51.2	8.9	18.4	55.7					

64.2 15.1

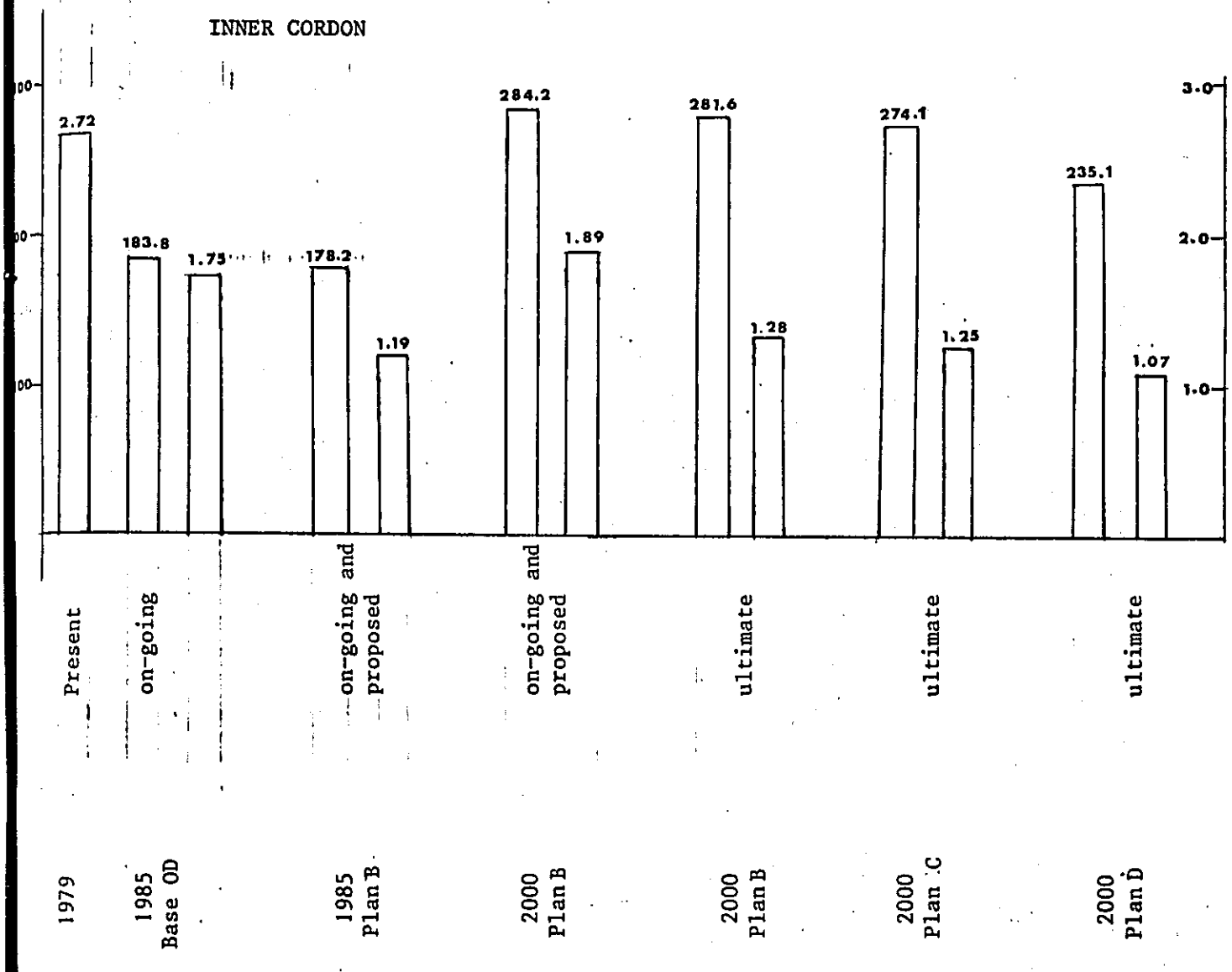
F - THE COMPARISON OF THE DEGREE OF CONGESTION BY PLANS

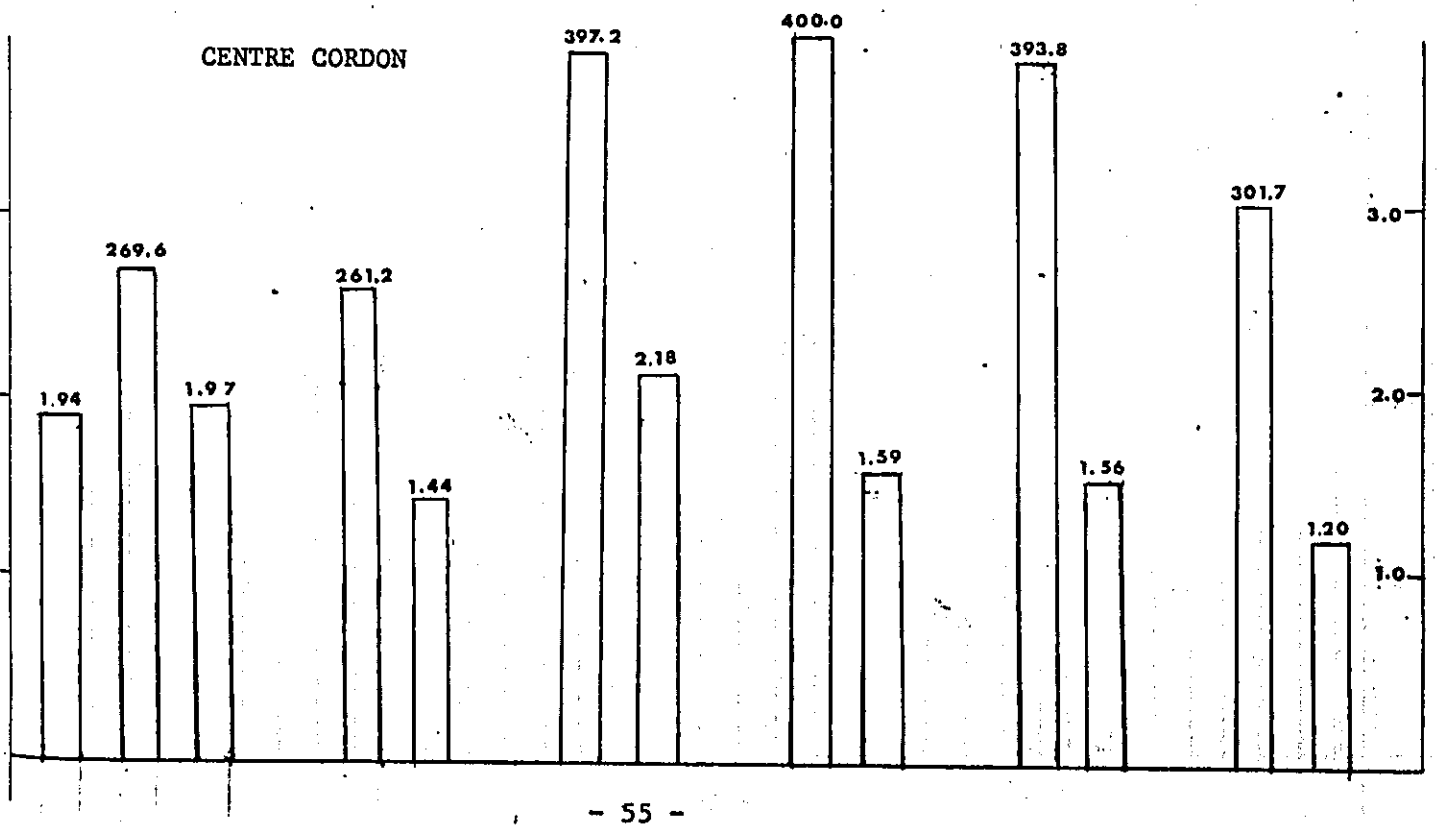
INNER CORDON

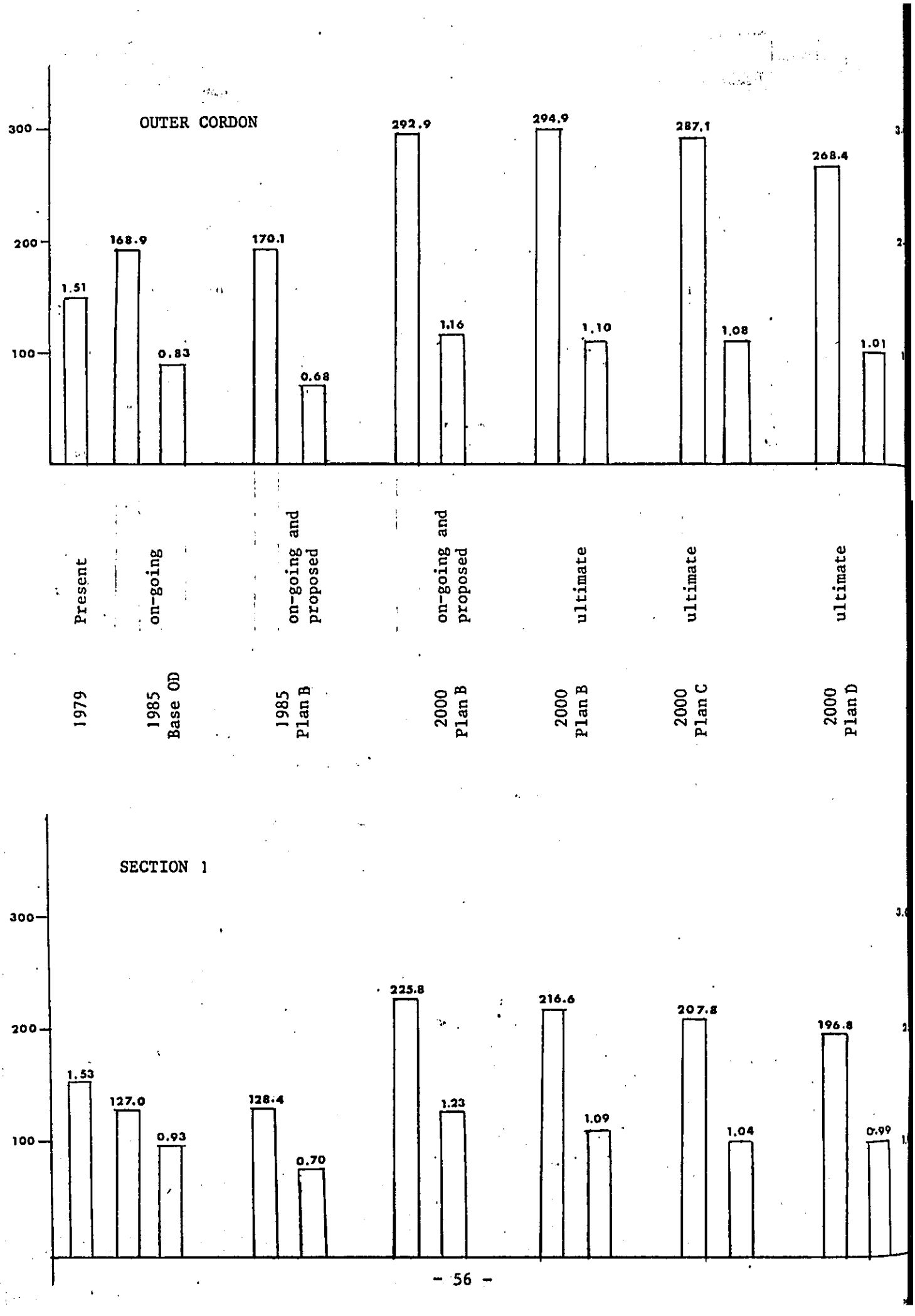
CENTER CORDON

OUTER CORDON

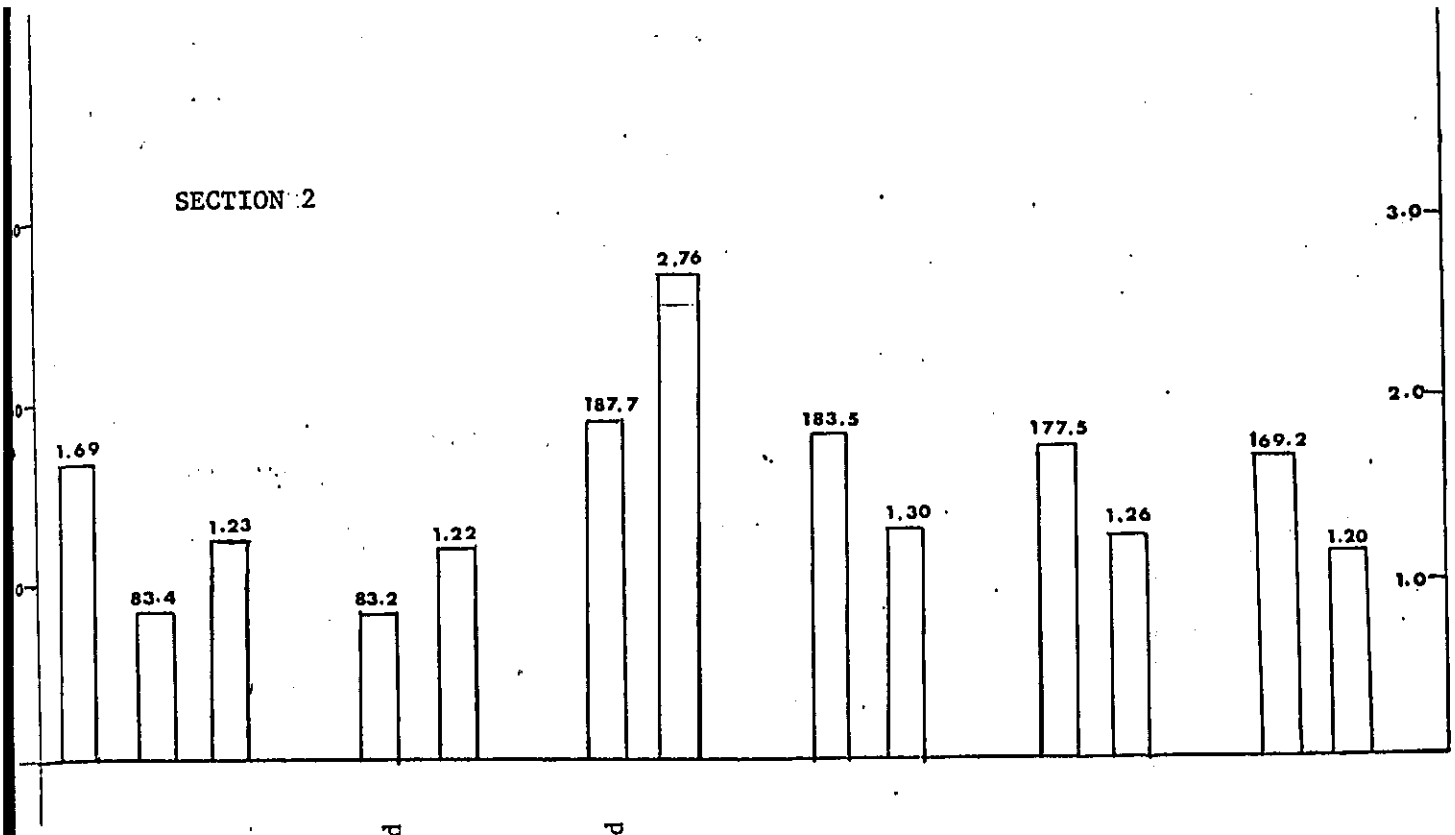
SECTION 1
SECTION 2
SECTION 3
SECTION 4
SECTION 5
SECTION 6
SECTION 7
SECTION 8


INNER CORDON
2.72
183.8
1.75
178.2
1.19
284.2
1.89
281.6
1.28
274.1
1.25
235.1
1.07
3.0
2.0
1.0
Present
on-going
on-going and proposed
on-going and proposed
ultimate
ultimate
ultimate
1979
1985 Base OD
1985 Plan B
2000 Plan B
2000 Plan B
2000 Plan C
2000 Plan D


CENTRE CORDON
1.94
269.6
1.97
261.2
1.44
397.2
2.18
400.0
1.59
393.8
1.56
301.7
1.20
3.0
2.0
1.0

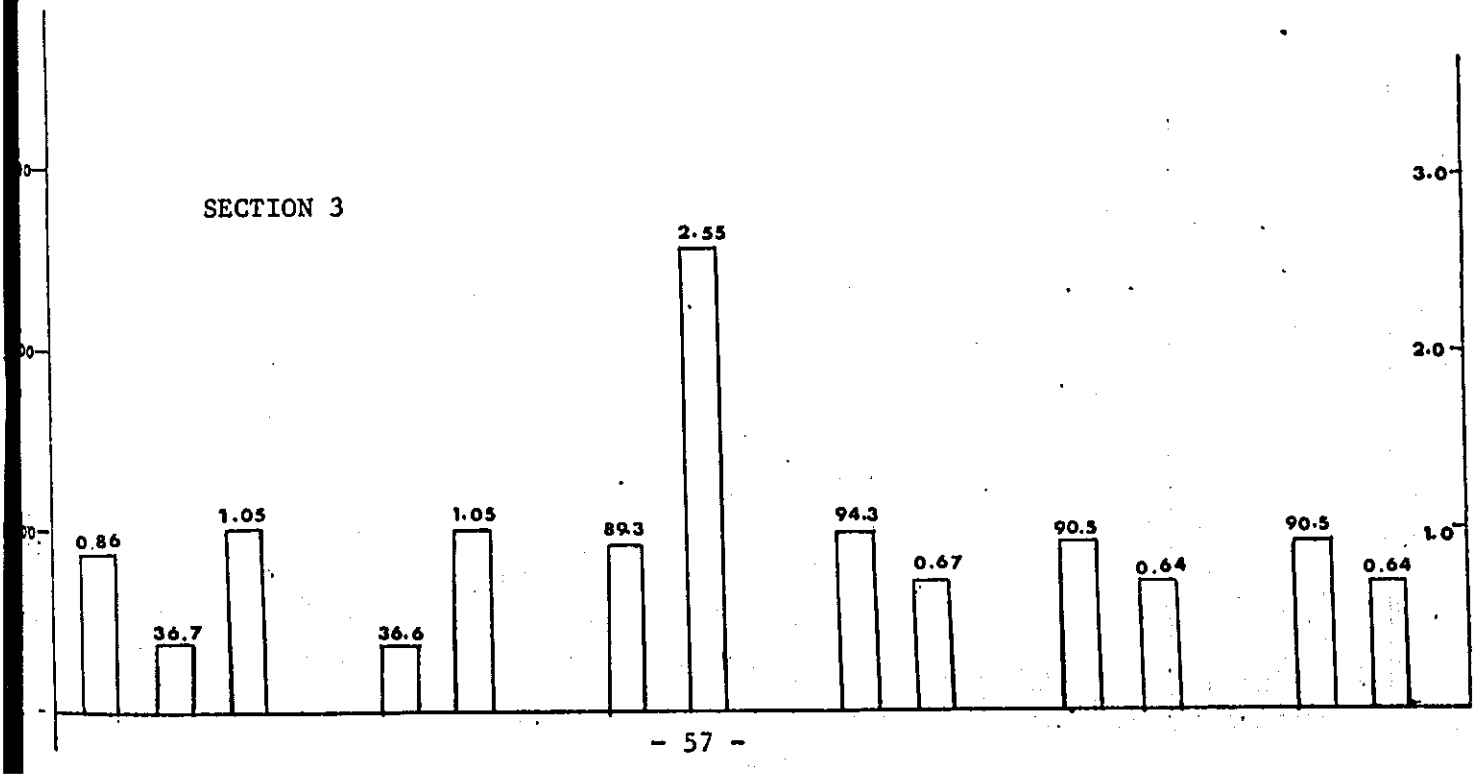

OUTER CORDON
300
200
100
1.51
168.9
0.83
170.1
0.68
292.9
1.16
294.9
1.10
287.1
1.08
268.4
1.01
Present
on-going
on-going and proposed
on-going and proposed
ultimate
ultimate
ultimate
1979
1985 Base OD
1985 Plan B
2000 Plan B
2000 Plan B
2000 Plan C
2000 Plan D
SECTION 1
300
200
100
1.53
127.0
0.93
128.4
0.70
225.8
1.23
216.6
1.09
207.8
1.04
196.8
0.99

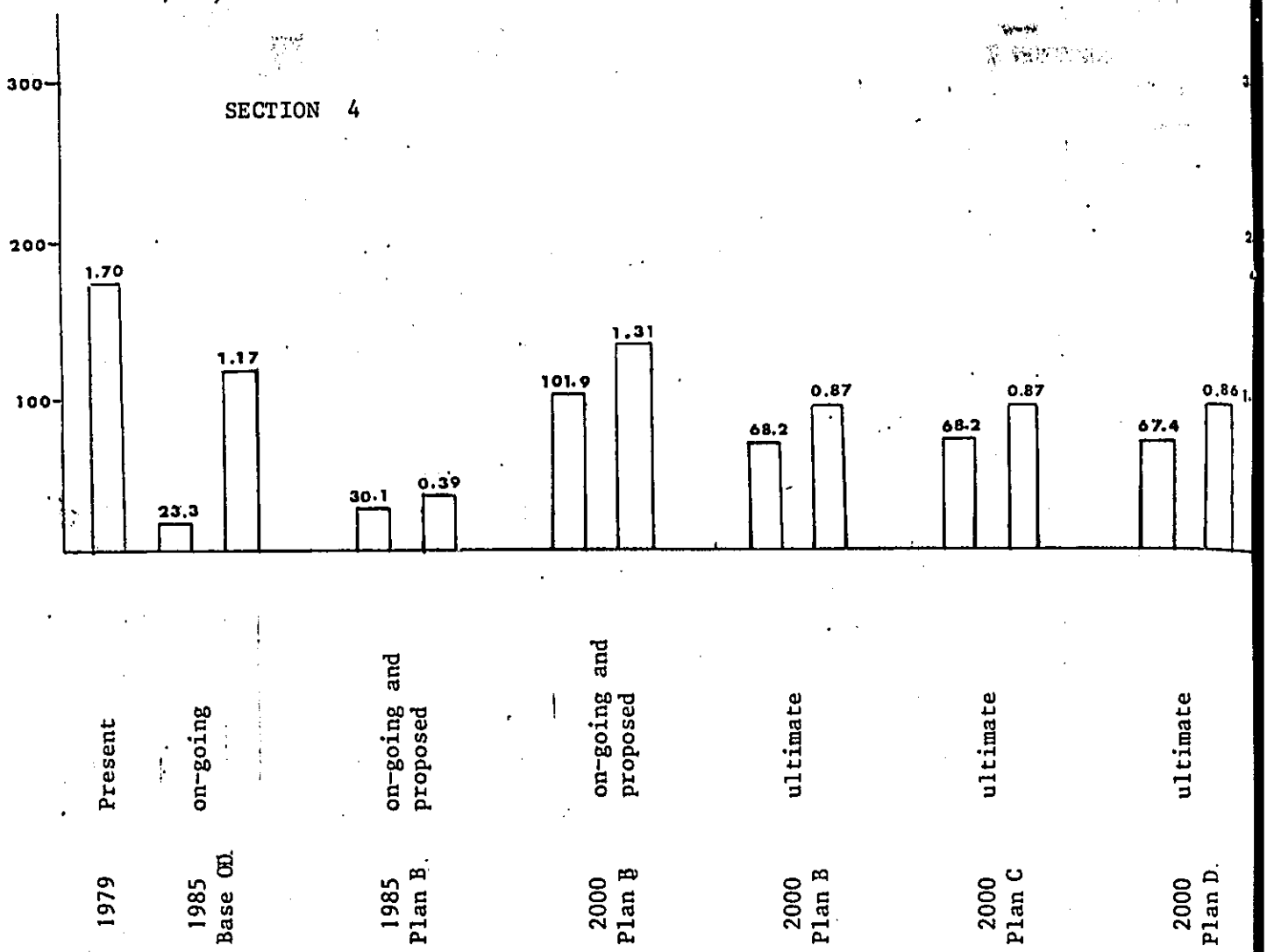
SECTION 2

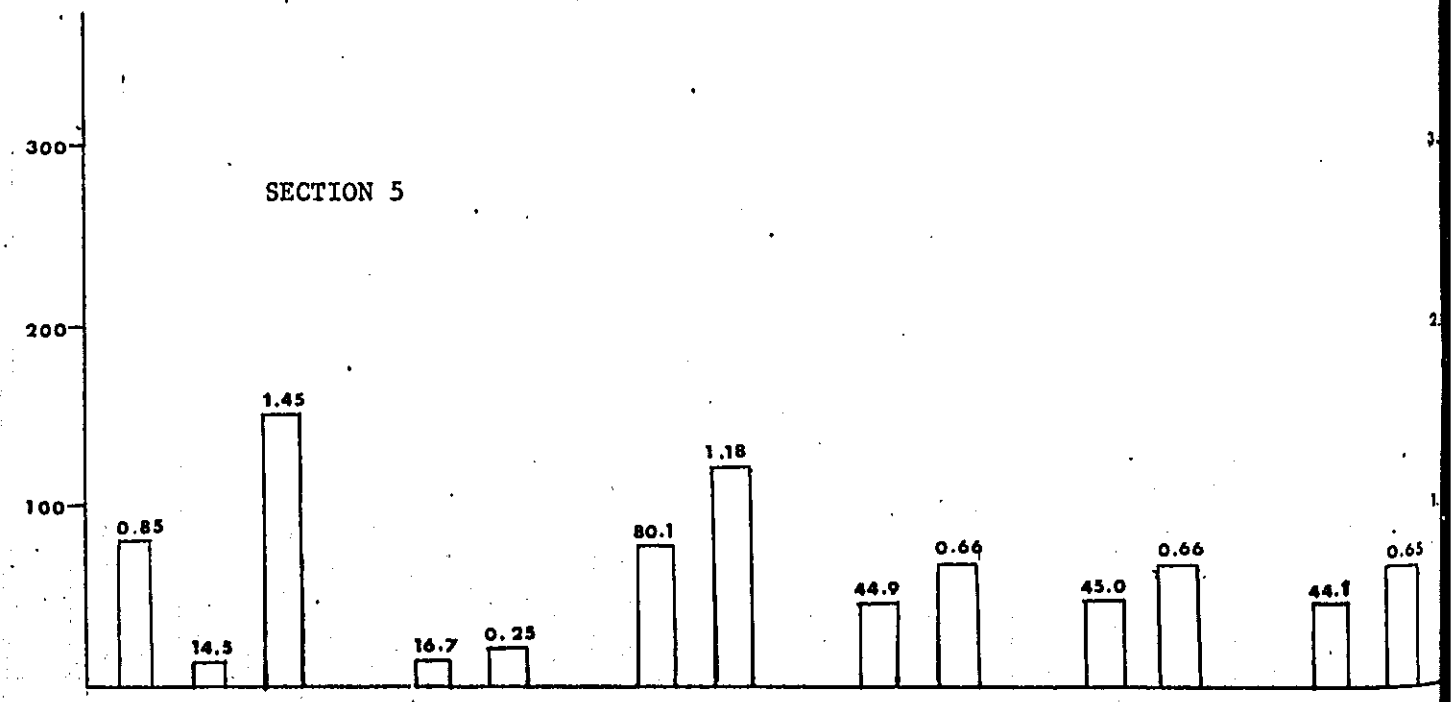


1979	1985 Base OD	1985 Plan B	2000 Plan B	2000 Plan B	2000 Plan C	2000 Plan D
Present	on-going	on-going and proposed	on-going and proposed	ultimate	ultimate	ultimate

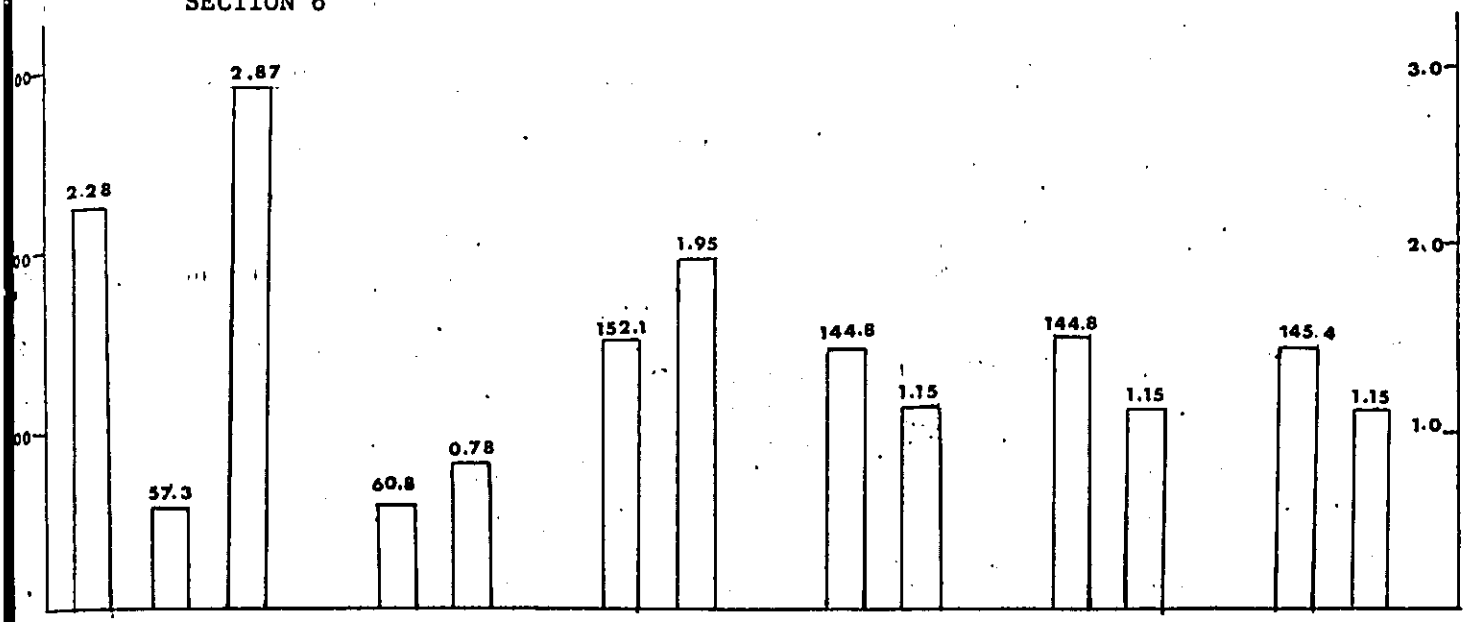
SECTION 3




SECTION 4
300
200
100
1.70
23.3
1.17
30.1
0.39
101.9
1.31
68.2
0.87
68.2
0.87
67.4
0.86
1979 Present
1985 Base OD on-going
1985 Plan B on-going and proposed
2000 Plan B on-going and proposed
2000 Plan B ultimate
2000 Plan C ultimate
2000 Plan D ultimate

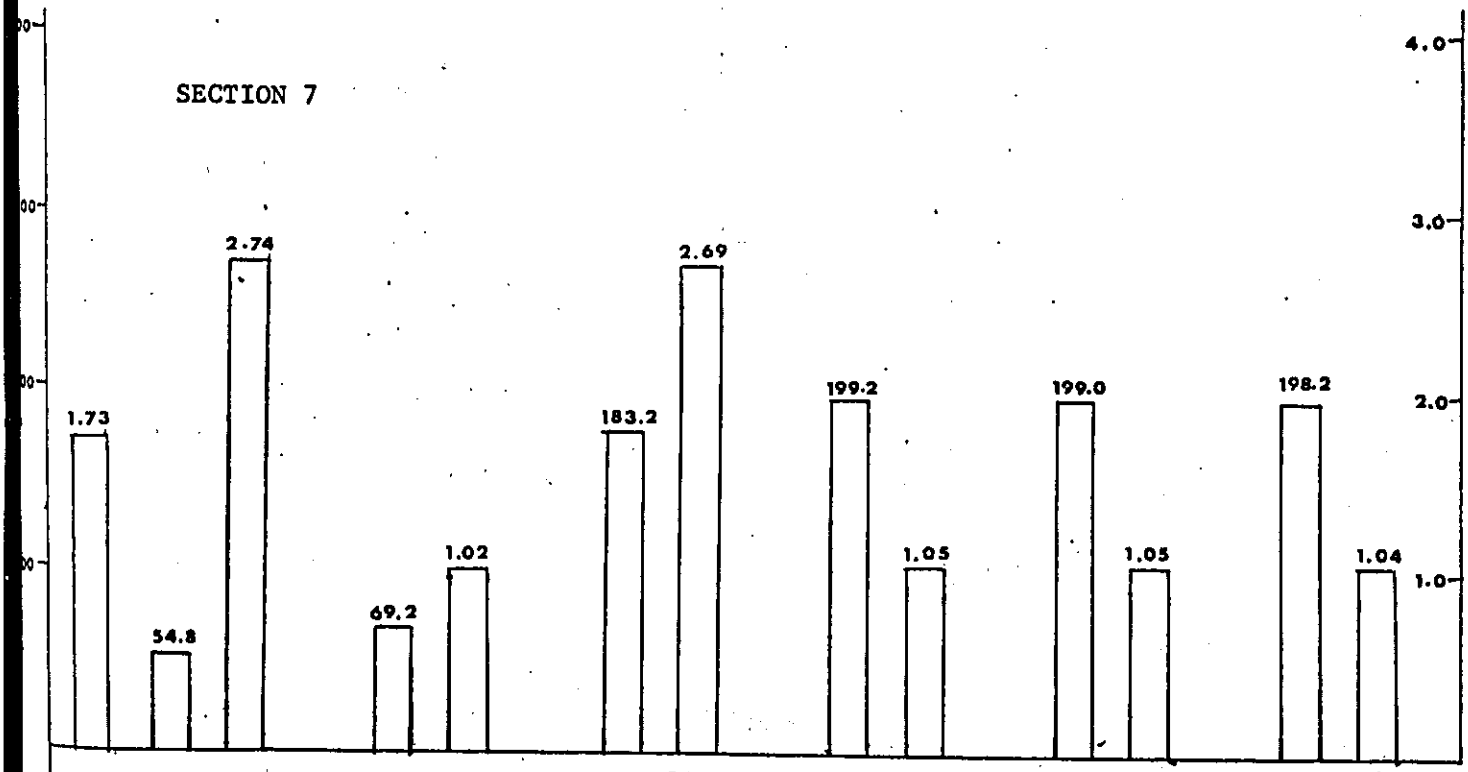

SECTION 5
300
200
100
0.85
14.5
1.45
16.7
0.25
80.1
1.18
44.9
0.66
45.0
0.66
44.1
0.65

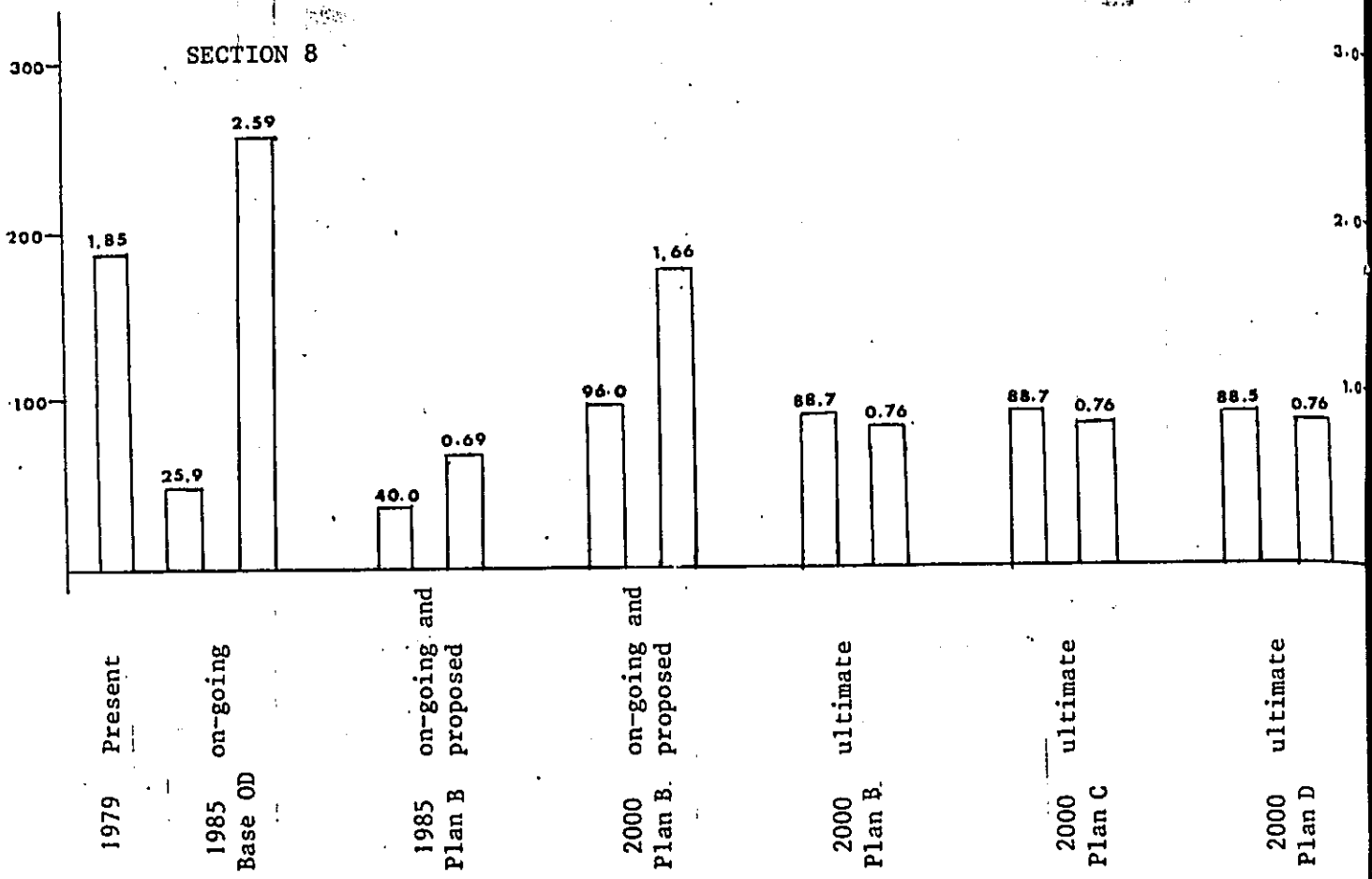
SECTION 6



1979	1985 Base OD	1985 Plan B	2000 Plan B	2000 Plan B	2000 Plan C	2000 Plan D
Present	on-going	on-going and proposed	on-going and proposed	ultimate	ultimate	ultimate

SECTION 7



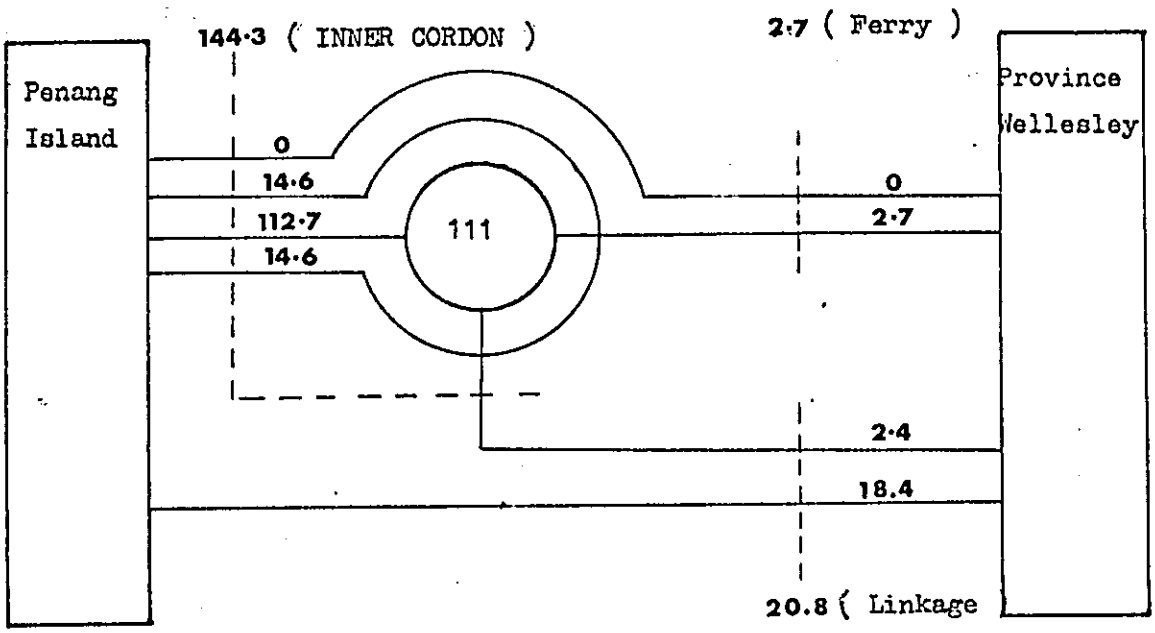

300
200
100
3.0
2.0
1.0
1.85
25.9
2.59
40.0
0.69
96.0
1.66
88.7
0.76
88.7
0.76
88.5
0.76
1979 Present
1985 on-going Base OD
1985 on-going and Plan B proposed
2000 on-going and Plan B proposed
2000 ultimate Plan B
2000 ultimate Plan C
2000 ultimate Plan D

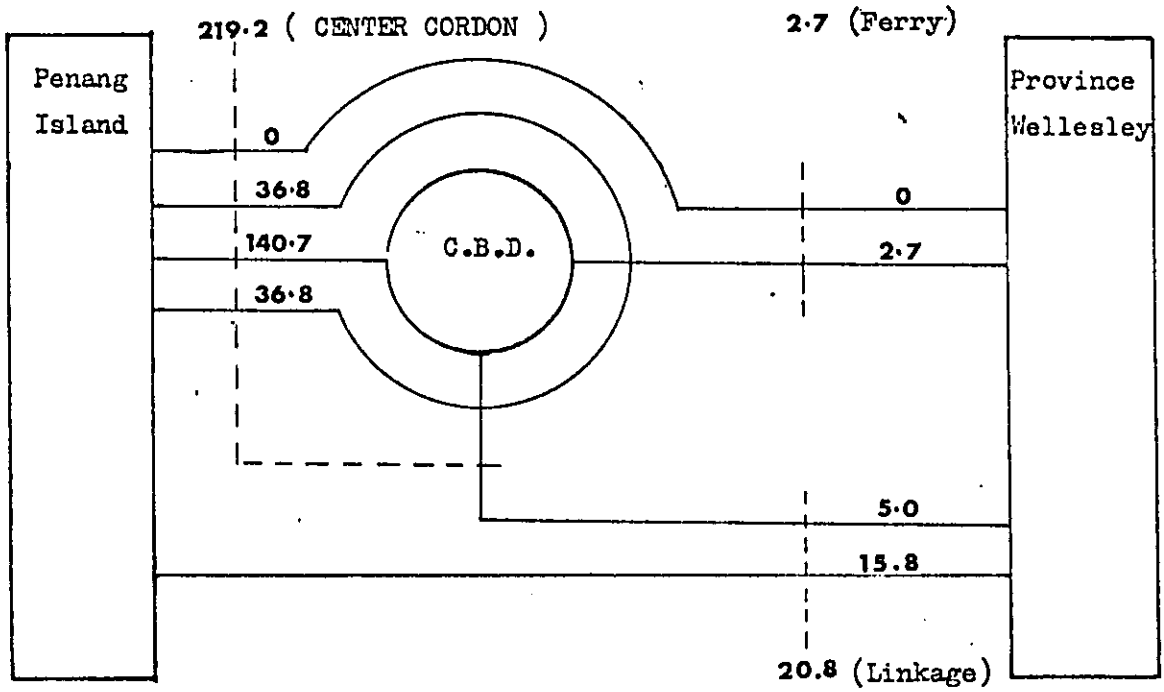
G - THE SITUATION ON THE INNER CORDON AND ON THE CENTER CORDON

1. 1985 Plan A - On Going
2. 1985 Plan B - On Going & Proposed
3. 2000 Plan B - On Going & Proposed
4. 2000 Plan B - Ultimate
5. 2000 Plan C - Ultimate
6. 2000 Plan D - Ultimate

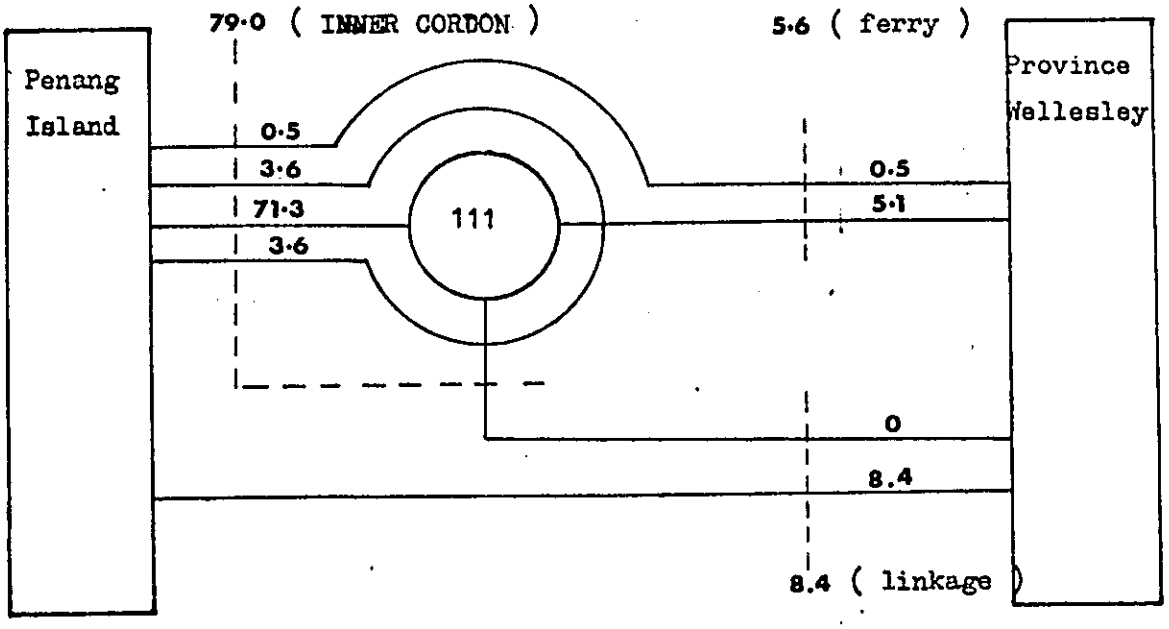
U(Unit:1000 p.c.u., trips)

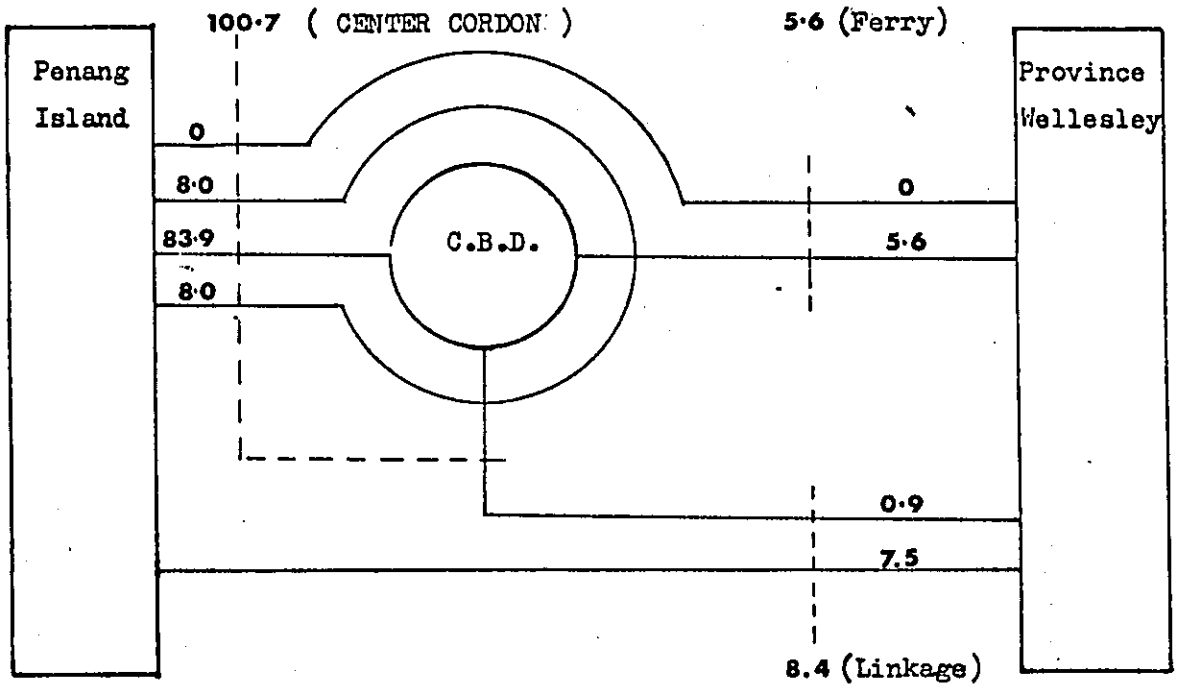
1985 - Plan A
On-going
P.C.U (ex. M/C)



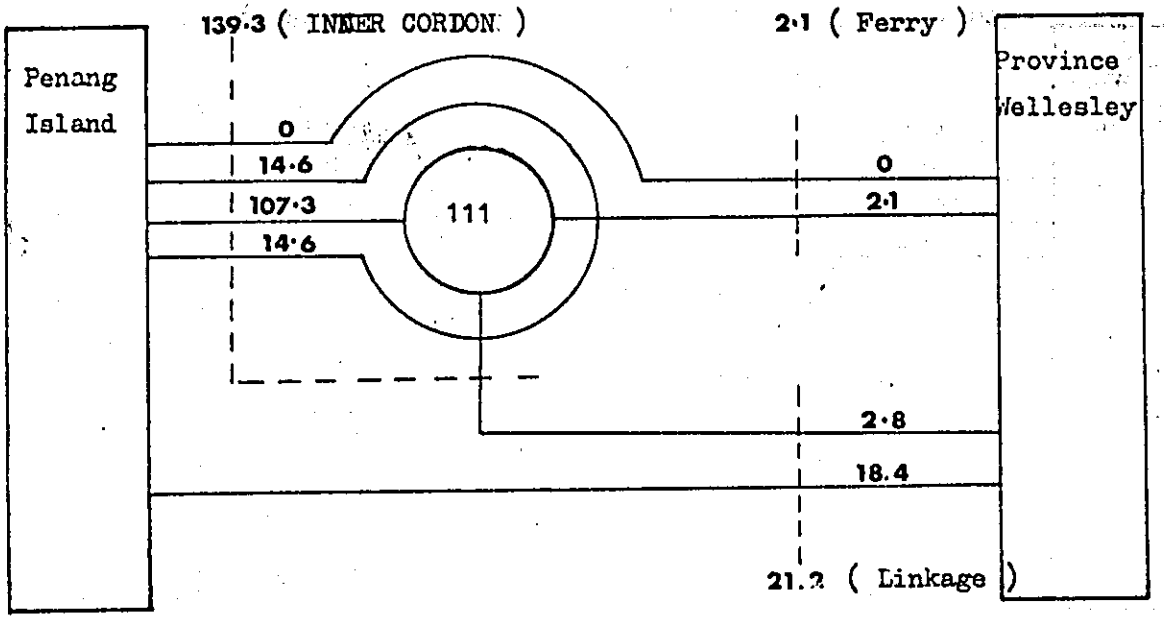


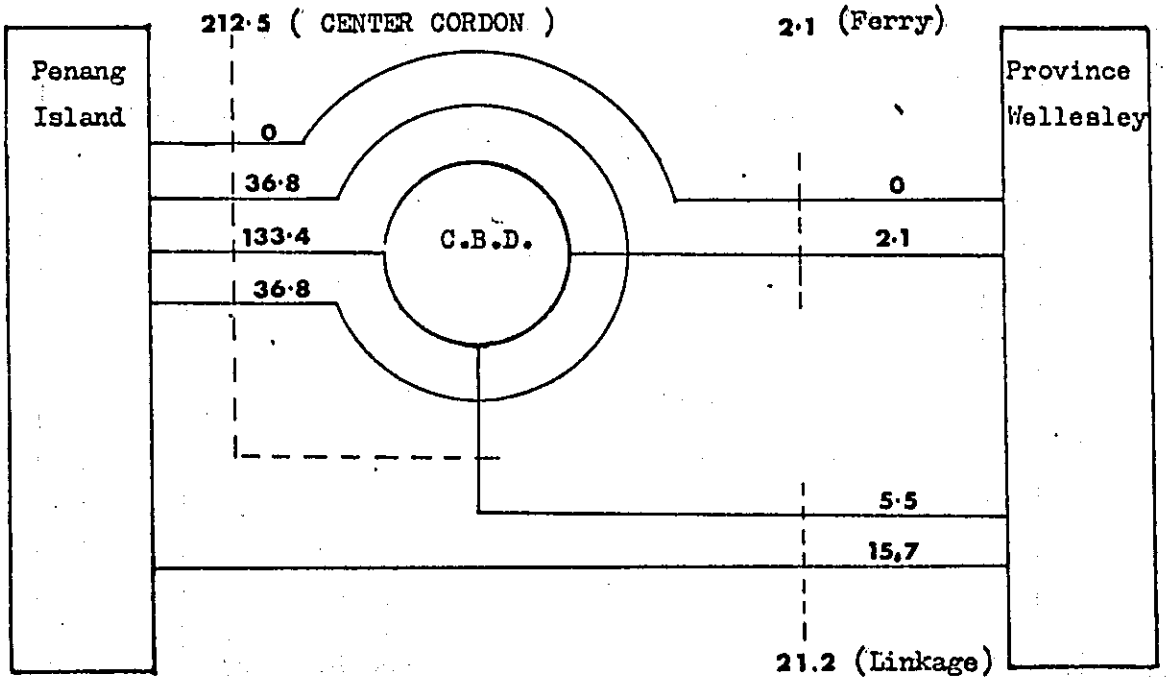
1985 - Plan A
On-going
Motorcycles



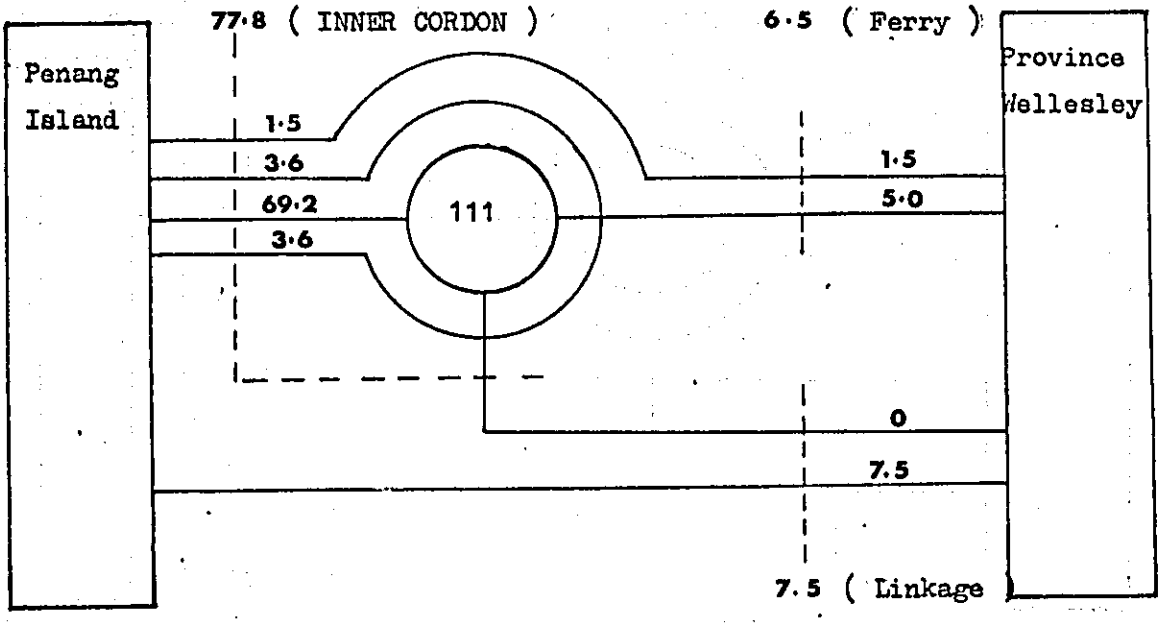


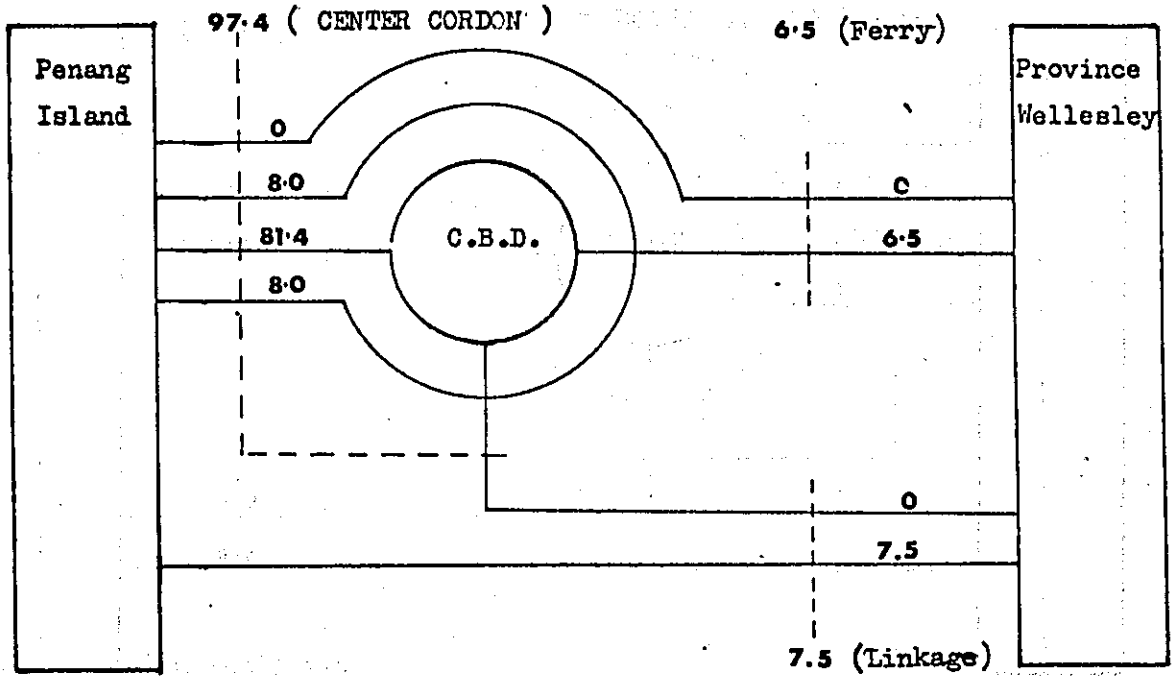
1985 - Plan B
On-going & proposed
P.C.U (ex. M/C)

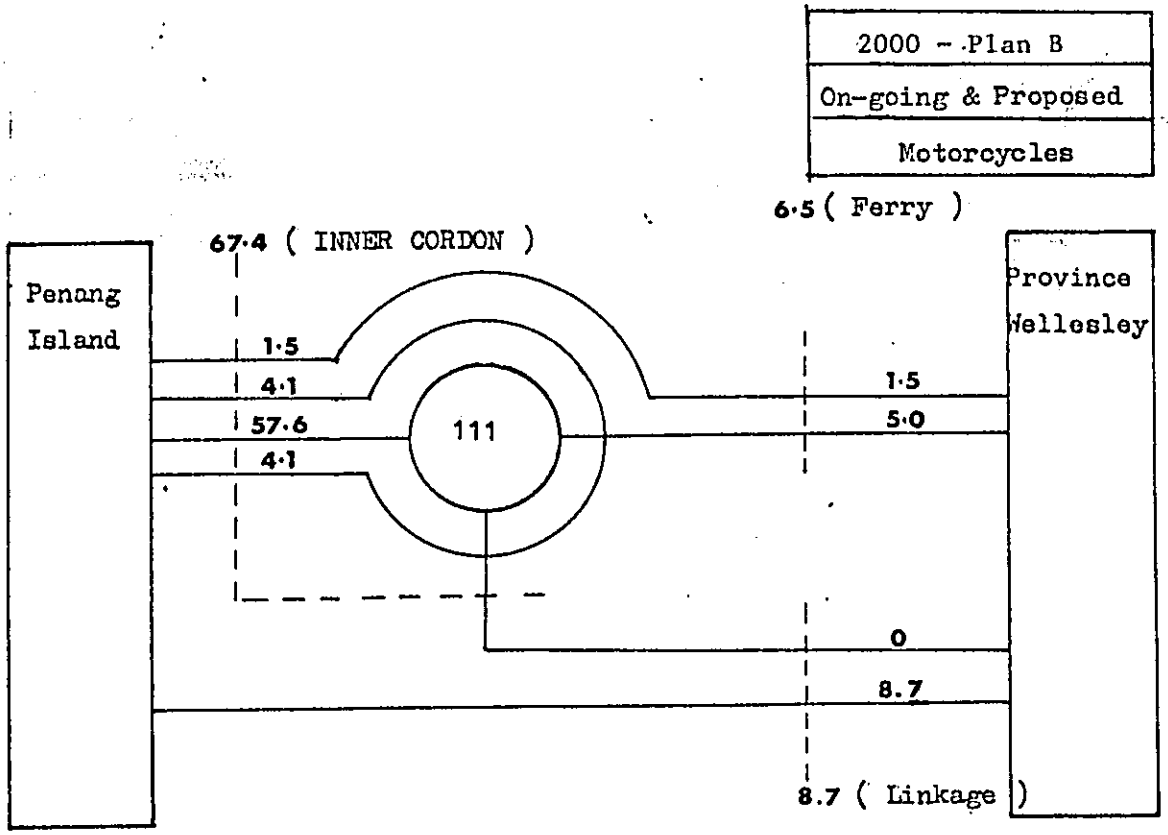


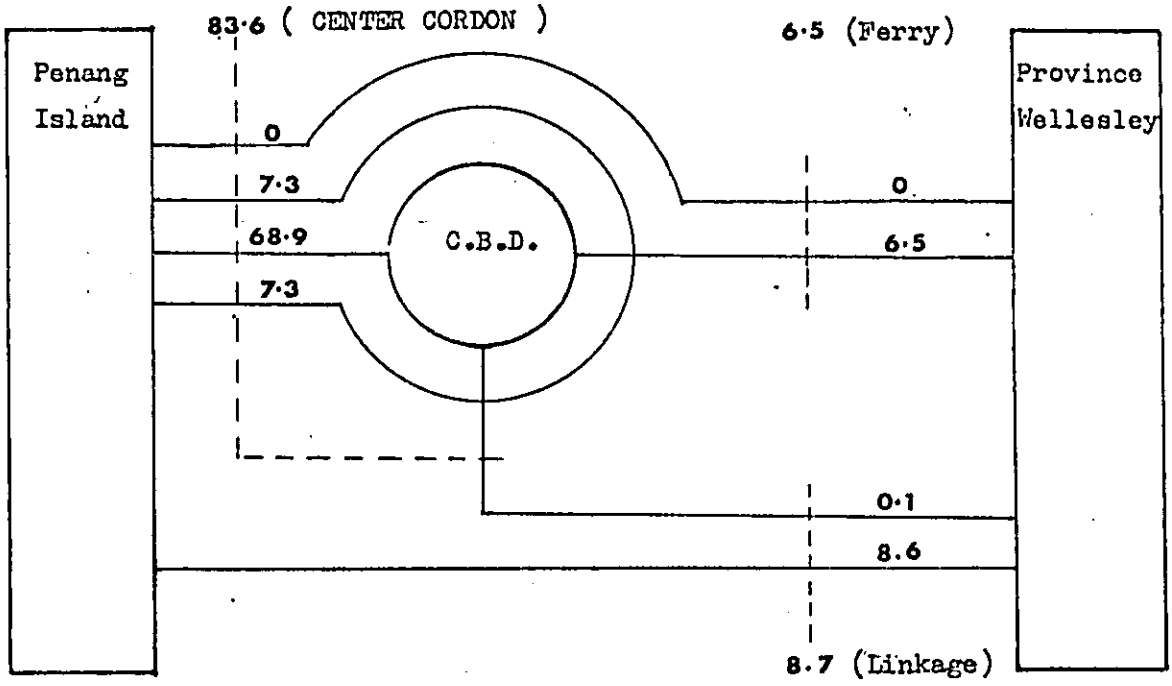


1985 - Plan B
On-going & Proposed
Motorcycles

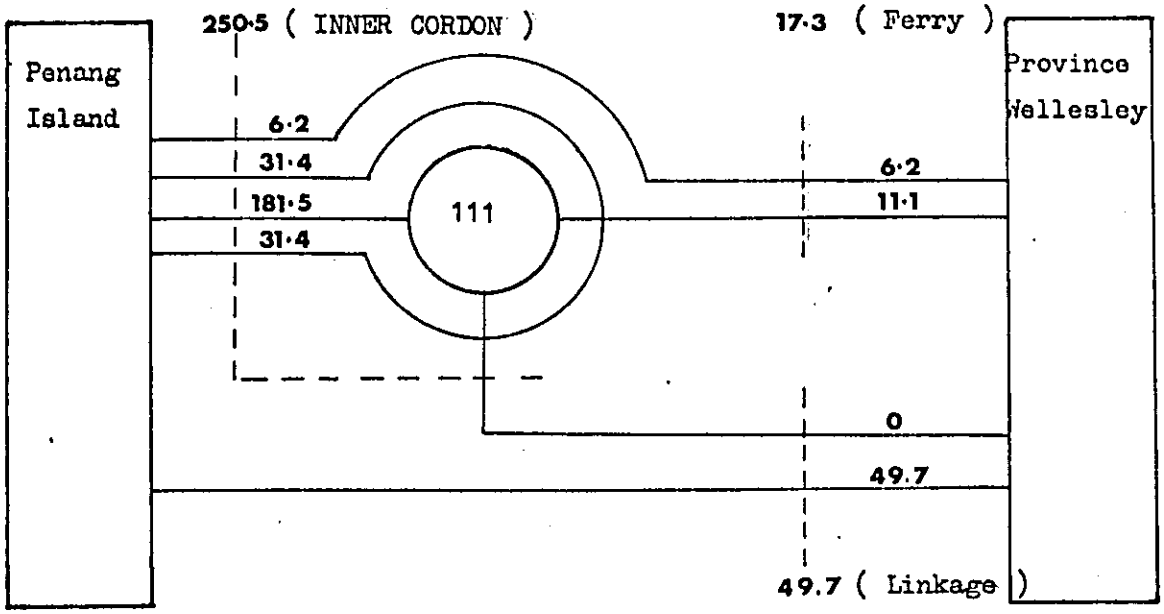


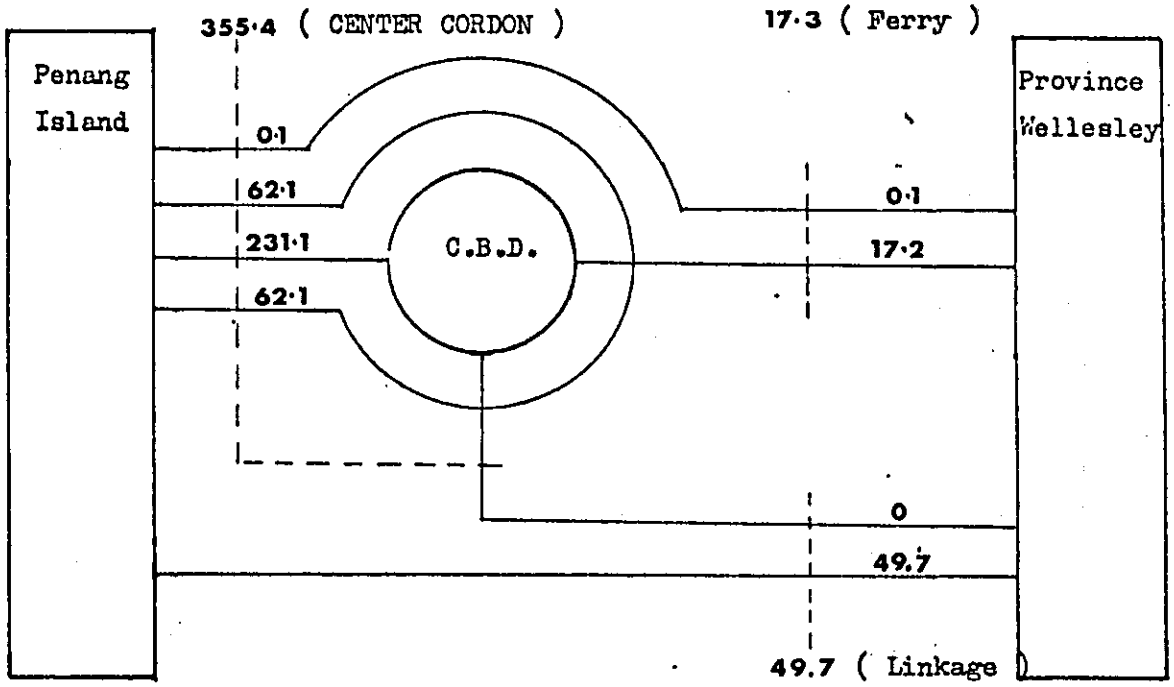



2000 - Plan B
On-going & Proposed
Motorcycles
6·5 (Ferry)
67·4 (INNER CORDON)
Penang Island
Province Wellesley
1·5
4·1
57·6
4·1
111
1·5
5·0
0
8.7
8.7 (Linkage)

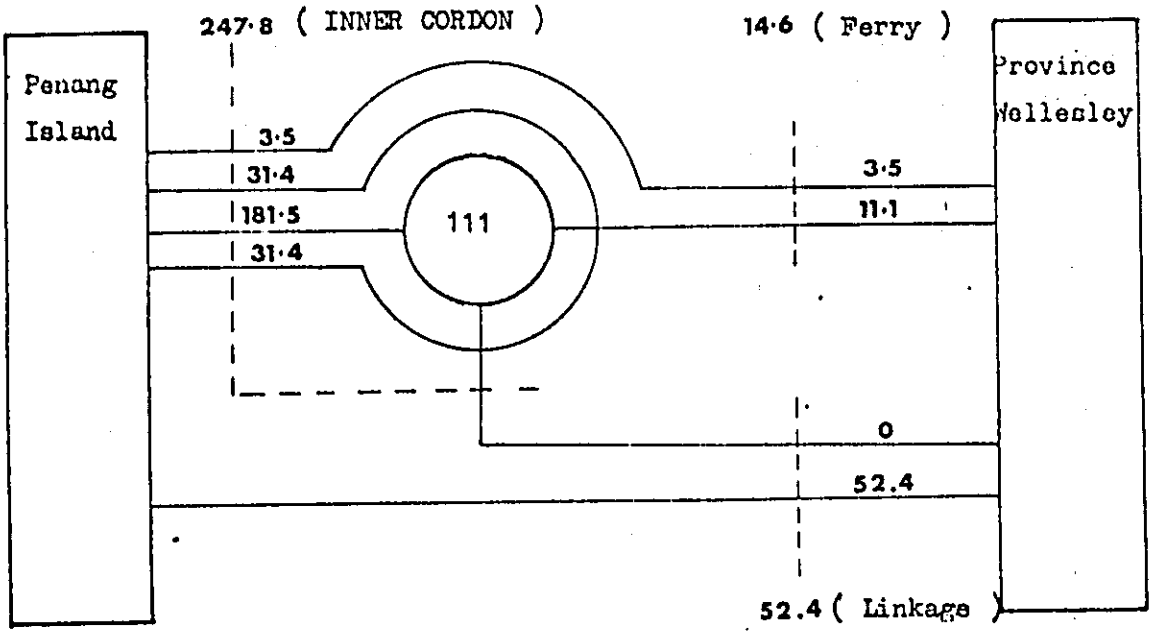

83·6 (CENTER CORDON)
6·5 (Ferry)
Penang Island
Province Wellesley
0
7·3
68·9
7·3
C.B.D.
0
6·5
0·1
8.6
8.7 (Linkage)

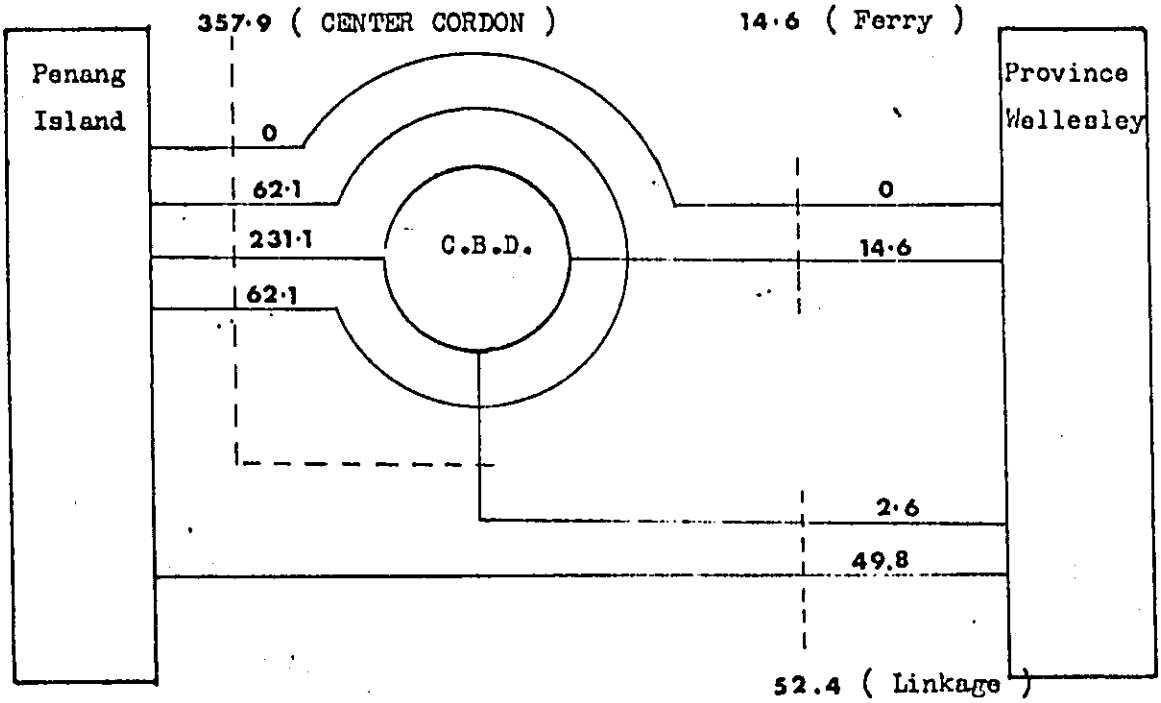
2000 - Plan B
On-going & Proposed
P.C.U (ex. M/C)





2000 - Plan B
Ultimate
P.C.U (ex. M/C)

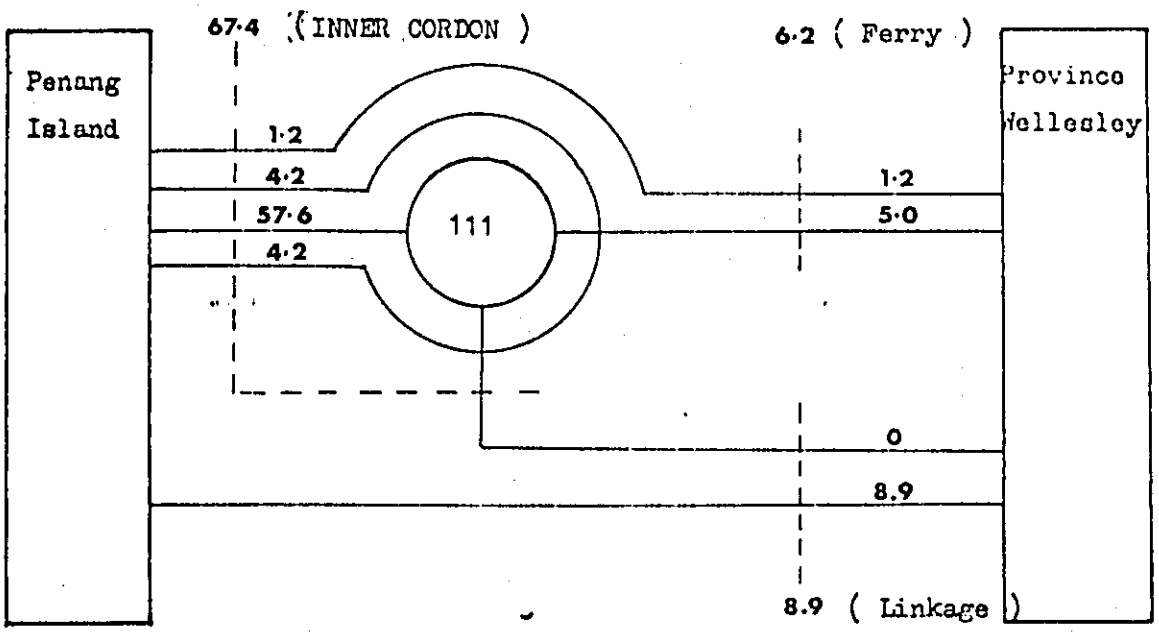


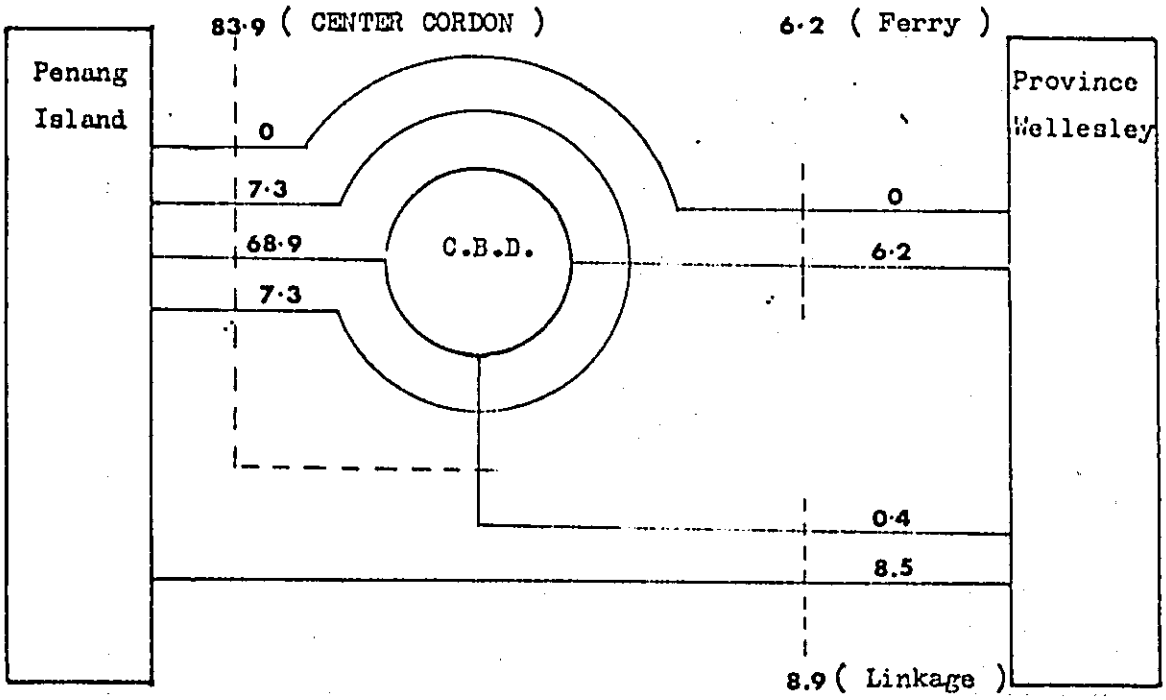


2000 - Plan B.

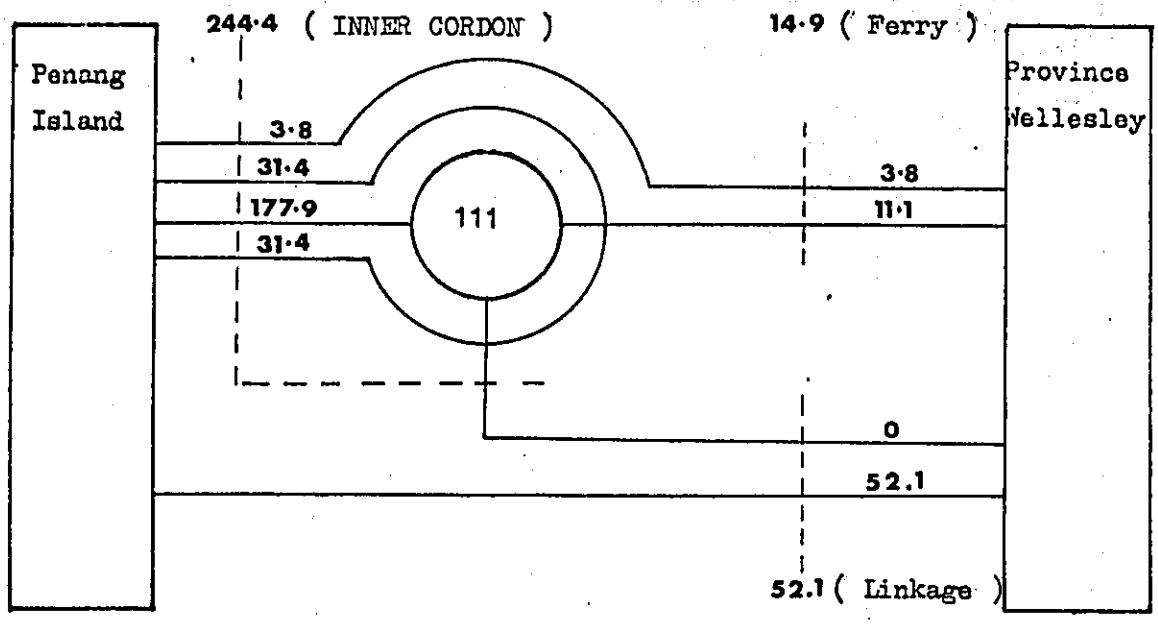
Ultimate

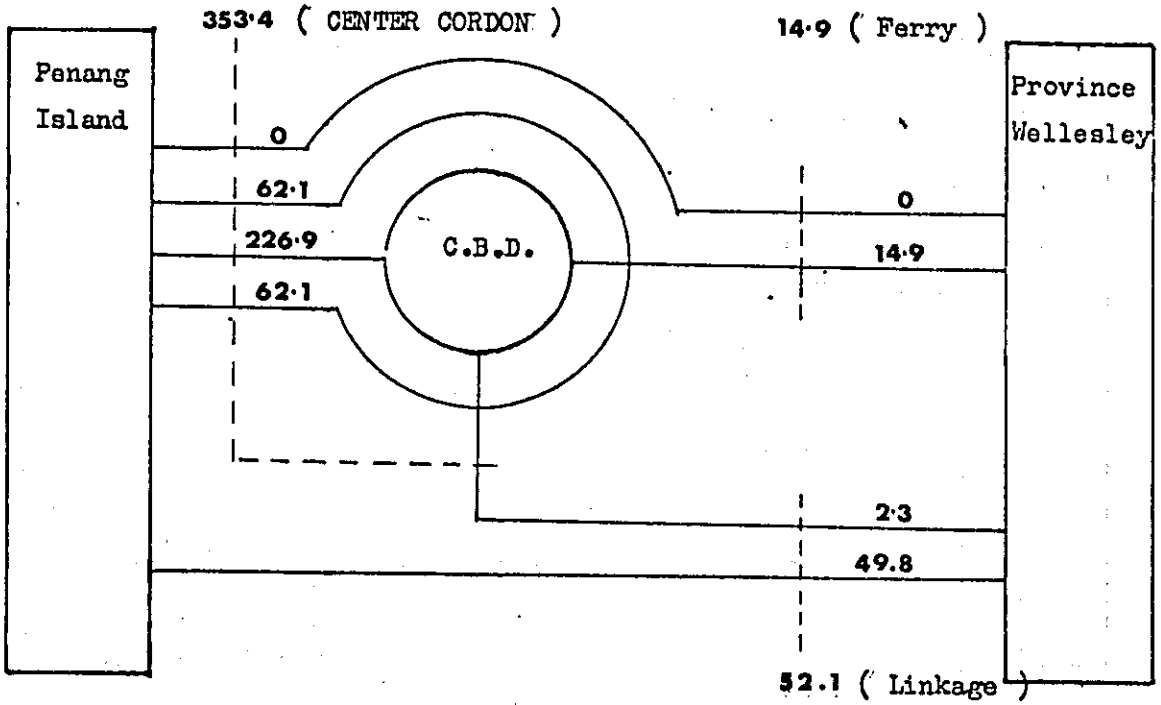
Motorcycles





2000 - Plan C
Ultimate
P.C.U (ex. M/C)

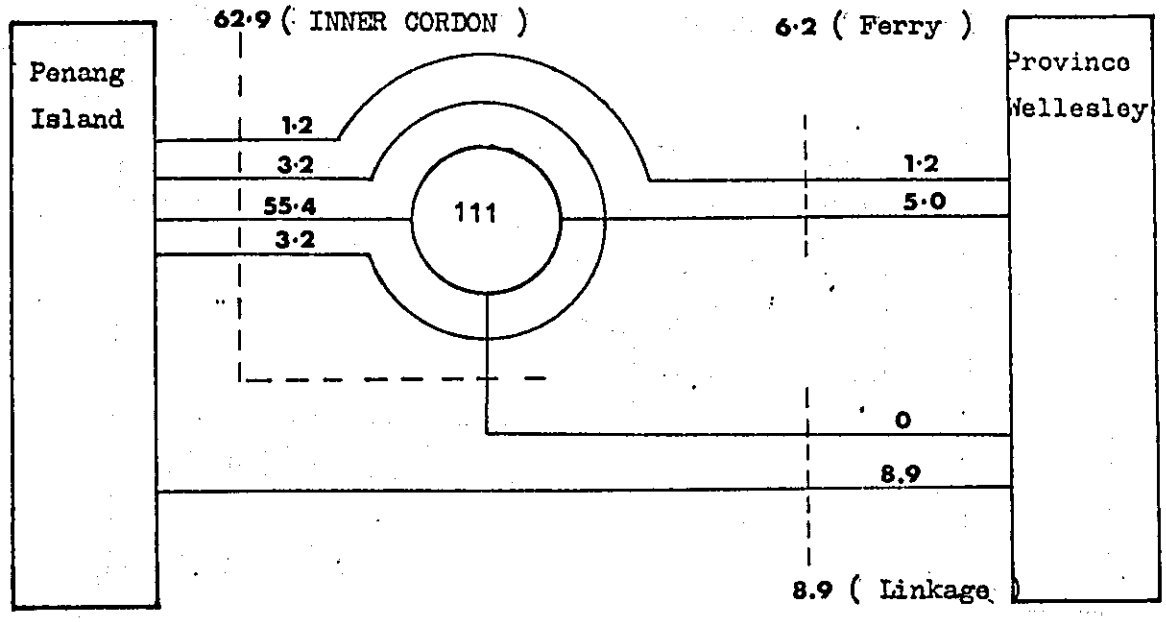


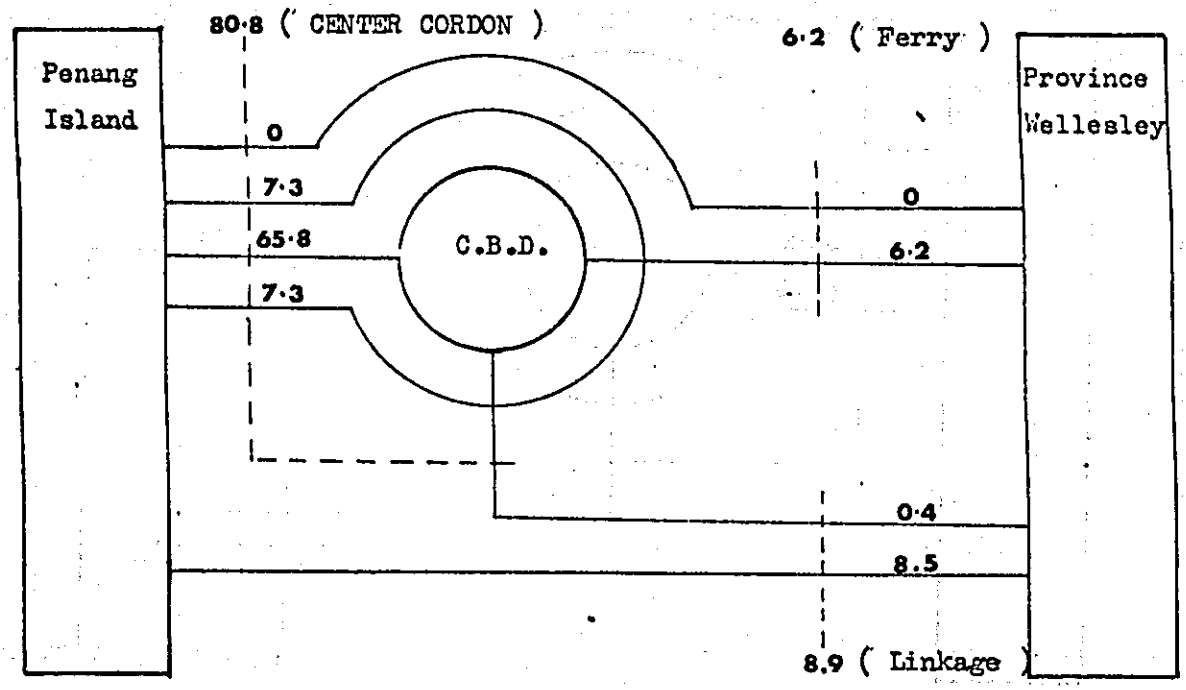


2000 - Plan C

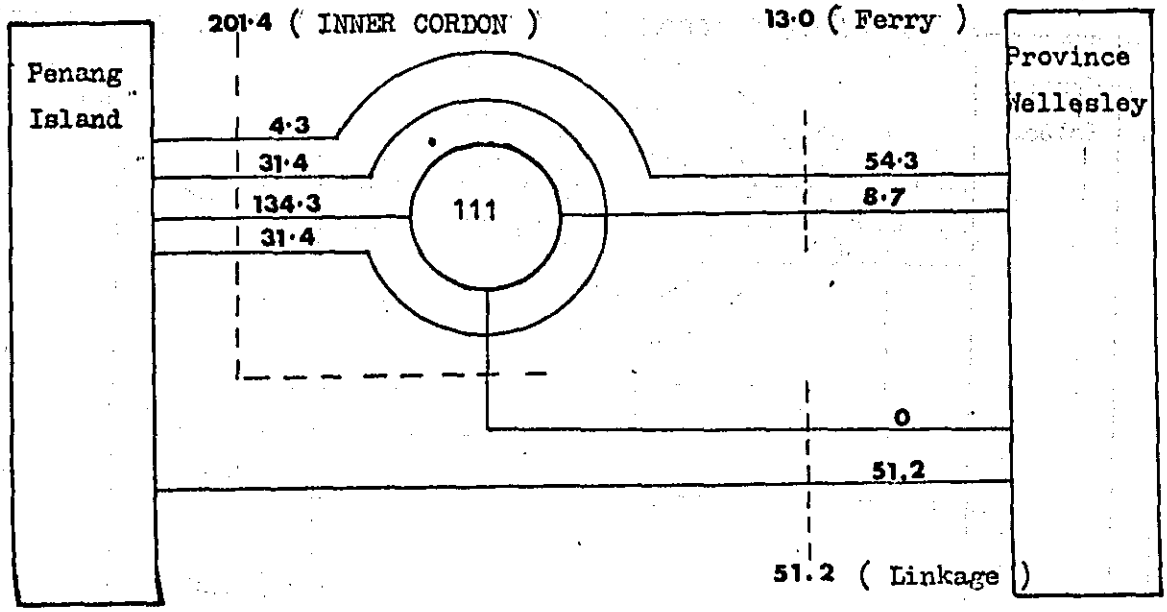
Ultimate

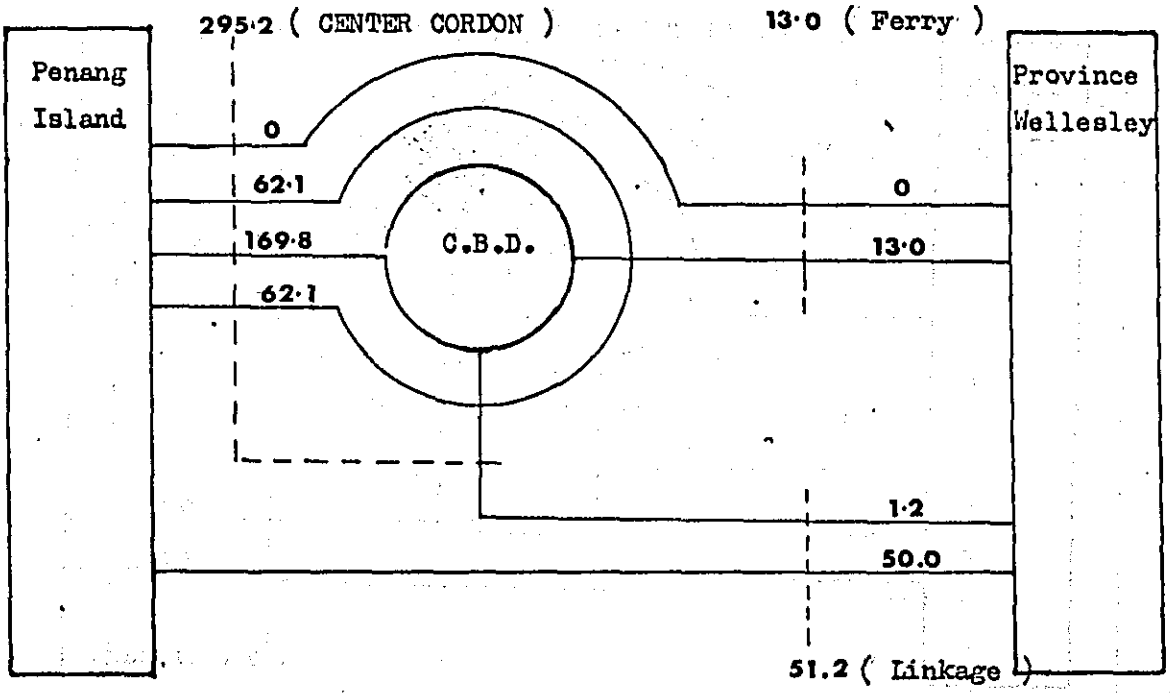
Motorcycles





2000 - Plan D
Ultimate
P.C.U (ex. M/C)

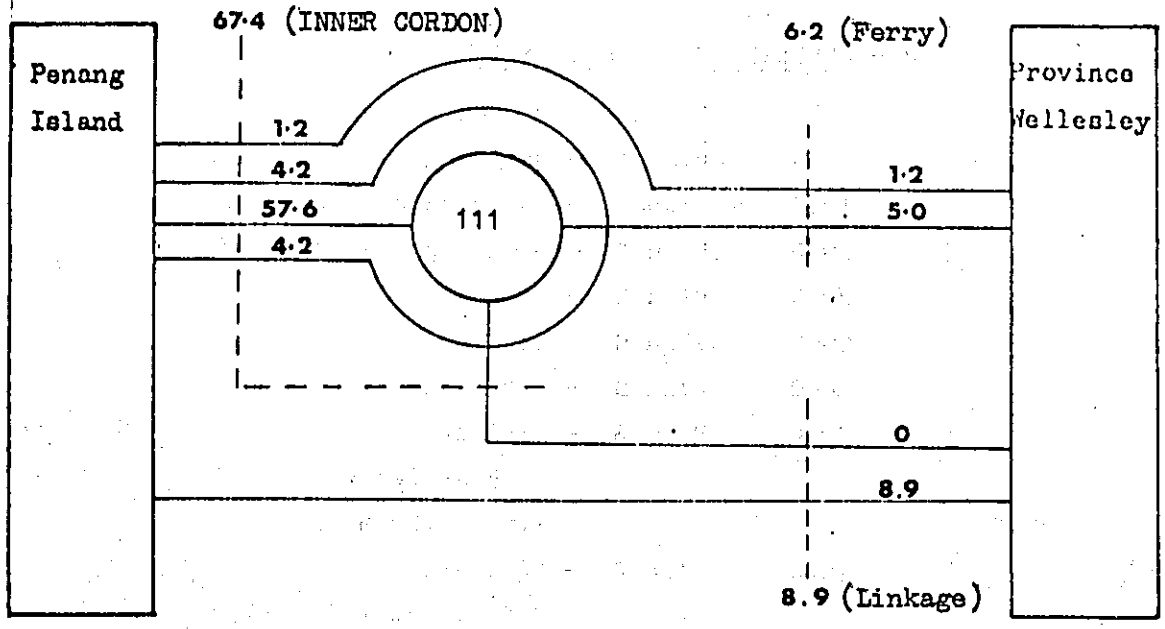


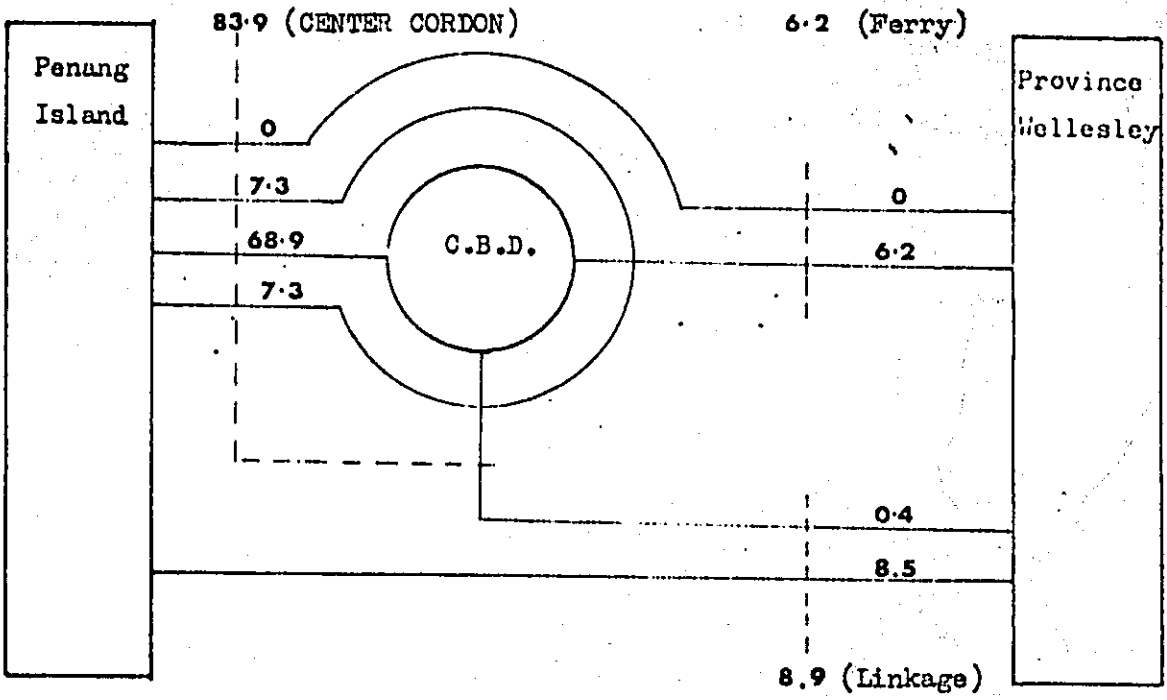


2000 - Plan D

Ultimate

Motorcycles

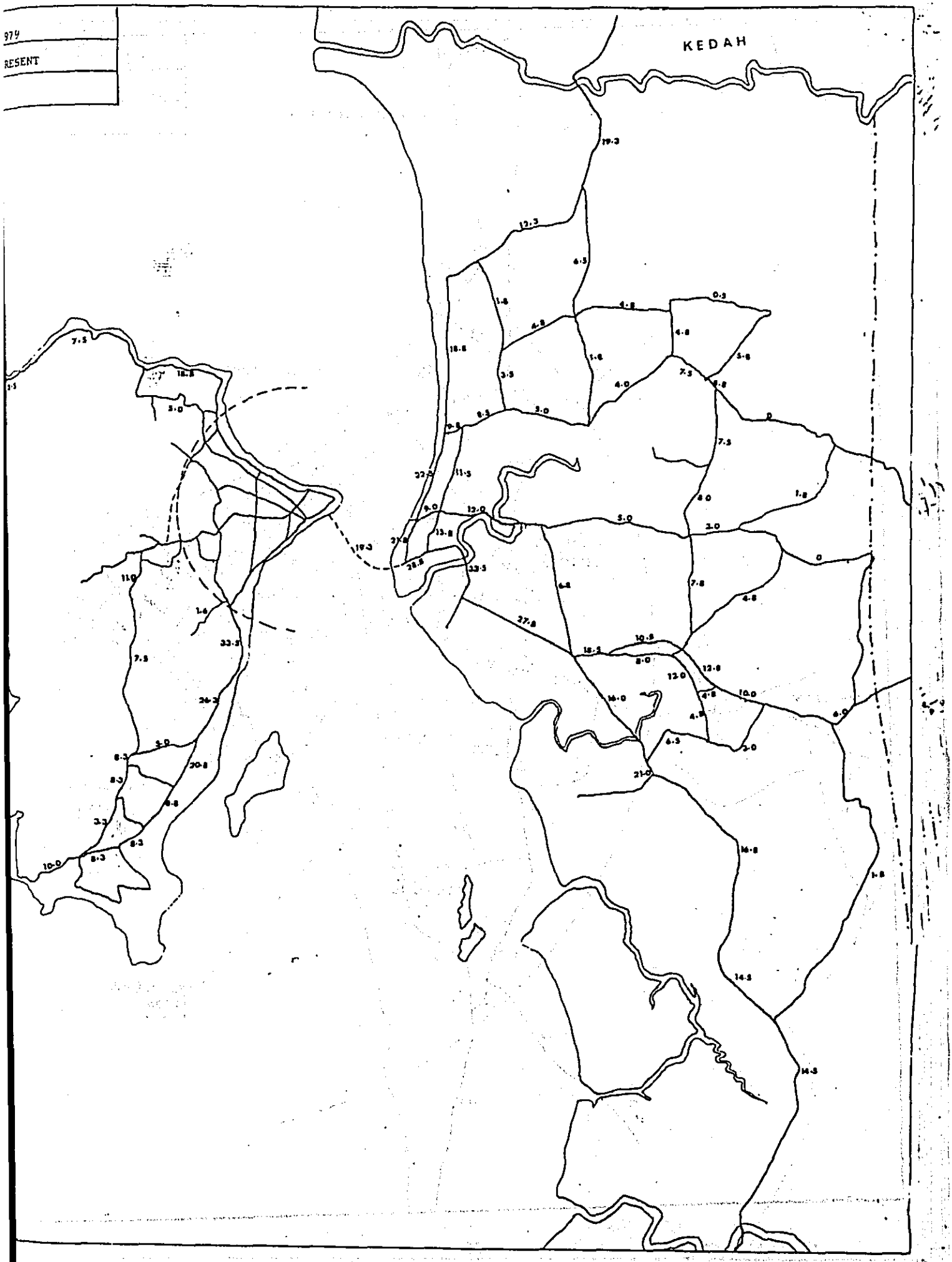


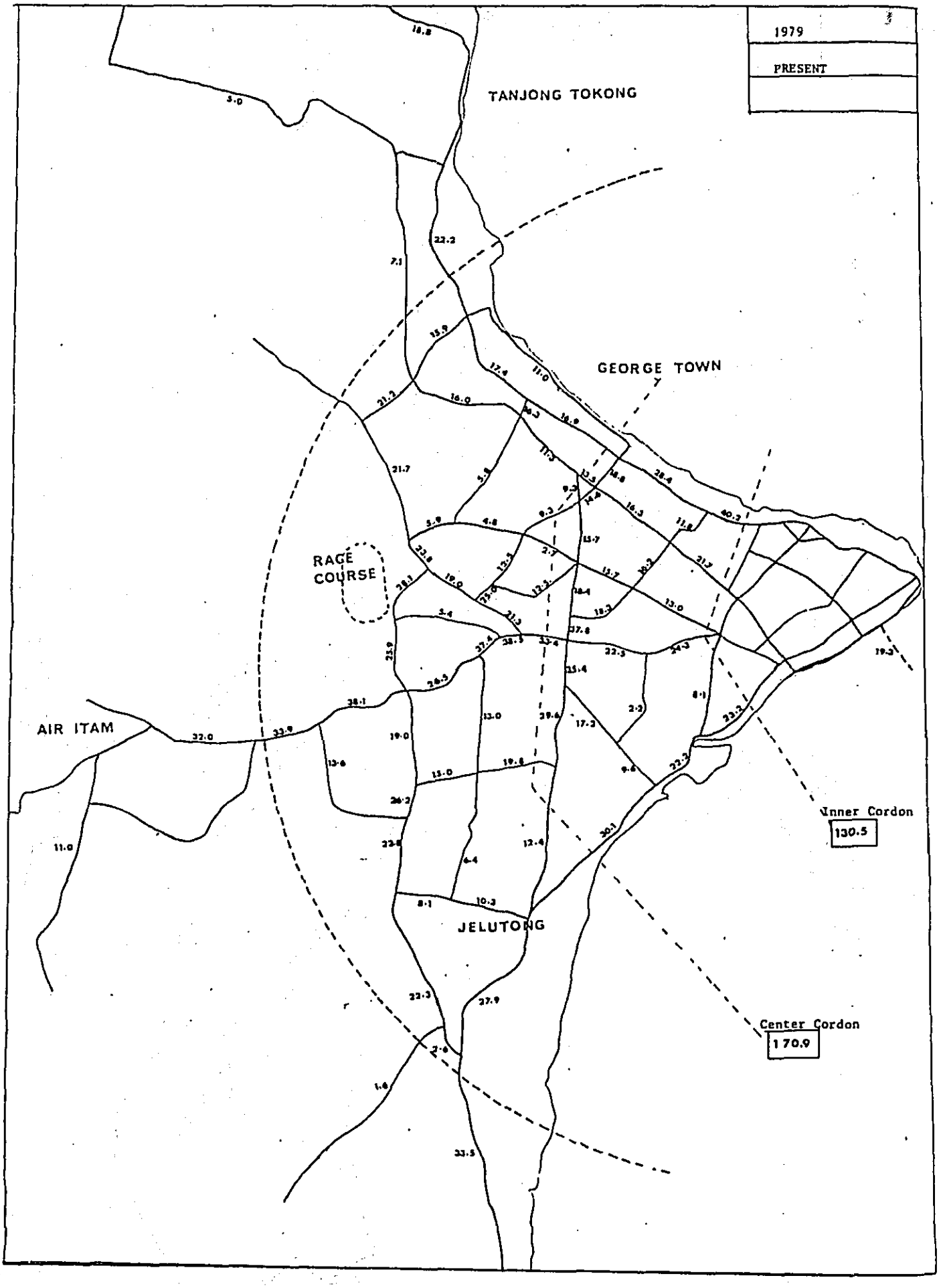


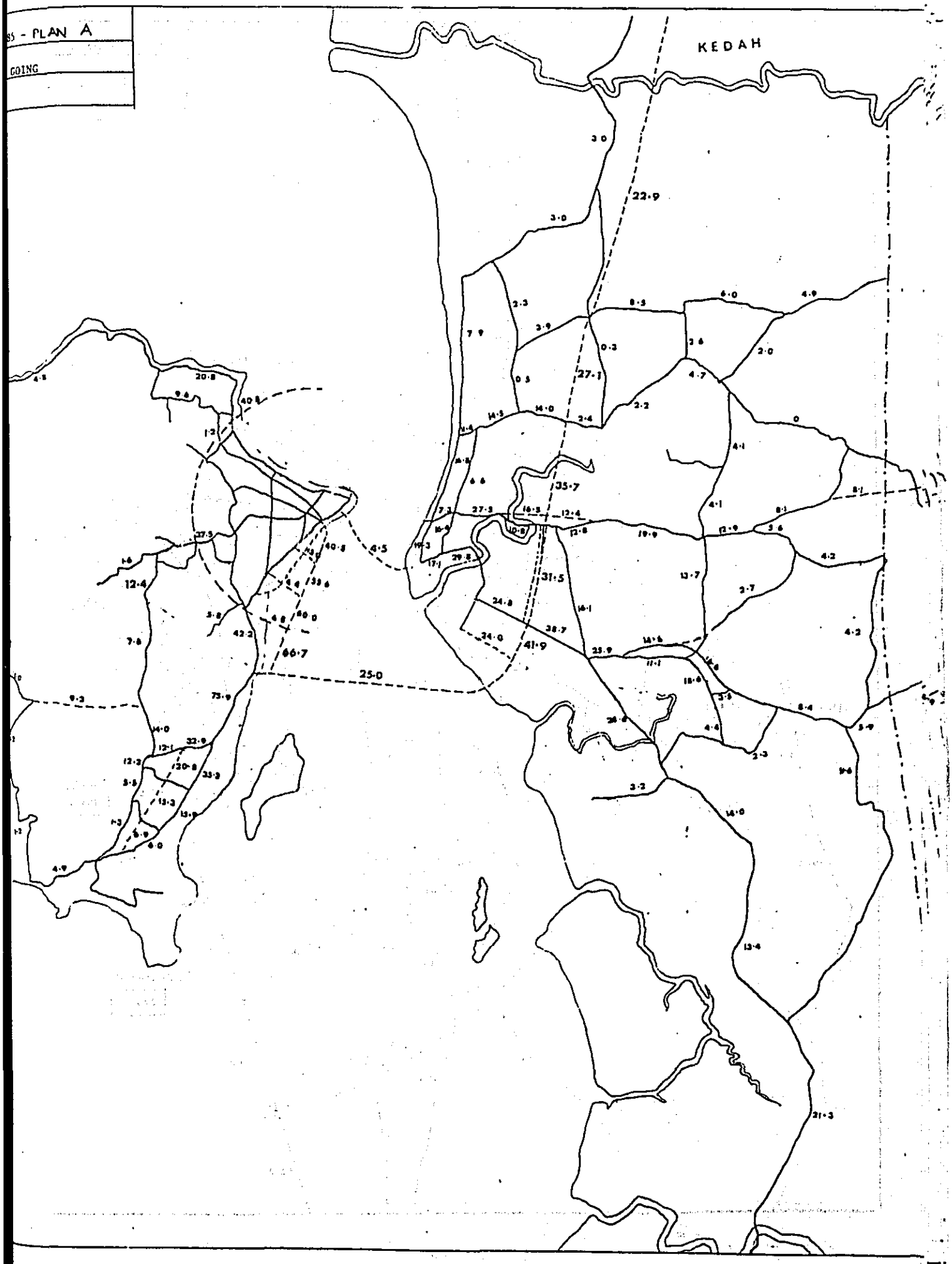
H - RESULTS OF TRAFFIC ASSIGN

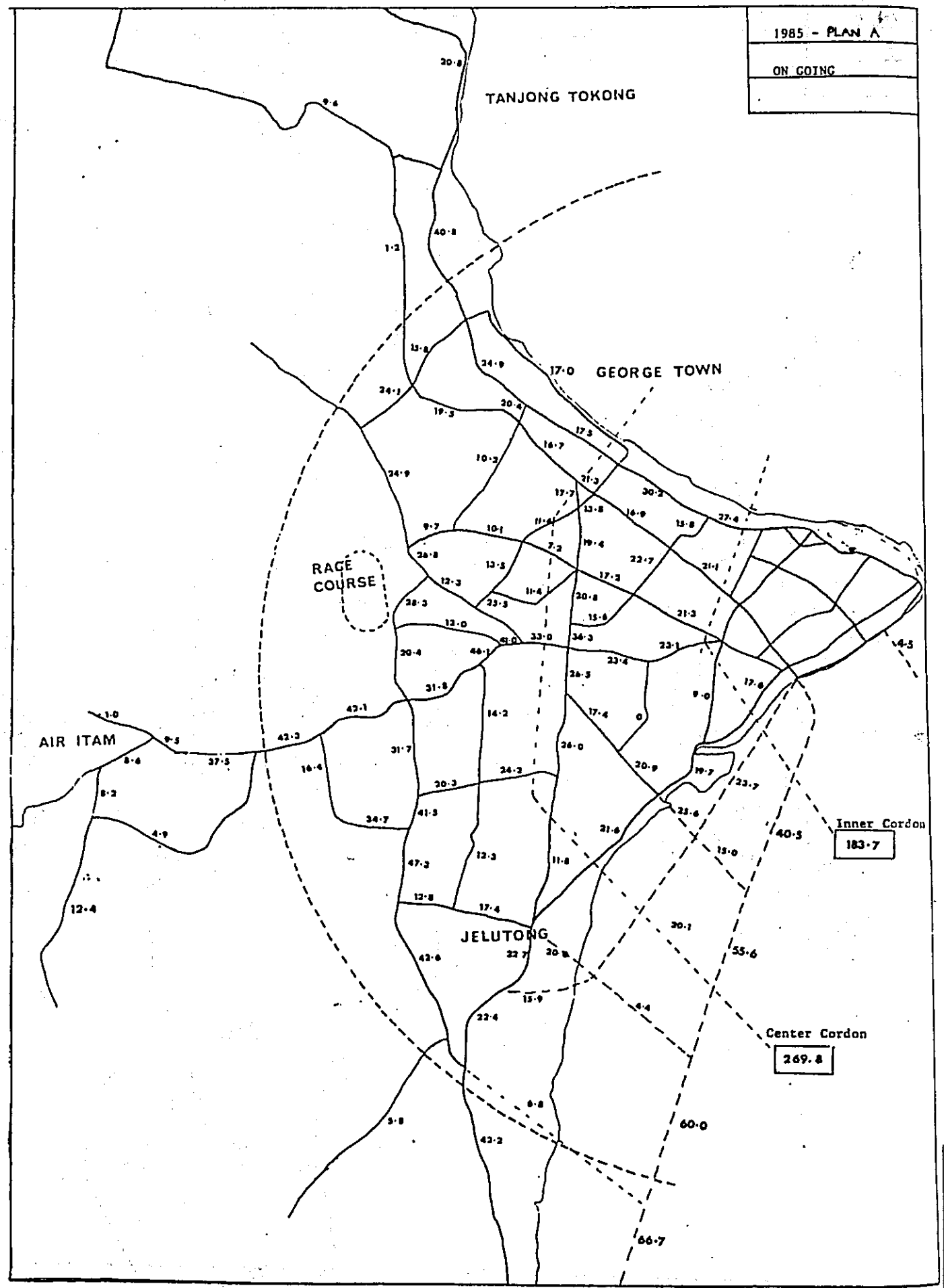
1979	Present	- Present
1985	Plan A	- On-going
1985	Plan B	- On-going and Proposed
2000	Plan B	- On-going and Proposed
2000	Plan B	- Ultimate
2000	Plan C	- Ultimate
2000	Plan D	- Ultimate
2000	Plan B	- Ultimate Without ferry P.C.U. (Ex M/C)
2000	Plan B	- Ultimate P.C.U. (Ex M/C)

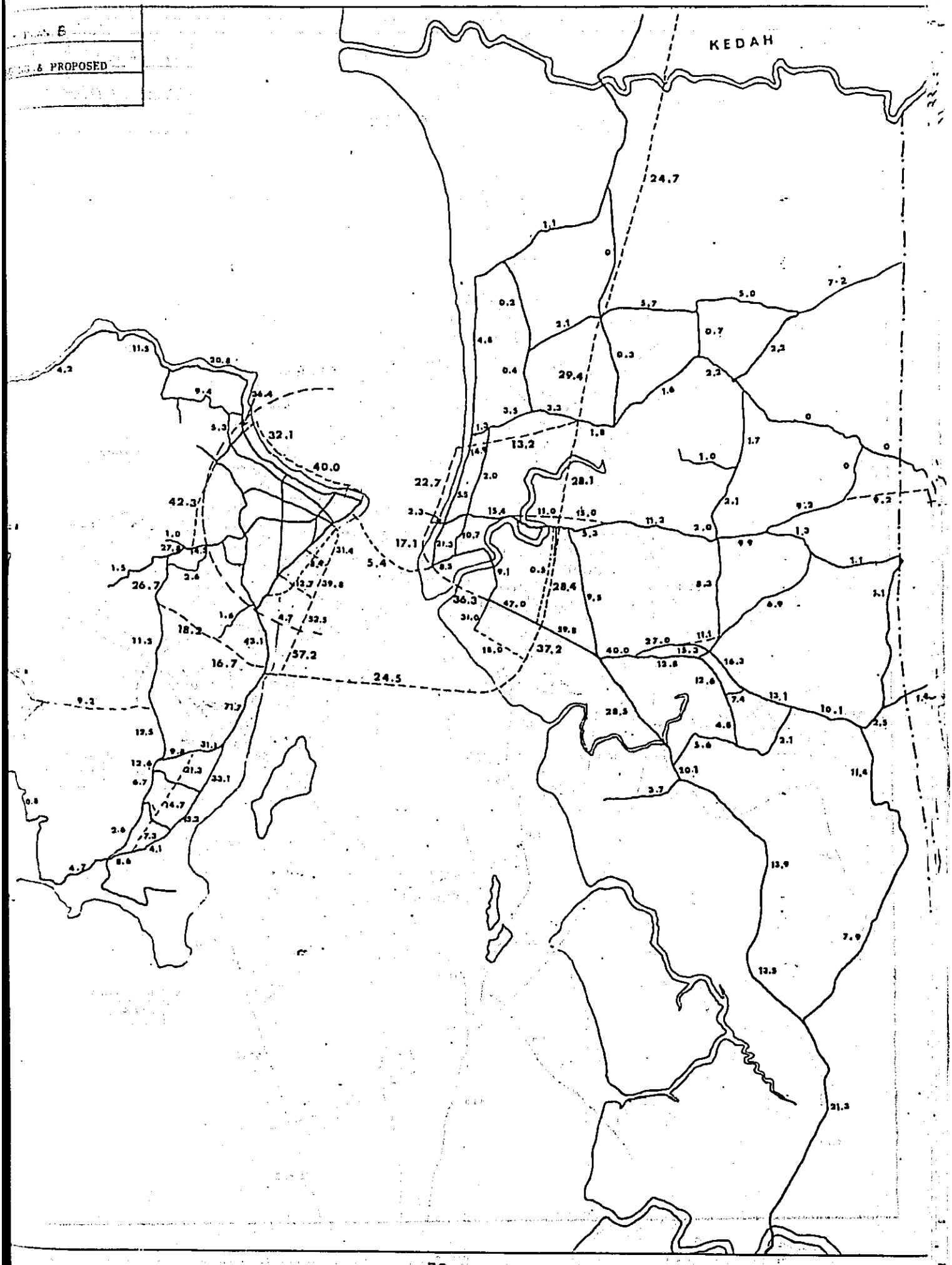
(Unit : 1000 p.c.u.)

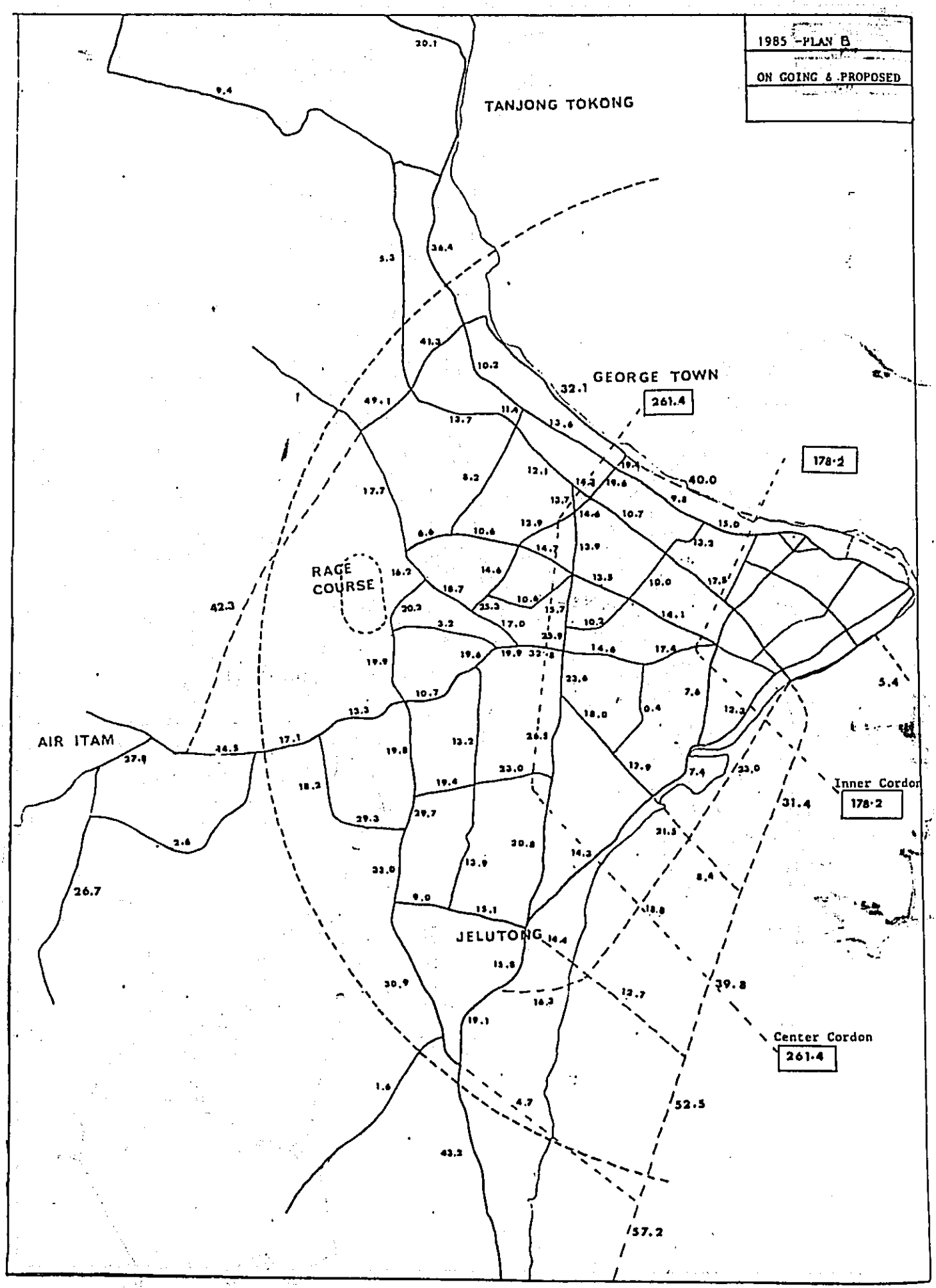

979
RESENT
KEDAH

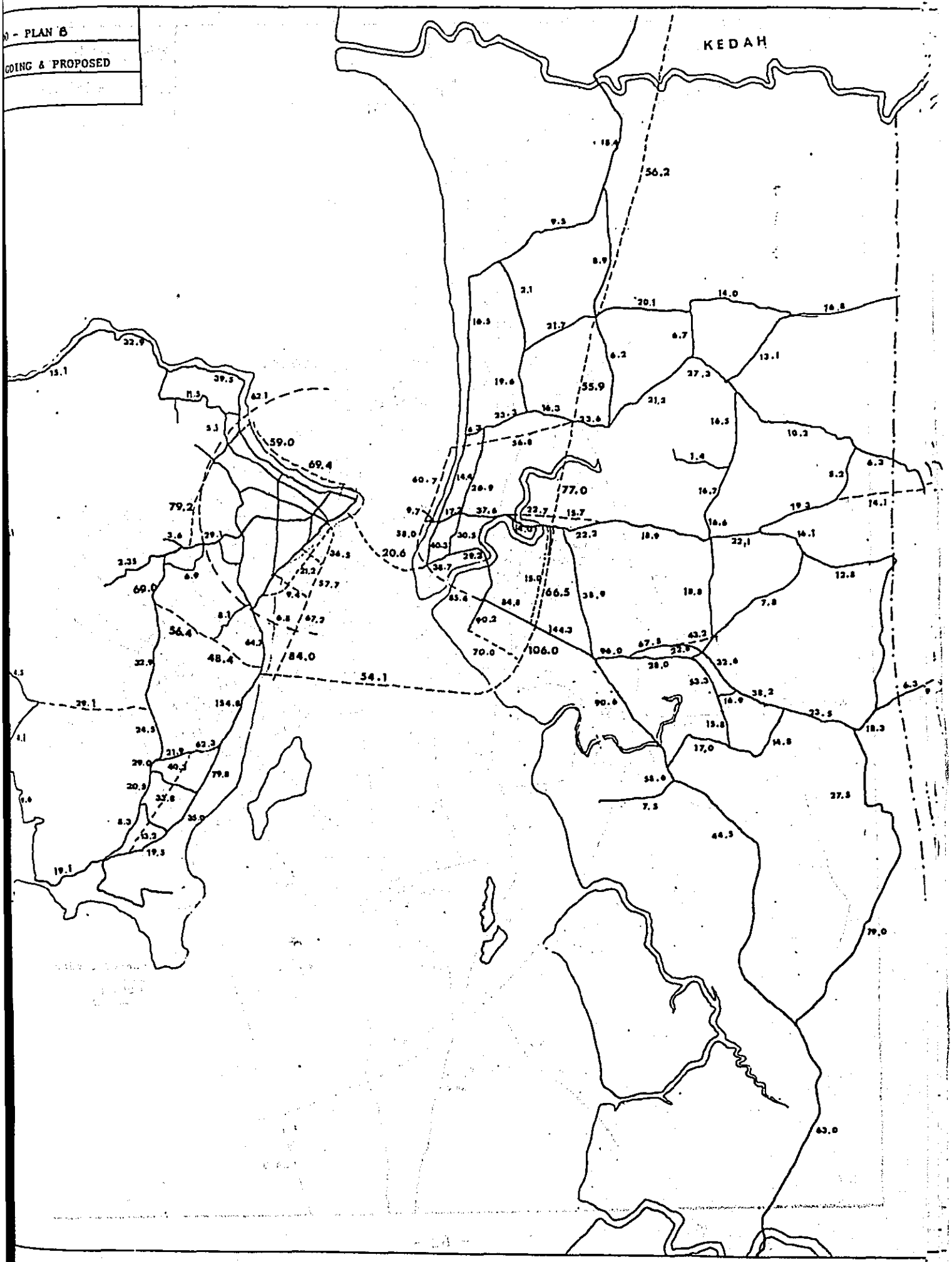

1979
PRESENT
TANJONG TOKONG
GEORGE TOWN
RACE COURSE
AIR ITAM
JELUTONG
Inner Cordon
130.5
Center Cordon
170.9

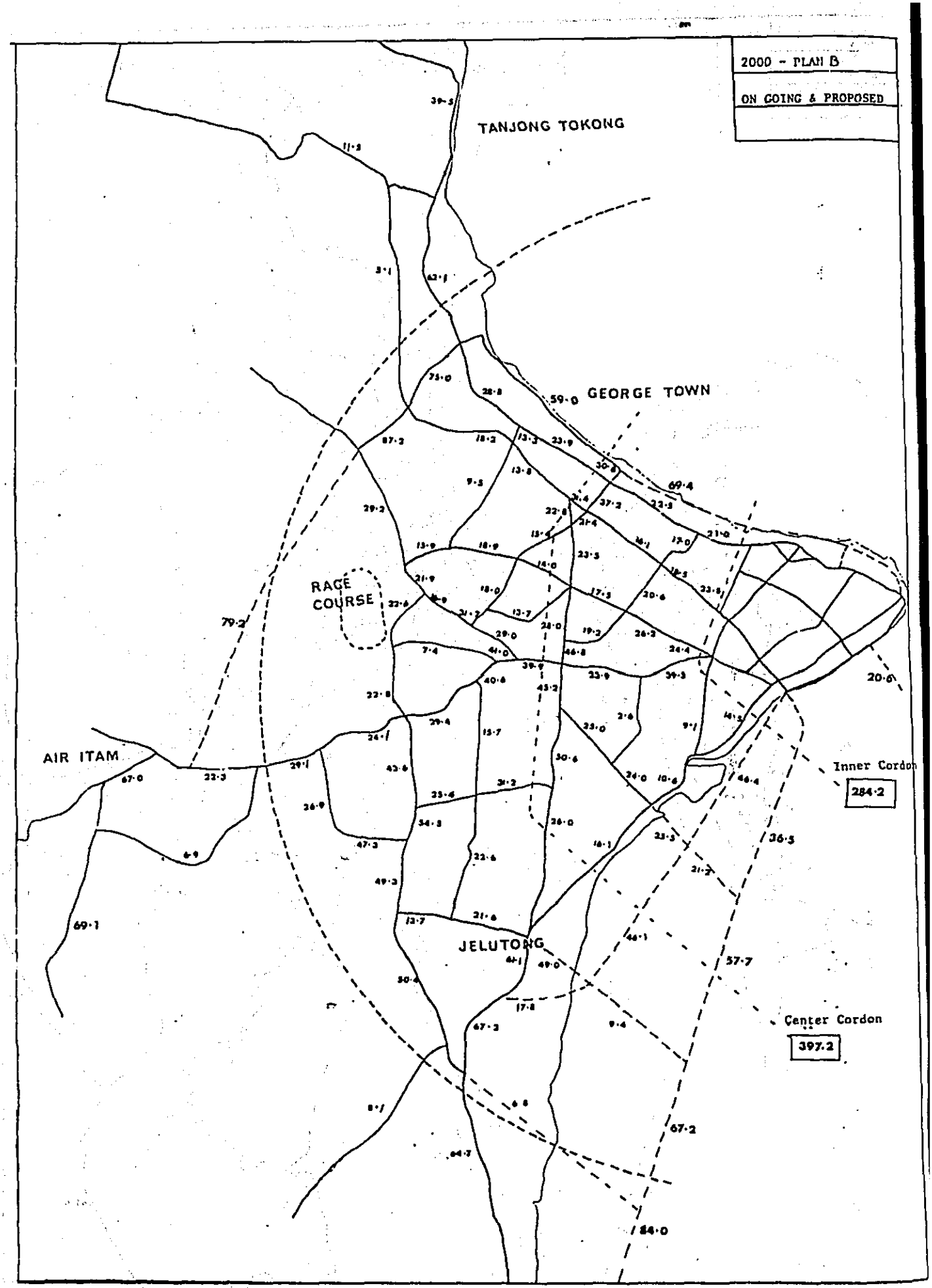

- PLAN A
GOING
KEDAH
22·9
27·1
35·7
31·5
41·9
25·0
66·7

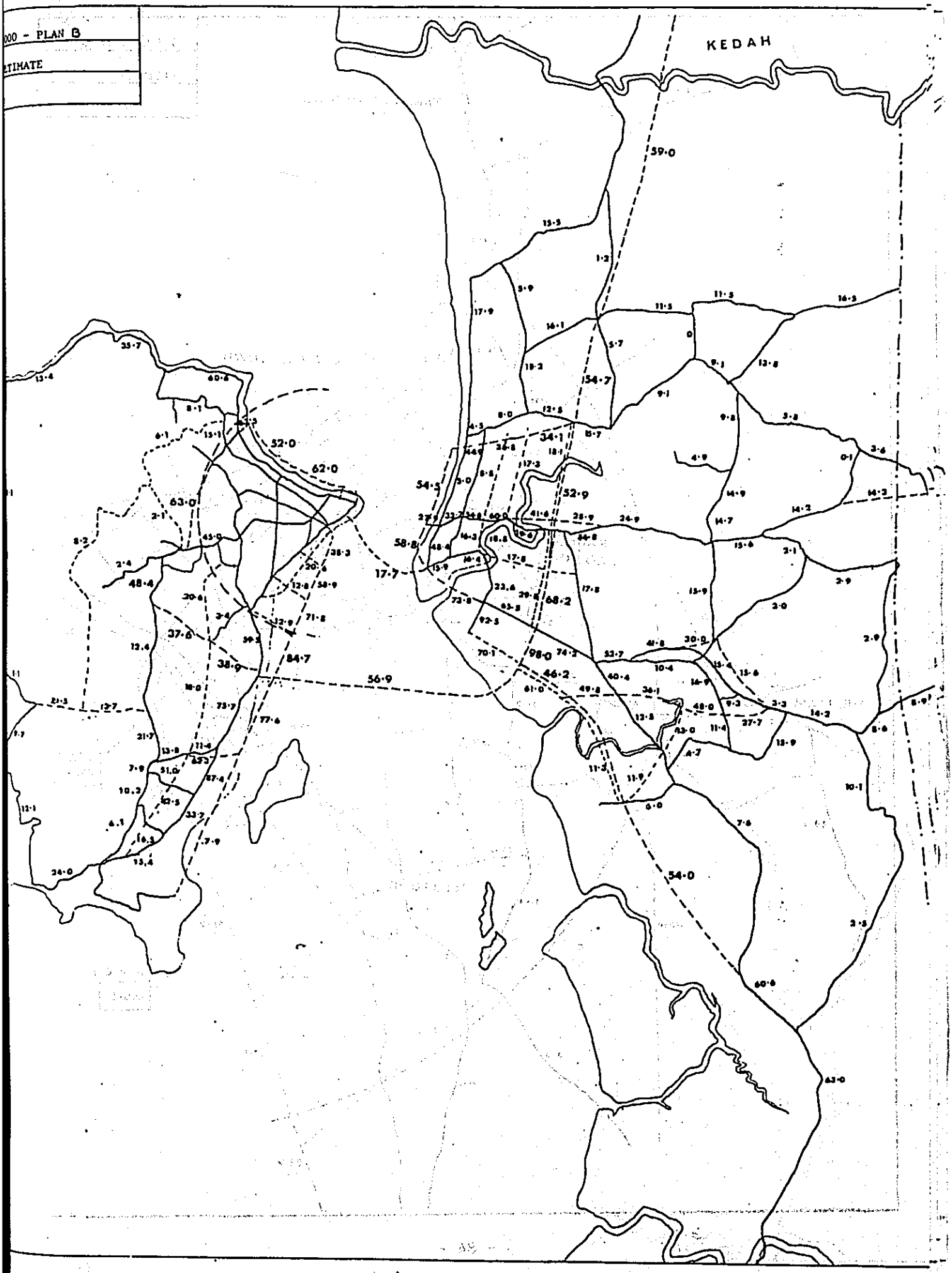

1985 - PLAN A
ON GOING
TANJONG TOKONG
GEORGE TOWN
RACE COURSE
AIR ITAM
JELUTONG
Inner Cordon
183.7
Center Cordon
269.8

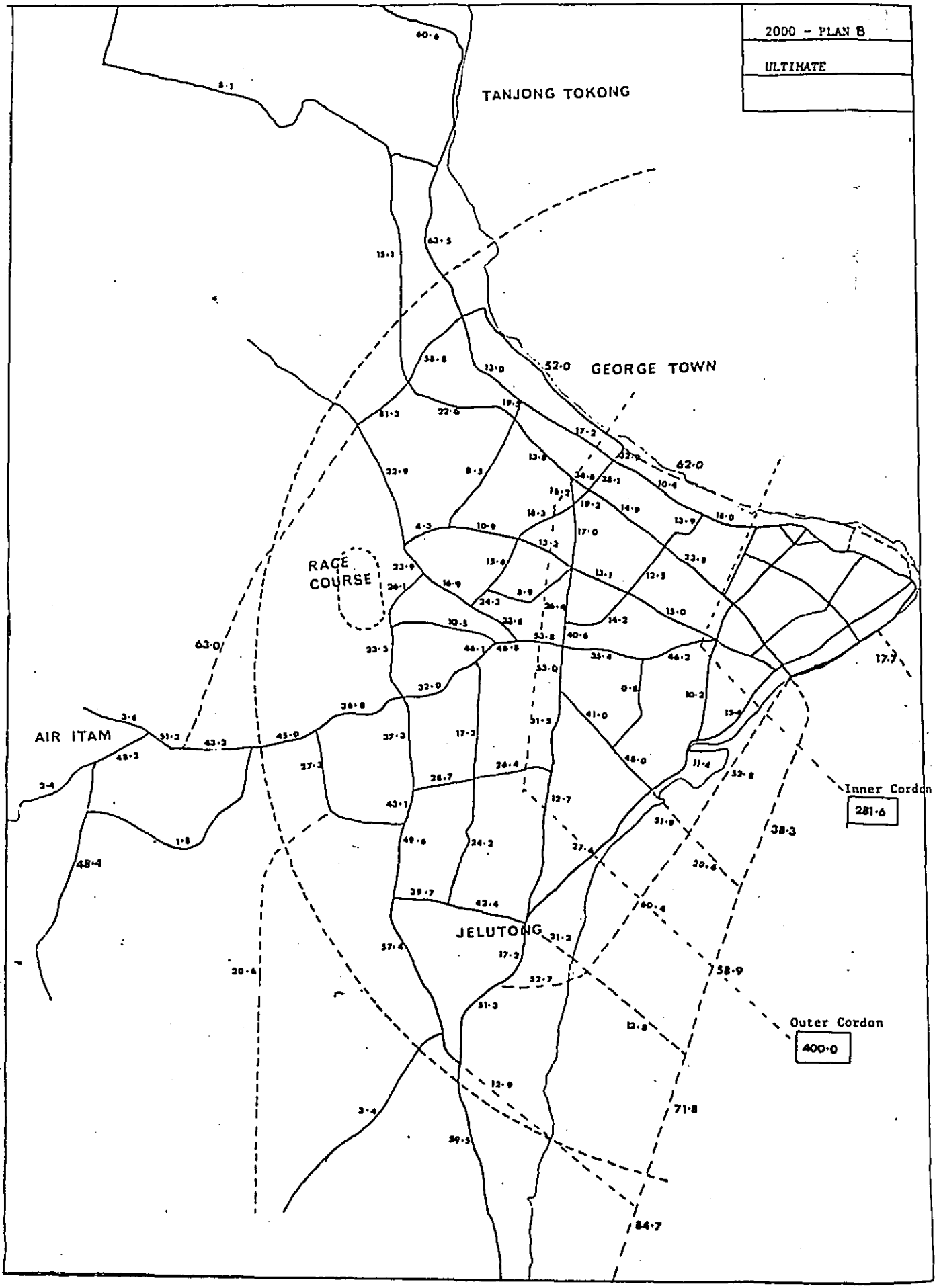

PROPOSED
KEDAH
24.7
29.4
13.2
22.7
28.1
32.1
40.0
42.3
17.1
5.4
26.7
18.2
16.7
57.2
24.5
36.3
28.4
37.2
10.1
13.1
21.3

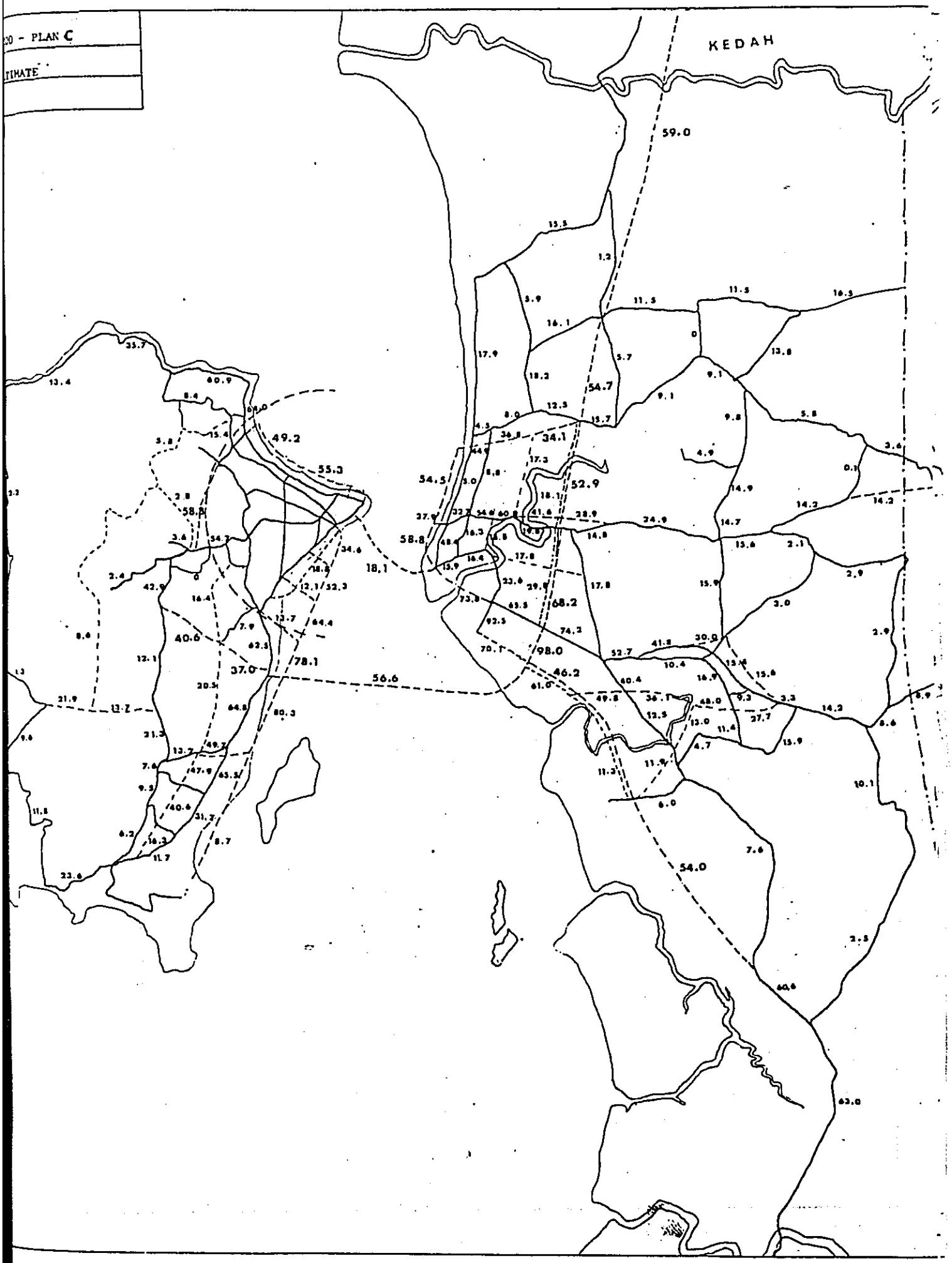

1985 -PLAN B
ON GOING & PROPOSED
TANJONG TOKONG
GEORGE TOWN
261.4
178·2
RACE COURSE
AIR ITAM
JELUTONG
Inner Cordon
178·2
Center Cordon
261.4

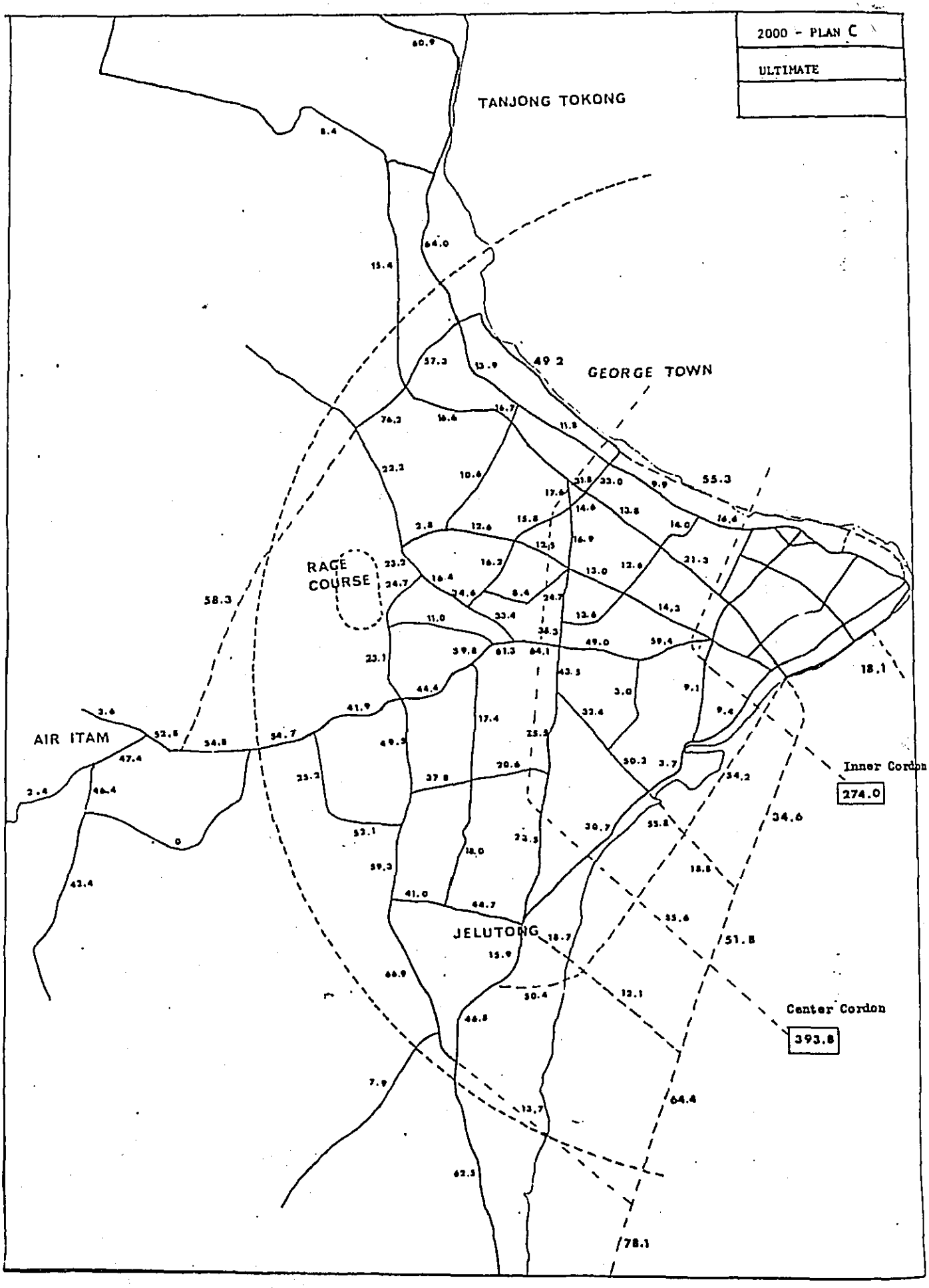

- PLAN 8
GOING & PROPOSED
KEDAH

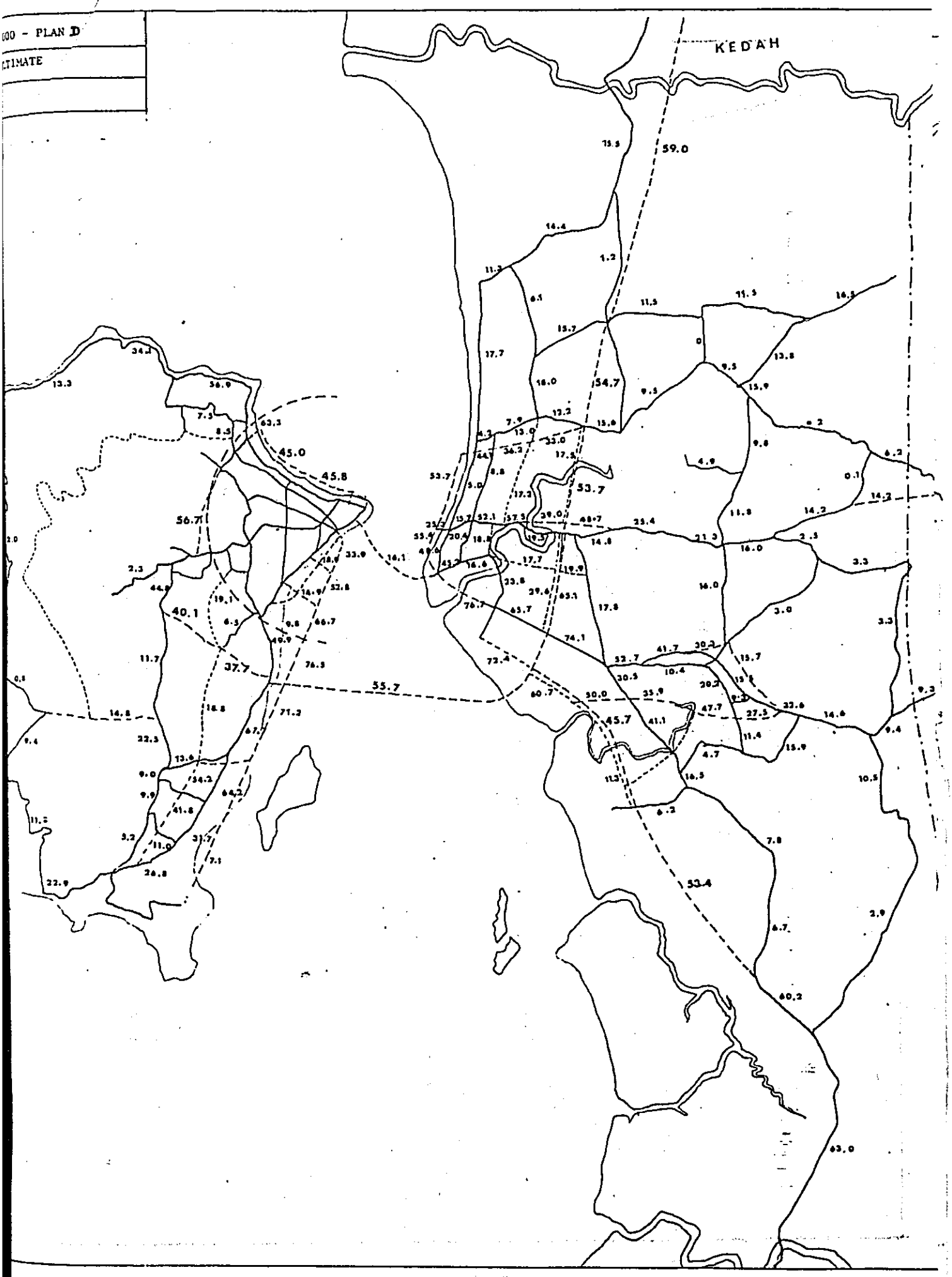

2000 - PLAN B
ON GOING & PROPOSED
TANJONG TOKONG
GEORGE TOWN
RACE COURSE
AIR ITAM
JELUTONG
Inner Cordon
284·2
Center Cordon
397.2

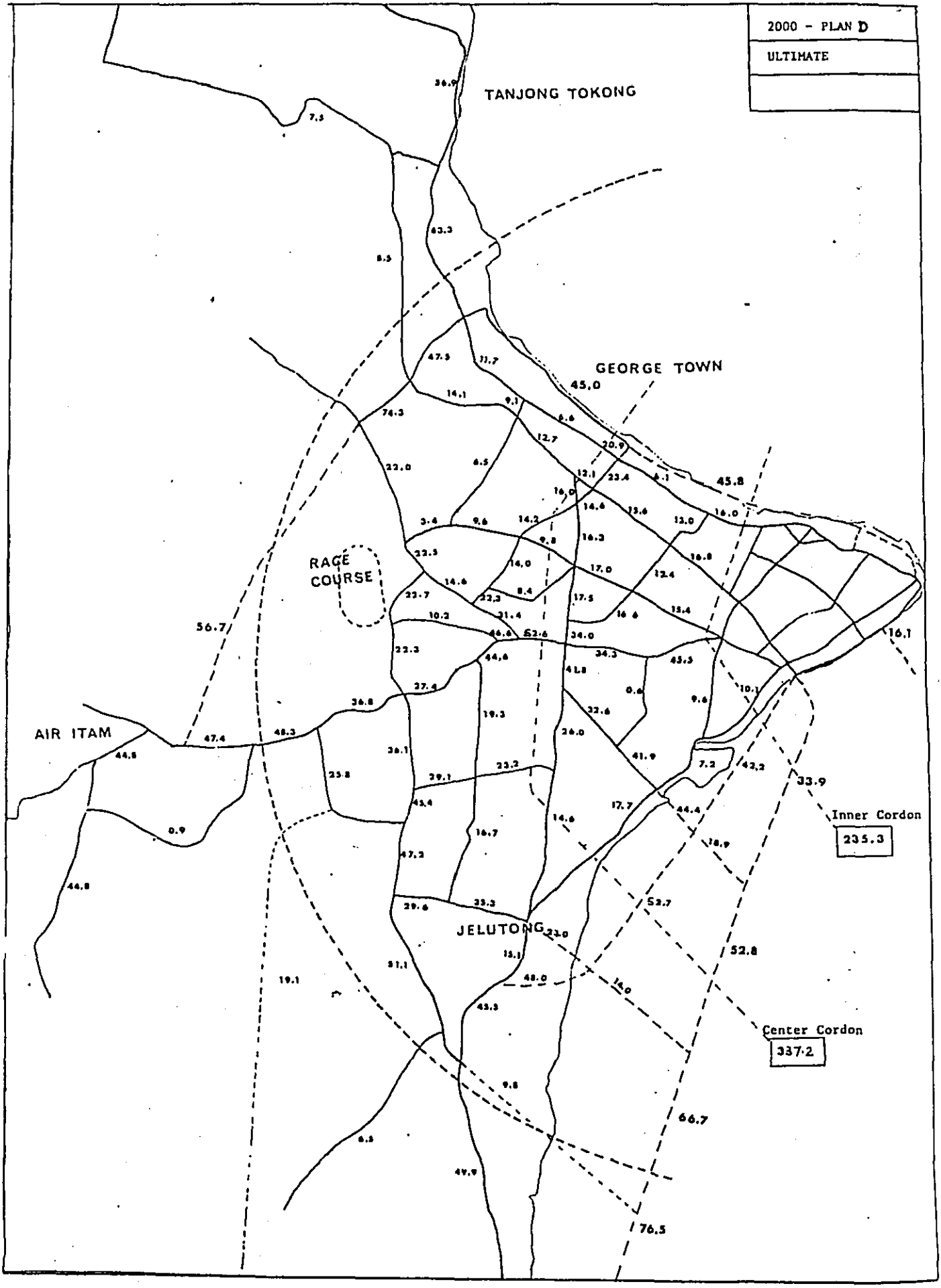

000 - PLAN B
TIMATE
KEDAH

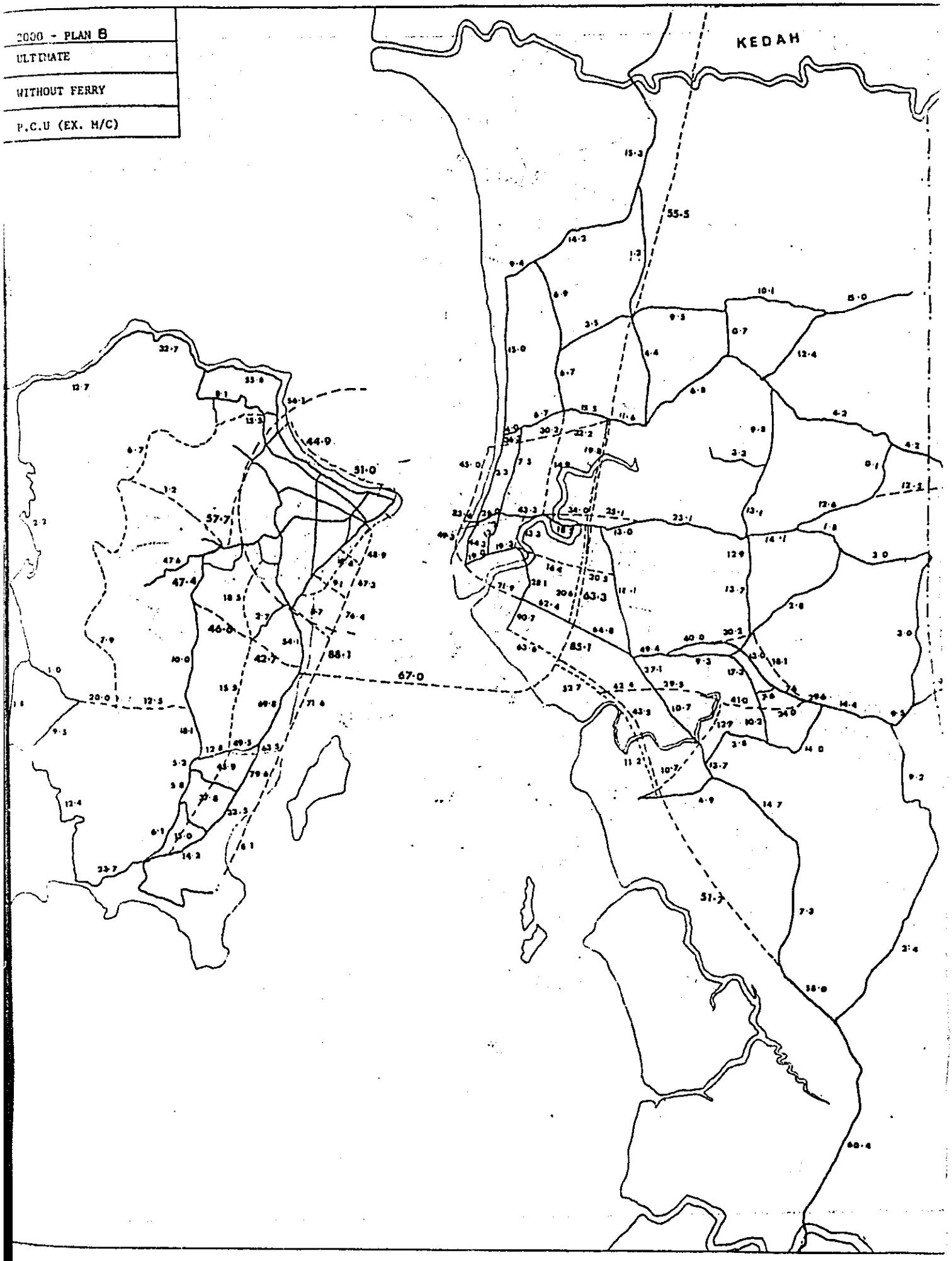

2000 - PLAN B
ULTIMATE
TANJONG TOKONG
GEORGE TOWN
RACE COURSE
AIR ITAM
JELUTONG
Inner Cordon
281·6
Outer Cordon
400·0

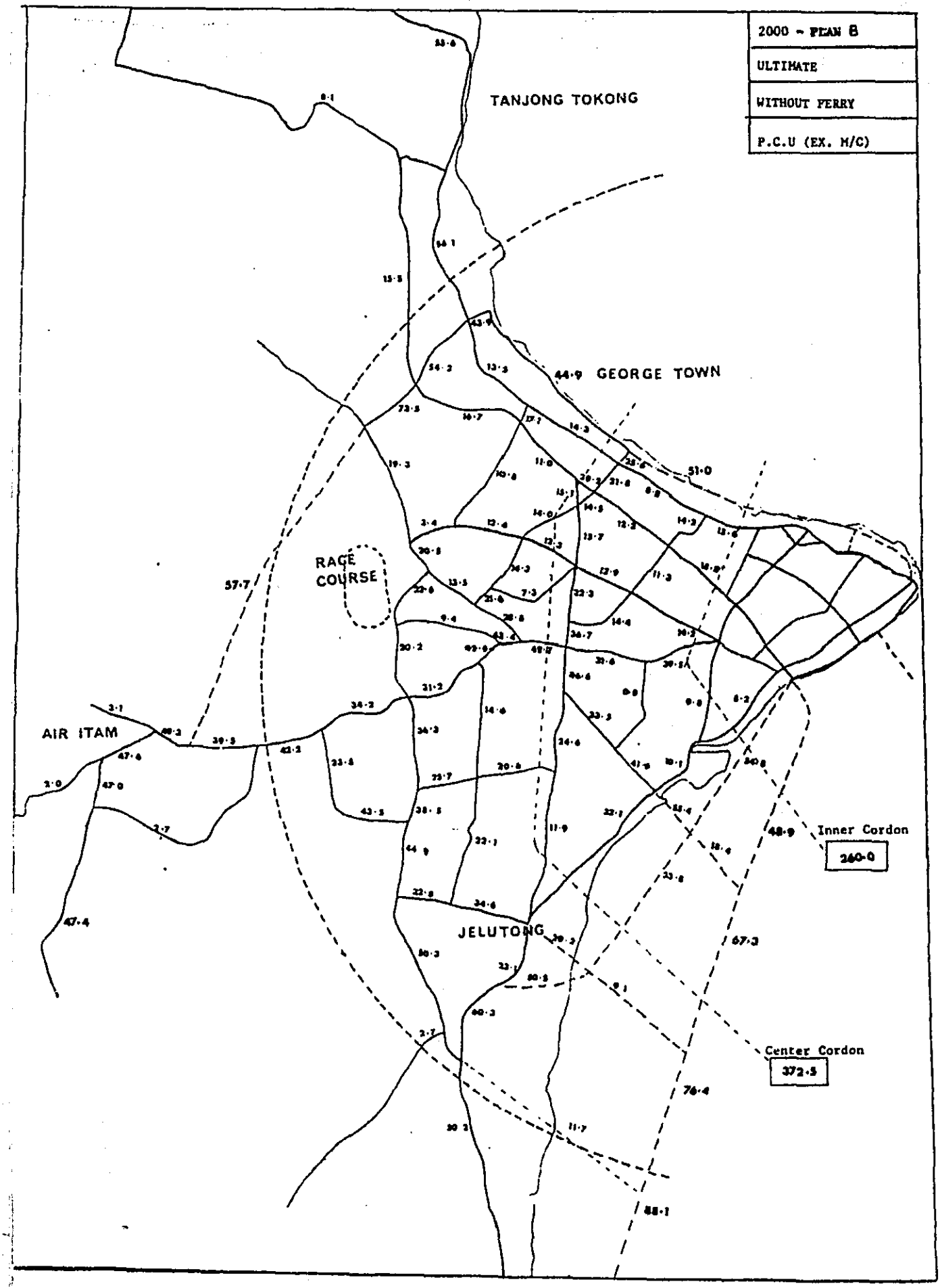

KEDAH

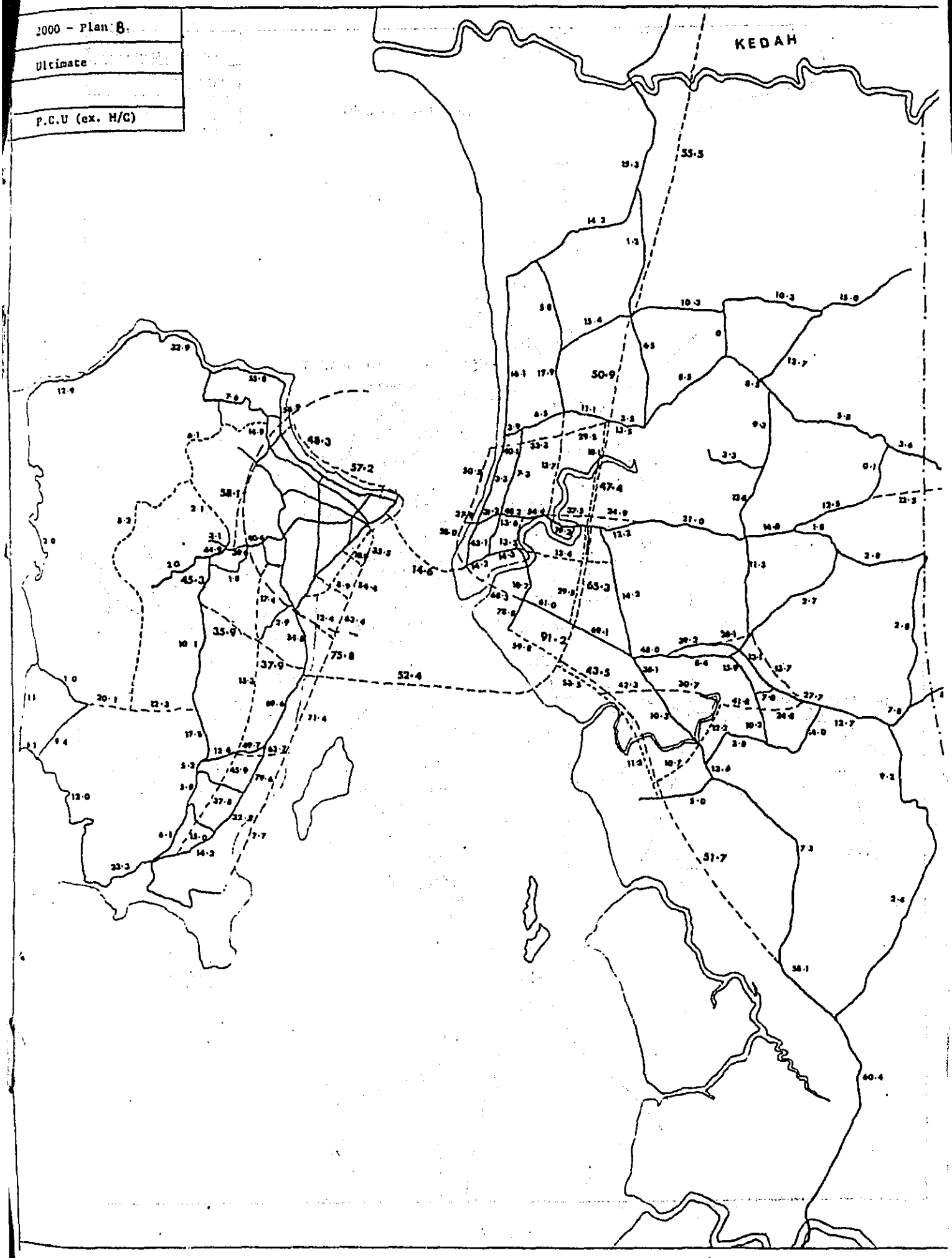

2000 - PLAN C
ULTIMATE
TANJONG TOKONG
GEORGE TOWN
RACE COURSE
AIR ITAM
JELUTONG
Inner Cordon
274.0
Center Cordon
393.8

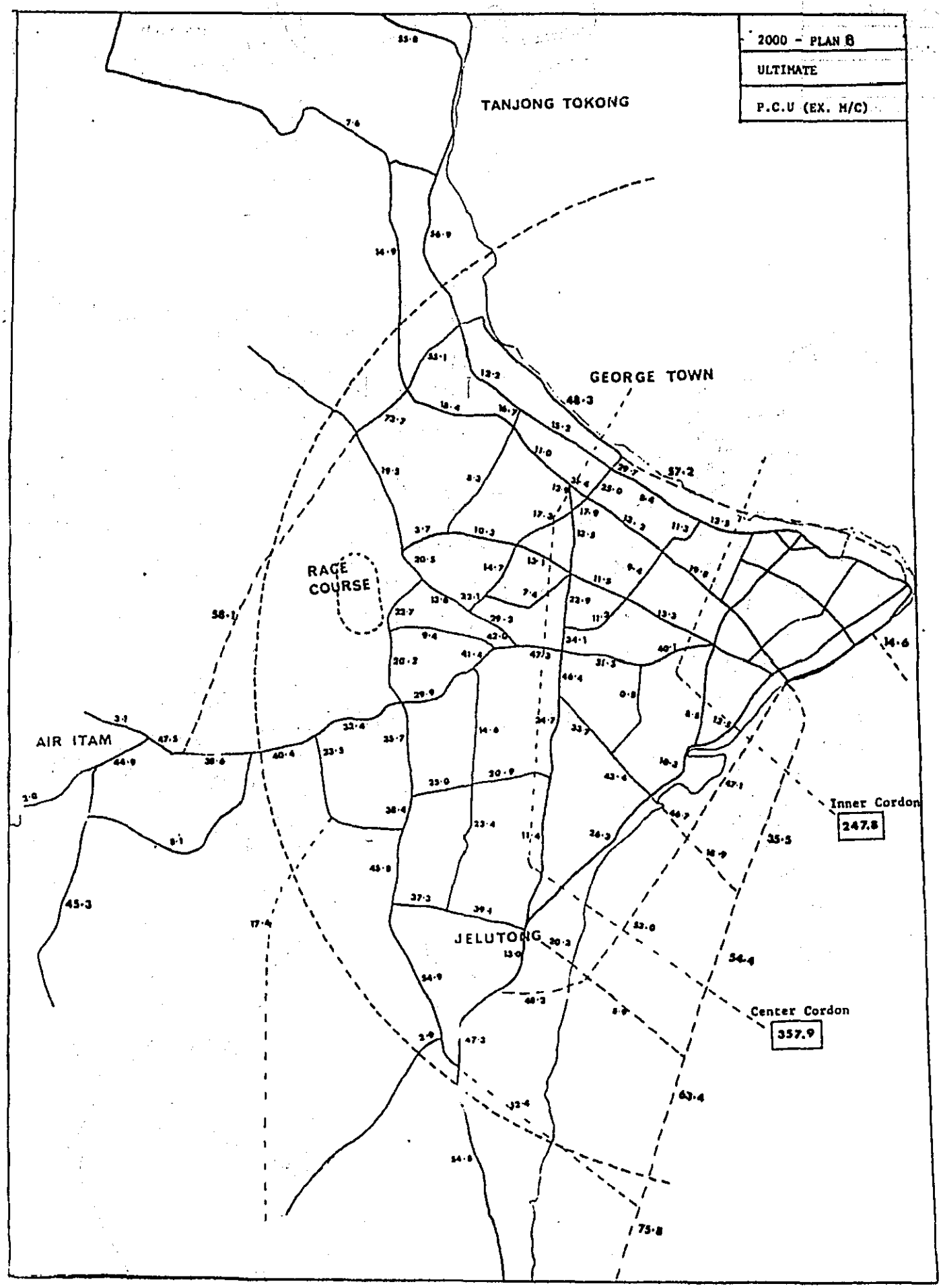

000 - PLAN D
LTIMATE
KEDAH
59.0
54.7
53.7
45.0
45.8
56.7
40.1
37.7
55.7
53.4
63.0
60.2


2000 - PLAN D
ULTIMATE
TANJONG TOKONG
GEORGE TOWN
RACE COURSE
AIR ITAM
JELUTONG
Inner Cordon
235.3
Center Cordon
337.2


2000 - PLAN B
ULTIMATE
WITHOUT FERRY
P.C.U (EX. M/C)
KEDAH


2000 - PLAN B
ULTIMATE
WITHOUT FERRY
P.C.U (EX. M/C)
TANJONG TOKONG
GEORGE TOWN
RACE COURSE
AIR ITAM
JELUTONG
Inner Cordon
260·0
Center Cordon
372·5


2000 - Plan B
Ultimate
P.C.U (ex. H/C)
KEDAH


2000 - PLAN 8
ULTIMATE
P.C.U (EX. H/C)
TANJONG TOKONG
GEORGE TOWN
RACE COURSE
AIR ITAM
JELUTONG
Inner Cordon
247.8
Center Cordon
357.9