

**URBAN TRANSPORT STUDY
IN
GREATER METROPOLITAN AREAS
OF
GEORGE TOWN, BUTTERWORTH AND BUKIT MERTAJAM
MALAYSIA**

**TRAFFIC ENGINEERING AND
MANAGEMENT STUDY
(EXISTING CONDITIONS)**

TECHNICAL REPORT - 15



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TRAFFIC ENGINEERING AND MANAGEMENT STUDY (EXISTING CONDITIONS)

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1. Existing Road Conditions

1.1 Street Network

a) Street network in George Town

The main streets which form the street network of George Town are illustrated in Fig. 1. In the north is Jalan Northam into which Gurney Drive and Jalan Kelawai merge. Jalan Burmah also runs along the north. From the west runs Jalan Macalister, and also Jalan Ayer Itam which passes through Green Lane. From the south Jalan Jelutong and Jalan Perak run into the Central Business District (C.B.D).

The main arterial streets forming the C.B.D street network are Penang Road, Leboh Light, Weld Quay, Leboh Pantai, Bridge Street and Jalan Brick Kiln. Some of these streets are designated as one-way streets to facilitate traffic circulation in the C.B.D.

The road network pattern is irregular as can be seen in the discontinuity of the streets, the skewed angles at which they often intersect and the presence of intersections which have more than four legs. Also, there are small roundabouts, most of which operate without signals.

b) Street network in Butterworth

The main streets which form the street network of Butterworth are illustrated in Fig. 2. Jalan Bagan Luar runs northwards along the coast and merge into Jalan Kampong Gajah. In the south New Chain Ferry Road merge into Chain Ferry Road. Jalan Assumption, Jalan Sungai Nyior, Jalan Siram and Jalan Raja Uda run into each other to form one road running parallel to Jalan Bagan Luar. North of New Chain Ferry Road is Jalan Telaga Ayer which merge into Jalan Permatang Pauh.

The main arterial streets forming the central area network are Jalan Bagan Luar, Jalan Telaga Ayer, Jalan Siram, Jalan Sungai Nyior and New Chain Ferry Road.

The road network is patterned like a ladder in the north and irregular in the south. However, only 3 intersections are signalized at this moment.

c) Street network in Bukit Mertajam

The main streets which form the street network of Bukit Mertajam are illustrated in Fig. 3. Jalan Arumugam Pillai

runs through the central area. Jalan Muthupalaniapa joins Jalan Besar from the south-east.

The arterial streets forming the central area street network are Jalan Arumugam Pillai, Jalan Besar and Jalan Aston. Jalan Besar and Jalan Aston are one-way streets which circulate traffic in the central area.

1.2 Width of the Right of Way

The right of way of the primary roads and district roads which form the city street network ranges from 40' to 100' in width (with existing carriageways ranging in width from 22' to 40') as illustrated in Fig. 4 to 6. The figures along the road links denote the width of the right of way of the road links. Most of them in George Town fall within 66' to 74', though those of Jalan Ayer Itam and Jalan Kelawei are 100' wide. In Butterworth, Jalan Bagan Luar is 66' wide, New Ferry Road is 74' wide and Jalan Telaga Ayer is 66' wide. In Bukit Mertajam Jalan Arumugam Pillai is 40' wide, Jalan Muthupalaniapa is 66' wide and Jalan Besar is 40' wide.

Right of ways ranging from 66' to 74' can at the most accomodate two lane-carriageways, which are the passageways for cars, footpaths and shoulders which provide spaces for bus stops, bicycles and trishaw passages as well as for parking.

1.3 Number of Lanes

As mentioned in 1.2 above, the number of lanes allocated for the passage of vehicles is mostly 2 lanes except for a few streets, like for example, Jalan Ayer Itam and Weld Quay in George Town and Jalan Bagan Luar in Butterworth. In some intersection approaches additional lanes for turning to the right are provided. Center markings with broken lines are always drawn, but continuous lines for side markings bordering shoulders which are seen in other countries are seldom seen here except along the one-way street of Penang Road.

1.4 Pavement

Most of the main streets inside the city are paved with asphalt concrete. Drainage channels between pavement and footpaths are mostly covered so that extra pavement spaces are available for traffic. However, open drains which are detrimental

to the safe and smooth flow of traffic can be seen in some places.

1.5

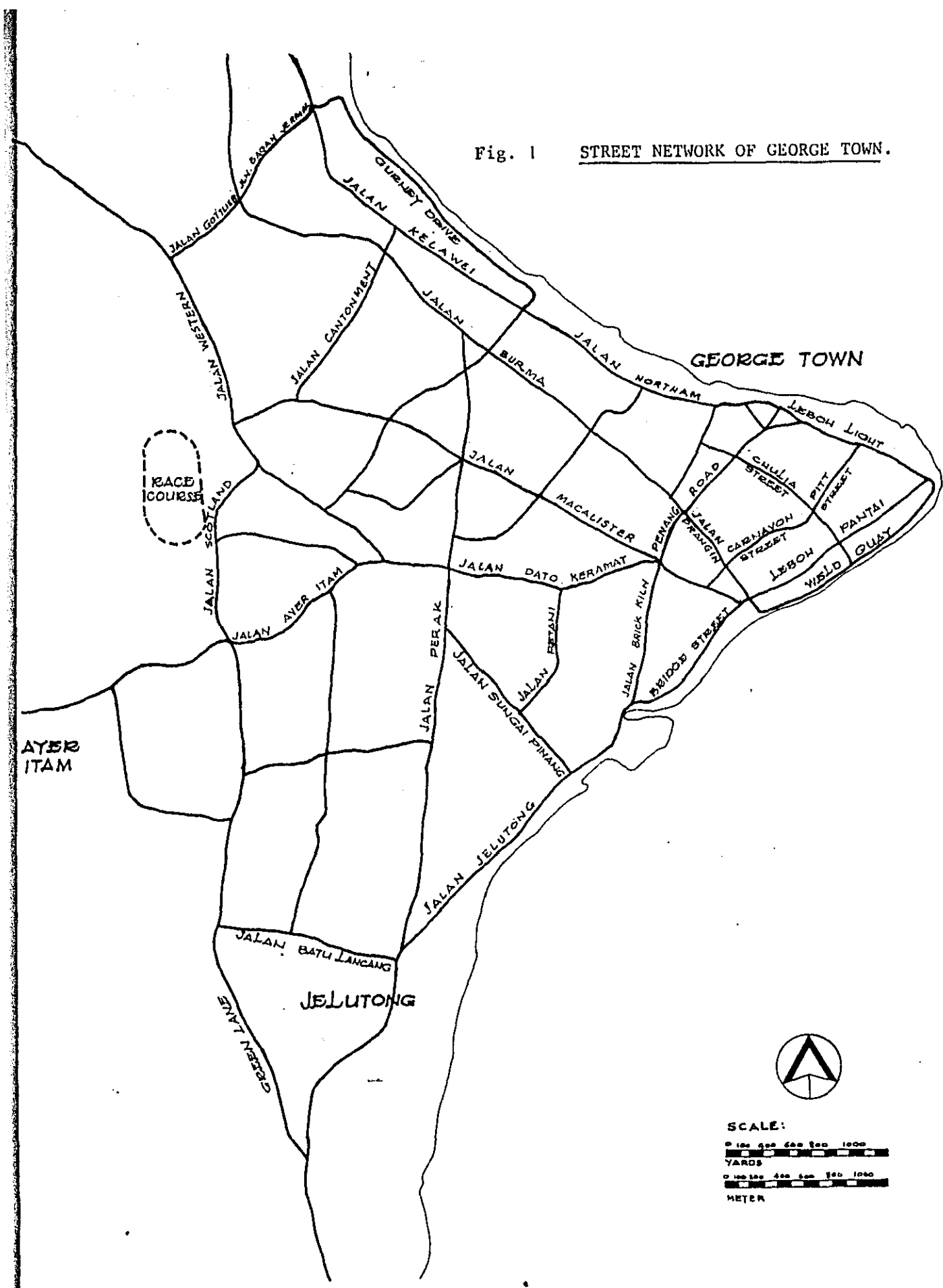
Intersection Geometric

Small dividing islands are installed on the approaches of intersections. These islands provide the pedestrians with safe walking space and help drivers delineate their way. Yellow globe flashings are installed on some islands.

At "T" intersections where one-way streets join with two-way streets, channelizing islands are so well installed that the points where traffic merge and the points where they diverge are well spaced out. This allows smooth traffic flow without the need for traffic signals. The roundabouts with small islands of about 20m to 30m in diameter are often seen. These movements, would be most effective if they have more than four legs and each leg carries relatively light traffic. However, we doubt the effectiveness of roundabouts which have very heavy traffic and where traffic intersects. Anyway, the traffic flow at the roundabout has to be examined first before it can be compared to the traffic flow with traffic signals. At most of the intersection approaches where space permits, additional clear marking are drawn for turnings to the right and/or left.

Typical layouts of intersection geometries are illustrated in Fig. 7.

Fig. 1 STREET NETWORK OF GEORGE TOWN.



SCALE:
 0 100 200 300 400 500 1000
 YARDS
 0 100 200 300 400 500 1000
 METERS

FIG. 2 STREET NETWORK OF BUTTERWORTH

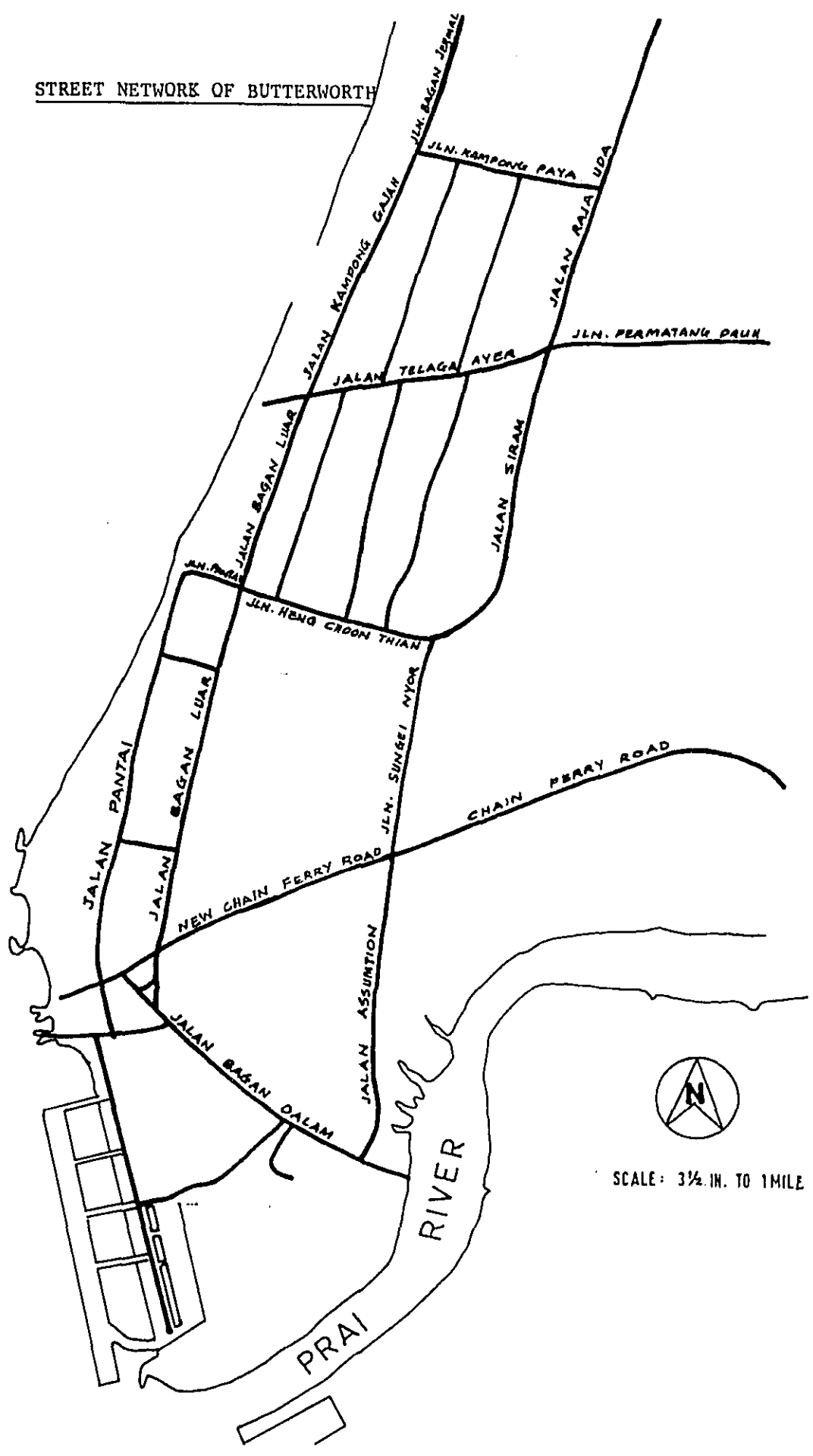


FIG. 3. STREET NETWORK OF BUKIT MERTAJAM.

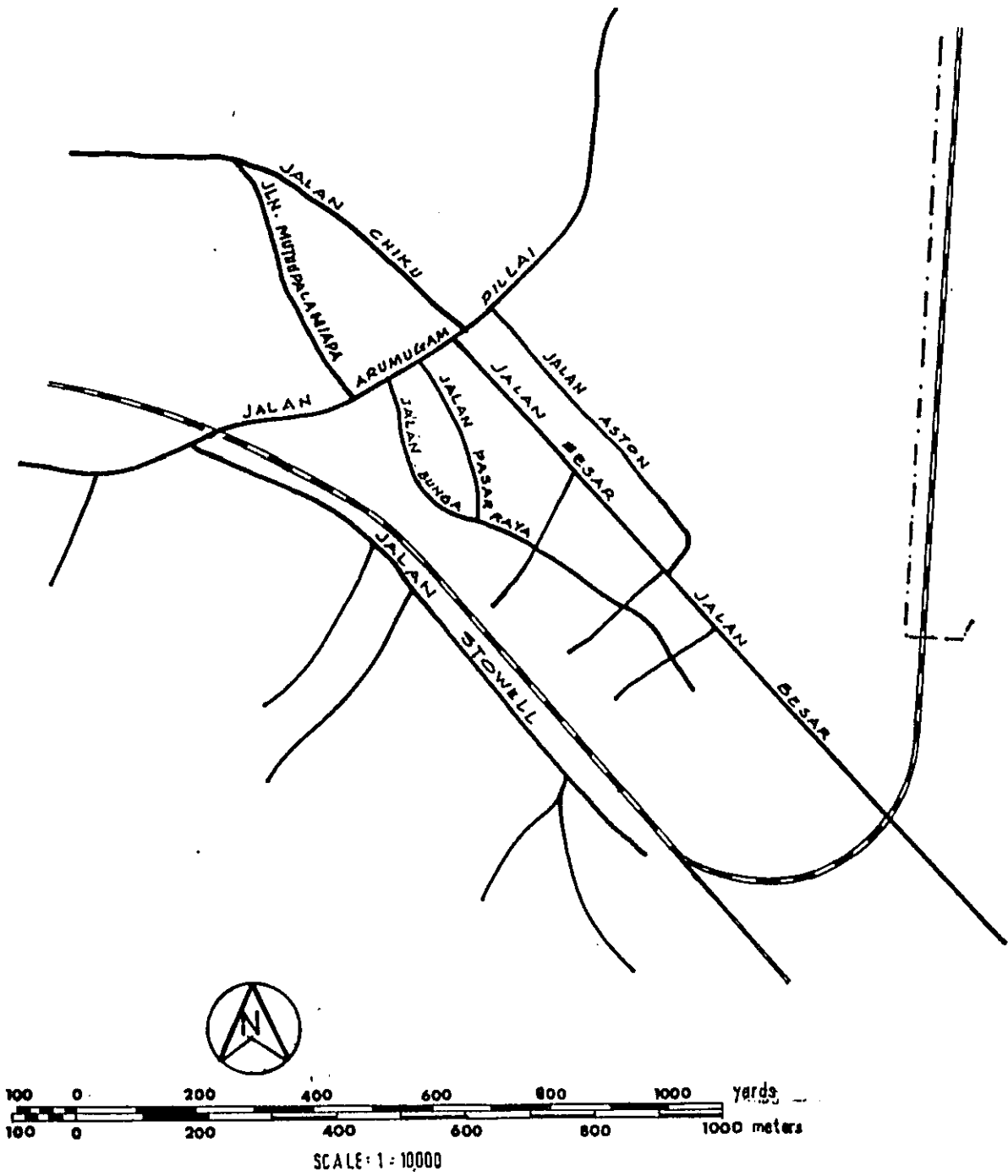


FIG. 4 THE RIGHT OF WAY OF THE PRIMARY ROADS AND DISTRICT ROAD OF GEORGE TOWN.

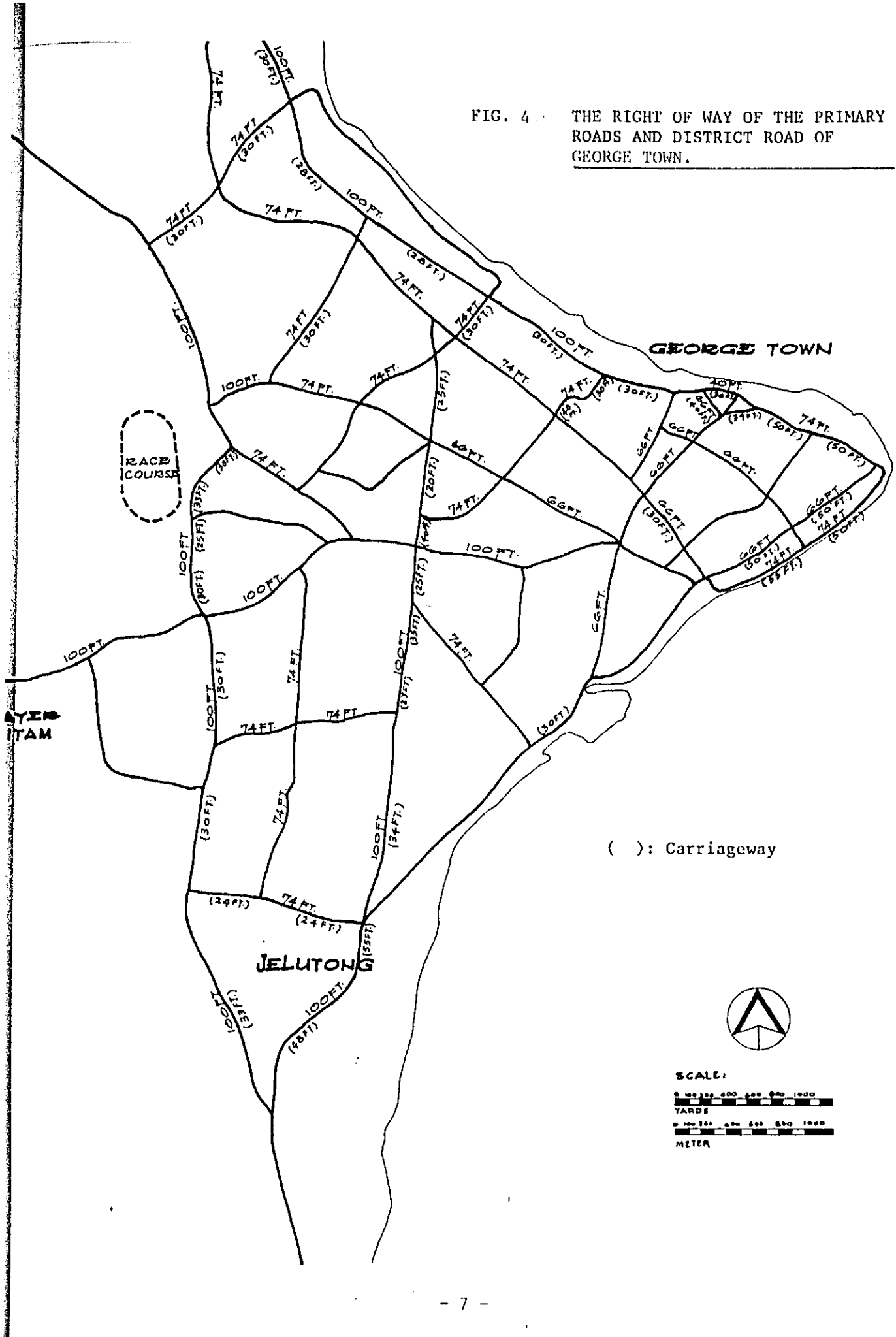
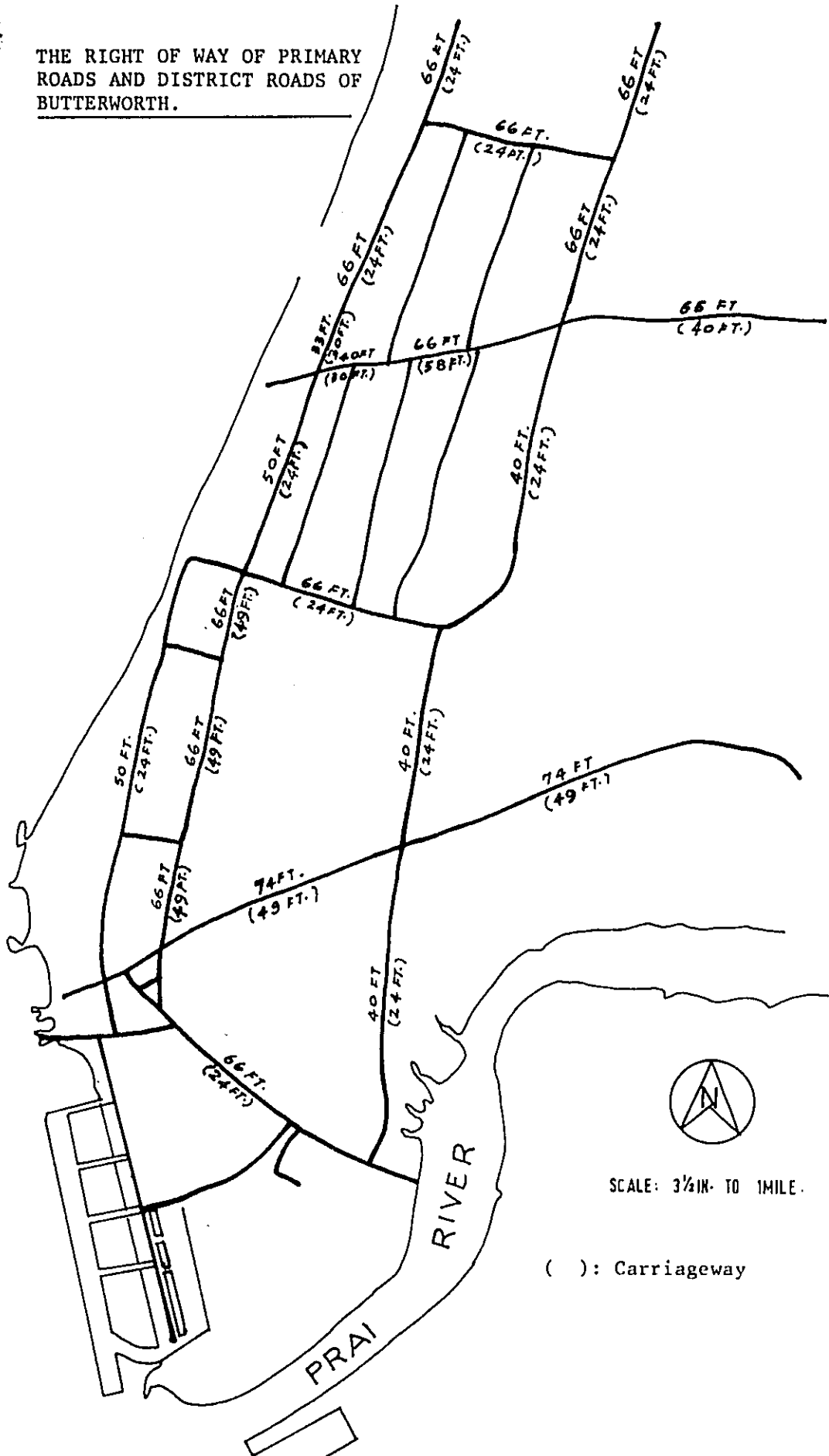


FIG. 5

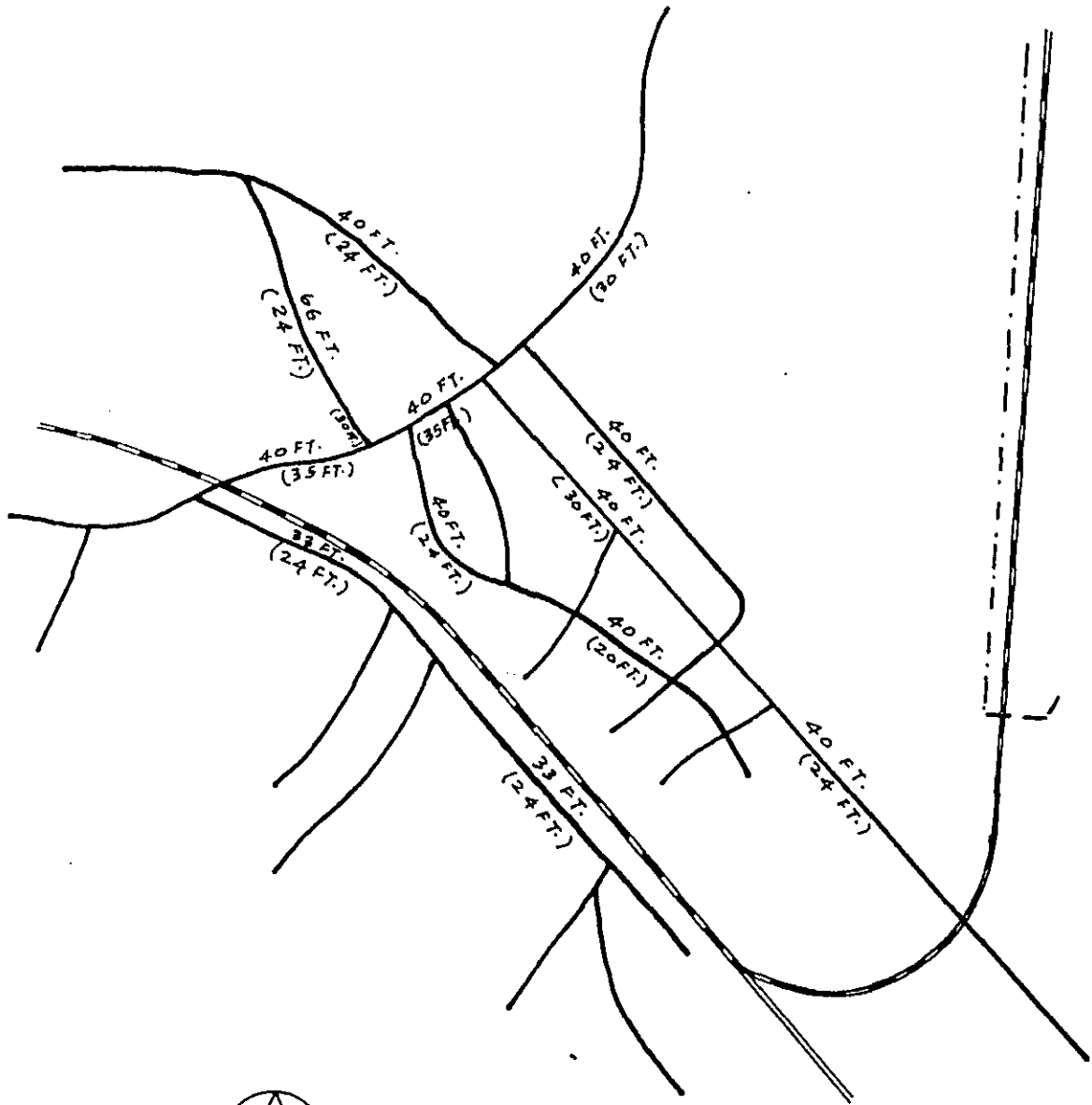
THE RIGHT OF WAY OF PRIMARY
ROADS AND DISTRICT ROADS OF
BUTTERWORTH.



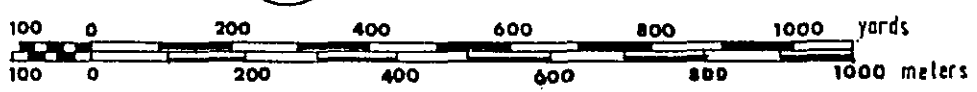
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(): Carriageway

Fig. 6 THE RIGHT OF WAY OF PRIMARY ROADS AND DISTRICT ROADS OF BUKIT MERTAJAM



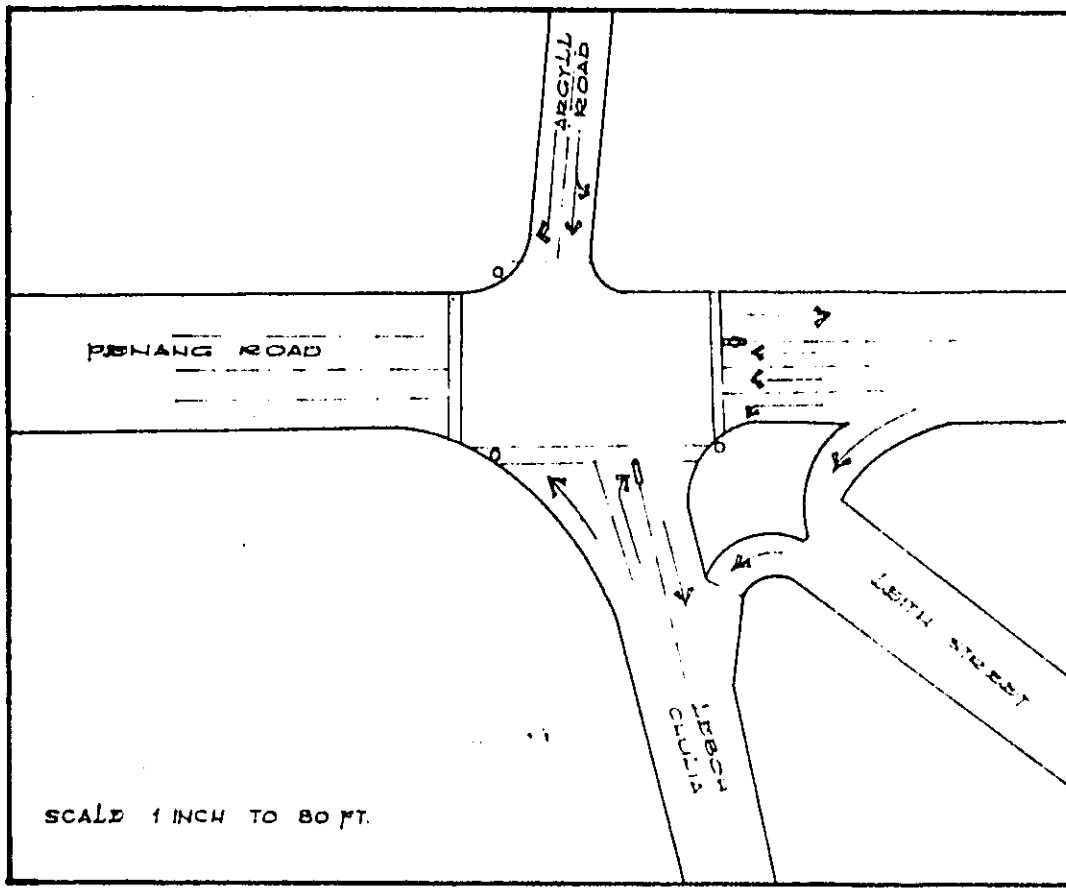
(): Carriageway



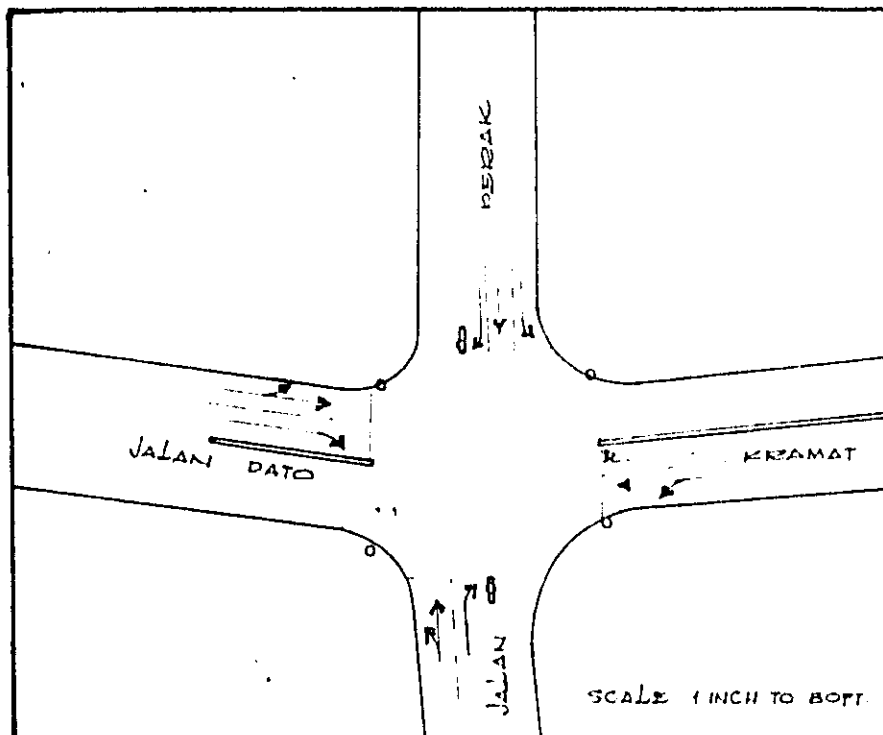
SCALE: 1:10,000

FIG. 7 : TYPICAL LAYOUT OF INTERSECTION

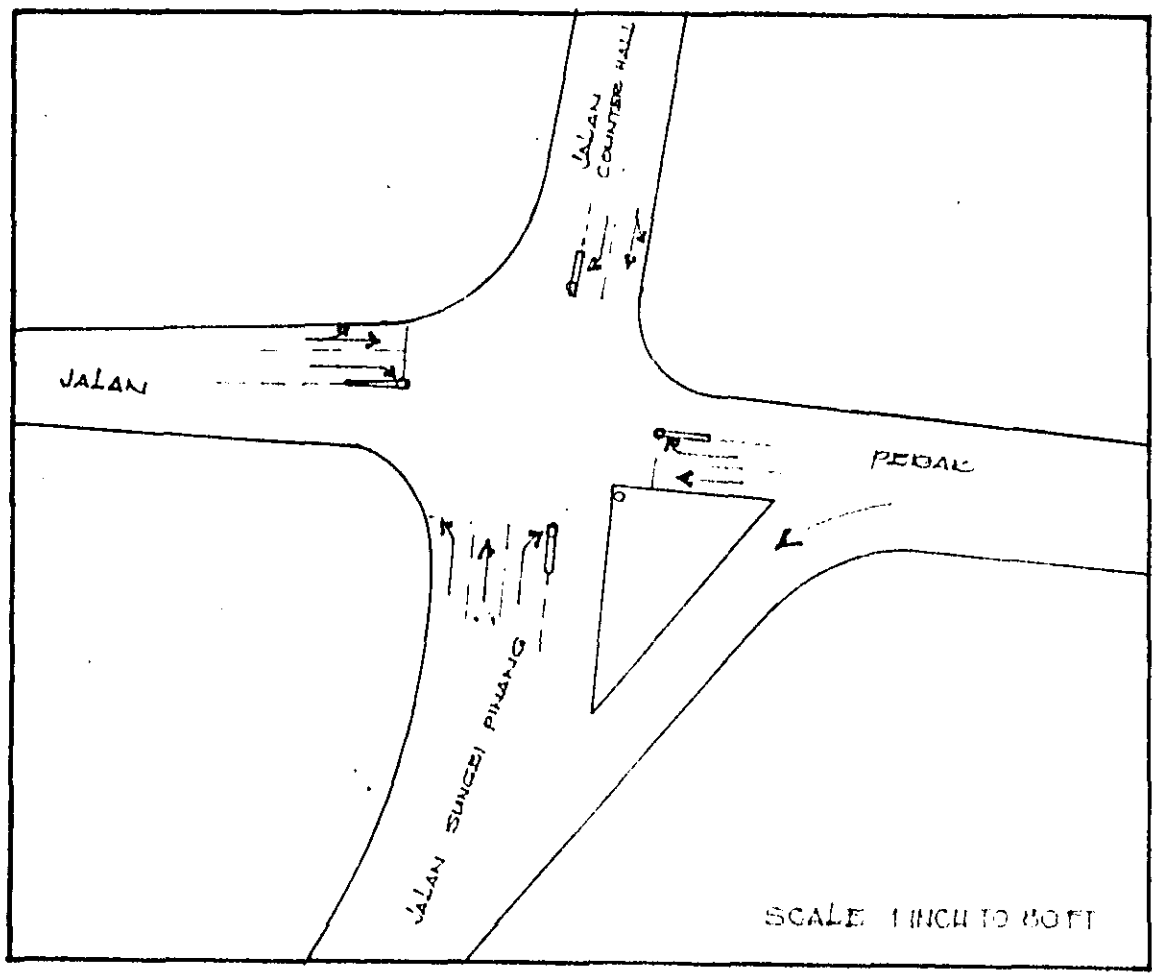
PERAK ROAD / ARGYLL ROAD/ CHULIA STREET / LEITH STREET (George Town)



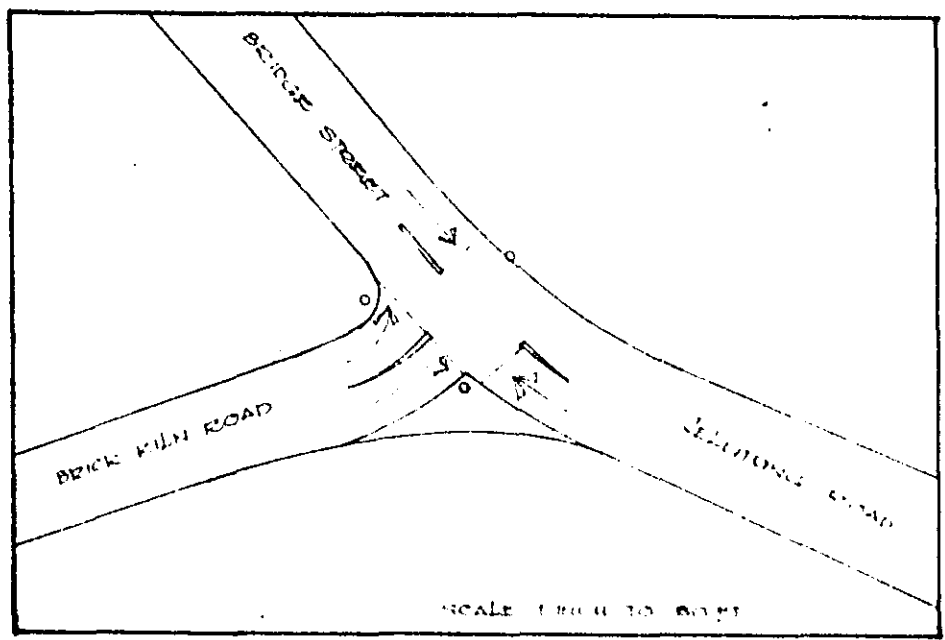
DATO KRAMAT ROAD / PERAK ROAD (George Town)



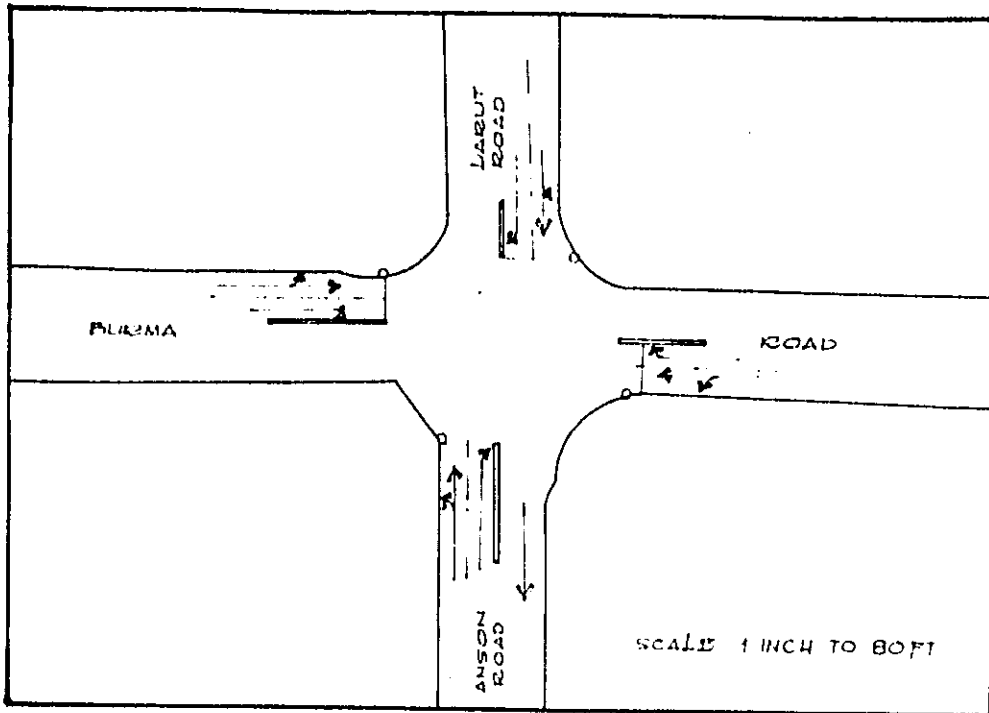
PERAK ROAD / SUNGEI PINANG ROAD / COUNTER HALL (George Town)



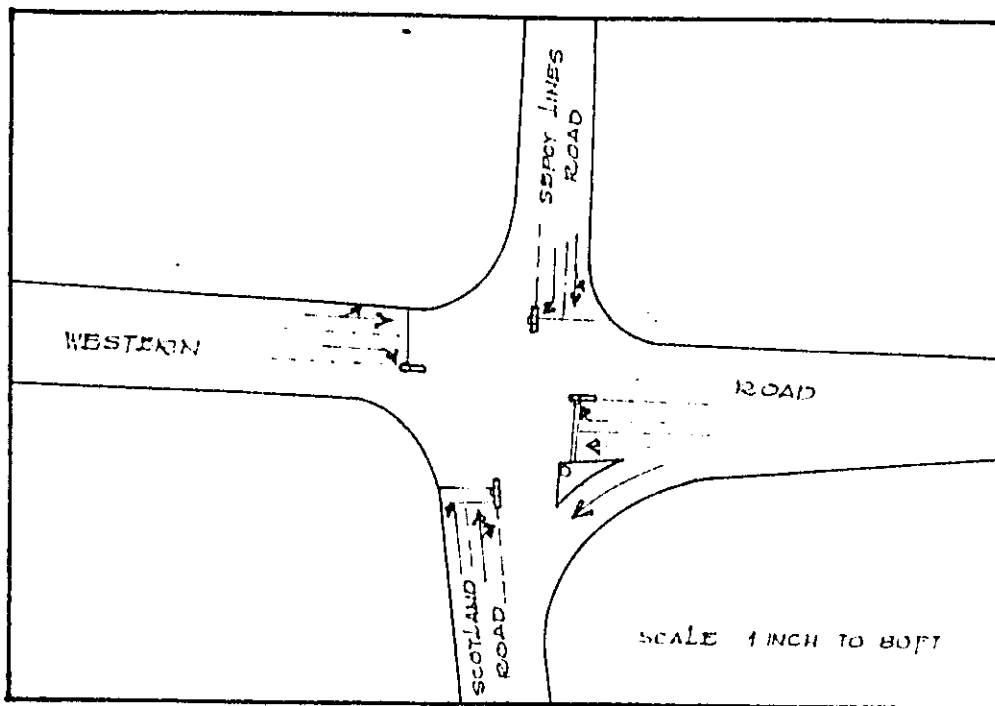
BRICK KILN ROAD / JELUTONG ROAD / BRIDGE STREET (George Town)



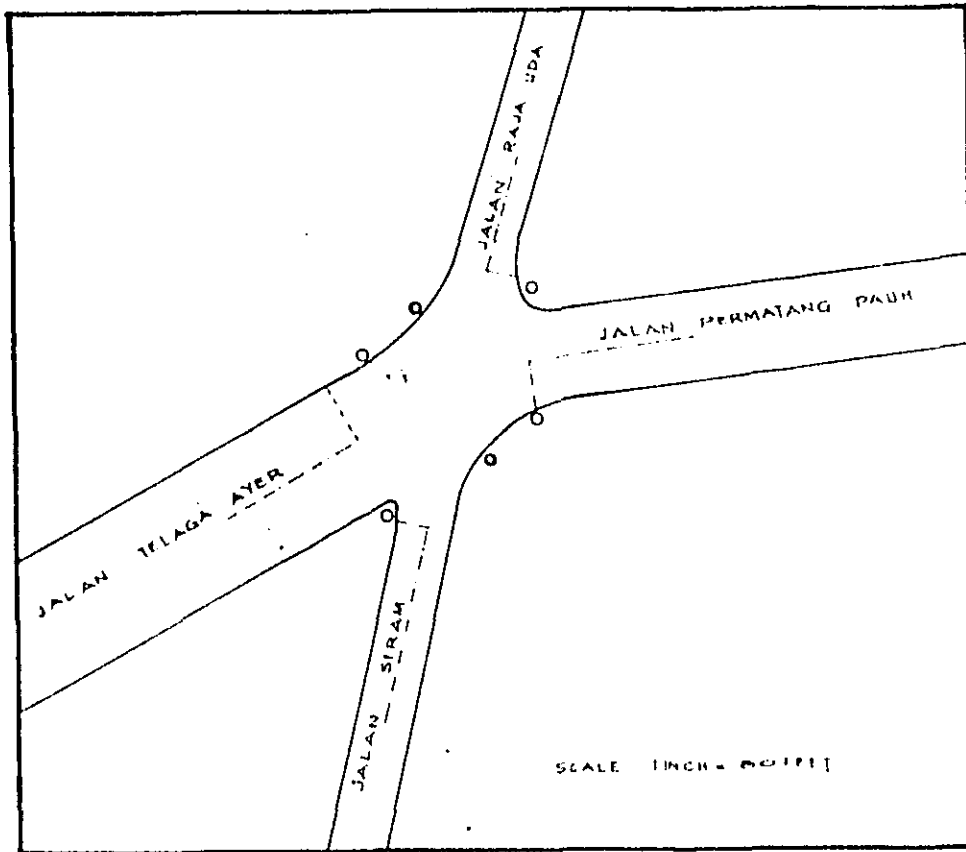
BURMA ROAD / ANSON ROAD / RALUT ROAD (George Town)



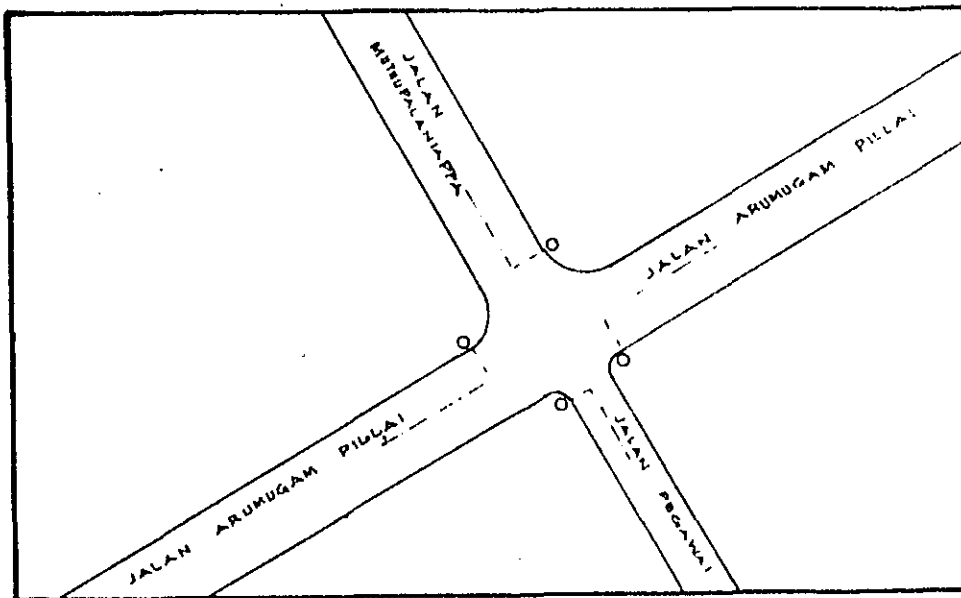
SCOTLAND ROAD / WESTERN ROAD / SEPOY LINES ROAD (George Town)



TELAGA AYER ROAD / PERMATANG PAUH ROAD / SIRAM ROAD / RAJA UDA ROAD
(Butterworth)



ARUMUGAM PILLAI ROAD / MUTHUPALANIAPA ROAD / JALAN PEGAWAI
(Bukit Mertajam)



Existing Traffic ConditionsTraffic Volume on Road Network

The daily traffic volume of cars on the road network of George Town, Butterworth and Bukit Mertajam are illustrated in Fig. 8 to 10. The traffic volume is estimated by the consultants on the basis of the data from the "George Town Intersection Traffic Study" conducted by the Municipal Council, 1977 and from the "Traffic counting survey" which is related to the O-D study.

In George Town, most of the traffic which goes to the C.B.D. from the west often use Jalan Northam which has a higher capacity and this road also avoids the congested areas like Magazine Circus which is always congested during peak hours. The traffic volume illustrated does not always reflect the desired lines which show the shortest routes from origin to destination. It is because on the way to the C.B.D. there are bottlenecks at the Magazine Circus as mentioned above, Jalan Brick Kiln/Bridge Street and Jalan Ayer Itam/Green Lane.

In Butterworth, the main traffic flow is on Jalan Bagan Luar, Jalan Kampong Gajah, New Chain Ferry Road and Chain Ferry Road, and they concentrate to the Ferry Terminal. However, the traffic moving between north and south might use Jalan Sungai Nyior, Jalan Siram and Jalan Raja Uda to avoid traffic congestion in the central area.

In Bukit Mertajam, most of the traffic converge at Jalan Arumugam Pillai from all directions and this is the most congested road in this area, more so during peak hours.

Turn Movement Flow at Major Intersections

Turn movement flow at some major intersections in George Town, Butterworth and Bukit Mertajam is illustrated in Fig. 11.

The traffic circulation in George Town is not simple because one-way streets are common, street network pattern is irregular and also diversion of traffic from congested intersection occurs. So, turn movement flow at intersections has some specific features which reflect the circulation pattern.

On the other hand, traffic circulation in Butterworth and Bukit Mertajam is rather simple, therefore, turn movement flows at intersections are also simple.

2.3 The Fluctuation of Traffic Volume

The hourly fluctuations of incoming traffic volume at cordon counting stations in George Town and traffic counting stations in Butterworth and Bukit Mertajam are illustrated in Fig. 12 and 13. The figures used for the graphs for George Town are from the "City of George Town Traffic Study" report by Ove Arup & Partners, 1975 while that for Butterworth and Bukit Mertajam are from the JKR traffic census data in 1978.

Peak hour traffic in George Town was recorded from 7.00 - 8.00 a.m. for incoming traffic and from 4.00 - 5.00 p.m. for outgoing traffic. Generally, peak hour concentration is high in the morning and evening on roads which carry commuting traffic but low in the daytime due to only a few business trips. However, in Butterworth peak hour for outgoing traffic is from 11.00 a.m - 12.00 noon which means there is a high percentage of business trips in the daytime. In Bukit Mertajam, peak hour traffic for both directions is in the evening which means there is very few commuting traffic in this area.

The concentration rates are as follows:-

George Town

Jalan Jelutong	incoming	11.3%	
	outgoing	12.1%	
Jalan Dato Keramat	incoming	9.9%	
	outgoing	14.1%	
Jalan Macalister	incoming	8.8%	
	outgoing	10.6%	
Jalan Burmah	incoming	9.2%	
	outgoing	11.2%	
Jalan Argyll	incoming	11.4%	one way
Jalan Northam	incoming	12.8%	
	outgoing	13.6%	
Total in all stations	incoming	9.9%	
	outgoing	11.8%	

Butterworth

Jalan Bagan Luar	incoming	9.6%
	outgoing	9.4%

Bukit Mertajam

Jalan Besar incoming 9.7%
outgoing 10.1%

(The concentration rate is defined as $\frac{\text{Peak hour volume}}{15 \text{ hour volume}}$)

2.4 Traffic Composition

Traffic composition of the selected intersections are tabulated in Table 1.

The number of cars and motorcycles predominate, taking up about 60% to 70% of the traffic volume while big trucks and buses together contribute to about only 3% of the volume. At some intersections, motorcycles exceed cars in number. Bicycles and trishaws together make up more than 20% of the traffic volume in the Central area.

Table 1 TRAFFIC COMPOSITION OF THE SELECTED INTERSECTIONS

INTERSECTION		BICYCLE	TRISHAW	M/CYCLE	CAR	LOHRT	BIG TRUCK & BUS	TOTAL
George Town								
Green Lane-Jalan Batu Lintang	Morning	882 (21.0%)	50 (1.3%)	1,210 (29.0%)	1,745 (42.7%)	155 (3.8%)	43 (1.0%)	4,085 (100%)
"	Evening	540 (12.1%)	53 (1.2%)	1,327 (29.6%)	2,281 (51.2%)	162 (3.7%)	89 (2.0%)	4,452 (100%)
Jalan Dato Keramat-Jalan Perak	Morning	994 (18.1%)	184 (3.3%)	2,478 (45.1%)	1,601 (29.1%)	92 (1.7%)	146 (2.7%)	5,395 (100%)
"	Evening	1,761 (21.2%)	313 (3.8%)	3,676 (44.4%)	2,243 (27.1%)	166 (2.0%)	128 (1.5%)	8,287 (100%)
Magnaine Circus	Morning	812 (18.3%)	252 (5.6%)	2,043 (46.0%)	1,054 (23.7%)	57 (1.3%)	226 (5.1%)	4,444 (100%)
"	Evening	1,119 (19.4%)	441 (7.7%)	2,420 (42.0%)	1,540 (26.8%)	70 (1.2%)	165 (2.9%)	5,755 (100%)
Jalan Northam-Jalan Larut	Morning	242 (6.3%)	79 (0.8%)	1,162 (30.0%)	2,329 (60.2%)	35 (0.9%)	70 (1.8%)	3,847 (100%)
"	Evening	189 (4.9%)	21 (0.5%)	1,229 (31.7%)	2,390 (61.6%)	25 (0.6%)	27 (0.7%)	3,681 (100%)
Jalan Jelutong-Jalan Perak	Morning	568 (15.6%)	40 (1.1%)	1,727 (47.4%)	1,025 (28.1%)	122 (3.3%)	164 (4.5%)	3,644 (100%)
"	Evening	353 (10.9%)	26 (0.8%)	1,549 (47.7%)	1,047 (32.3%)	100 (3.1%)	169 (5.2%)	3,246 (100%)
Carmarvon Circus	Morning	461 (14.3%)	177 (5.5%)	1,602 (49.7%)	785 (24.4%)	72 (2.2%)	126 (3.9%)	3,233 (100%)
"	Evening	811 (18.9%)	298 (6.8%)	1,908 (43.6%)	1,157 (26.3%)	49 (1.1%)	154 (3.5%)	4,377 (100%)
Jalan Burma-Jalan Pangkor	Morning	150 (6.4%)	13 (0.4%)	867 (39.2%)	1,851 (82.3%)	31 (1.0%)	22 (0.7%)	2,969 (100%)
"	Evening	168 (5.9%)	14 (0.5%)	863 (30.6%)	1,660 (59.5%)	39 (1.4%)	59 (2.1%)	2,823 (100%)
Jalan Jelutong-Jalan Brick Kiln	Morning	577 (14.3%)	70 (1.7%)	1,853 (46.5%)	1,187 (29.8%)	65 (2.2%)	212 (5.3%)	3,562 (100%)
"	Evening	643 (16.7%)	58 (1.5%)	1,922 (48.4%)	1,062 (26.7%)	96 (2.4%)	190 (4.8%)	3,971 (100%)
Penang Road-Jalan Burma	Morning	658 (14.4%)	285 (6.2%)	1,812 (39.7%)	1,615 (35.3%)	40 (0.9%)	152 (3.5%)	4,562 (100%)
"	Evening	914 (14.3%)	453 (7.2%)	2,766 (43.9%)	1,977 (31.4%)	35 (0.5%)	151 (2.4%)	6,294 (100%)
Jalan Northam -Jalan Pangkor	Morning	190 (6.4%)	13 (0.4%)	867 (29.2%)	1,851 (62.3%)	31 (1.0%)	22 (0.7%)	2,969 (100%)
"	Evening	168 (5.9%)	14 (0.5%)	863 (30.6%)	1,660 (59.5%)	39 (1.4%)	59 (2.1%)	2,823 (100%)
Green Lane-Jalan Air Itar	Morning	1,433 (17.7%)		3,180 (39.3%)	3,049 (37.7%)	268 (3.3%)	163 (2.0%)	6,093 (100%)
"	Evening	307 (6.8%)		1,457 (32.8%)	2,302 (51.9%)	283 (6.4%)	95 (2.1%)	4,439 (100%)
Jalan Macalister-Jalan Perak	Morning	1,479 (18.8%)		2,498 (31.6%)	3,246 (41.3%)	466 (5.9%)	168 (2.2%)	7,857 (100%)
"	Evening	952 (13.9%)		2,416 (35.9%)	3,159 (46.0%)	203 (3.0%)	113 (1.6%)	6,863 (100%)
Penang Road-Laloh Chulia	Morning	464 (21.9%)		615 (30.9%)	831 (39.2%)	52 (2.5%)	126 (5.9%)	2,118 (100%)
"	Evening	526 (15.8%)		1,190 (35.7%)	1,460 (43.9%)	51 (1.9%)	102 (3.1%)	3,329 (100%)
Butterworth								
Chain Ferry Road-Jalan Sungai Nyior	Morning		531 (14.0%)	1,881 (49.6%)	991 (26.2%)	120 (3.2%)	265 (7.0%)	3,786 (100%)
"	Evening		326 (9.4%)	1,208 (34.9%)	1,463 (42.3%)	159 (4.6%)	303 (8.8%)	3,459 (100%)
Jalan Telaga Ayer-Jalan Sirim	Morning		797 (21.6%)	1,878 (51.0%)	709 (19.3%)	136 (3.7%)	163 (4.4%)	3,683 (100%)
"	Evening		347 (12.3%)	1,078 (38.6%)	962 (34.7%)	213 (7.7%)	125 (4.5%)	2,725 (100%)
Bukit Mertajam								
Jalan Arumama Pillai-Jalan Besar	Morning		832 (21.1%)	2,002 (52.9%)	754 (19.1%)	121 (3.1%)	149 (3.8%)	3,938 (100%)
"	Evening		501 (15.0%)	1,370 (43.7%)	1,008 (31.8%)	154 (4.8%)	139 (4.4%)	3,172 (100%)

Note: * George Town Intersection Traffic Study, 1977
** Intersection Survey by Study Team, 1979

FIG. 8 : EXISTING TRAFFIC VOLUME ON THE ROAD NETWORK OF GEORGE TOWN.

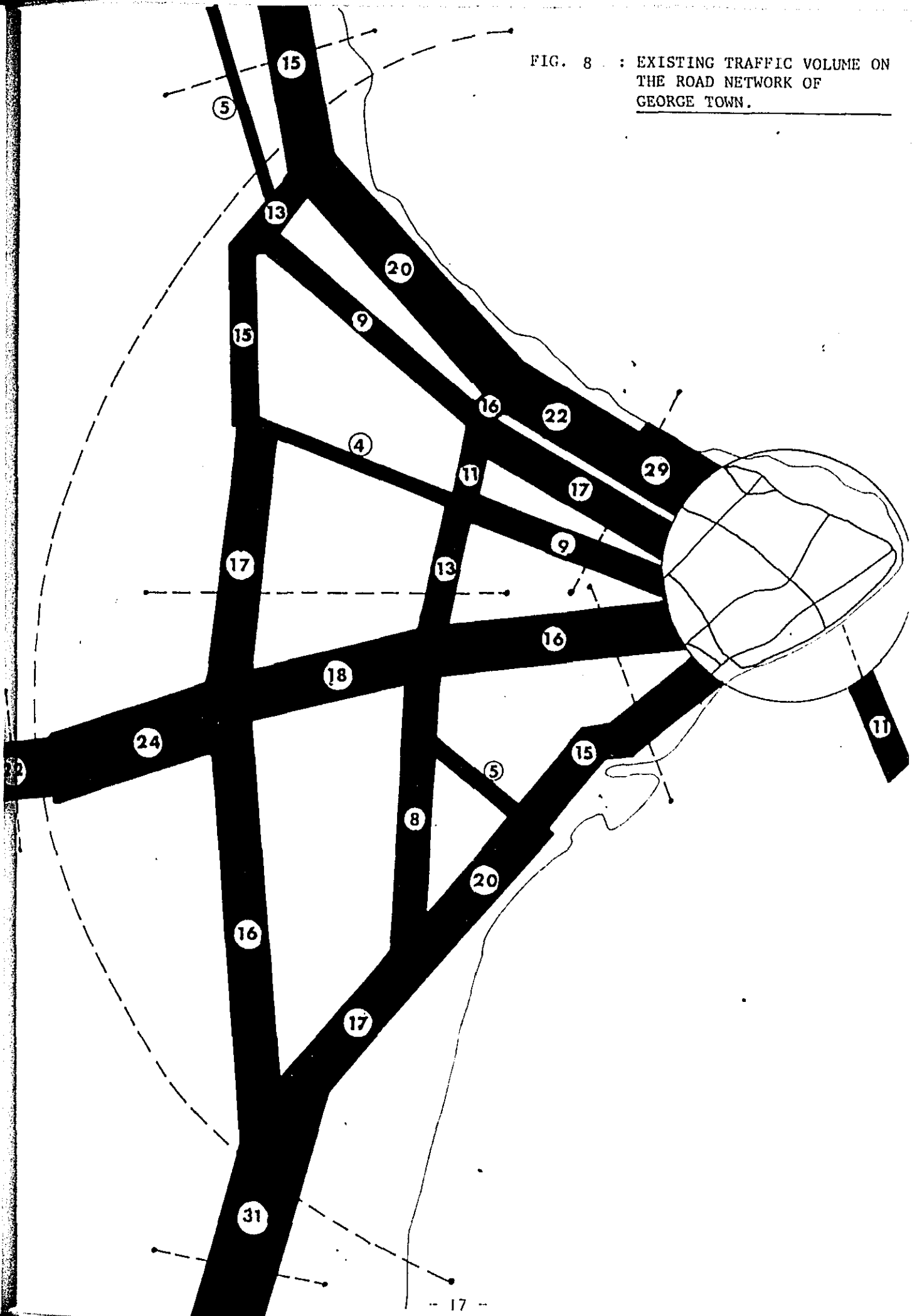
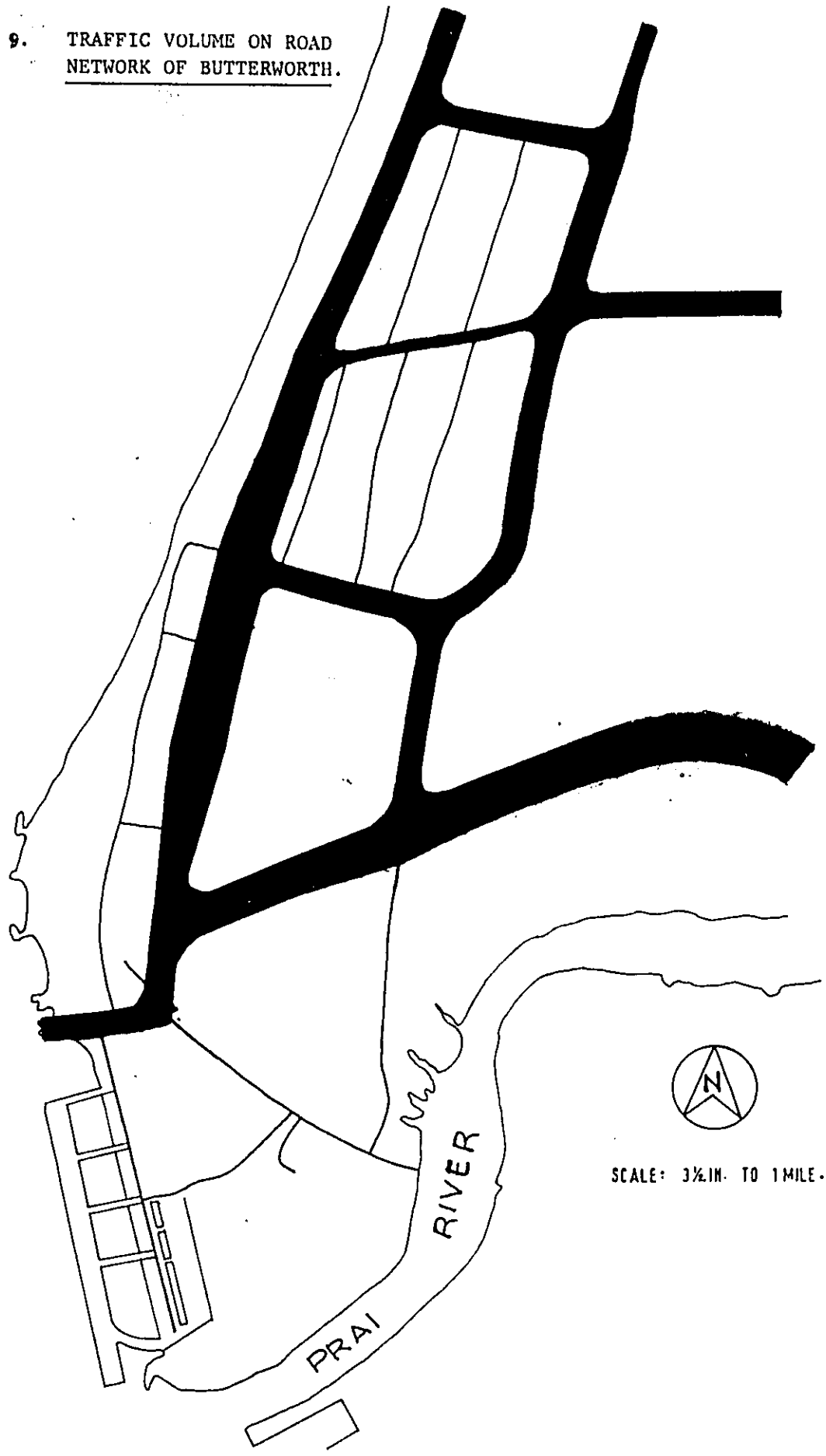


FIG. 9. TRAFFIC VOLUME ON ROAD NETWORK OF BUTTERWORTH.



SCALE: 3/4 IN. TO 1 MILE.

Fig. 10 TRAFFIC VOLUME ON ROAD NETWORK
OF BUKIT MERTA JAM

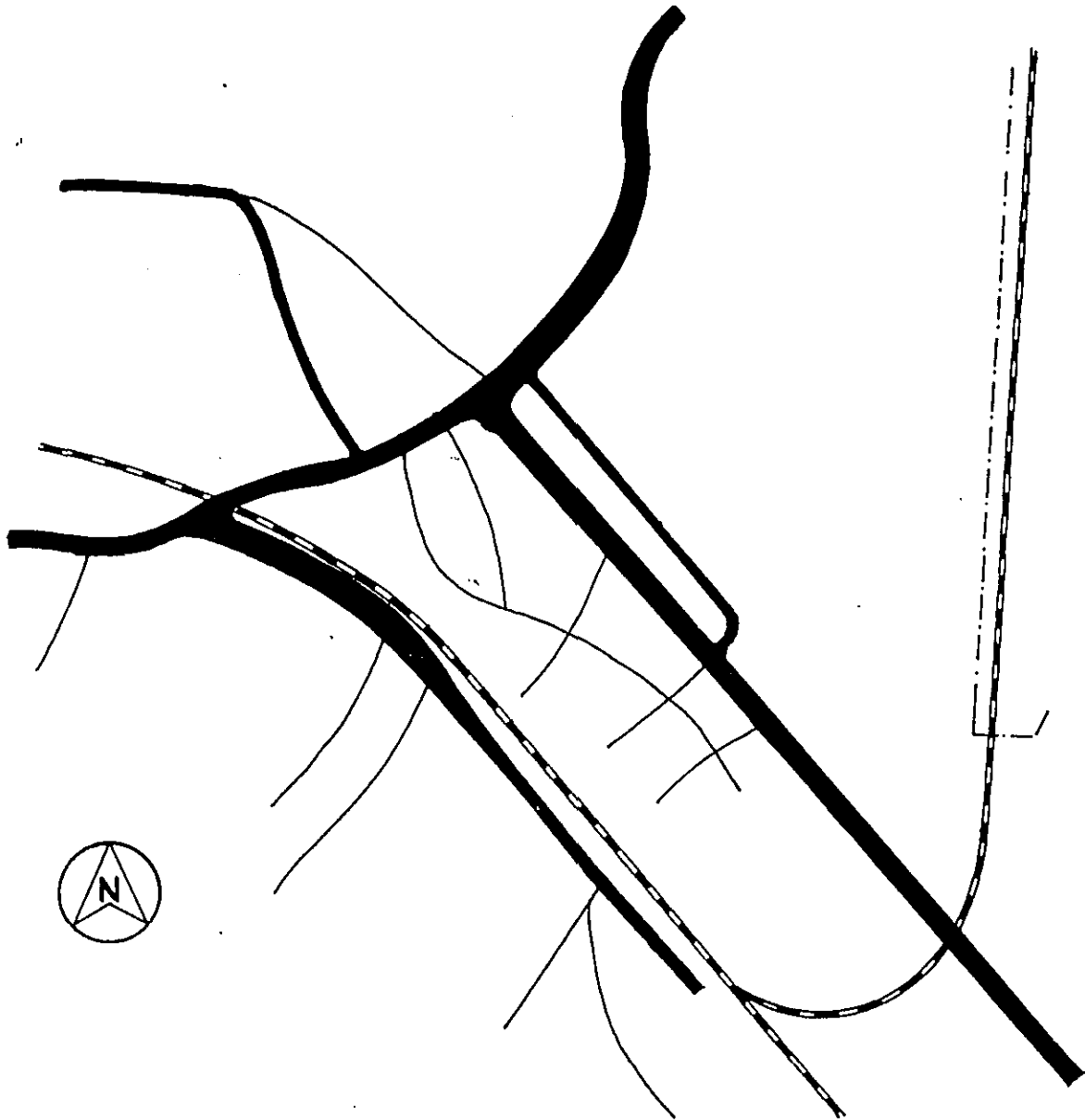
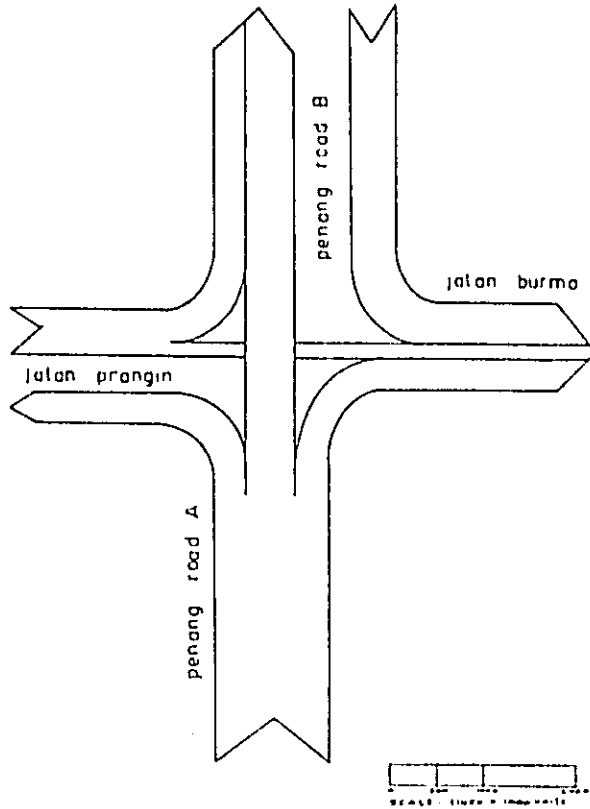
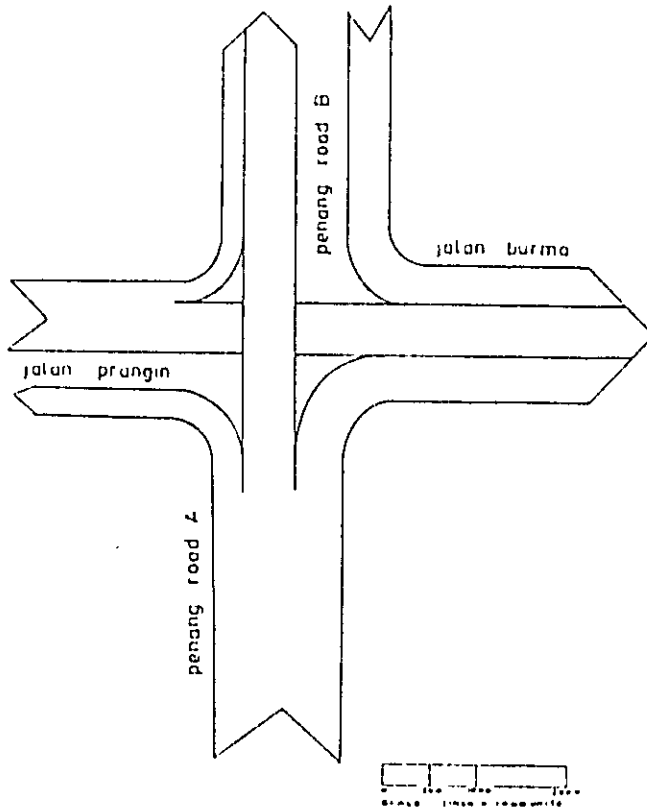


Fig. 11 TURN MOVEMENT FLOW AT MAJOR INTERSECTIONS

Penang Road/Jalan Burma/Jalan Prangin

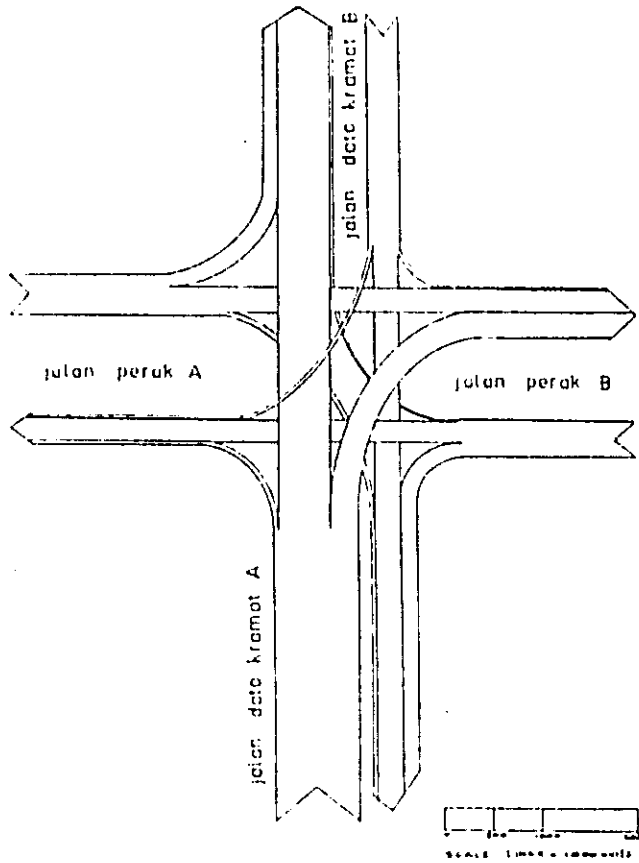


Vehicles (morning peak)

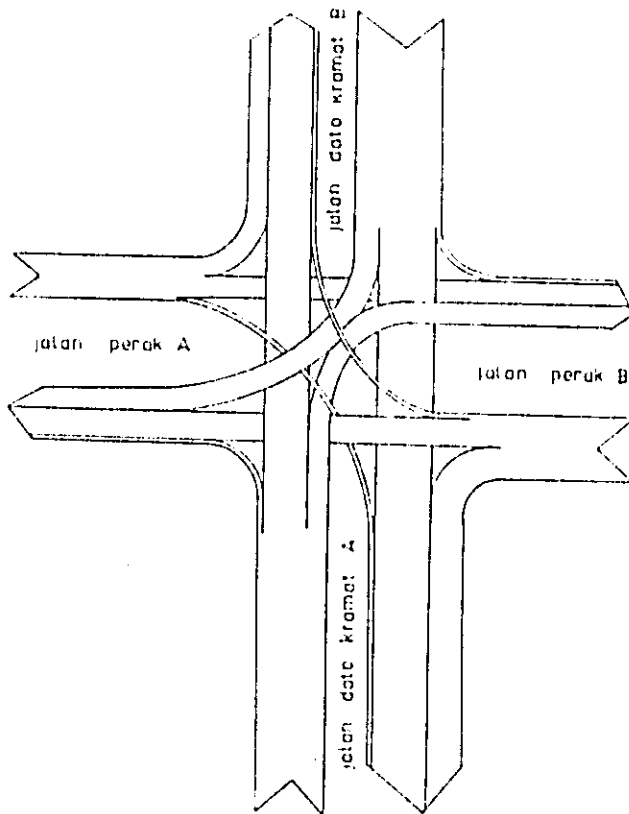


Vehicles (evening peak)

Jalan Dato Keramat/Jalan Perak

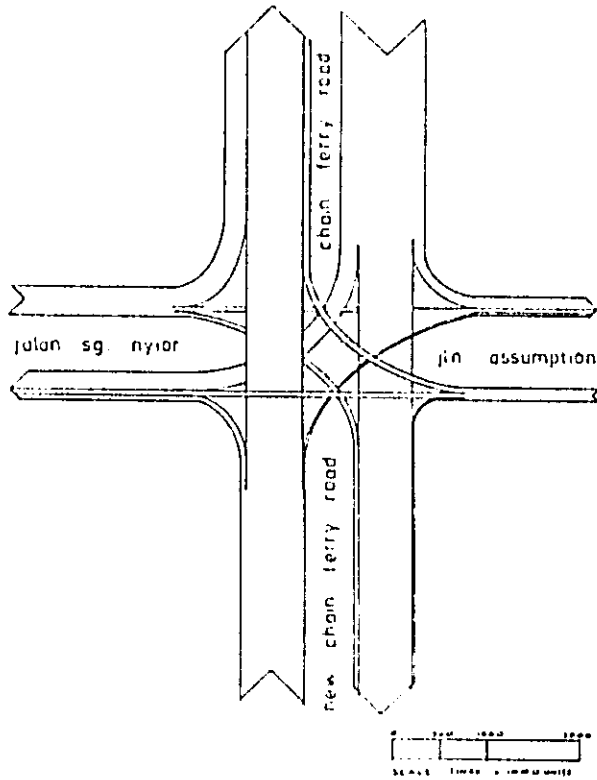


Vehicles (morning peak)

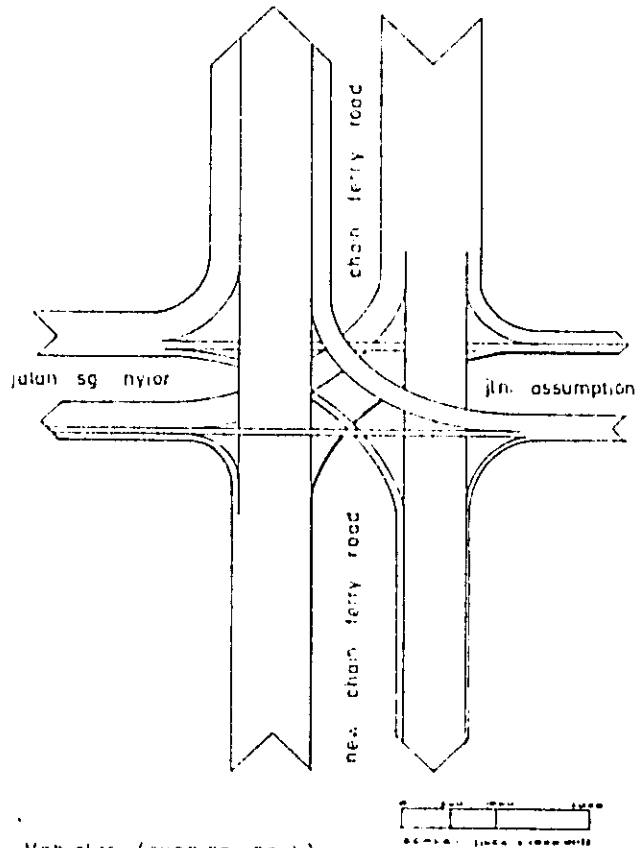


Vehicles (evening peak)

New Chain Ferry Road/Chain Ferry Road/
 Jalan Sg. Nyior/Jalan Assumption

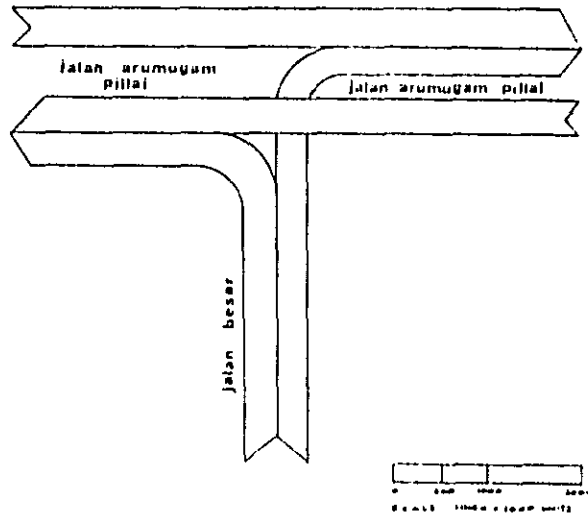


Vehicles (morning peak)

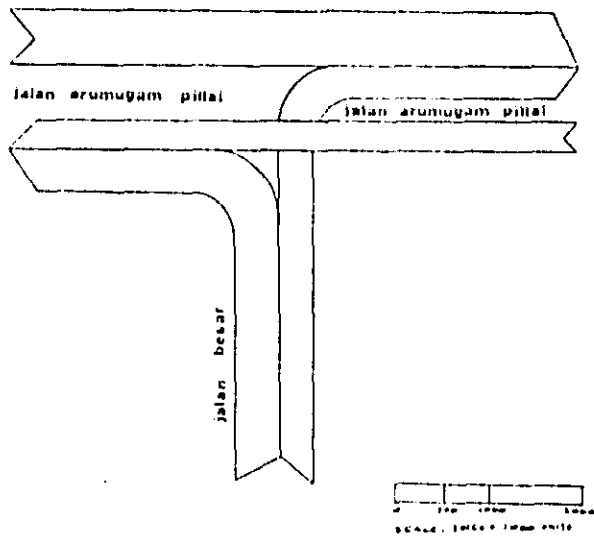


Vehicles (evening peak)

Jalan Arumugam Pillai/Jalan Besar



Vehicles (morning peak)

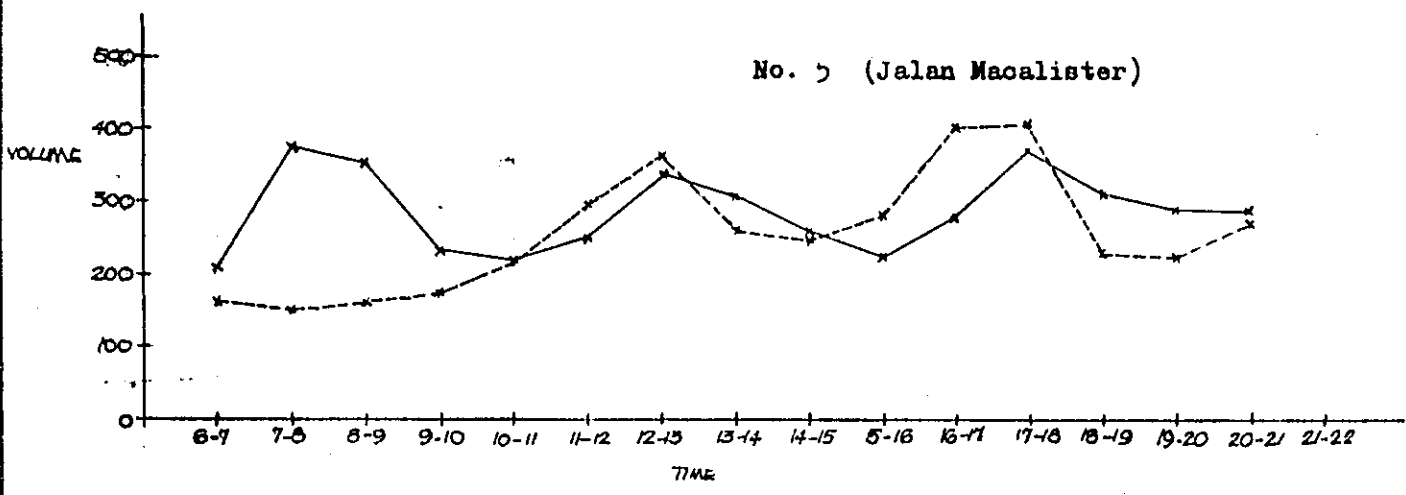
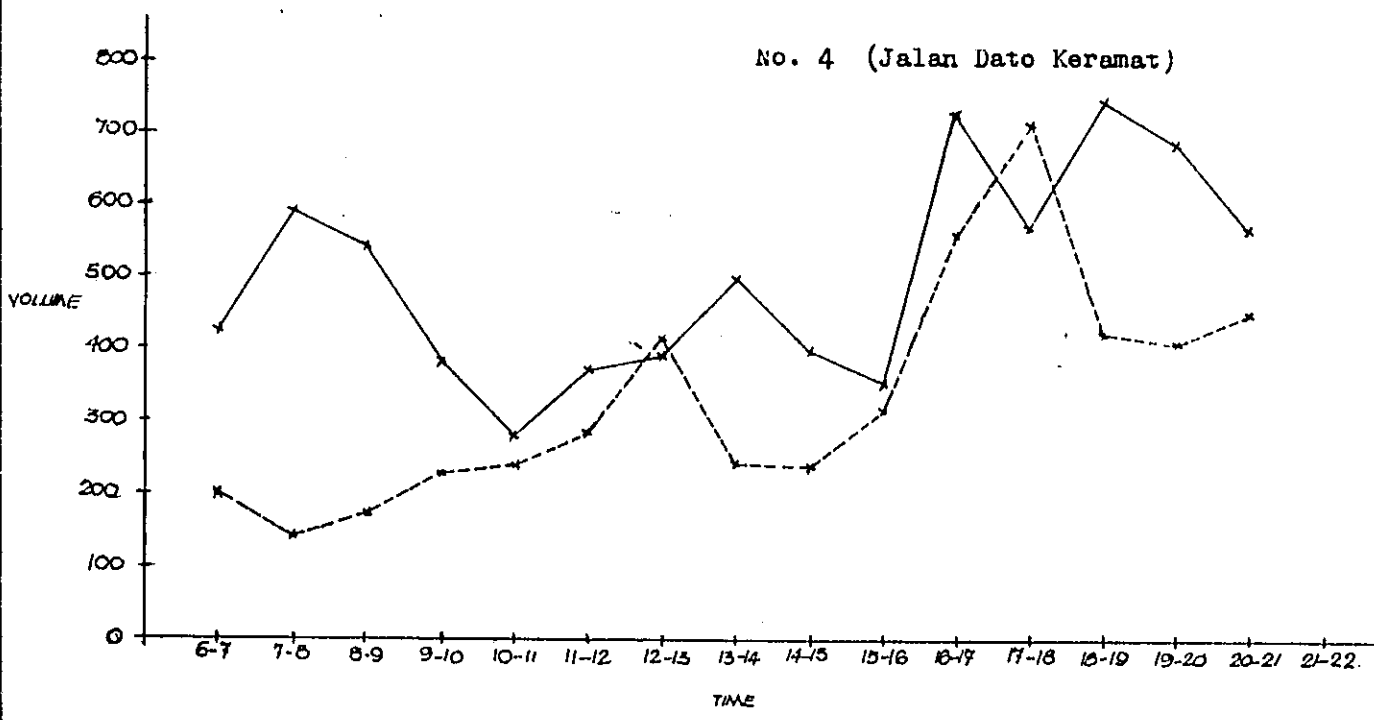
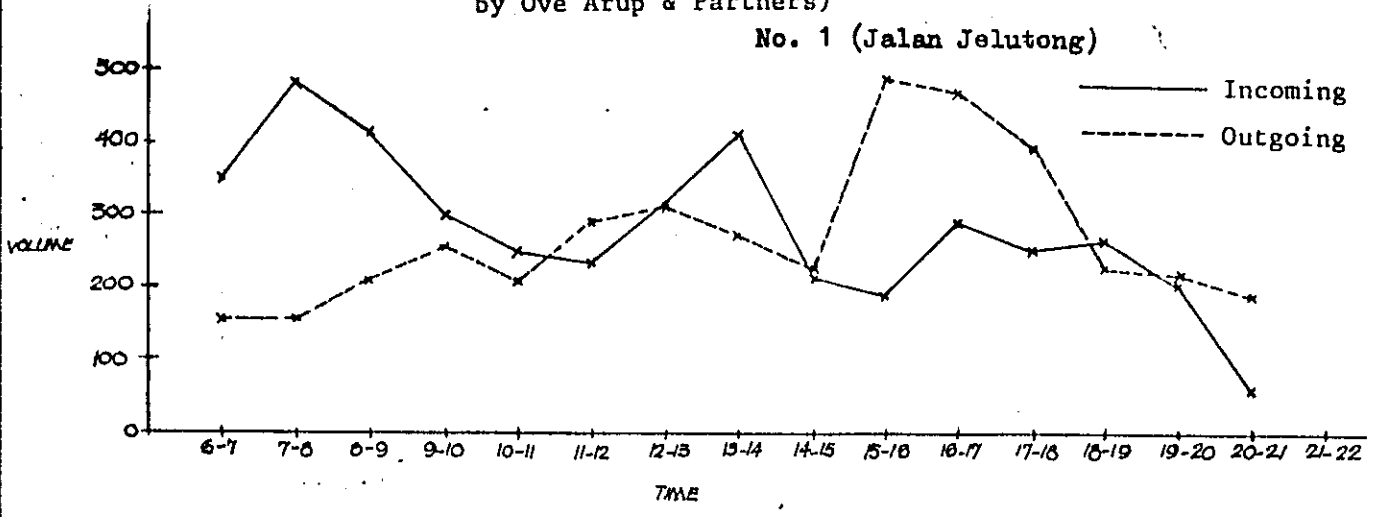


Vehicles (evening peak)

Fig. 12

THE HOURLY FLUCTUATION OF INCOMING AND OUTGOING TRAFFIC VOLUME AT CORDON STATIONS IN GEORGE TOWN

(Source: "City of George Town Traffic Study" by Ove Arup & Partners)



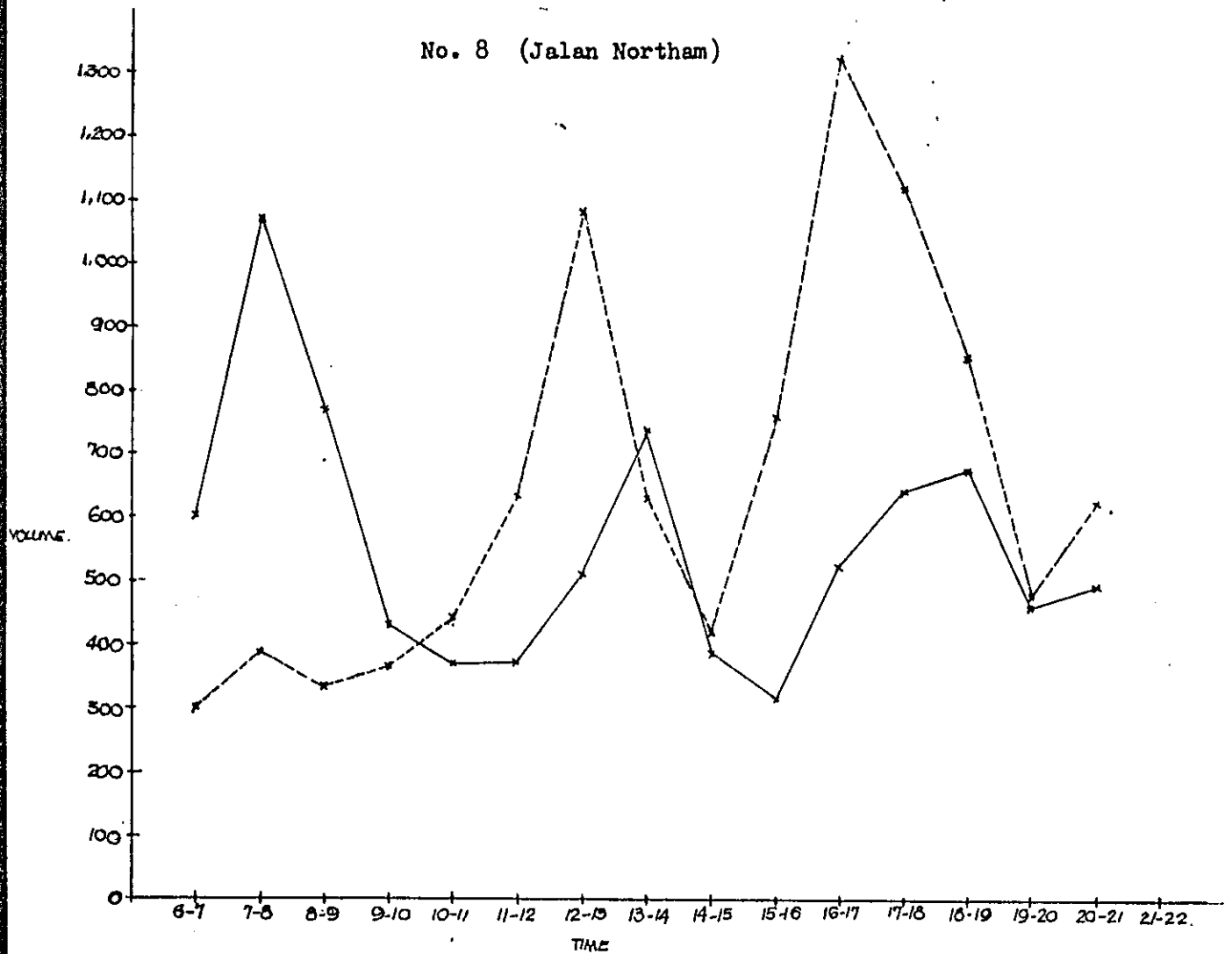
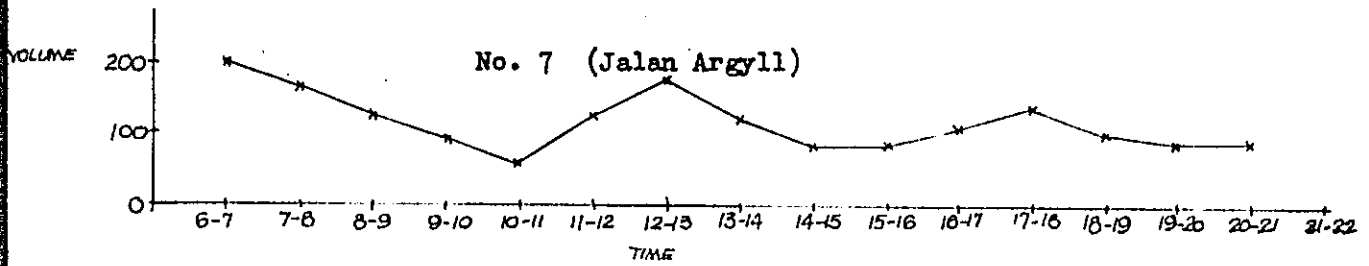
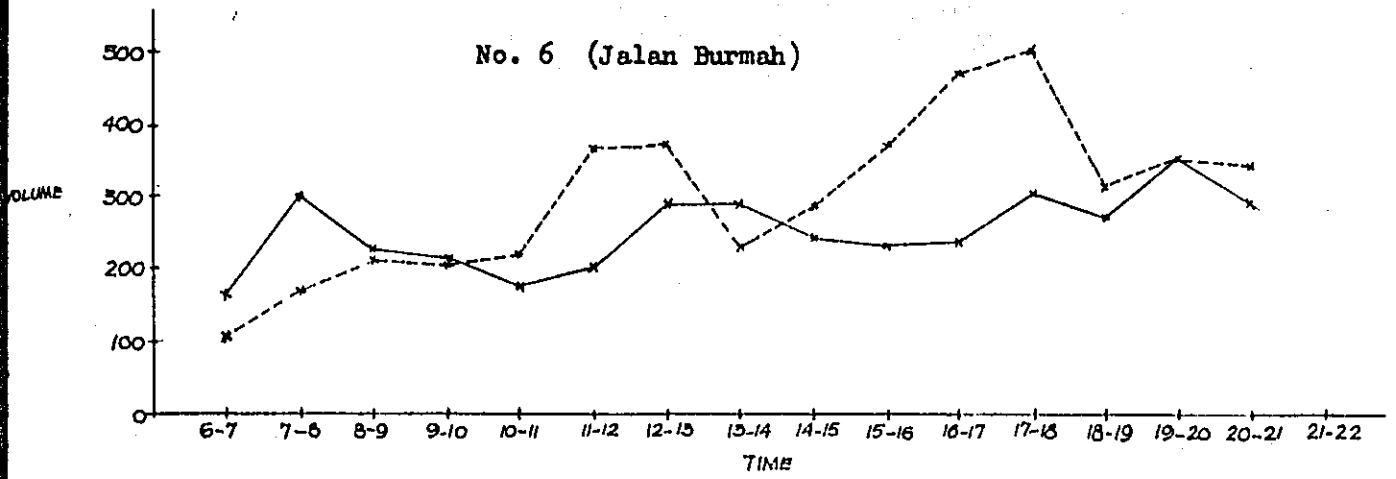
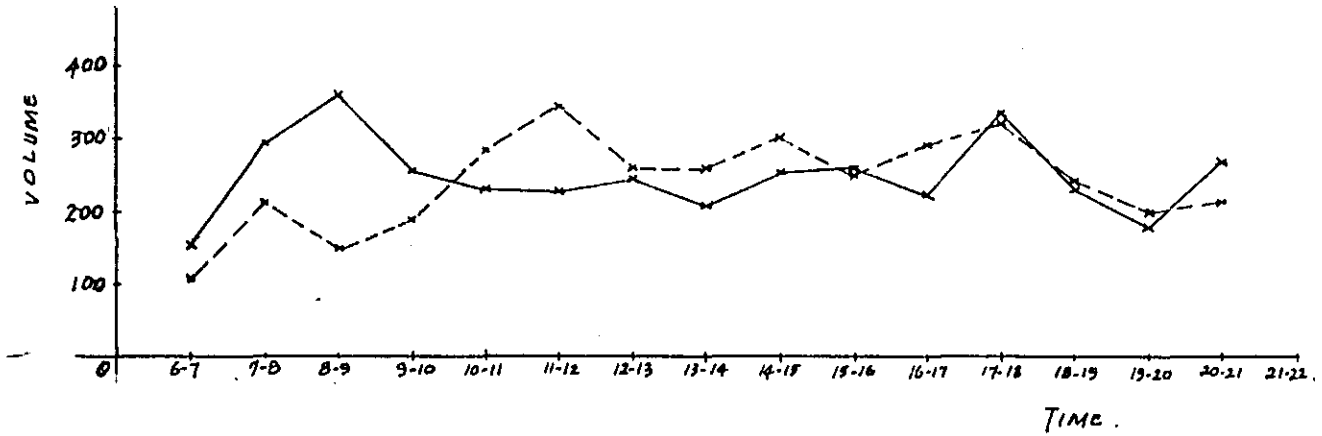


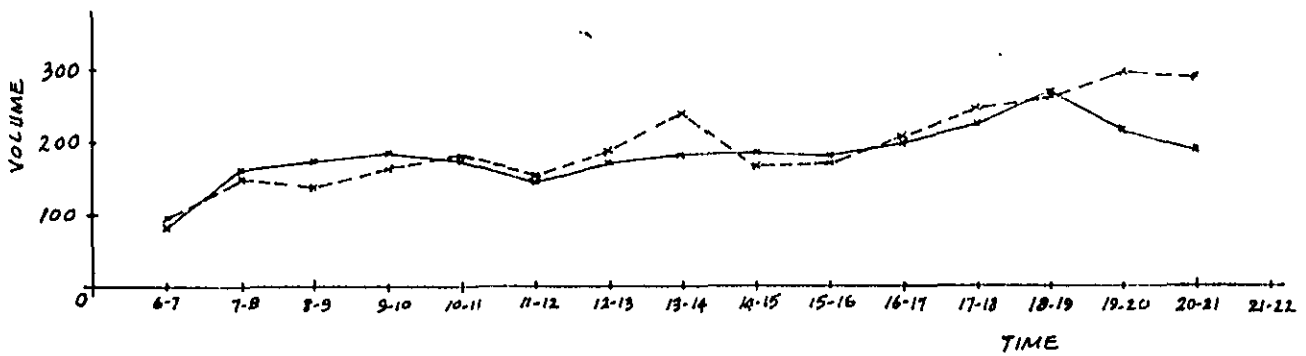
Fig. 13

THE HOURLY FLUCTUATION OF INCOMING AND OUTGOING TRAFFIC VOLUME AT JKR CENSUS STATION IN BUTTERWORTH AND BUKIT MERTAJAM

Station 007 (Jalan Bagan Luar - Butterworth)



Station S9 (Jalan Besar - Bukit Mertajam)



3. The Traffic Signal and Its System

3.1 The Traffic Signal System

A traffic signal inventory was undertaken in George Town, Butterworth and Bukit Mertajam.

a) The traffic signal system in George Town.

A list of intersections with traffic signals drawn up according to the type of traffic signal control in George Town is as follows:-

- (1) Fixed time traffic signal installation
 - Leboh Chulia / Leboh Pitt
 - Leboh Chulia / Leboh Pantai
 - Jalan Anson / Jalan Burmah
 - Jalan Burmah / Jalan Pangkor
 - Jalan Burmah / Jalan Cantonment
 - Jalan Siam / Jalan Dato Keramat
 - Jalan Brook / Western Road
 - Pengkalan Weld traffic signal -- Manually controlled
- (2) Pedestrian crossing traffic signal - Push-button type
 - Jalan Ayer Itam / Methodist School
 - Jalan Ayer Itam / Han Chiang School
 - Jalan Ayer Itam / Chung Ling High School
 - Jalan Carnavon Pedestrian traffic signal
 - Jalan Jelutong Pedestrian traffic signal
 - Jalan Dato Keramat Pedestrian traffic signal
- (3) Fixed time traffic signal installation with linking Facility (with overhead and high intensity signal)
 - Penang Road / Leboh Kimberly / Jalan Phee Choon
 - Penang Road / Jalan Burmah
 - Jalan Burmah / Transfer Road
- (4) Vehicle actuated traffic signal installation (with overhead and high intensity signal)
 - Penang Road / Leboh Chulia
 - Jalan Dato Keramat / Jalan Perak
 - Jalan Sg. Pinang / Jalan Perak
 - Jalan Scotland / Western Road
 - Jalan Sg. Pinang / Jalan Jelutong
 - Kg. Melayu / Boundary Road
 - Jalan Thean Tek / Jalan Ayer Itam
 - Jalan Brick Kiln / Bridge Street
 - Jalan Ayer Itam / Green Lane / Jalan Scotland

There are 26 traffic signal operating in George Town. Of these 26 traffic signals, 11 are fixed time traffic signals of which 3 are coordinated and 6 are pedestrian-crossing traffic signals which are actuated by push-buttons located at both ends of the pedestrian-crossing. 9 of these traffic signals are fully actuated signals which are installed at critical intersections which are mostly located at the peripheral area of the city. Fig. 14 illustrates the location of each type of traffic signals in George Town.

Loop detectors are installed 30' - 40' before the stop lines at each intersection approach. 3 seconds are usually adopted as extension unit. The local controllers utilized for fixed time control are "Auto-Flex, Fixed Time, Signal Type-14" manufactured by The General Electric Company. This controller is modified to function as a coordinated or interlinked unit as seen on Penang Road. The "Autoflex, Type 18" vehicle actuated controller, also manufactured by GEC, is used at 9 intersections, most of which are outside the central area.

b) The traffic signal system in Butterworth and Bukit Mertajam.

A list of intersections with signals drawn up according to the type of traffic signal control in Butterworth and Bukit Mertajam is as follows:-

(1) Fixed time traffic signal installation

Butterworth

Jalan Bagan Luar / Jalan Telaga Ayer

Jalan Telaga Ayer / Jalan Raja Uda / Jalan Permatang Pauh

New Chain Ferry Road / Jalan Sg. Nyior / Chain Ferry Road

Bukit Mertajam

Jalan Arumugam Pillai / Jalan Muthupalaniapa

Jalan Kulim / Jalan Maju

(2) Pedestrian crossing traffic signal - Push-button type

Butterworth

Jalan Bagan Luar / St. Mark's Secondary School

Jalan Raja Uda / Kwang Hua Primary School

There are 5 traffic signals operating in Butterworth, 3 of which are fixed time traffic signals while 2 are pedestrian crossing traffic signals. Also there are 2 traffic signals operating in Bukit Mertajam and both of them are fixed time traffic signals.

In addition, the Municipal Council of Province Wellesley will be installing a fixed time traffic signal at the Jalan Arumugam Pillai / Jalan Aston intersection in Bukit Mertajam. Fig. 15 and Fig. 16 illustrates the location of each type of traffic signals in Butterworth and Bukit Mertajam.

3.2 Installations and Operational Characteristics

Pedestal-type installations and signal heads situated on the near-left and far-right corners of intersections are standard. Recently, mast arms for horizontal overhead displays have been introduced on busy streets to increase their visibility. The display face on the Pedestrian traffic signal shows symbolic walking or standing figures and these are found along Penang Road.

Presence-type, loop vehicle detectors are installed for traffic actuated control. Generally speaking, actuated traffic signal operations are reasonably well adjusted to traffic demands although high traffic volume at peak hours force fixed-time signal operations with long cycle lengths to be extended to the maximum at each phase. Free-flow operations for certain movements, for example, allowing turning to the left during phases of crossing movements can be seen at some key intersections. This type of operation results in high traffic volume at intersections and high discharge rates.

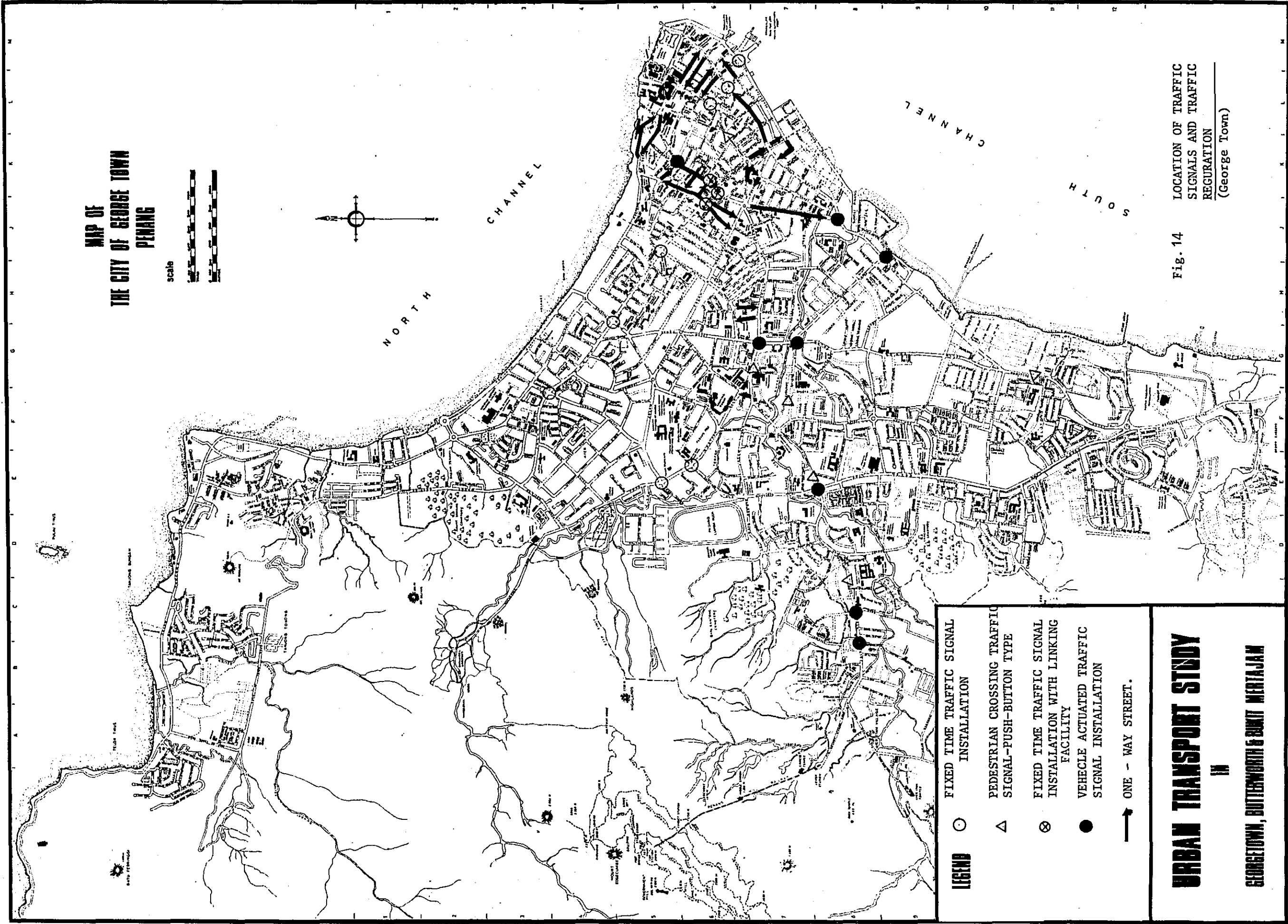
Signal phases and timing adopted at present at key intersections with signals are illustrated in Fig. 17.

3.3 Traffic Signal Maintenance

Traffic signal installation and maintenance in George Town is currently carried out by the General Electric Company which is under contract to the Municipal Council, Penang Island. Maintenance work carried out by the company is specified below:-

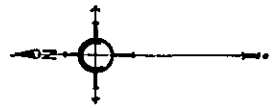
- 1) Daily checks at all intersections with traffic signals to ascertain their functioning order.
- 2) Monthly inspections and maintenance of control mechanism and/or detectors.
- 3) Beck-and-call service for maintenance of control mechanism and/or detectors.
- 4) Changing and maintaining lamps in signal heads as required.
- 5) Painting all poles once every nine months.

However, in Province Wellesley, maintenance is carried out by the General Electric Company only occasionally as when there is problems at the traffic signals.



**MAP OF
THE CITY OF GEORGE TOWN
PENANG**

scale



NORTH

CHANNEL

CHANNEL

SOUTH

Fig. 14
LOCATION OF TRAFFIC SIGNALS AND TRAFFIC REGULATION (George Town)

- LEGEND**
- ● FIXED TIME TRAFFIC SIGNAL INSTALLATION
 - △ PEDESTRIAN CROSSING TRAFFIC SIGNAL-PUSH-BUTTON TYPE
 - ⊗ FIXED TIME TRAFFIC SIGNAL INSTALLATION WITH LINKING FACILITY
 - VEHICLE ACTUATED TRAFFIC SIGNAL INSTALLATION
 - ONE - WAY STREET.

URBAN TRANSPORT STUDY
IN
GEORGETOWN, BUTTERWORTH & BUKIT MERTAJAJAM

Fig. 15
 LOCATION OF TRAFFIC SIGNALS
 AND TRAFFIC REGURATION
 (Butterworth)

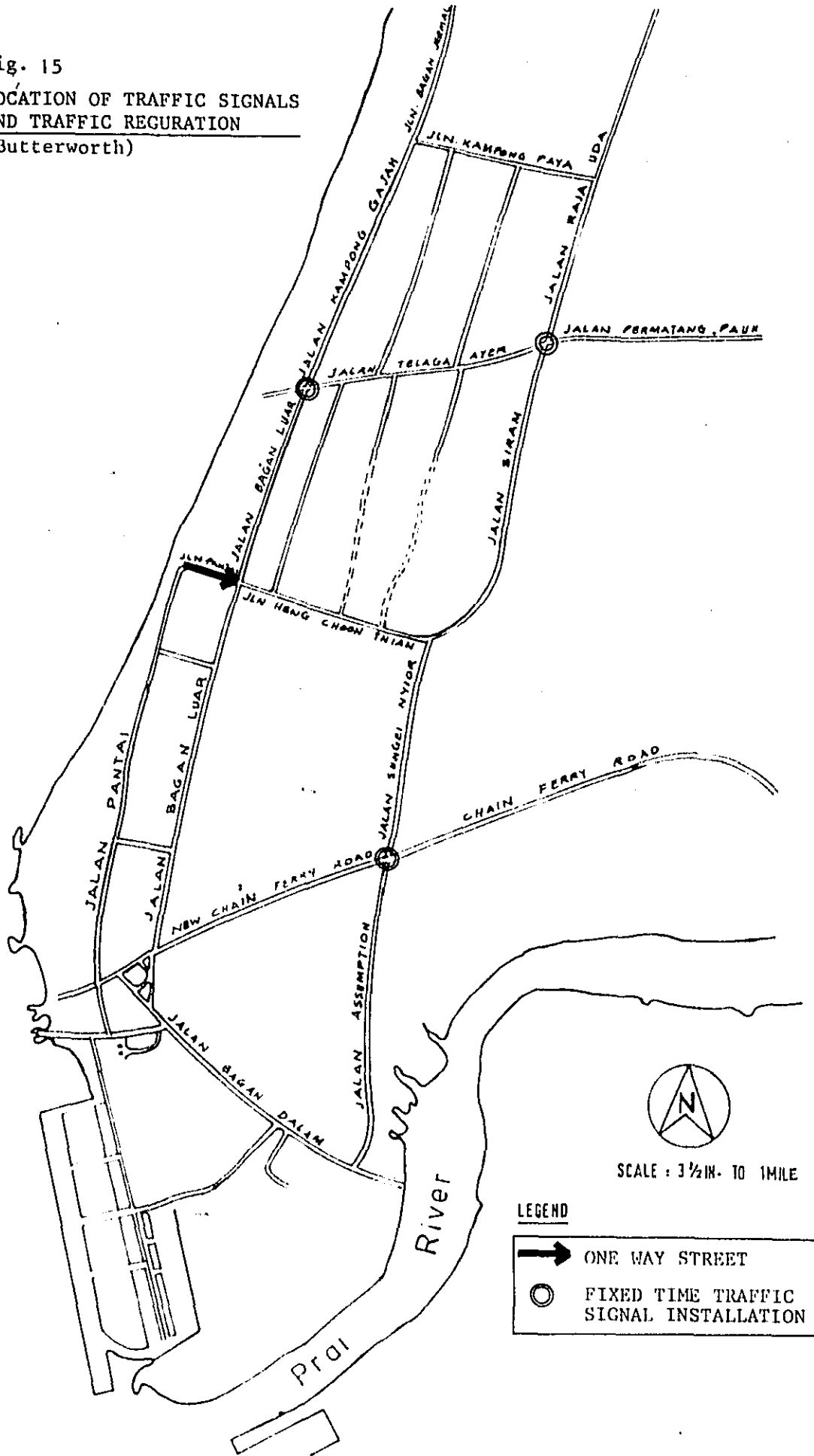


Fig. 16 LOCATION OF TRAFFIC SIGNALS AND TRAFFIC REGURATION (Bukit Mertajam)

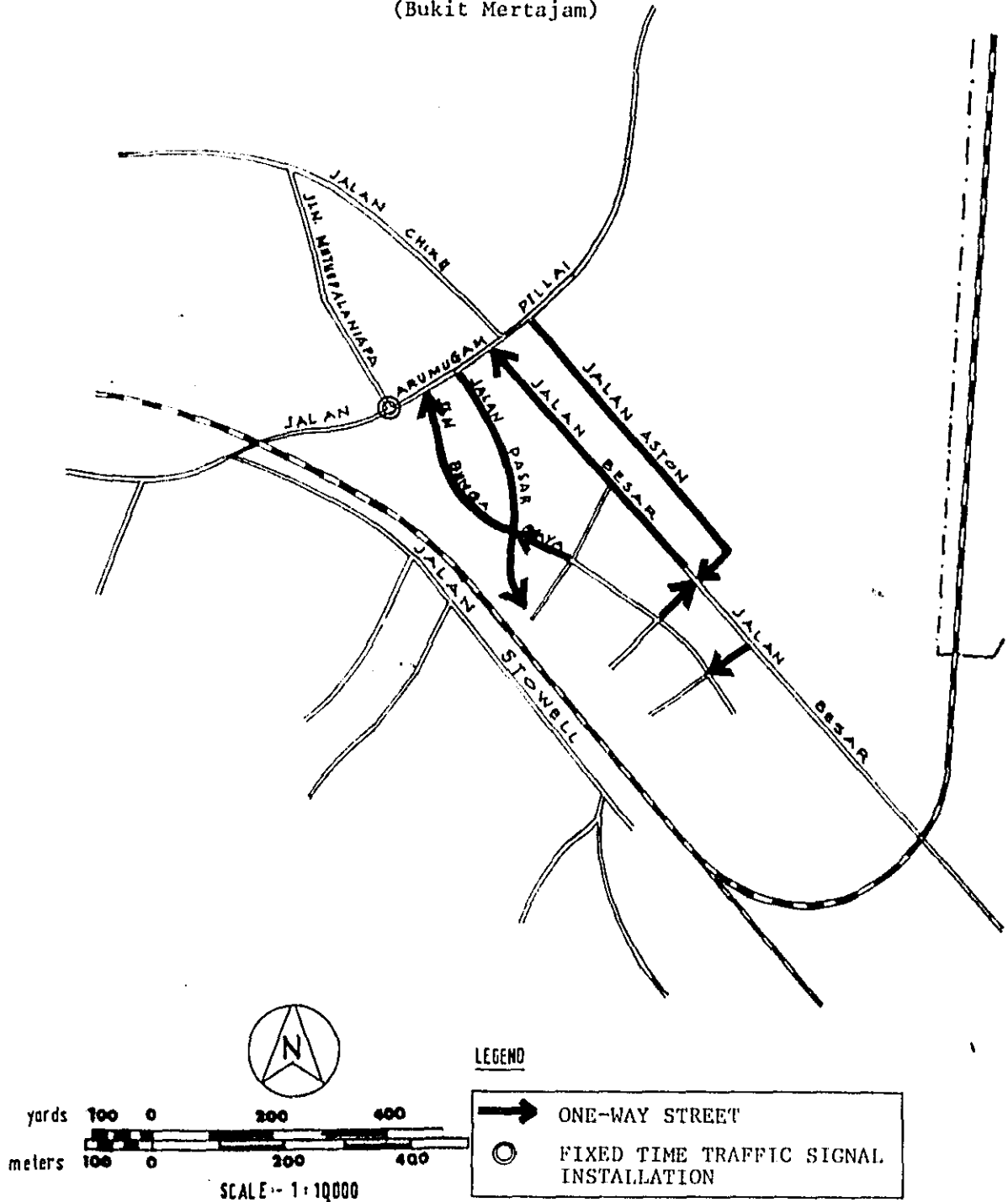
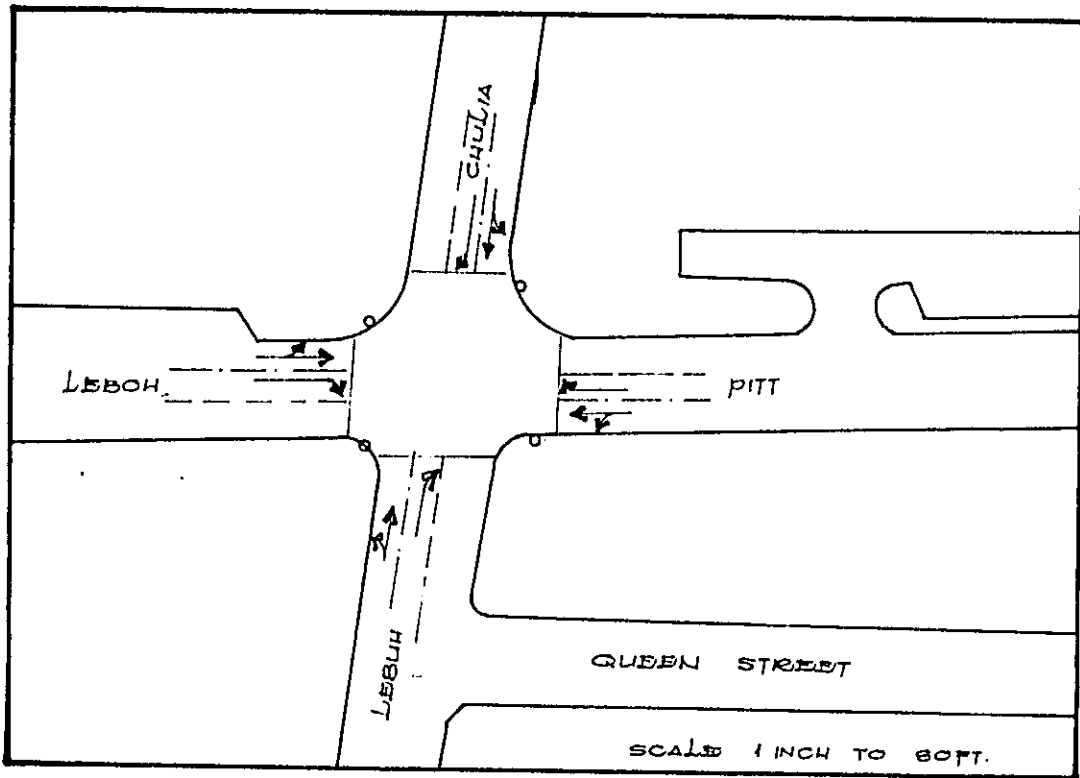
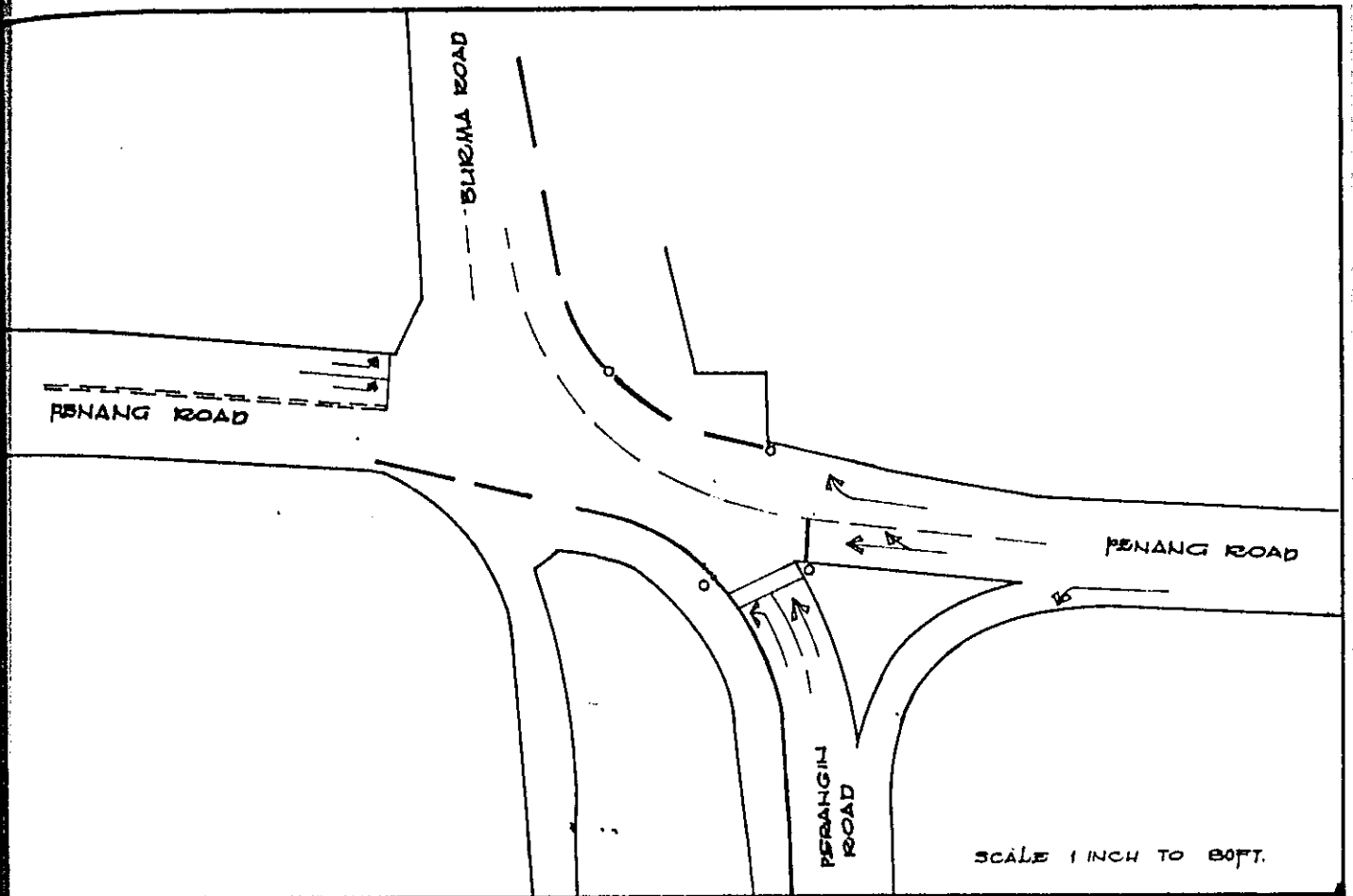


Fig. 17 SIGNAL PHASES AND TIMING AT KEY INTERSECTIONS
 Leboh Chulia/Leboh Pitt



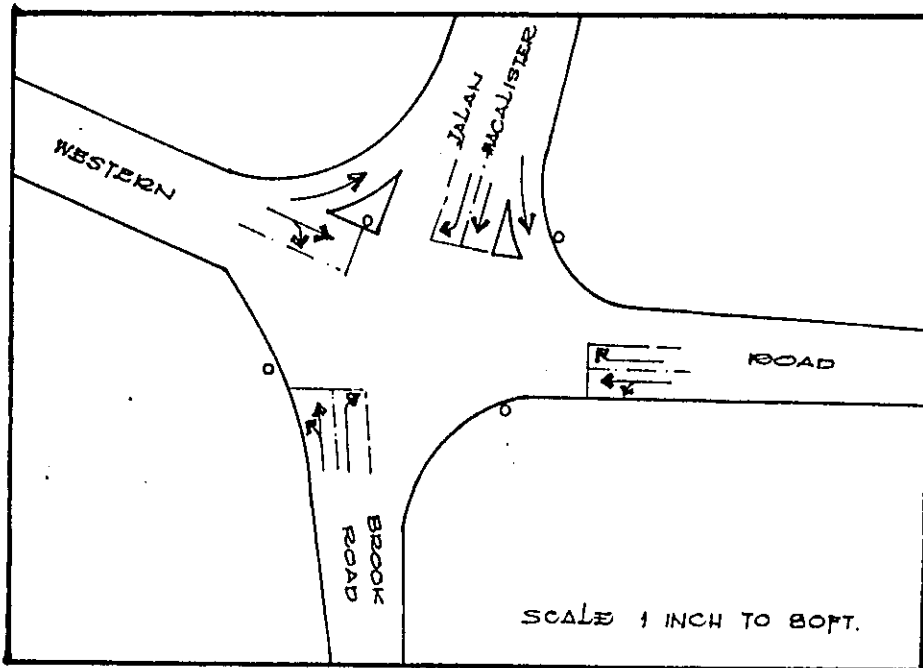
	PHASE	DURATION
1		Green : 18 sec Amber : 3 sec All Red: 5 sec
2		Green : 22 sec Amber : 3 sec All Red: 5 sec
TOTAL		56 sec

Penang Road/Jalan Burma /Jalan Prangin



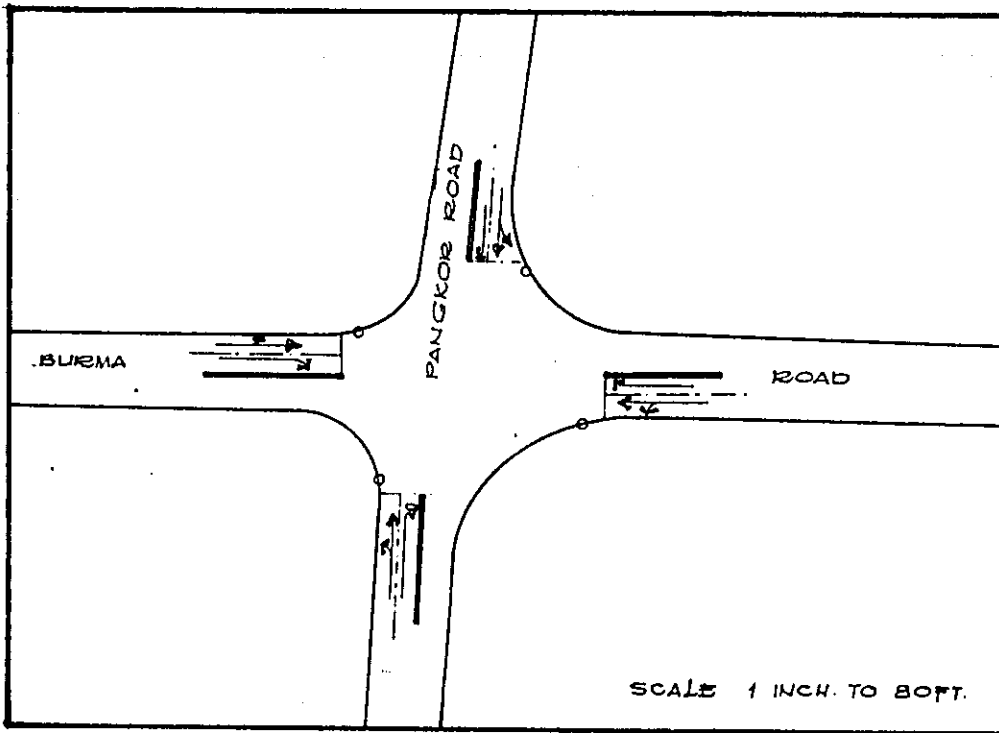
	PHASE	DURATION
.1		Green : 21 sec Amber : 3 sec
.2		Green : 21 sec Amber : 3 sec
.3		Green : 18 sec Amber : 3 sec
TOTAL		69 sec

Jalan Macalister/Jalan Western/Jalan Brook



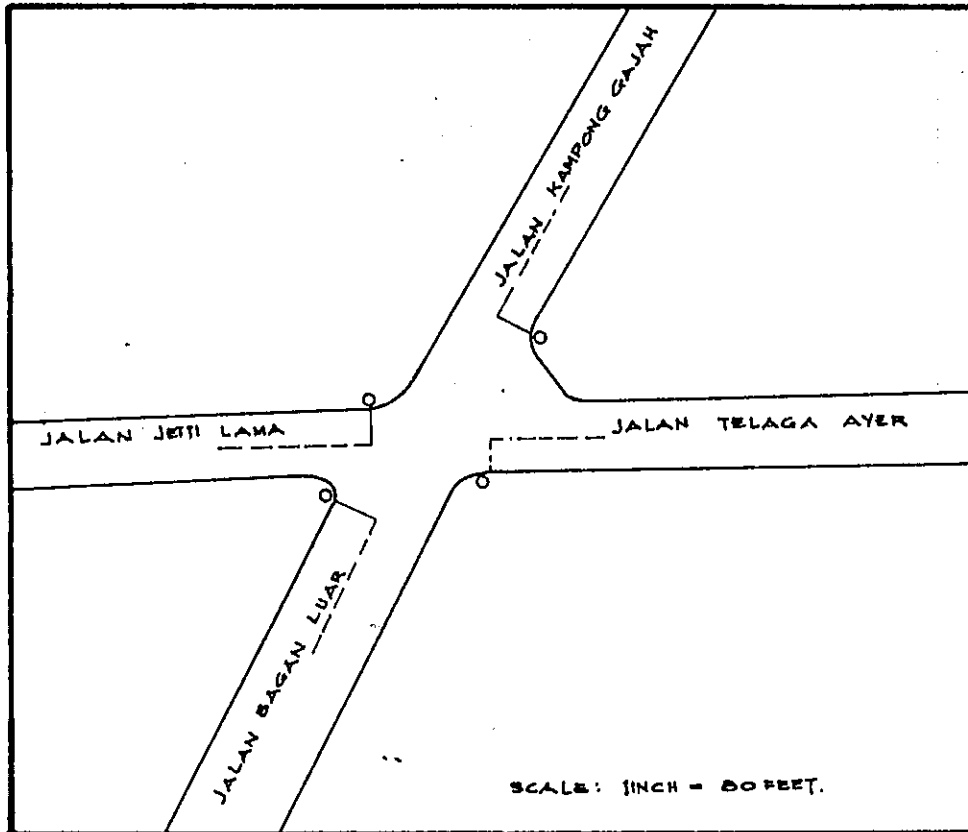
	PHASE	DURATION
1		Green : 18 sec Amber : 3 sec
2		Green : 35 sec Amber : 3 sec
TOTAL		59 sec

Jalan Pangkor/Jalan Burma



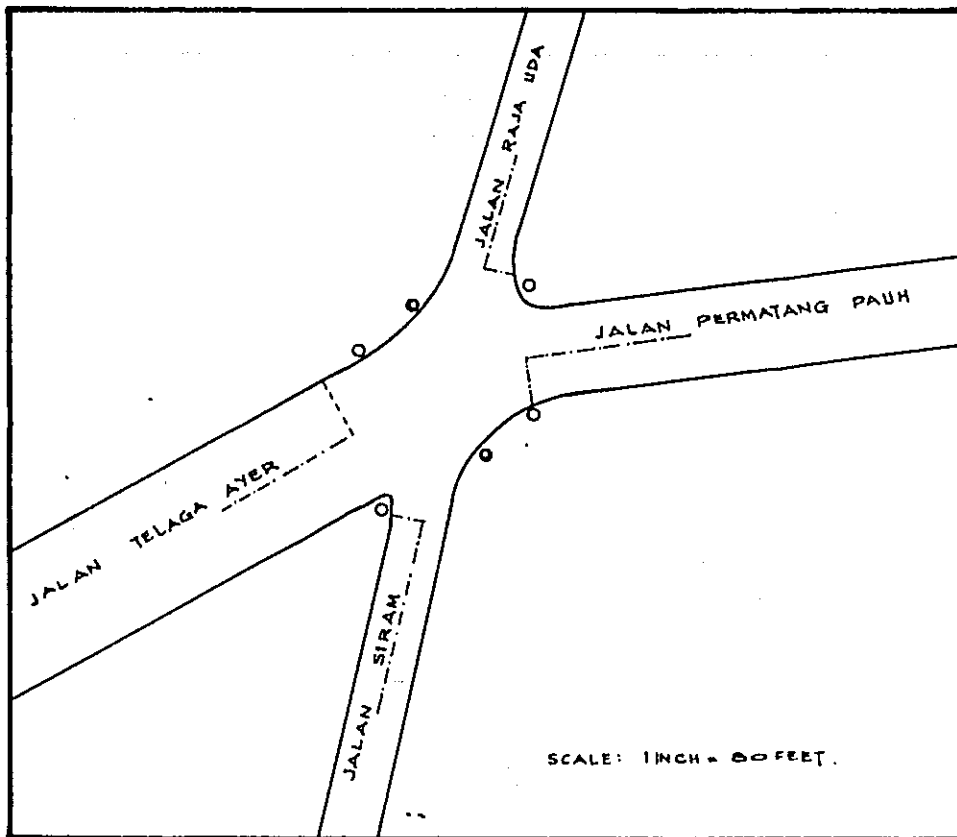
	PHASE	DURATION
1		Green : 24 sec Amber : 3 sec All Red : 4 sec
2		Green : 28 sec Amber : 3 sec All Red : 4 sec
TOTAL		66 sec

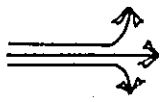

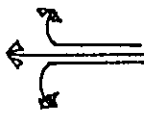

Jalan Bagan Luar/Jalan Jeti Lama/Jalan Kampong Gajah/
Jalan Telaga Ayer



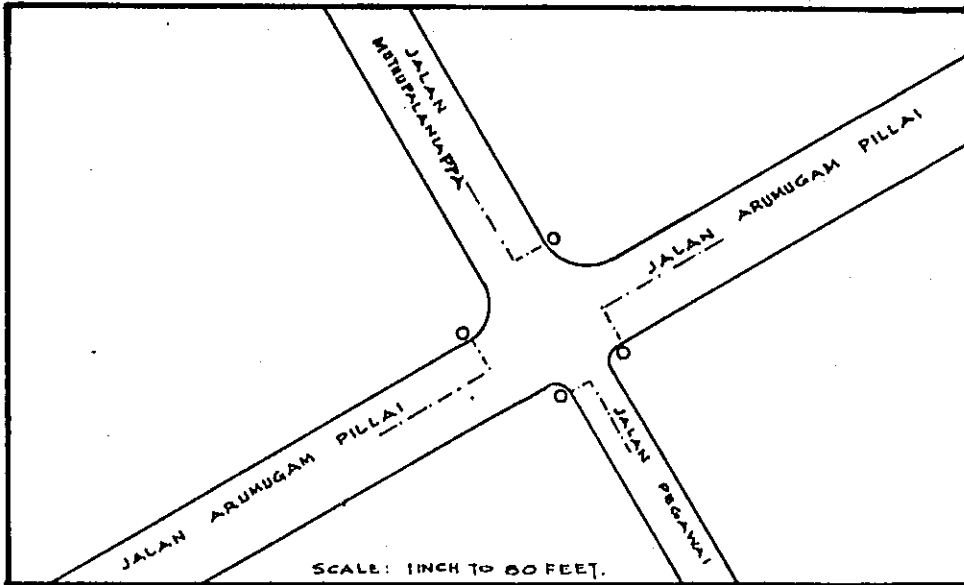
	PHASE	DURATION
1		Green : 63 sec Amber : 3 sec All Red : 3 sec
2		Green : 36 sec Amber : 3 sec All Red : 3 sec
TOTAL		112 sec

Jalan Telaga Ayer/Jalan Raja Uda/Jalan Permatang Pauh/
Jalan Siram



	PHASE	DURATION
1		Green : 26 sec Amber : 3 sec
2		Green : 36 sec Amber : 3 sec
3		Green : 36 sec Amber : 3 sec
4		Green : 24 sec Amber : 3 sec
TOTAL		134 sec

Jalan Arumugam Pillai/Jalan Muthupalaniapa/Jalan Pegawai



	PHASE	DURATION
1		Green : 22 sec Amber : 3 sec
2		Green : 25 sec Amber : 3 sec All Red : 3 sec
3		Green : 31 sec Amber : 3 sec All Red : 3 sec
TOTAL		93 sec

4.
4.1

Traffic Regulations

Traffic Signs and Traffic Markings

In order to attain safe, smooth and efficient traffic flow through the application of available traffic engineering methodologies, controls and traffic technologies, traffic signs and markings as well as traffic signals are essential tools which must be consistently applied.

The consistency of the installation and application of traffic signs and markings is extremely necessary and this has been widely recognized. This has resulted in development of manuals for this purpose. One of the most comprehensive manuals is the revised edition of the "Manual on Uniform Traffic Control Devices for Streets and Highways" by the U.S. Department of Transportation, Federal Highway Administration - 1971, which is available for reference. The Highway Planning Unit of the Government of Malaysia has initiated on a subcommittee basic the preparation for the standardization of traffic signs and markings to be consistently applied throughout the country.

One of the moves was the Government of Malaysia Gazette on traffic signs (size, colour and type) (Amendment) Rules 1979, issued on 1st March 1958, which offered the revision of the Road Traffic Ordinance 1968, Rule 6 of the Traffic Signs (size, colour and type). In this revision, most of the size, colour and type of the traffic signs were changed into internationally recommended ones which are widely adopted all-over the world.

While signs and markings have for the most part been standardized and properly installed in Penang State, most of them do not comply with the revised rules as mentioned above and some are so rotten with rust or so dilapidated that they do not function properly. The Municipal Council of Penang Island has started the program to upgrade and modernize the traffic signs system in the city. The main points of this program can be cited from the specification issued by the city which is as follows:

1. Street nameplates are to be installed.
2. Aluminium is to be used for sign plate materials.
3. Reflective sheeting is to be used for the faces of all signs where reflectivity is required.

- 1) "Scotchlite" Retro-reflective sheeting, Engineer Grade is used for street names, signs and other traffic signs except some important signs which require higher reflectivity.
- 2) Scotchlite High Intensity Grade sheeting is to be used for some important signs such as, other danger signs, AWAS signs, no entry signs, turning prohibition signs, no 'U' turn sign, speed limit sign and signs of approach to junction of roads leading to main centers.

As far as traffic markings are concerned, dotted center lines, continuous center lines and double continuous center lines which means no passing, lane line, stop line respectively and two lines showing pedestrian crossing, arrow marks designating the passage or the use of vehicles which intend to go in the direction of the arrow and diagonal markings showing parking lot, are usually seen. Some of these markings are too worn out to be clearly visible, although they are properly installed. Most of the markings are poorly reflective. Cold paint of ICI standard is usually used and at some important intersections, polymer plastic marking sheetings with aluminium backing are used to lighten the visibility. The zebra marking with black and white stripes has started to be installed for the pedestrian crossings.

4.2

One-way Streets, Turning Restrictions

One-way streets now adopted in the central area of George Town and Bukit Mertajam are illustrated in Figs. 14 to 16.

The one-way streets in George Town have been introduced mainly through a trial and error method to alleviate congestions which take place at critical intersections where traffic would otherwise be congested. These critical intersections are Jalan Brick Kiln / Bridge Street, Penang Street, Penang Road / Jalan Macalister (roundabout), Penang Road / Jalan Burmah, Penang Road / Leboh Chulia, Leboh Chulia / Leboh Pantai and Leboh Light / Leboh Pitt.

Traffic circulation as a result of this one-way system functions so well that there are very few congestions which retard economic and social activities in the day, although some severe congestions take place at some critical intersections, such

as at Jalan Brick Kiln / Bridge Street, Magazine Circus, etc., during the morning and evening peak hours.

One-way streets in Bukit Mertajam were introduced to alleviate congestion on the roads in the central area. However, congestion of roads can be seen at some intersections, eg. Jalan Arumugam Pillai / Jalan Besar, and also parked cars prevent smooth traffic flow.

In Butterworth, there is only a single one-way street, ie. part of Jalan Pantai.

Turning restrictions are widely adopted especially in George Town to comply with the one-way circulation system.

4.3

Other Traffic Regulations

Parking, speed limits, no overtaking, trishaw stands, stopping before entering intersections, and "Give Way" are major concerns of the traffic regulations imposed in George Town, Butterworth and Bukit Mertajam. These regulations are for the most part properly applied, but regulations are hardly applied to bicycles, trishaws and pedestrians.

5. Traffic Accidents

5.1 Traffic Accident Statistics

The yearly statistics for traffic accidents for Penang Island and Province Wellesley is as follows:

Penang Island

Year	No. of accidents	No. killed
1969	2,470	53
1970	2,315	46
1971	2,335	54
1972	2,832	82
1973	3,039	60
1974	3,899	83
1975	5,072	73
1976	4,787	62
1977	5,109	78
1978	5,161	83
1979 (up to July)	2,120	31

(Source: Police Traffic Departments)

Province Wellesley

Year	No. of accidents	No. killed
1974	1,525	78
1975	1,714	80
1976	2,013	68
1977	1,887	58
1978	1,919	67
1979 (up to July)	881	36

(Source: Butterworth Police Station)

Generally, it can be said that the number of traffic accidents in Penang Island is increasing while that of Butterworth has exceeded the peak but is still fluctuating.

5.2 Analysis of Traffic Accidents

An analysis has been made of the traffic accident records from April 1st to June 30th 1979 which is kept in the Police Station from the result shown below, it can be seen that there is a necessity for the improvement of the traffic situation and the traffic facilities.

Number of accidents by urban, suburban and rural areas

Penang Island

	No. of roads	%of the total
Urban area (George Town)	62	29.6
Suburban area	138	66.2
Rural area	9	4.2
	<hr/>	<hr/>
	209	100.0%

Butterworth

Urban area	23	32.8
Suburban area	15	21.4
Rural area	32	45.8
	<hr/>	<hr/>
	70	100.0%

This would suggest that safety measures should be undertaken in suburban areas where traffic movement is faster and where bicycle, trishaw and motorcycle traffic is still heavy, although these figures seldom show that traffic in suburban areas is very dangerous.

5.3

A List of Roads by Frequency of Accidents

The roads that can be listed according to the frequency of accidents are shown in the next page.

PENANG ISLAND

FROM April to June, 1979

<u>NAME OF ROAD</u>	<u>NO. OF ACCIDENTS</u>	<u>PERCENTAGE</u>
Jalan Ayer Itam	66	12.3
Green Lane	58	10.8
Jalan Gelugor/Green Lane Roundabout	53	9.9
Jalan Dato. Keramat	40	7.4
Jalan Gelugor	39	7.3
Jalan Sungai Nibong	39	7.3
Jalan Tanjong Tokong	33	6.1
Jalan Ayer Itam	33	6.1
Genting Village Cross Road	29	5.4
Jalan Burmah	26	4.8
Jalan Perak	24	4.5
Jalan Kelawai	23	4.3
Jalan Northam	24	3.9
Jalan Balik Pulau Village	21	3.9
Penang Road	18	3.4
Weld Quay	14	2.6
TOTAL	537	100.0%

PROVINCE WELLESLEY

<u>NAME OF ROADS</u>	<u>NO. OF ACCIDENTS</u>	<u>PERCENTAGE</u>
Jalan Permatang Pauh	37	19.6
Chain Ferry Road	34	18.1
Jalan Bagan Luar	30	15.9
Jalan Baru	20	10.5
Jalan Bagan Ajam	20	10.5
Jalan Lahar Yooi	18	9.0
Jalan Bagan Jermal	15	7.9
Jalan Sungai Puyu	15	7.9
TOTAL	189	100.0%

From the above figures, it can be seen that the frequency of accidents is highest for Ayer Itam Road. This does not necessarily mean that it is the most dangerous road, because the number of accidents is almost directly dependent on the traffic volume and the length of the road. Traffic accident rate, that is, accident frequency per 100 million vehicle-mile must be adopted for the comparison of the proneness of roads to accidents.

5.4 Traffic Accident Configuration

The accidents reported were classified according to the combination of the road users involved. The results are described as follows:-

<u>Jalan Ayer Itam</u>	No. of Accidents	Percentage
car and car	: 11	16.7
car and lorry	: 2	3.0
car and m/cycle	: 20	30.3
car and pedestrian	: 4	6.1
car and bicycle	: 4	6.1
car and others	: 2	3.0
lorry and m/cycle	: 1	1.5
lorry and pedestrian	: 1	1.5
m/cycle and m/cycle	: 2	3.0
m/cycle and bicycle	: 6	9.1
m/cycle and pedestrian	: 12	18.2
m/cycle and others	: 1	1.5
Total	66	100.0

<u>Green Lane</u>	No. of Accidents	Percentage
car and car	: 16	27.6
car and lorry/bus	: 6	10.4
car and bicycle	: 3	5.2
car and m/cycle	: 14	24.1
car and pedestrian	: 4	6.9
car and others	: 7	12.1
lorry and m/cycle	: 1	1.7
m/cycle and m/cycle	: 5	8.6
m/cycle and others	: 2	3.4
Total	58	100.0

Jalan Gelugor/Green Lane Roundabout

	No. of Accidents	Percentage
car and car	: 14	26.4
car and lorry	: 5	9.4
car and m/cycle	: 12	22.6
car and bicycle	: 5	9.4
car and pedestrian	: 5	9.4
car and others	: 2	3.8
lorry and lorry	: 2	3.8
lorry and pedestrian	: 1	1.9
m/cycle and m/cycle	: 3	5.7
m/cycle and bicycle	: 3	5.7
m/cycle and pedestrian	: 1	1.9
Total	53	100.0

<u>Jalan Dato Keramat</u>	No. of Accidents	Percentage
car and car	: 8	20.5
car and lorry	: 5	12.9
car and m/cycle	: 2	5.1
car and bicycle	: 1	2.6
car and pedestrian	: 4	10.3
car and others	: 1	2.6
lorry and m/cycle	: 2	5.1
lorry and bicycle	: 2	5.1
lorry and pedestrian	: 2	5.1
m/cycle and m/cycle	: 2	5.1
m/cycle and bicycle	: 2	5.1
m/cycle and pedestrian	: 8	20.5
Total	39	100.0

<u>Jalan Gelugor</u>	No. of Accidents	Percentage
car and car	: 7	17.9
car and lorry	: 2	5.1
car and m/cycle	: 8	20.5
car and bicycle	: 1	2.6
car and pedestrian	: 3	7.7
car and others	: 3	7.7
lorry and m/cycle	: 4	10.2
lorry and bicycle	: 1	2.6
lorry and others	: 3	7.7
m/cycle and m/cycle	: 1	2.6
m/cycle and bicycle	: 1	2.6
m/cycle and pedestrian	: 5	12.8
Total	39	100.0

<u>Jalan Permatang Pauh</u>	No. of Accidents	Percentage
car and car	: 3	8.0
car and lorry	: 4	10.9
car and m/cycle	: 5	13.5
car and bicycle	: 1	2.7
car and pedestrian	: 4	10.9
car and others	: 1	2.7
lorry and m/cycle	: 3	8.0
lorry and bicycle	: 1	2.7
lorry and pedestrian	: 1	2.7
m/cycle and m/cycle	: 4	10.9
m/cycle and bicycle	: 5	13.5
m/cycle and pedestrian	: 5	13.5
Total	37	100.0

<u>Jalan Chain Ferry</u>	No. of Accidents	Percentage
car and car	: 11	32.4
car and lorry	: 3	8.8
car and m/cycle	: 4	11.8
car and pedestrian	: 5	14.7
car and others	: 1	2.9
lorry and lorry	: 2	5.9
lorry and m/cycle	: 3	8.8
m/cycle and m/cycle	: 4	11.8
m/cycle and bicycle	: 1	2.9
Total	34	100.0

<u>Jalan Bagan Luar</u>	No. of Accidents	Percentage
car and car	: 3	10.0
car and lorry/bus	: 6	20.0
car and m/cycle	: 10	33.3
car and pedestrian	: 5	16.7
lorry/bus and lorry/bus	: 1	3.3
m/cycle and pedestrian	: 5	16.7
Total	30	100.0

The frequency of the various combinations of vehicles and road users involved in accidents vary from road to road with regard to the roads and the characteristics of the traffic along it. Generally, car/motorcycle, motorcycle/pedestrian and car/car accidents are the main concern of traffic engineers involved in the improvement of roads and traffic conditions.

6. Parking

6.1 Introduction

A detailed parking survey was conducted and a summary of it is included in the Technical Report - 06.

In George Town, parking is generally prohibited only along a limited portion of the streets and City has allocated parking zones in the downtown area where parking is allowed on one side or on both sides of the streets with the parking charge imposed by the Municipal Council. At present, there seems to be sufficient parking space if off-street parking is included, although some wholesale areas and retail areas are very congested with commercial vehicles involved in loading and unloading activities that the smooth flow of traffic is severely hampered for some time.

In the central area of Butterworth and Bukit Mertajam, parking on both sides of the streets is allowed on most streets except for some back lanes in Bukit Mertajam, where only parking on one side is allowed. There seems to be sufficient parking space in these areas, although some wholesale areas in Bukit Mertajam are very congested with commercial vehicles.

6.2 Parking facilities in George Town

a) On-street Parking

Fig. 18 shows the parking control imposed on the streets in the C.B.D. and its peripheral areas of George Town. The prohibition of parking is limited only to the portions of the streets where traffic concentrates. Most of the streets allow two sides parking. Parking on one side is allowed only on streets where both side parking severely hinder the passage of vehicles. Potential Capacity of on-street parking within the above-mentioned area is estimated to amount to about 16,000 units.

b) Off-street Parking

Public off-street parking is limited to the Central Business District. These parking spaces are mainly for cars and motor-cycles. The total capacity of car-parks and motor-cycle parks recorded is 679 units and 243 units respectively. Private off-street parking space owned by the Private sectors including hotels, restaurants, public buildings and shopping centers can accommodate a total of 1,534 parking units.

c) The present parking capacity in the C.B.D. area and its peripheral area of George Town.

The total capacity is made up of the following:

On-street parking (16,682 units)	:	Charged on-street parking (690 units)
	:	Free on-street parking (15,992 units)
Off-street parking (2,213 units)	:	Public off-street parking (679 units)
	:	Private off-street parking (1,534 units)

Altogether, the total number of 18,893 units of parking space is available in the-mentioned areas.

6.3

Parking Facilities in Butterworth

a) On-street Parking

Fig. 19 shows the parking control imposed on the streets in the central area of Butterworth. Prohibition of parking is limited only to the main streets and some congested streets. Most of the streets allow parking on both sides. The potential capacity of on-street parking within this area is estimated to amount to about 3,550.

b) Off-street Parking

In Butterworth, there are only a few Public off-street parking spaces and the total capacity is 240 units.

c) The present parking capacity in the central area of Buttwrworth

The total capacity is made up of the following:

On-street parking	:	Free on-street parking (3,555 units)
Off-street parking (240 units)	:	Public off-street parking (240 units)

Altogether, the total number of 3,795 units of parking space is available in the above-units mentioned areas.

6.4

Parking Facilities in Bukit Mertajam

a) On-street Parking

Fig. 20 shows the parking control imposed on the streets in the central area of Bukit Mertajam. There are no parking prohibitions and most of the streets allow parking on both sides except for some back lanes which allow only parking on one sides. Potential Capacity of on-street parking within this area is

estimated to amount to about .

b) Off-street Parking

There is no specific off-street parking spaces in Bukit Mertajam.

c) The present parking capacity in the central area of Bukit Mertajam.

The total capacity is made up of the following:

On-street parking : Free on street parking
(1,584 units)

Therefore, the total number of 1,584 units of parking space is available in the above-mentioned areas.

6.5

Parking Characteristics

From the parking survey conducted, basic information on parking characteristics was obtained. The distribution of the purposes of parking is shown below:

	Percentage %
1. Going to work	16.8
2. Business engagement	26.8
3. Shopping/Marketing	15.9
4. For food/Entertainment	10.2
5. School	0.3
6. Social visit	7.6
7. Goods & freight delivery	13.0
8. Others	9.4
Total	100.0

These figures seem to reflect the general use of the vehicles although it is a little biased because the sample was drawn from the business and office areas.

The distribution of the walking time to the destination is shown below:

Walking Time (minutes)	Percentage %
0	0.0
1	42.1
2	17.2
3	12.0
4	2.9
5	18.8
6	2.3
7	1.0
8	0.0
10	1.6
11 - 15	1.8
15 over	0.3
Total	100.0

More than two-thirds of the number of drivers park within 3 minutes walking distance, that is, 200 m from their destinations. The duration of parking differs on the purpose of parking. The distribution of the duration of parking by purpose is shown below:

(percentage)

Duration	Purpose	Going to work	Business engagement	Shopping/ Marketing	Delivery of goods
Less than 30 min.		34.4	46.0	60.3	68.8
31 min. to 1 hr.		8.2	21.5	31.7	18.8
1 hr. to 3 hrs.		1.6	11.7	8.0	10.4
3 hrs. to 5 hrs.		6.6	3.9	0.0	0.0
5 hrs. to 8 hrs.		8.2	5.9	0.0	0.0
Over 8 hrs.		41.0	11.0	0.0	2.0
		100.0	100.0	100.0	100.0

In the central area, only about 48% of car owners have their own garages, so more than half of them have to park on the streets (40%) or in the vacant land (12%) in their residence, while 83% of car owners outside the central area have their own garages in their residence.

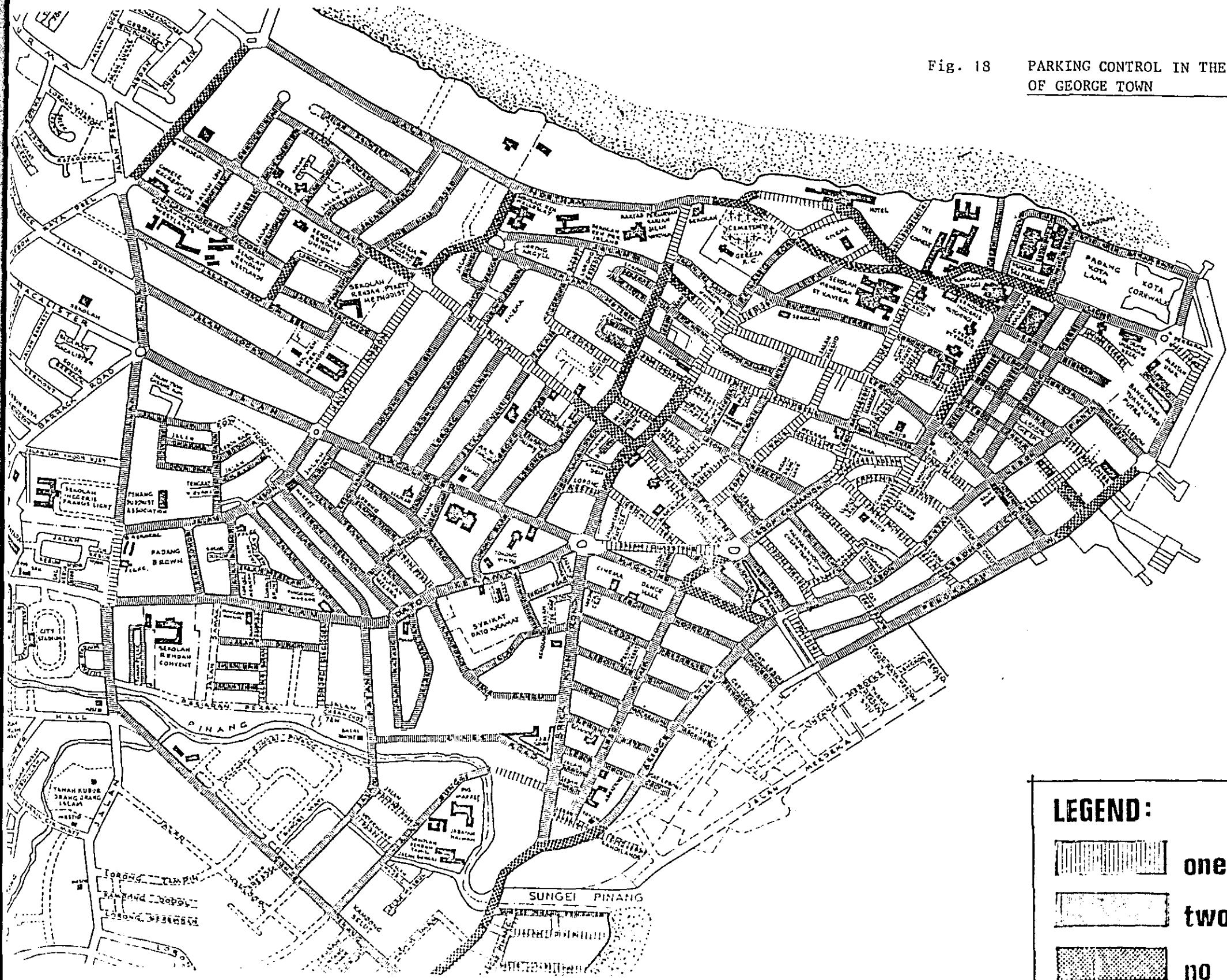
6.6

Present Supply and Demand of Parking Place

As long as the present conditions of parking control continues, available parking space can be said to be able to accommodate the present parking demand. However, on-street parking is closely related to the traffic capacity on the roads because the former will decrease as the traffic volume increases.

Parking for loading and unloading purpose presents critical problems in the port area, wholesale area, especially along Jalan Pantai in George Town and Jalan Bunga Raya in Bukit Mertajam, retail shops and the market area, especially along Penang Road. This suggests the necessity for the development of truck terminals or loading and unloading facilities away from the street in the above mentioned areas.

Fig. 18 PARKING CONTROL IN THE C.B.D OF GEORGE TOWN



LEGEND:

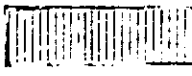


-  one side parking
-  two side parking
-  no parking

Fig. 19
 PARKING CONTROL IN THE
 CENTRAL AREA OF BUTTERWORTH

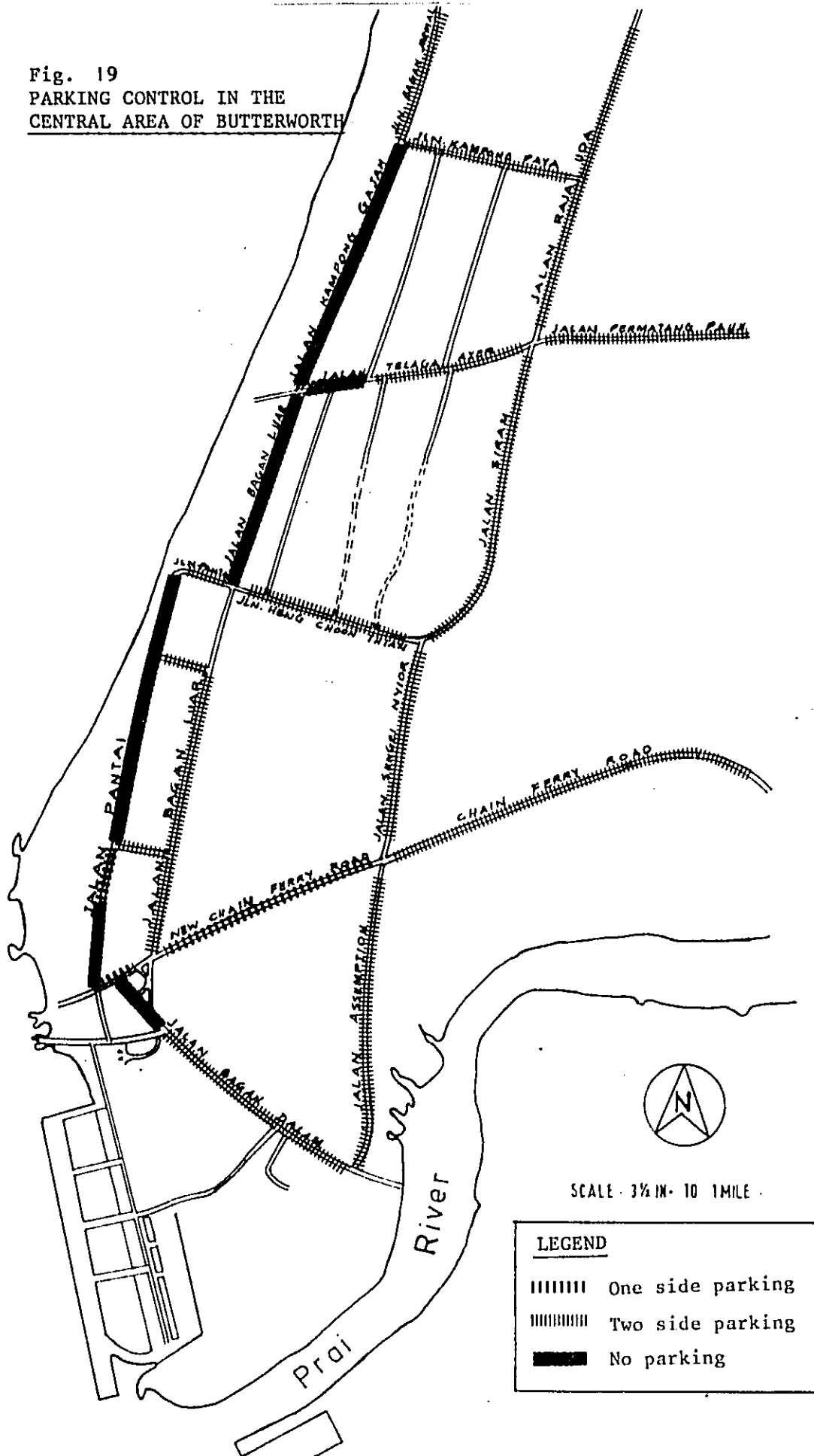
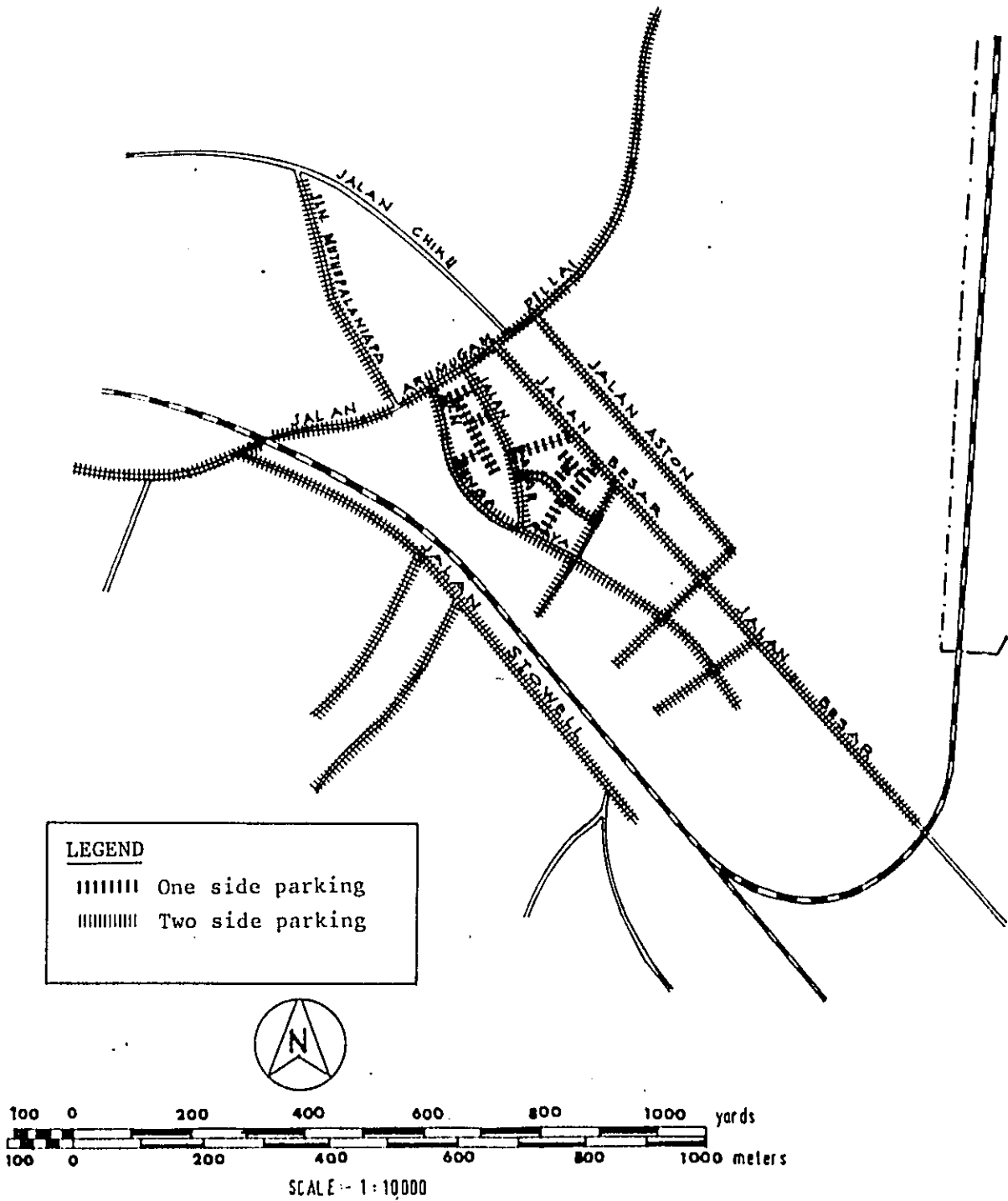


Fig. 20 PARKING CONTROL IN THE CENTRAL AREA OF BUKIT MERTAJAM



7. Pedestrian Facilities

7.1 General

Pedestrian facilities which can be seen in the central areas of George Town, Butterworth and Bukit Mertajam are described below.

(1) Sidewalks

There are many variations of sidewalks from 3' width to 10' width. However, there are many hawkers, who hawk on sidewalks and this obstructs pedestrians

(2) Five-foot-way

There are many so called five-foot-ways in the commercial areas which must have been built by shop-owners in front of their shops. However, these five-foot-ways are different from the level of carriageway and there exist many obstructions, eg. pillars and the act of distribution of goods from the shops. Therefore, it is difficult to walk on these five-foot-ways, especially during peak hours at shopping.

(3) Pedestrian-crossings in signalized intersections

There are some intersections where pedestrian-crossings are located. However, most of them have no specific signal for pedestrians. Furthermore, at some intersections, it is very difficult for pedestrians to cross the road even if there is a pedestrian crossing, due to a continuous indication to vehicular traffic, "turn left" and/or "turn right".

(4) Pedestrian-crossings with push-button type traffic signals

This type of pedestrian-crossings can be seen near schools and at busy pedestrian spots.

(5) Pedestrian-crossings with yellow flashing globe

This type of pedestrian crossings are seldom seen in the central area. However, this type of pedestrian-crossings are very useful because drivers here are educated enough to stop their car and allow pedestrians to get across the road.

(6) Over-head pedestrian bridge

The main purpose of installation of an over-head pedestrian bridge is to avoid surface crossing of the road. However, there are difficulties for old people and the handicapped to use this bridge.

7.2

Pedestrian Facilities in George Town

Fig. 21 illustrates pedestrian facilities in the central area of George Town. Generally speaking, pedestrian facilities in George Town seems to be insufficient and pedestrians are often in dangerous situations.

Sidewalks are mainly installed on main roads, either on one side or on both sides. However, the width of sidewalks are not wide enough at busy spots, eg. Penang Road and Jalan Burmah so that pedestrians have to walk on the carriageway.

Five-foot-ways can be seen in many places, even alongside main streets. However, as mentioned in 7.1, there are many obstructions at five-foot-ways which many pedestrians to walk on the carriageway, especially during peak hours.

Pedestrian-crossings are insufficient at present especially since there is no installation of pedestrian-crossings at some signalized intersections and no signals at pedestrian-crossing. Therefore, many pedestrian cross the roads at any part and this increases the possibility of traffic accidents between vehicle and pedestrian.

There is only one over-head pedestrian bridge which is at the jetty in George Town and this bridge connects the ferry terminal and the Municipal Council bus terminal. The main pedestrian movement at this place is between the ferry terminal and the bus terminal, so that many pedestrians use this bridge. However, some pedestrians still cross over to Weld Quay on the surface of the road, even though there are guare rails to prevent pedestrians from doing so.

7.3

Pedestrian Facilities in Butterworth

Fig. 22 illustrates the pedestrian facilities found in the central area of Butterworth.

There are sidewalks along both sides of Jalan Telaga Ayer and New Chain Ferry Road but only on one side along some part of Jalan Bagan Luar.

Five-foot-ways are only around the Jalan Bagan Luar/Jalan Telaga Ayer Intersection.

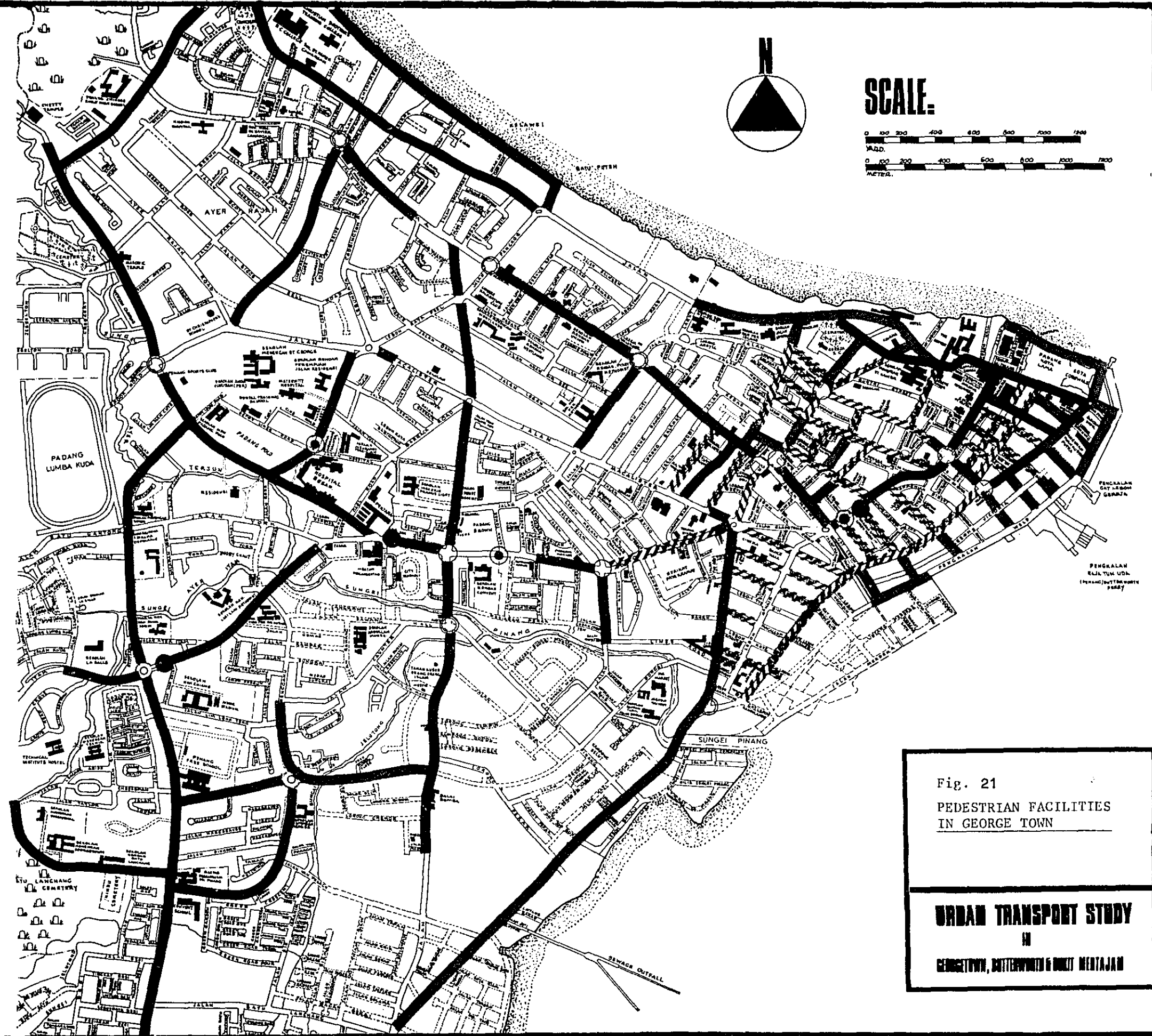
There is only one pedestrian crossing with the yellow flashing globe and there is an absence of intersection with pedestrian crossing.

7.4

Pedestrian Facilities in Bukit Mertajam

Fig. 23 illustrates the pedestrian facilities found in the central area of Bukit Mertajam.

There are no sidewalks in the central area and pedestrians have to walk along the five-foot-way or on the carriageway. Besides, there are no pedestrian-crossings in the central area.



LEGEND:








-  Sidewalk on one side.
-  Sidewalk on both sides
-  Five-foot-way.
-  Signalized intersection with pedestrian crossing
-  Signalized intersection without pedestrian crossing
-  Pedestrian crossing with push-button type traffic signals
-  Pedestrian crossing with yellow flashing globe

Fig. 21
PEDESTRIAN FACILITIES
IN GEORGE TOWN

URBAN TRANSPORT STUDY
II
GEORGETOWN, BUTTERWORTH & BUKIT MERTAJAJ

Fig. 22
 PEDESTRIAN FACILITIES IN
 BUTTERWORTH

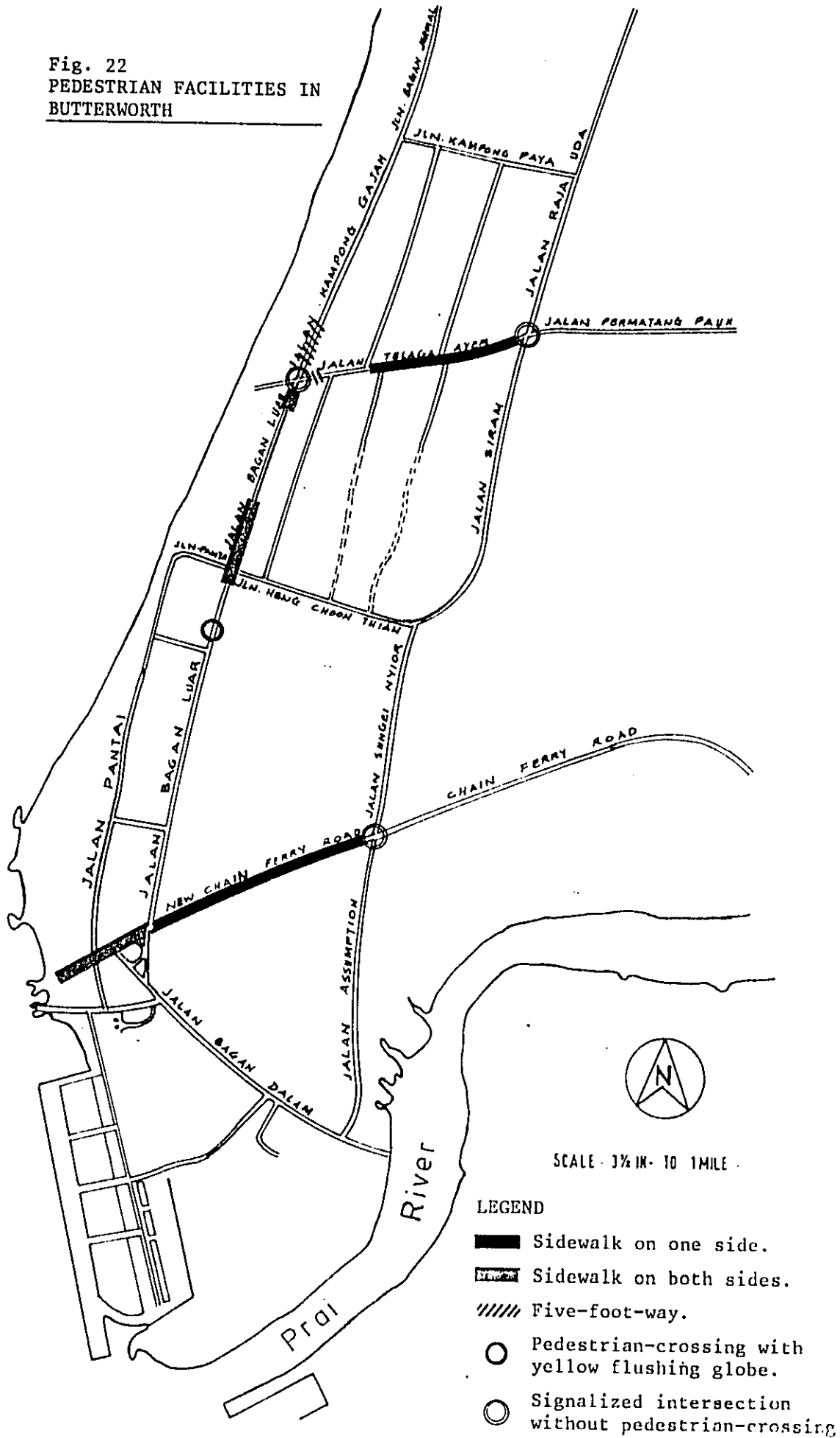
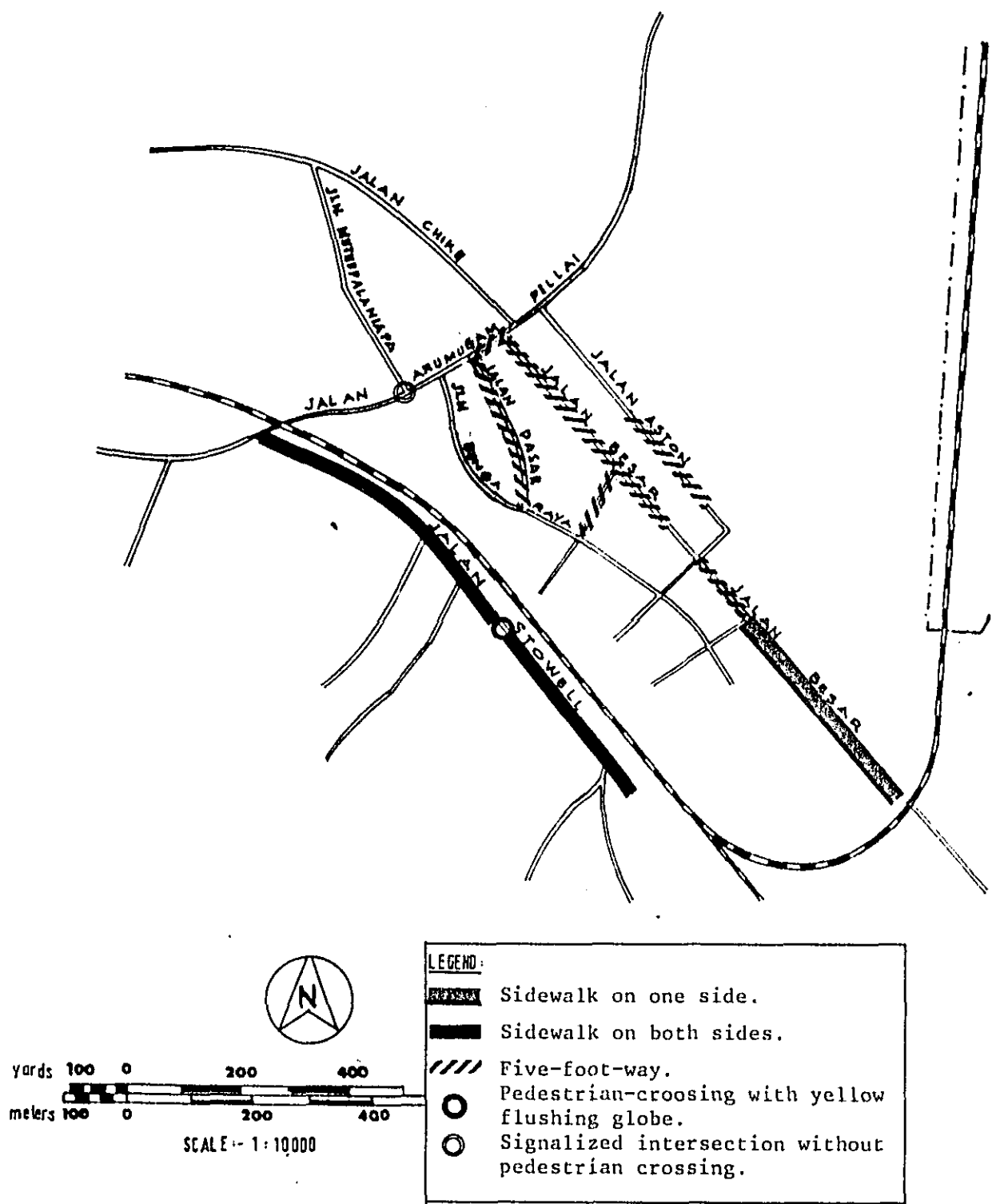







Fig. 23 PEDESTRIAN FACILITIES IN BUKIT MERTAJAM



LEGEND:

-  Sidewalk on one side.
-  Sidewalk on both sides.
-  Five-foot-way.
-  Pedestrian-crossing with yellow flashing globe.
-  Signalized intersection without pedestrian crossing.

